River Tarrant Preservation Society

Low flows and drying of the River Tarrant – history, causes, impacts and potential solutions

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Contents

Summary 1

1. Introduction 5

2. Historic evidence of flow changes and drying of the River Tarrant 9

2.1 Availability of historic evidence of change 9

2.2 Anecdotal evidence of changes to the River Tarrant 9

2.3 Evidence of changes to the Tarrant fishery 10

2.4 Evidence from water mills 11

2.5 Conclusion from review of historic evidence 12

3. Water Framework Directive status of the River Tarrant 13

3.1 WFD classification of the River Tarrant 13

3.2 Review of WFD status in the Middle Stour Tributaries report 14

4. Assessment of abstraction impacts 16

4.1 Drivers of flows in chalk streams 16

4.2 The CSF lumped parameter model for the Tarrant-Pimperne 20

4.3 Validation of the CSF model 22

4.4 Comparison of validation of the CSF and Wessex models 26

4.5 Modelled impacts of abstraction on river flows and river drying 31

4.6 Modelled compliance with EFIs 33

4.7 Effectiveness of the AIM scheme 35

4.8 How reliable is the modelling? 36

4.8.1 Reliability of the Wessex Basin Model 37

4.8.2 Validity of Wessex Water conclusions on Pimperne Brook impacts 40

4.8.3 Reliability of CSF modelling 42

4.9 Measured evidence of Black Lane impacts 45

4.9.1 Evidence from the Black Lane shut-down in 2016-17 45

4.9.2 Use of Woodyates GWLs for impact assessment and model validation 47

4.10 Flow losses in lower River Tarrant 53

4.10.1 Measured amounts of flow losses, 1996-2004 & 2015-18 53

4.10.2 Measured flow losses in 2024 56

4.10.3 The relationship between flow losses and groundwater levels 59
4.10.4 Influence of Stour valley abstractions on Tarrant GWLs and flows 62
4.11 Conclusions from the review of abstraction impacts 65
4.11.1 Conclusions from the modelling of abstraction impacts 65
4.11.2 Conclusions from measured evidence of abstraction impacts 67
4.11.3 Conclusions from review of River Tarrant losses 67
4.11.4 Conclusions on the WFD status of the hydrological flow regimes 68
4.11.5 Conclusions on the need for action to reduce abstraction impacts 68
5. Potential solutions 69
5.1 Types of potential solutions 69
5.2 Making best use of existing River Stour supplies 69
5.2.1 Existing supplies in the Stour valley 69
5.2.2 Proposal for a CSF-type of scheme to minimise Tarrant-Pimperne impacts 71
5.2.3 Investigation of proposed redistribution of abstraction from Middle Stour sources 75
5.2.4 Possible use of South West Water's Bournemouth sources 76
5.3 Possible new sources to replace Tarrant-Pimperne supplies 77
6. Next steps 79
6.1 Review of this report by the EA and Wessex Water 79
6.2 Review of geomorphological evidence 80
Appendix A – Dr David Solomon report on historical and fisheries aspects 82
Appendix B – Article on Tarrant from Field magazine, 1997 105
Appendix C – Extracts on determining abstraction zones of influence from Middle Stour Tributaries report 109

Figures

Figure 1 - Location of water supply abstractions in and around the Tarrant catchment 5
Figure 2 - Monthly average abstraction from Middle Stour sources 6
Figure 3 - Locations of public water supply sources close to the lower River Tarrant 6
Figure 4 - Layout of Wessex Water's new GRID pipeline 7
Figure 5 - Monthly average abstraction from Tarrant-Pimperne groundwater sources 8
Figure 6 - Location of water mills in the lower Tarrant valley 11
Figure 7 - Schematic representation of a typical chalk valley 16
Figure 8 - Locations of boreholes and spot flow gauging sites 17
Figure 9 - Relationship between GWLs and river flows in Tarrant and Pimperne valleys 18
Figure 10 - Relationships between GWLs at locations in Tarrant-Pimperne catchments 19
Figure 11 - Variation in average monthly effective rain in Tarrant catchment 20

Figure 12 - Tarrant-Pimperne catchment boundary assumed in CSF model 21
Figure 13 - CSF model validation: modelled vs historic measured GWLs 23
Figure 14 - CSF model validation: modelled vs historic measured Tarrant-Pimperne flows 25
Figure 15 - Flow validation comparison of the Wessex model and the CSF model 26
Figure 16 - GWL validation comparison of the Wessex Regional model and the CSF model 27
Figure 17 - Tarrant flow signature plot 1974 to 1991 28
Figure 18 - Tarrant flow signature plot 2015 to 2024 29
Figure 19 - Comparison of CSF and Wessex modelling of impacts on lower Tarrant flows 32
Figure 20 - Examples of EFI flow failures shown by CSF modelling 35
Figure 21 - Stubhampton AIM operation 2020 to 2024 36
Figure 22 - Wessex modelling of effect of AIM on Monkton flows in 2022 drought 36
Figure 23 - Wessex Water explanation of lack of impact from Black Lane and Shapwick 38
Figure 24 - Conceptual illustration of 'cone of depression' and 'zone of influence' 39
Figure 25 - Examples of poor validation fits for Wessex model in Pimperne catchment 41
Figure 26 - Abstraction as % of recharge for Pimperne compared to other chalk streams 42
Figure 27 - Abstractions before and after the Black Lane shut-down 45
Figure 28 - Lower Tarrant measured flows during Black Lane shut-down 46
Figure 29 - Effective rain around time of Black Lane shut-down 46
Figure 30 - Location of Woodyates OBH relative to River Tarrant area 47
Figure 31 - Average monthly abstraction at Black Lane 2015 to 2024 48
Figure 32 - Wessex Water plot of Preston Farm flows vs Woodyates GWL 49
Figure 33 - Revised plot of Preston Farm flows vs Woodyates GWL, showing different years 50
Figure 34 - Drying of the Pimperne Brook relative to Woodyates GWLs 51
Figure 35 - Newfield Farm GWLs relative to Pimperne drying 52
Figure 36 - River Tarrant flow accretion and losses 2017-18 53
Figure 37 - Crawford spot flows vs Keyneston Bridge GWLs and river bed level 53
Figure 38 - River Tarrant flow accretion and loss in 2016-17 and 1997-98 54
Figure 39 - Gauged leakage losses between Preston Farm and Tarrant Crawford 55
Figure 40 - Spot flow gauging locations for 2024 leakage survey 57
Figure 41 - Measured flow losses in summer 2024 58
Figure 42 - Comparison of flow losses in 2017 and 2024 59
Figure 43 - Variation of valley bottom GWLs relative to adjacent river bed levels 60
Figure 44 - GWLs, river bed level and the river drying at Keyneston Bridge 61
Figure 45 - Modelled GWLs relative to river bed level at Keyneston Bridge 61
Figure 46 - Location of boreholes in Middle Stour valley 63
Figure 47 - Minimum recorded GWLs in the Middle Stour valley 64
Figure 48 - Changes in Middle Stour abstraction since 1970 64
Figure 49 - CSF modelled impact of abstraction on Tarrant Keyneston GWLs 65
Figure 50 - Existing public water supply sources in the Stour valley 70
Figure 51 - Wessex Water planned reduction in future supplies 74
Figure 52 - Forecast reduction in SWW's supplies into the Bournemouth zone 77

Tables

Table 1 - History of WFD classifications for River Tarrant water body 13
Table 2 - Comparison of observed and modelled frequency of drying of lower river 30
Table 3 - Modelled impact of abstraction on drying of the lower River Tarrant 31
Table 4 - Comparison of Wessex and CSF modelling of abstraction impacts 33
Table 5 - EFI standards for 'Good' Ecological Status 34
Table 6 - Wessex modelled EFI compliance for historic flows at Preston Farm 34
Table 7 - CSF modelled EFI compliance for historic flows at Preston Farm 34
Table 8 - Outputs of Wessex Water sources 71
Table 9 - Licence constraints on additional water from Wessex Water lower Stour sources 72
Table 10 - Proposed licence changes to reduce Tarrant-Pimperne abstraction impacts 72
Table 11 - Planned reductions in South GRID supply sources in Wessex Water's WRMP24 74
Table 12 - Planned AMP8 Middle Stour WFD over-abstraction investigations due by end of 2026 75

Summary

The scope of this report

This report examines the increasing incidence of low flows and drying in the River Tarrant, a chalk stream in Dorset. It offers new evidence of the impact of groundwater abstraction for public water supply, based on hydrological modelling and historic research into the river's flow regime and fish populations. The report concludes that over-abstraction is the main cause of the unnatural drying of the lower River Tarrant and proposes an actionable solution, involving redistribution of the amounts taken from various existing supplies in the Middle Stour valley.

Refer to page no.

Historical and Ecological Evidence of Flow Reduction

Prior to the 1950s, the lower River Tarrant was almost always flowing, even during dry years. Anecdotal accounts from long-term residents, historical press reports, and the history of water mills and fisheries suggest a previously near-perennial flow regime. 9-12

Local press reports from 1929 and 1933 refer to drying-out of parts of the upper Tarrant in the years of exceptional drought. In 1929 one report said that *"the villagers are having the unique experience of walking over the bed of the rivulet at Tarrant Monkton dryshod, a circumstance without parallel for a very prolonged period"*. This is nowadays an annual phenomenon. No mention is made in these old press reports of drying-out of the lower river; if it happened, it would surely be a more newsworthy story than drying of the upper reaches. 9

The change in frequency of drying came after substantial groundwater abstraction for public water supplies began around 1950. Notably, the only recent year in which the lower river did not dry was 2017, when the Black Lane pumping station was shut down for refurbishment. This correlation strongly implicates abstraction in the drying of the lower Tarrant, especially since rainfall that year was below average. 12 Figure 18

Fish rescues have been mounted in most of the last 20 years, sometimes involving thousands of fish. In contrast, there were only two rescues mentioned in the very detailed fishery sections of the River Board/Authority Annual Reports between 1951 and 1974. This again illustrates the change in frequency of drying. These rescues, particularly of juvenile salmon, suggest that the river now dries often enough to disrupt aquatic life severely. The presence of Atlantic salmon, an IUCN endangered species that is at critical status in the River Stour, underscores the Tarrant's importance as a vital salmon spawning and nursery habitat. 10 86

Water Framework Directive (WFD) Classification Issues

The Tarrant's Water Framework Directive fish status of "Poor" is based upon the lack of minnows and stone loach at a site downstream of Tarrant Rushton. The EA suggests that this is due to obstructions preventing re-colonisation following eradication by low flows. A nearby site investigated by the Freshwater Biological Association in the early 1960s showed a good mixed fish community (including minnows and stone loach), representing *"one of the highest levels of natural fish production ever recorded"*. Obstacles to migration have changed little in the past sixty years. The deterioration of the fish community from showing "one of the highest levels of natural fish production" to "Poor" is shocking and almost certainly due to the deteriorating flow regime. 13-15 95

	Refer to page no.
The Water Framework Directive's 2019 and 2022 classifications rated the hydrological regime of the River Tarrant as "Supports Good" and "High," respectively. However, despite the "Poor" ecological status for fish, the Environment Agency state that improvements would be "Disproportionately Expensive." This contradiction reflects a systemic failure: hydrological ratings ignore clear evidence of abstraction-related flow reduction, while ecological damage is not adequately linked to flow loss.	97
Based on both hydrological analysis and ecological decline, the report recommends reclassifying the WFD hydrological regime for both the River Tarrant and the Pimperne Brook to "Does Not Support Good." This would provide regulatory justification for enforcing abstraction reductions.	15, 35, 42, 68

Hydrological Modelling: Wessex vs CSF Models

The report compares two hydrological models: Wessex Water's regional groundwater model and the Chalk Streams First (CSF) lumped parameter model developed for this study. Both models were used to simulate historic groundwater levels (GWL), river flows and the frequency of drying in the Tarrant-Pimperne catchment. Key findings include:

		Refer to page no.
1.	CSF modelling gives better fits to historical flow, river drying and GWL data than the Wessex model, in both the Tarrant and Pimperne valleys.	26-30
2.	Wessex modelling has a questionable built-in assumption that the Black Lane abstraction has no impact on the Tarrant, based on short-term pump shut-off tests.	40
3.	Wessex modelling greatly overestimates the frequency of river drying in the lower river, showing it occurred every year since 1970, whereas records show drying only about every other year.	30-31
4.	CSF modelling gives a better fit to records of the lower Tarrant drying and indicates that, without abstraction, the lower river would not have dried since 1970.	30-31
5.	The CSF modelling shows that the existing abstractions cause extensive drying and failures of Environmental Flow Indicators (EFIs) in the lower River Tarrant.	33-35
6.	Abstractions from Black Lane and Stubhampton are identified as the main culprits for the drying of the lower River Tarrant, but a lowered water table in the Stour valley due to the Shapwick abstraction could also be a factor.	62-64
7.	Both models agree that the AIM (Abstraction Incentive Mechanism) scheme offers minimal benefit.	37

Despite uncertainties in both models, the CSF model's conclusions are better supported by historic and hydrogeological data. The evidence suggests abstraction, especially at Black Lane, is the primary cause of lower river drying, including in dry winters, and thereby damaging salmon spawning and juvenile survival. 66

Refer to page no.

Physical Evidence and Flow Loss

Since 2015, monitoring has shown that the lower Tarrant consistently loses flow between Preston Farm and the Stour confluence. Flow losses are distributed evenly with no particular leakage "hotspots," indicating that lower groundwater levels and over-abstraction are the underlying problems, rather than more leakage through an increasingly porous river bed. 53-56

The drying seen every year since 2018 coincides with increased abstraction to support Wessex Water's GRID pipeline. During the 2017 shutdown of Black Lane, the river remained flowing, despite low rainfall—compelling evidence that abstraction is linked to drying of the lower river. 45-47, 59

The relationship between Woodyates GWLs and Tarrant flows in 2017 has been used by Wessex Water to argue against this impact, but data from other recent years shows too much scatter to draw reliable conclusions. Thus, the claim that Black Lane abstraction has no effect is not credible. 47-50

Reassessment of the AIM Scheme

The report argues that the revised AIM scheme (proposed for another 5 years) will achieve even less than the original, and may not be worth continuing. The CSF modelling shows that without AIM the duration of the drying of the river at Keyneston would have increased by 4 days from the recorded 137 days to 141 days. 35

Proposed Solution: Redistribution of abstraction from Middle Stour sources

The report's primary recommendation is a reallocation of existing Middle Stour abstraction licences, allowing the reduction or near-cessation of abstraction from the Tarrant-Pimperne sources, without reducing total water supply. 71-75

Two alternative water sources, Sturminster Marshall and Corfe Mullen, have spare output capacity and are already connected via the Wessex GRID pipeline. These sources could replace the Tarrant-Pimperne abstractions with minimal infrastructure changes. However, existing licences limit how much these alternative sources can supply. The report proposes: 72

- Reducing the annual average licences for Black Lane, Stubhampton, and Shapwick to a combined 4.5 Ml/d, used mainly for local supplies.
- Maintaining their peak daily limits for emergencies, combined with a new operating agreement to limit their use on a 'best endeavours' basis. 72
- Increasing the licensed outputs for Sturminster Marshall and Corfe Mullen to match their deployable output levels in the latest Water Resource Management Plan.

Critically, this proposal does not increase total licensed water abstraction, thereby meeting the WFD's "no deterioration" requirement. Future deterioration would be avoided, because increased supplies for a rising population are more than offset by the water companies' planned reductions in leakage and per capita consumption. Water availability for downstream users, such as South West Water's Bournemouth supply, would not be affected. 73-74, 76

Wessex Water has no plans for reducing Corfe Mullen supplies on sustainability grounds, but is 74

Refer to page no.

considering a reduction in the Sturminster Marshall supplies. Concerns over impact of the Sturminster Marshall source appear to be related to flows in the River Stour. However, Stour flows in the River Stour will be enhanced by the proposed reductions at Black Lane, Stubhampton and Shapwick, off-setting any impact of increased abstraction at Sturminster Marshall.

Investigation of the proposed solution

The AMP8 (2025-30) plans already includes investigations of the sustainability of the Sturminster Marshall, Corfe Mullen and Shapwick sources, due for completion by the end of 2026. However, there is no planned investigation into over-abstraction in the Tarrant or Pimperne water bodies. This is consistent with disputed classification of the hydrological regime in these water bodies as "Supports Good". 75

It is proposed that, in the light of this report, the AMP8 investigations should include the River Tarrant and Pimperne Brook and should also consider the feasibility and effectiveness of the redistribution of Middle Stour abstractions proposed in this report. The investigation should make recommendations for the optimum use of all the Middle Stour abstractions to minimise ecological impacts on the affected water bodies, including the River Tarrant and Pimperne Brook. 75-76

If the AMP8 investigations are completed by the end of 2026 as currently planned, the proposed 42 months of trials of the changed abstraction licences could start in 2027. The trials should include an extensive programme of monitoring of river flows, groundwater levels and duration of the various streams drying. 76

The report recommends that the licence changes are trialled for 42 months, giving time to observe improvements in groundwater levels, river flows and ecological status. If successful, this would confirm the viability of the proposed solution.

Alternatives, such as importing water from other regions, would be costly, slow to implement and difficult to justify, at least in the short/medium term. 77-78

Next Steps

The report calls on the Environment Agency and Wessex Water to:

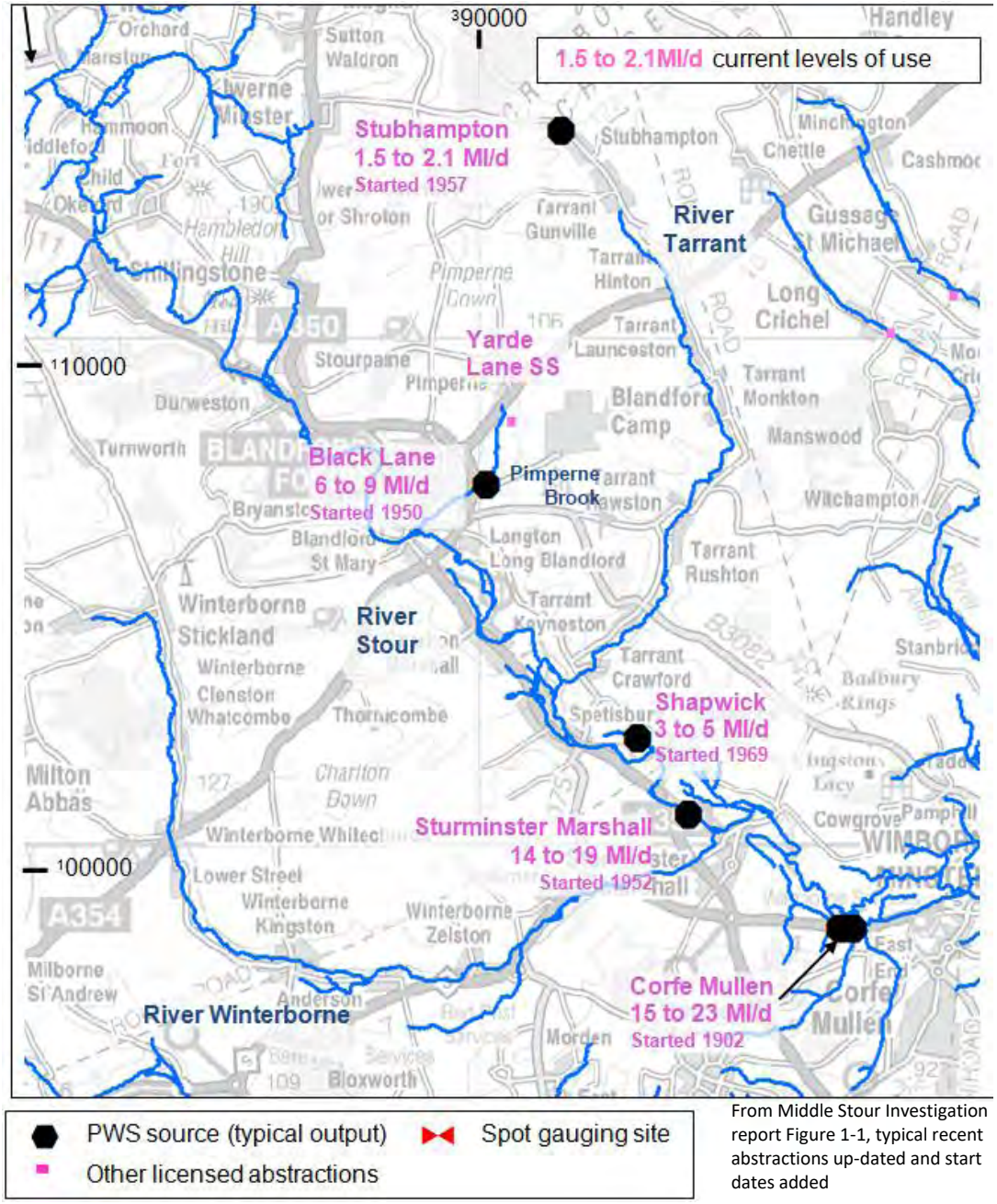
- Accept the evidence of abstraction impacts.
- Prioritise a pragmatic and rapid solution, rather than prolonged debate of impacts.
- Add investigation of Tarrant and Pimperne abstraction impacts and this report's proposed solution into the current planned AMP8 investigations. 79
- Convene a meeting to plan the investigations, licence changes and flow restoration programme.

This approach would incur minimal capital costs and could reverse decades of ecological degradation. Given the weight of historical, hydrological, and ecological evidence, the report argues that action is both justified and urgent.

1. Introduction

This report examines the history of low flows and drying of the River Tarrant. It takes a new look at potential impacts of groundwater abstractions for public water supplies, using a lumped parameter model of the Tarrant catchment and provides new evidence of abstraction impacts through some work on the recorded history of changes to the river and its fisheries. It considers potential solutions to abstraction impacts and proposes next steps for their possible implementation.

The locations of abstractions in and near the Tarrant catchment are shown below:



From Middle Stour Investigation report Figure 1-1, typical recent abstractions up-dated and start dates added

Figure 1 - Location of water supply abstractions in and around the Tarrant catchment

The monthly average abstractions from the Middle Stour public water supply sources since 1970 are shown below:

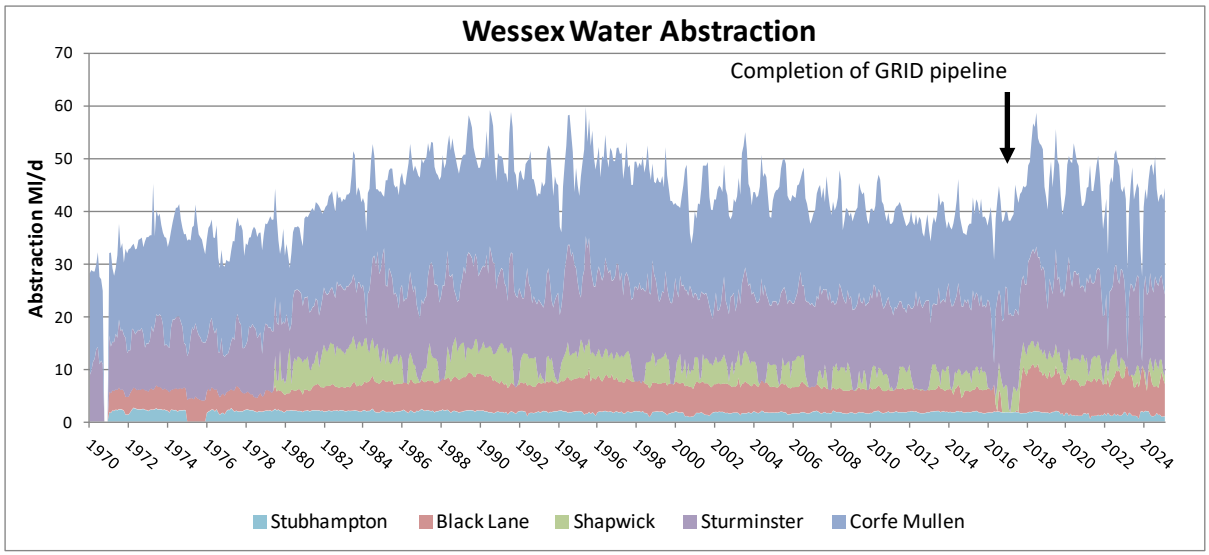


Figure 2 - Monthly average abstraction from Middle Stour sources

As well as the Stubhampton borehole within the topographic Tarrant catchment, the larger Black Lane and Shapwick groundwater abstractions are close to the lower river as shown below:

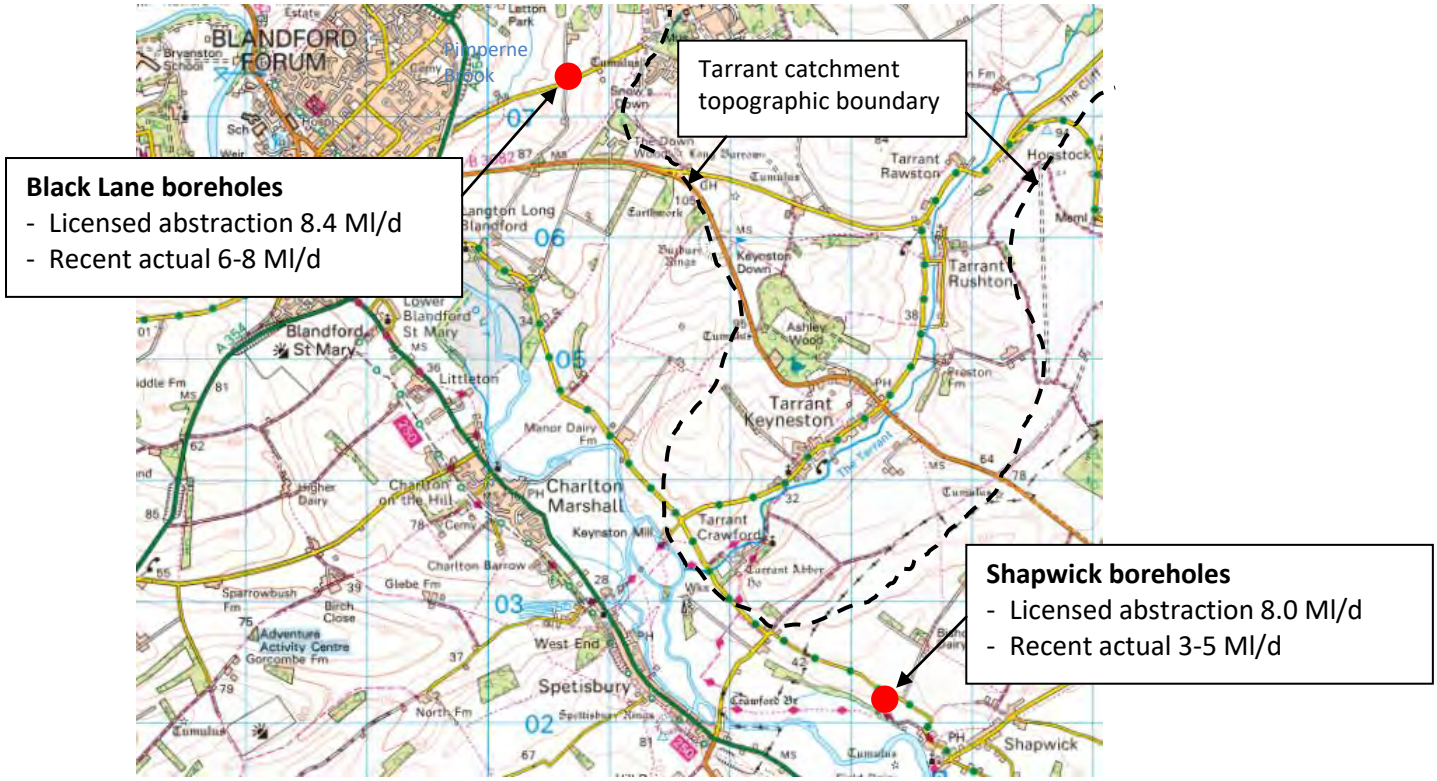


Figure 3 - Locations of public water supply sources close to the lower River Tarrant

There has been some recognition of potential abstraction impacts through Wessex Water's use of Ofwat's Abstraction Incentive Mechanism (AIM) scheme[1], which reduced the abstraction at Stubhampton to half its licensed amount (ie down to 1.09 Ml/d) at times of low groundwater levels.

[1]Ofwat Guidelines on the AIM scheme, February 2016 https://www.ofwat.gov.uk/publication/guidelines-on-the-abstraction-incentive-mechanism/

However, the full Stubhampton abstraction of 2.18 Ml/d is only about 2% of the average annual recharge by rainfall into the aquifer under the Tarrant valley, so its impact on flows is small and the benefits of the AIM scheme abstraction reductions are correspondingly slight.

The AIM scheme was scheduled to run for 5 years from 2019, coming to an end in 2024. Wessex Water has suggested its continuation for another five years, but with shorter duration of the cut-back of the Stubhampton abstraction, further reducing its effectiveness.

Wessex Water's new GRID pipeline links the lower Stour sources to the Hampshire Avon catchment as shown below:

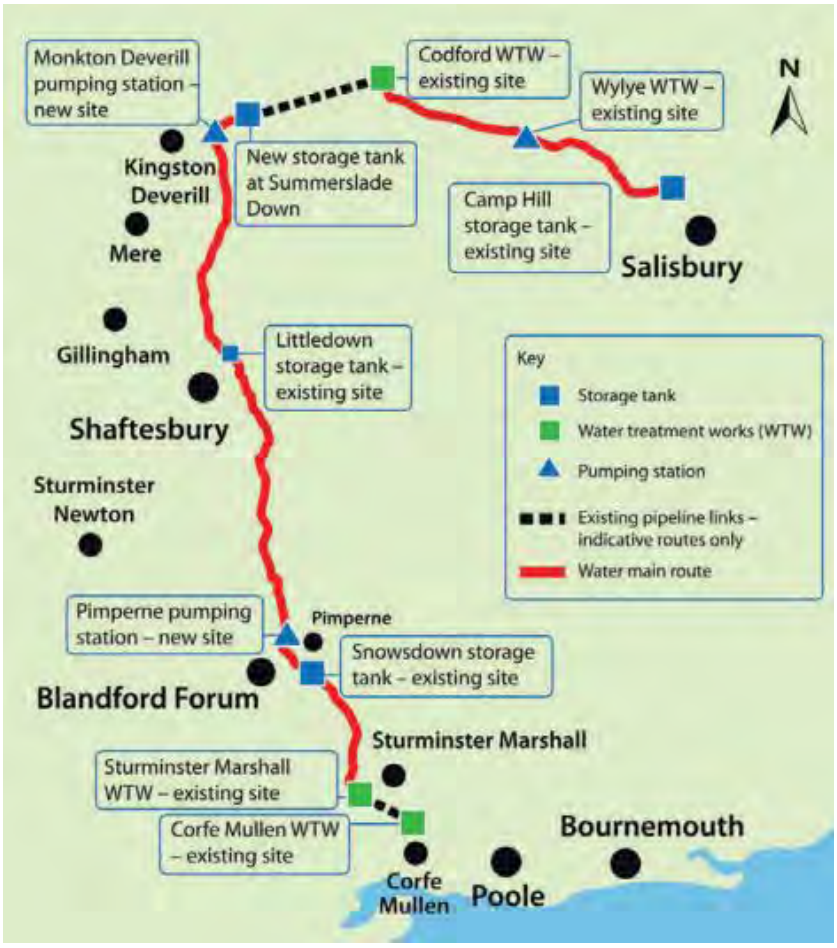


Figure 4 - Layout of Wessex Water's new GRID pipeline

The completion of the GRID pipeline was followed by an increase in abstraction from sources around the Tarrant-Pimperne area as shown below:

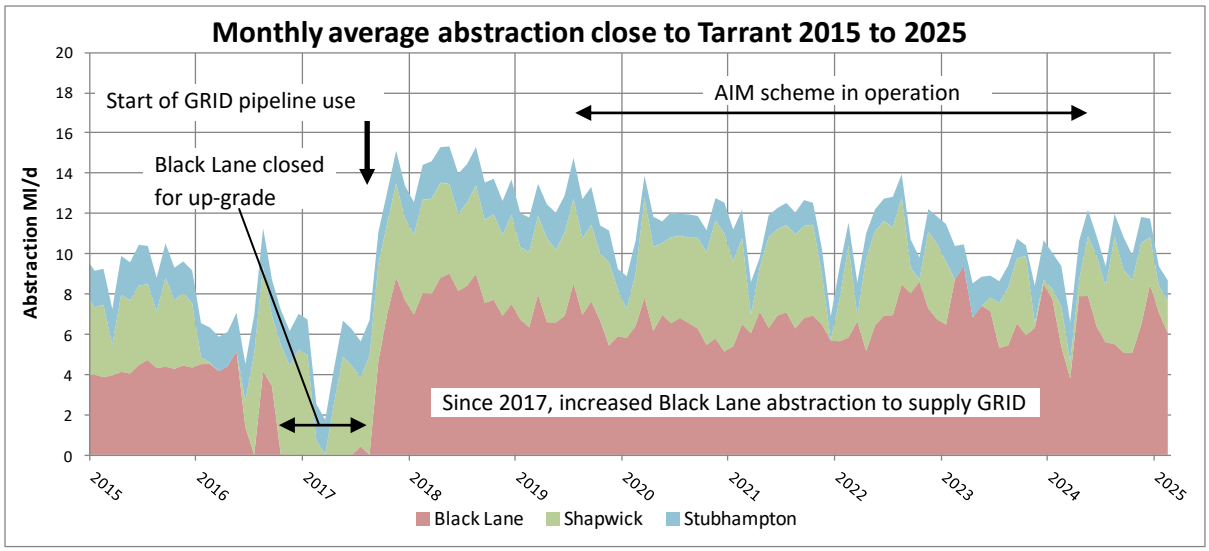


Figure 5 - Monthly average abstraction from Tarrant-Pimperne groundwater sources

One of the purposes of the GRID pipeline is stated in Wessex Water's latest water resource management plan (WRMP) as "*to reduce abstraction at environmentally sensitive sources in the upper Hampshire Avon Catchment*"[2]. In other words, as stated in the 2018 report on investigations into abstraction impacts on middle Stour tributaries, sources in the lower Stour valley, including the Black Lane and Shapwick sources, are being used to supply "*about 15 Ml/d of available water from underutilised PWS sources in the Stour catchment*"[3] to enable reduced abstraction in the Hampshire Avon and its tributaries, particularly the Rivers Wylye and Bourne.

Although there is no reason in principle why underutilised sources in one catchment should not be used to allow reduced abstraction in another, the environmental benefits in the receiving catchments should not be at the expense of unacceptable impacts in the supplying catchment – robbing Peter to pay Paul. Therefore, the extent to which the Middle Stour sources affect flows and ecology in the River Tarrant is a key issue for seeking Tarrant improvements.

[2] Wessex Water WRMP24, Main Technical Report, page 8
[3] Middle Stour Tributaries Investigation, Draft Final Report, Summary page (i), Wessex Water , 30 March 2018

2. Historic evidence of flow changes and drying of the River Tarrant

2.1 Availability of historic evidence of change

There is no flow gauging station in the River Tarrant and spot flow gaugings have only been done sporadically since the early 1990s, although about monthly since 2015. There is good coverage of groundwater level data through observation boreholes in the Tarrant and Pimperne catchments, but only since the early 1990s. There are no available data on measured river flows or groundwater levels dating back to before 1970, so it is not possible to assess the effects of the abstractions using measured data from the Tarrant and Pimperne catchments.

Therefore, some historic research into the history of changes to the River Tarrant and its fishery has been done by Dr David Solomon, as reported in Appendix A and summarised below.

2.2 Anecdotal evidence of changes to the River Tarrant

An example of the recording of local anecdotal evidence is given in an article from Field magazine in 1997, copied in Appendix B. This refers to interviews of long-term local residents who knew the river before the 1970s, with mention of the river never drying, salmon spawning and uses of the river which would seem inconceivable today.

One woman, who had lived in Tarrant Monkton since 1951, recalled that in the 1950s and early 1960s there was enough water throughout the summer for children to paddle or even swim; it then (1977) dried there every summer. Another resident of the village since 1939 stated that he could not recall the river drying in the summer at Tarrant Monkton until the sixties. A third long-term resident, this time living in Tarrant Launceston since 1933, stated that flows before 1950 were occasionally low enough there to kill trout. After about 1970, there were no trout present and the river dries out regularly, as can be seen on the flow signature plots for the 1970s shown on Figure 17.

A local press report in 1929 stated "t*he Tarrant stream is dry, and villagers are having the unique experience of walking over the bed of the rivulet at Tarrant Monkton dry shod, a circumstance without parallel for a very prolonged period".* Another local paper report in 1929 describes an impromptu trout rescue at Tarrant Monkton. The report shows that there were numerous trout at Tarrant Monkton in 1929, some of substantial size, with flows that were enough to support a good population of adult trout in all but exceptionally dry years. Nowadays, the river dries in most years at Tarrant Monkton (see later flow signature plot in Figure 18) and trout are rarely seen this far up the river, and then only as juveniles.

The 1929 press report confirms the rarity of the river drying at Tarrant Monkton in pre-abstraction times. The flow signature plots since 1974 (see Figures 17 and 18) show that the river now dries at Tarrant Monkton almost every year. The lack of mention of the lower river drying in 1929 also seems significant – if the river was dry at the lower Tarrant villages in 1929, surely that would also have been mentioned in a local paper report?

A note was penned by NRA geologist Dr William Stanton in about 1991 included the statement that "*in exceptionally dry years the river is dry just above the confluence with the Stour*". In contrast, this reach has dried out in eight of the past nine years. The only year that the lower river did not dry was

2017, after the cessation of abstraction at Black Lane from October 2016 to August 2017 for up-grading of the pumping station (see later Figure 18). This is compelling circumstantial evidence of the Black Lane abstraction causing drying of the lower river.

2.3 Evidence of changes to the Tarrant fishery

There is a long history of salmon in the Tarrant, from a number of sources, going back to 1866, when salmon were seen and caught as high up as Tarrant Rushton. Most are "one-off" observations rather than the result of regular surveys, but they do build-up into a coherent picture of the stream being a significant spawning and nursery area for Stour salmon.

In the early 1960s biologists from the River Laboratory in East Stoke (on the Frome upstream of Wareham) looked at the fish populations in many Dorset streams, including the Tarrant. Juvenile salmon were noted as present at the single site sampled at Tarrant Rushton in 1964-67.

During the River Avon salmon radio tracking programme from 1986 to 1990, 15 radio-tagged salmon were tracked entering and migrating extensively in the Stour system (it must be borne in mind that the location of tagging, at Mudeford, is on the joint estuary of the Avon and Stour). Five were recorded passing, or were observed, upstream of Shapwick. It is quite possible that all these fish entered and spawned in the Tarrant; two were located during searches on foot. It is unfortunate that the Stour was not considered part of the study area, and thus was not checked as regularly as the Avon catchment.

Unfortunately, no part of the River Tarrant has been included in the routine fish monitoring programme operated by electric fishing by the Environment Agency and its predecessors over the past fifty years or more. Two sites have been fished on an *ad hoc* basis. The first, at Charlton Cottage, between Tarrant Rushton and Preston Farm, was sampled on four occasions between 2003 and 2018. Significantly, no juvenile salmon were recorded at Charlton Cottage, despite them being recorded up stream at Tarrant Rushton in the 1960s survey. The other site, at Tarrant Abbey, yielded seven juvenile salmon when sampled on a single occasion in July 2010.

The Tarrant has a long history of fish being trapped by falling flows, to die or be rescued and transferred elsewhere. Fish rescues have been mounted in most of the last 20 years, with numbers of trout being saved from pools on the drying stretches ranging from a few to more than 2000. There appear to have been many fewer such rescues required fifty years ago. One major rescue was reported in September 1961, with a smaller operation a year later. These were the only rescues mentioned in the very detailed fishery sections of the River Board/River Authority Annual Reports between 1951 and 1974. Fish rescues appear to have become much more frequent in recent decades – not just in the frequency of occurrence (which may merely reflect a more consistent allocation of manpower) but also in terms of large-scale results (say, over 2000 fish rescued in a particular year). This is a strong indication that stream drying has become more frequent, especially with respect to the lower part of the stream (from Tarrant Rushton downstream).

It would appear that the Stour has had a small run of salmon for hundreds if not thousands of years, persisting until the present. This is likely to be genetically distinct from the stock in other southern chalk streams, and genetically adapted to the conditions prevailing in the Stour. The main spawning areas appear to have been the main river between about Longham and Blandford, and the

chalkstream tributaries the Tarrant, Allen and Moors River (River Crane). The Stour stock would appear to be particularly depressed at present (no rod catch, few reports and southern stocks generally under great pressure), and is likely to be reduced to a few tens of individuals each year.

In these circumstances the fact that salmon are persisting in the Tarrant (juveniles present in both the last two fish rescues) means that this tributary is likely to be disproportionately important to the future of the Stour stock, and would warrant particularly sensitive management, including doing everything possible to allow a flow regime suitable for salmon spawning and juvenile survival.

2.4 Evidence from water mills

In the Domesday Book, six mills were registered on the River Tarrant[4]. One of these may have been Tarrant Keyneston mill, which is actually located on the River Stour (see Figure 6). The Mills Archive[5] includes four mills at Tarrant Rawston, Tarrant Rushton, Preston Farm and Tarrant Crawford (the mill at Tarrant Abbey).

The mill at Tarrant Abbey is described in a report on the abbey[6], which includes an excerpt from the 1885 OS map showing the location of a disused mill (Map 6 in Appendix 3 of the report). The abbey itself was founded as an independent monastery in 1186 and then re-founded in either 1228 or 1233 as a Cistercian nunnery. The siting of an abbey at this location, suggests that the lower river flowed perennially at that time – otherwise, why not site it close to the River Stour or upstream at Tarrant Rushton or Rawston, where the flow is nowadays more reliable?

The locations of mills in the area of the lower Tarrant are as shown below:

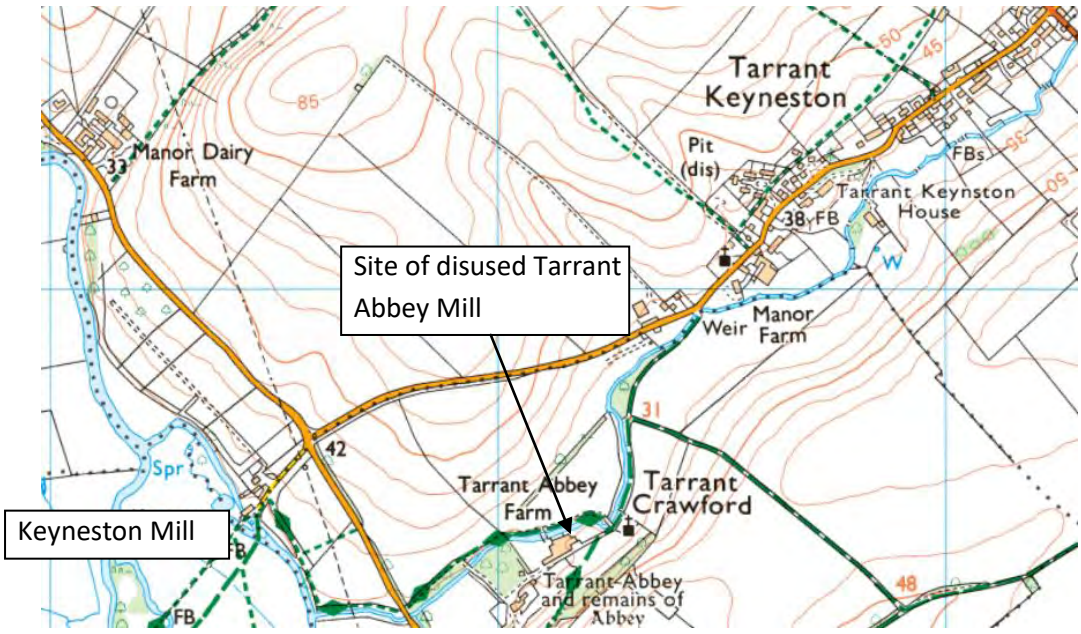


Figure 6 - Location of water mills in the lower Tarrant valley

[4] Dorset Ancestors web-site https://dorset-ancestors.com/category/tarrant-keyneston/
[5] Mills Archive listing for Dorset https://new.millsarchive.org/mills/mills-in-historic-county/?which=33
[6] NJ Bryant , An Investigation into the Ecclesiastical History of Tarrant Crawford, 2000 https://oldjapbikeguy.wordpress.com/tarrant-crawford-abbey-the-definitive-guide/

The presence of Tarrant Abbey Mill so close to the Keyneston Mill on the Stour (which flows perennially) suggests that flows in the lower Tarrant would have been reliably available in late summer and autumn, ie post-harvest, in almost all years. It is hard to imagine that the construction of the mill would have been worthwhile, or that the operation would have been commercially viable, if the river had dried as frequently as occurs in recent times, for example as shown on the flow signature plots on Figures 17 and 18.

Therefore, while not representing conclusive proof, the presence of mills on the Tarrant strongly suggests that the stream once had a much more reliable flow regime, especially in the lowermost reaches.

2.5 Conclusion from review of historic evidence

The anecdotal evidence from local people and press, and the evidence from the history of the fishery and water mills in the Tarrant valley all point to a flow regime in the lower river that was virtually perennial up to the time that substantial public water supplies from groundwater started in around 1950.

Before the major groundwater abstraction started, the lower river could still dry in extreme droughts, as was recorded in 1933, but it was a rarity. It is significant that the only year in recent times that the lower river did not dry was 2017, after the cessation of abstraction at Black Lane from October 2016 to August 2017 for up-grading of the pumping station. The increasingly frequent drying of the lower river since the increase in abstractions started in the 1950s and the decline in the fishery provides strong circumstantial evidence of the severe impact of abstraction.

3. Water Framework Directive status of the River Tarrant

3.1 WFD classification of the River Tarrant

The most recent (2022) Water Framework Directive (WFD) classification of the River Tarrant is 'Poor' ecological status. This classification would be a driver for abstraction reductions if linked to low flows or a drying river, but unfortunately it is solely on the grounds of the poor ecological status of 'Fish'. The hydrological regime of the river is deemed to be 'High' status, an even higher classification than 'Supports Good', so it provides a strong justification for Wessex Water taking no action to reduce abstraction.

The history of WFD classifications of the Tarrant is shown below[7]:

Classification Item	2009	2011	2016	2019	2022
Ecological	Good	Moderate	Bad	Poor	Poor
Biological quality elements	Moderate	Moderate	Bad	Poor	Poor
Fish	Moderate	Moderate	Bad	Poor	Poor
Invertebrates	High	High	High	High	High
Macrophytes and Phytobenthos Combined			Good	Good	Good
Macrophytes Sub Element			Good	Good	Good
Physico-chemical quality elements	High	High	High	High	High
Ammonia (Phys-Chem)	High	High	High	High	High
Dissolved oxygen	High	High	High	High	High
Phosphate	High	High	High	High	High
Temperature	High	High	High	High	High
pH	High	High	High	High	High
Hydromorphological Supporting Elements	Supports good	Supports good	Supports good	Supports good	Supports good
Hydrological Regime	High	Does not support good	Supports good	Supports good	High

Table 1 - History of WFD classifications for River Tarrant water body

It will be seen that the fish assessment is "Poor" for both 2019 and 2022; this in turn forces the Biological Quality Elements and the Ecological Assessments, of which fish form part, to be "Poor" also on the "weakest link" principle.

The WFD fish status of "Poor" is based upon the lack of minnows and stone loach at the site downstream of Tarrant Rushton used for assessment. The EA suggests that this is due to obstructions to upstream movement preventing re-colonisation following eradication by low flows. A nearby site investigated by the Freshwater Biological Association in the early 1960s showed a good mixed fish community (including minnows and stone loach), was said by one of the researchers as representing *"one of the highest levels of natural fish production ever recorded"*. The presence of topographical features representing potential hindrance to up and downstream migration has changed very little in the past sixty years. The deterioration of the fish community from showing "one of the highest levels of natural fish production" to "Poor" is shocking and almost certainly due

[7] Table assembled from WFD cycles 1 to 3 data on EA's Catchment Explorer https://environment.data.gov.uk/catchment-planning/WaterBody/GB108043016070?cycle=3

to the deteriorating flow regime.

The "Reason for not attaining Good [WFD fish classification]" since 2018 is given as "Barriers – ecological discontinuity". This is assumed to refer to the problem of fish becoming stranded as parts of the stream dry out, and the difficulty of ascending to re-colonise when flows returned. Thus this, coupled with the WFD hydrological assessment of "Supports Good" (2019), and "High" (2022), overlooks completely the probability that decreased stream flow is implicated. This suggests that the Environment Agency (who is responsible for administering the WFD) considers the situation to be as good as it is going to get, and that no further action can be justified. This is clearly an unacceptable situation.

The Black Lane abstraction is in the Pimperne Brook catchment, but only about 500 m from the Pimperne-Tarrant topographic boundary (see Figure 1). The Pimperne water body is classified as 'Heavily Modified' under the WFD, with only 'Moderate' ecological potential on the grounds of some chemical contaminants. The Pimperne hydrological regime was assessed as 'Does not support Good' from 2011 to 2018, but up-graded to 'Supports Good' from 2019 to 2022[8], despite the increase in Black Lane abstraction to feed the Wessex GRID pipeline. The classification of the Pimperne hydrological regime as 'Supports Good' is unhelpful to the case for reducing abstraction – down-grading to 'Does not support Good' would strengthen the case for reduction of the Black Lane abstraction to the benefit of the Tarrant.

3.2 Review of WFD status in the Middle Stour Tributaries report

Wessex Water's 2018 report on the Middle Stour Tributaries Investigation looked in detail at the impact of various Stour catchment abstractions, including the Stubhampton, Black Lane and Shapwick abstractions. The report made extensive use of an improved version of the Wessex regional groundwater model to assess the impact of the abstractions on groundwater levels, river flows and the frequency of drying of the winterbourne sections of the rivers. The executive summary of the report includes these conclusions:

> *"The calibration of the Wessex Basin Model (WBM, a regional chalk groundwater/river flow model) has been improved so it can be used to define the impact of the PWS [public water supply] sources upon the Tarrant."*
>
> *"An adequate calibration of the Pimperne Brook has not been achieved and pump test data has been used to define the Black Lane impact upon the Pimperne Brook."*
>
> *"The historical use of the Stubhampton source has caused 14 days per year of extra drying on average (1970-2016) (Gunville to Luton). Under full licence abstraction conditions, this increases to 17 days a year."*
>
> *"The predicted stream flow changes due to abstraction, compared to natural conditions, are assessed not to adversely impact the winterbourne or perennial ecology of the River Tarrant."*
>
> *"The low diversity of fish species in the Tarrant [ie the cause of the 'Poor' Tarrant fish*

[8] EA Catchment Explorer https://environment.data.gov.uk/catchment-planning/WaterBody/GB108043016020?cycle=3

classification] … is not a function of lower flows due to abstraction but rather barriers in the river that restrict the upstream migration of coarse fish and minor species."

"The hydrological impact assessment has concluded (subject to further testing) that the Black Lane PWS abstraction (or others) does not impact the winterbourne behaviour (timing or location of drying) of the Pimperne Brook."

"The Black Lane source (subject to the findings from the spring 2018 recession monitoring) does not impact flow in the Pimperne Brook, therefore, a mitigation measure is not required, hence it is proposed that the abstraction from Yarde Lane and associated augmentation to the Pimperne Brook is stopped i.e. removed from the licence."

"As detailed the current and future levels of abstraction from the PWS sources has not impaired the WFD status and will not cause a deterioration, respectively. Therefore, an options appraisal has not been undertaken, however, changes to two sources are proposed [ie including the Stubhampton AIM scheme] to address local concerns and to ensure sensible use of water resources."

These conclusions are used by Wessex Water to justify no plan for any action to reduce abstraction in the Tarrant and Pimperne other than the Stubhampton AIM. The Environment Agency appears to have accepted Wessex Water's conclusions to justify the WFD 'Supports Good' classification of the hydrological regimes for both the River Tarrant and the Pimperne Brook.

The hydrological assessments and modelling presented in the following Section 4 of this report cast major doubt on the validity of Wessex Water's conclusions and the validity of the 'Supports Good' classifications of the Tarrant and Pimperne Brook flow regimes, which are blocking any further action on abstraction reduction.

4. Assessment of abstraction impacts

4.1 Drivers of flows in chalk streams

The overarching driver of baseflows in chalk streams is the groundwater level relative to the springs and river bed levels at any given point, as shown in Figure 7[9]:

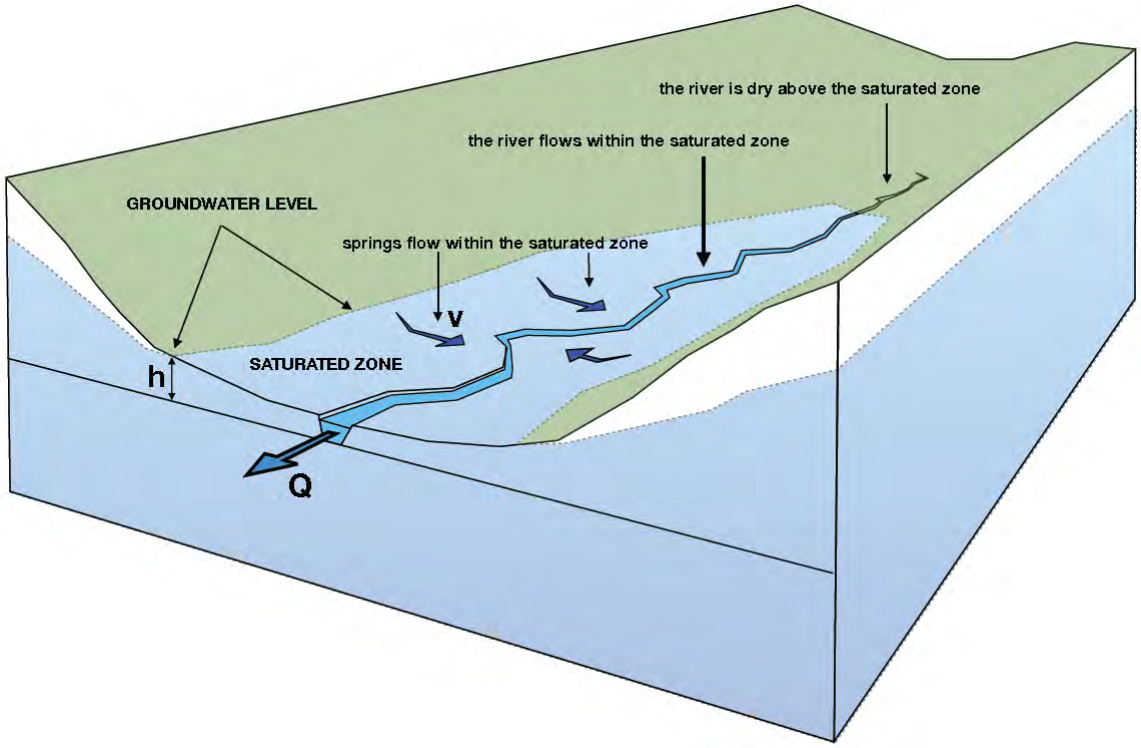


Figure 7 - Schematic representation of a typical chalk valley

As groundwater levels rise, so does the force of gravity (hydraulic head) driving water to the springs and seepages in the valley and stream below. In addition, as groundwater levels rise, so increasing numbers of springs up the valley start to spill water from the aquifer to the stream.

Recorded data in chalk valleys always show a close relationship between the rise and fall of chalk stream flows and aquifer groundwater levels. The relationship is non-linear – ie for a given unit of rise in GWL, river flows increase a lot more at high GWLs than at low GWLs. As explained above, this is because the higher GWLs cause more springs to start flowing further up the valley, and the spring outflows to be faster. This clear relationship between GWLs and flows is always seen in chalk streams, and is the case for the River Tarrant and the Pimperne Brook as shown in the examples below (with locations shown on Figure 8):

[9] Diagram from page 36 of the CaBA Chalk Stream Strategy https://catchmentbasedapproach.org/learn/chalk-stream-strategy/

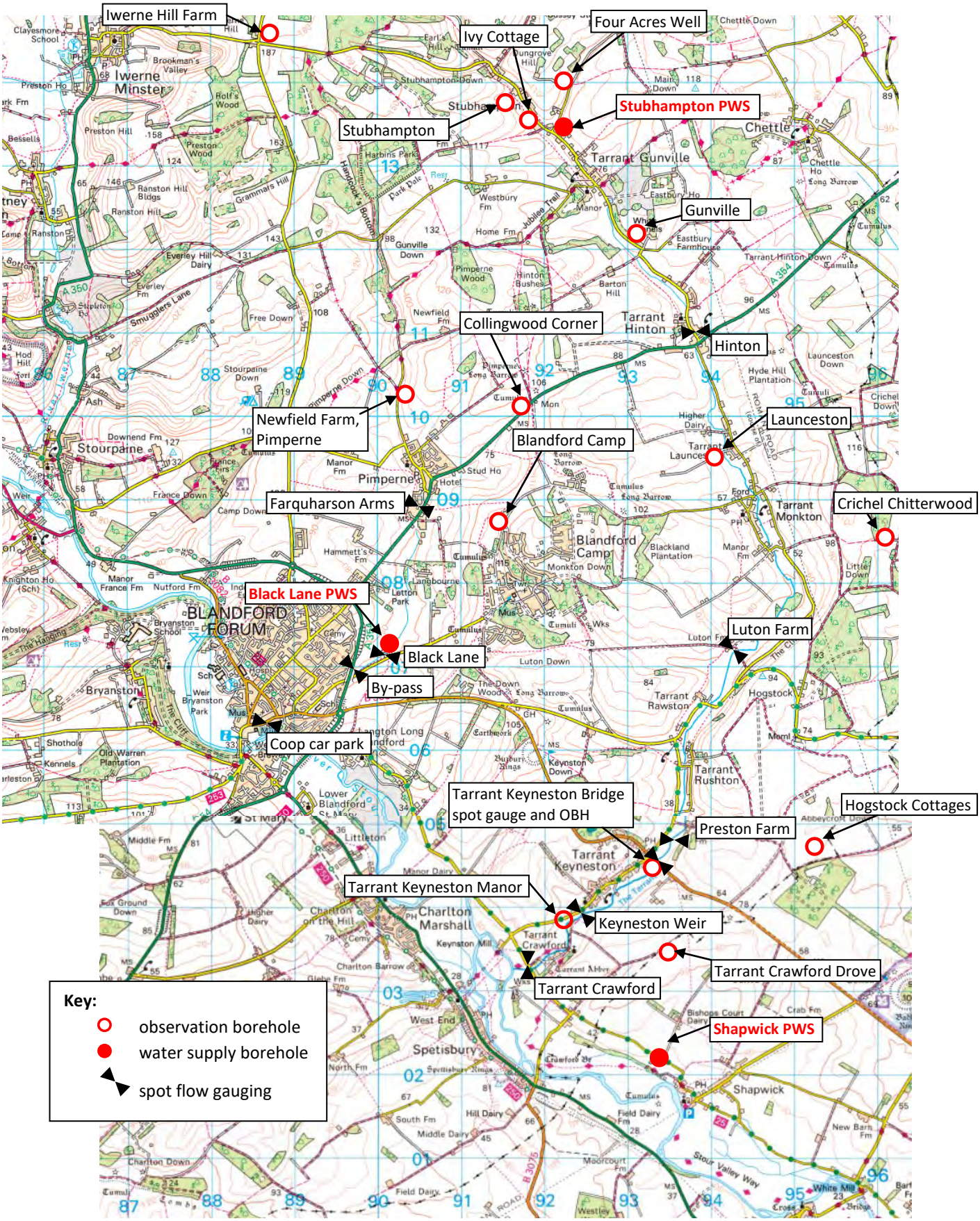
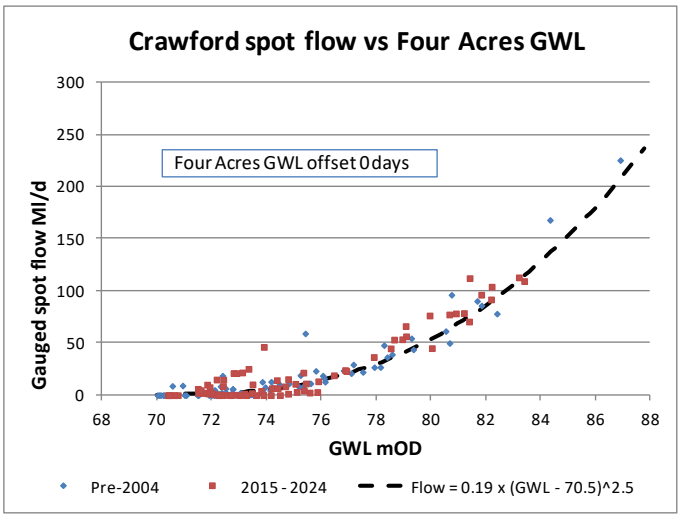
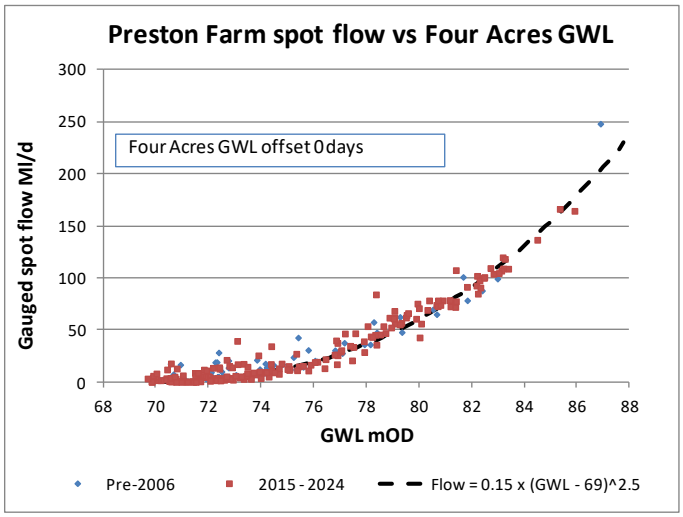
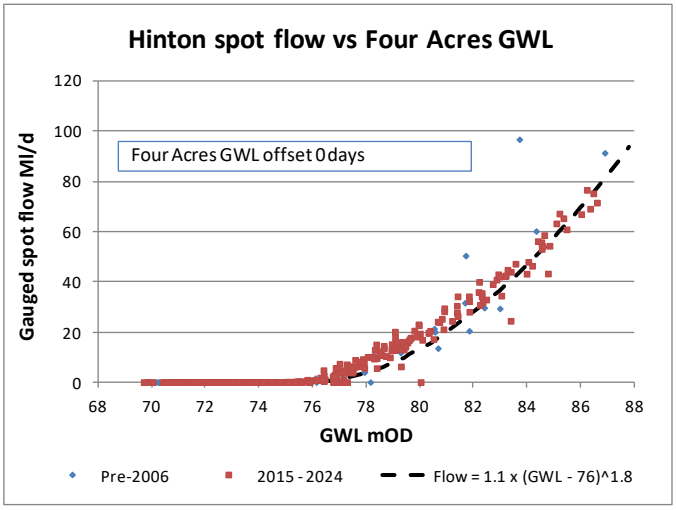
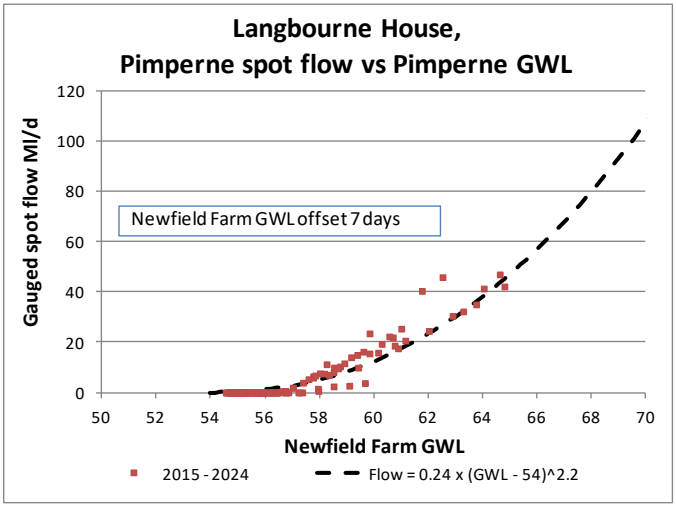


Figure 8 - Locations of boreholes and spot flow gauging sites







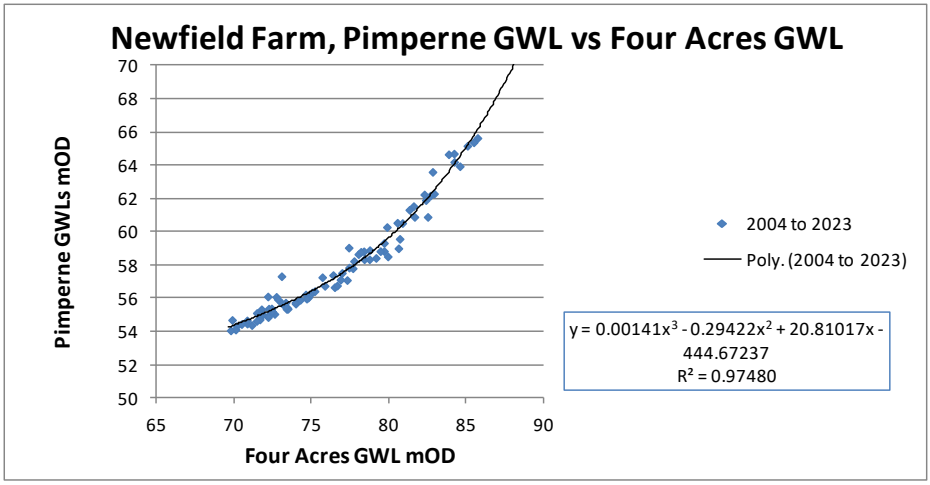


Note: There are no continuously recording flow gauging stations in the Tarrant and Pimperne valleys, so the 'spot flows' are obtained by wading the river with current meters, typically about once per month. As a result, the gauged spot flows can include surface water run-off, but the sporadic data do not allow base flows to be separated. Therefore, the best-fit equations shown on the plots are fitted to the lower envelope of the data and points lying above the best-fit lines are likely to include surface run-off.

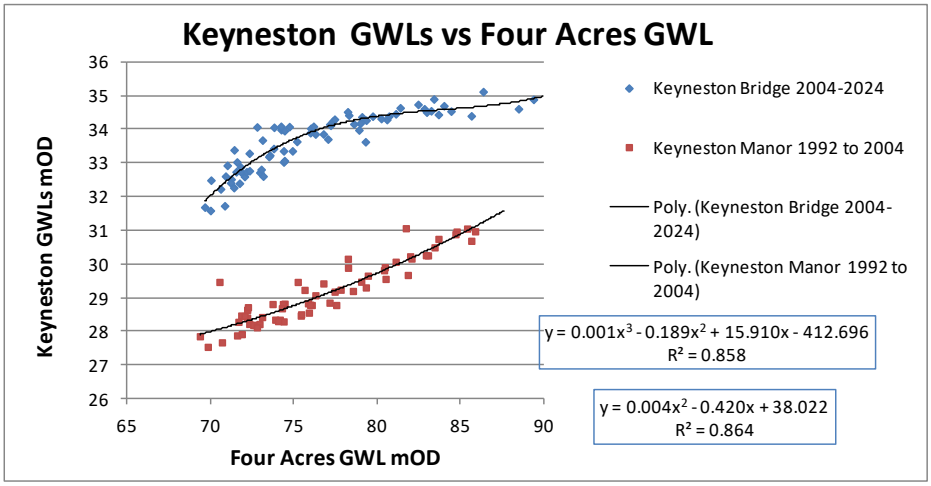
Figure 9 - Relationship between GWLs and river flows in Tarrant and Pimperne valleys

The closeness of the scatter plot fits shown above suggests that river and spring flows in these catchments are almost entirely driven by the concepts of a) the water table head driving flow, and b) the increasing area of outcropping springs as the water table rises up the valley, as illustrated in Figure 7.

The groundwater levels rise and fall by different amounts in different parts of the catchment – fluctuating more at the edges of the valley and less in the valley bottoms. There are also slight differences in the timing of the fluctuations because of the differences in time it takes for effective rain to percolate down to the water table. However, the GWLs in different parts of the catchment rise and fall in unison as can be seen by comparing the GWLs variations in different parts of the catchment, as shown in the examples below (locations shown on Figure 8):



The Newfield Farm borehole in the Pimperne valley is located about 5 km from the Four Acres borehole in the upper Tarrant valley.



The Keyneston boreholes in the lower Tarrant valley are located about 11 km from the Four Acres borehole.

Note: The best fit for Keyneston GWLs shown in the lower plot assumes that the Four Acres GWLs lag the Keyneston GWLs by 10 days. This is presumed to be because of the longer time taken for effective rain to reach the water table at Four Acres. There is no time lag allowed in the upper plot of Pimperne GWLs.

Figure 10 - Relationships between GWLs at locations in Tarrant-Pimperne catchments

The groundwater levels throughout the catchment rise and fall together as the aquifer fills through effective rain and then slowly empties due to Tarrant and Pimperne stream outflows, abstraction outflows and underflow within the chalk bedrock.

Typically, the GWLs rise in the wetter months from October through to March when the air is cool, evapotranspiration is at a minimum and a higher proportion of the rainfall sinks down to the aquifer (known as ' effective rain '); and GWLs fall through the summer when evapotranspiration reduces the effective rain percolation to the chalk, while the groundwater continues to discharge to the river and the down-slope aquifer. Therefore chalk-stream flows tend to be at their highest in late spring and lowest in the autumn. The variation in average monthly effective rain in the Tarrant catchment is shown below[10]:

[10] Daily effective rain 1970 to 2023 as used in Wessex Regional groundwater model and provided in Excel file '4R_WSX109_Catchments 6-7-8_PP Tarrant recharge.xlsx'

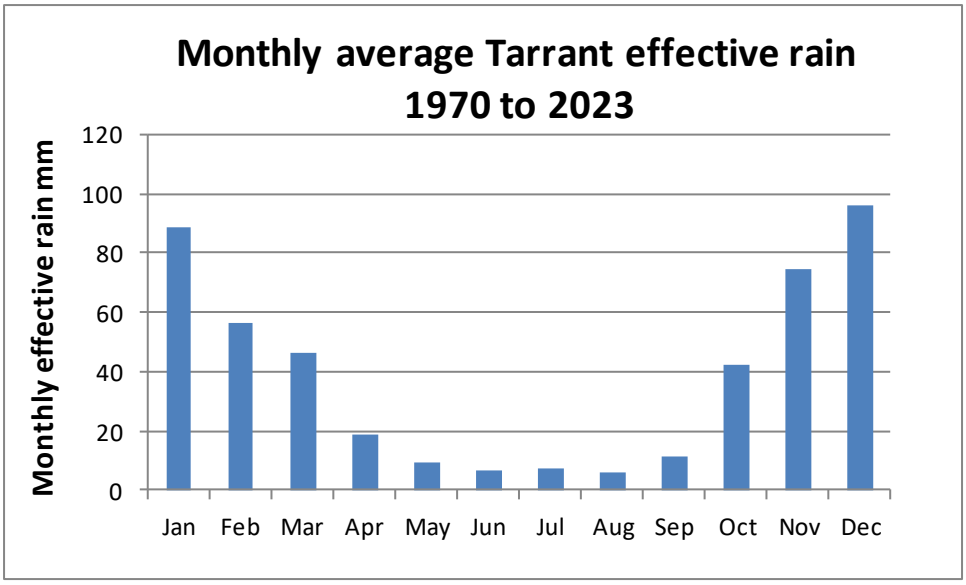


Figure 11 - Variation in average monthly effective rain in Tarrant catchment

Groundwater abstraction notwithstanding, the total amount of winter rainfall and how much of it sinks into the ground as 'effective rain' largely determines the volume of river flows during the following summer. If groundwater levels are high in the spring after a good winter recharge, then (natural) flows will hold up well through the summer. If groundwater levels are low in the spring after a dry winter, then generally the chalk stream will be very low by the end of summer.

With the aquifer acting as a reservoir, groundwater abstraction suppresses the rise in GWLs during periods of recharge and exaggerates the GWL decline during dry periods. The main impact of abstraction on baseflows can be interpreted as coming through its effect on the aquifer water balance, regional water table fluctuations and hence flows, rather than the localised impacts of borehole cones of depression which are superimposed on the rises and falls of the regional water table.

4.2 The CSF lumped parameter model for the Tarrant-Pimperne

The relationship between GWLs and flows described above can be used to simulate GWLs and river flows in the Tarrant and Pimperne valleys using a lumped parameter, termed the Chalk Streams First (CSF) model. The model assumes that the topographic catchments of the Tarrant and Pimperne operate as a single 71 km^2 chalk catchment with twin chalk stream outflows via the River Tarrant and the Pimperne Brook, as shown below:

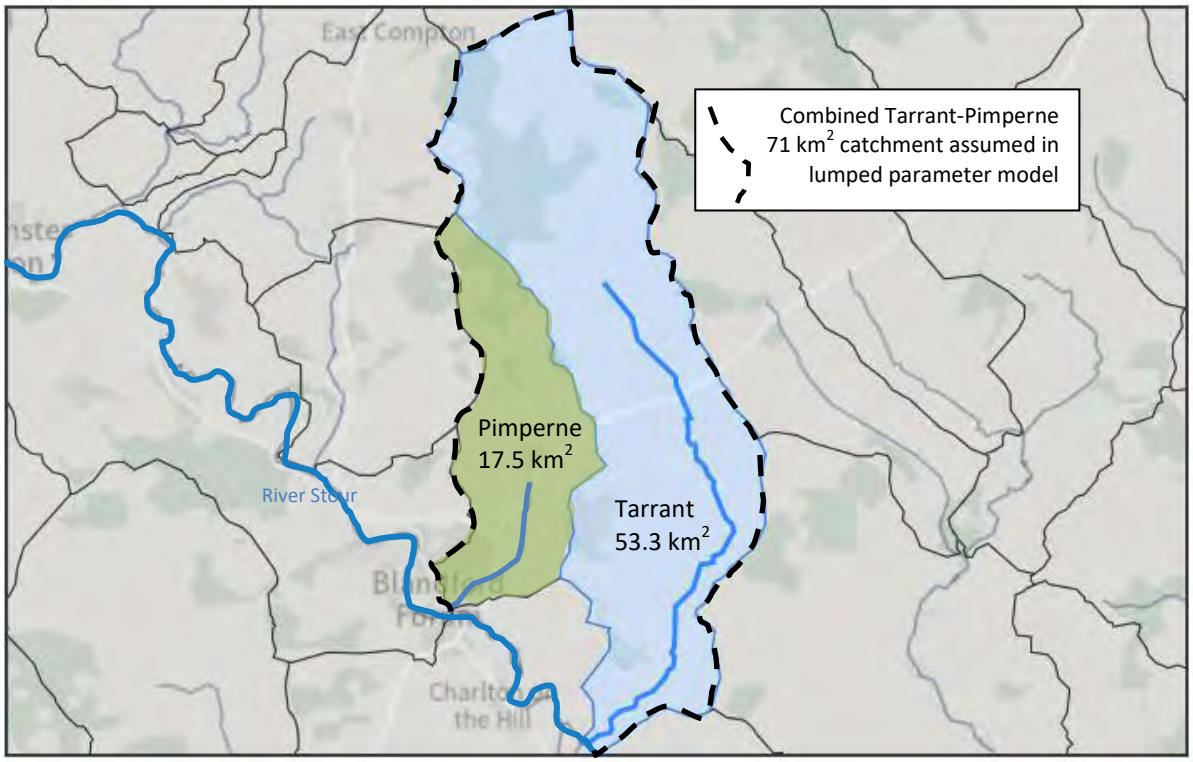


Figure 12 - Tarrant-Pimperne catchment boundary assumed in CSF model

The CSF model was developed originally for assessing abstraction impacts on the River Kennet and has subsequently been used to assist in the promotion of the CSF proposal for re-naturalising flows in the Chilterns chalk streams[11]. The principles behind the CSF model are:

a) that chalk stream baseflows are driven by the hydraulic head of the regional water table, as shown schematically in Figure 7, and by the relationship between river flows and groundwater levels shown in Figure 9.

b) that the hydraulic head of the water table is determined by the aquifer water storage within the catchment, which rises due to recharge from rainfall and falls due to river outflows, throughflows (within the aquifer) and abstraction.

The CSF model is an Excel spreadsheet of about 80 Mb, including all the graph plotting and analysis routines. The model uses daily data for effective rain, as used in Wessex Water's regional groundwater model, to simulate daily groundwater levels and river flows at the locations of all the observation boreholes and spot flow gauging sites in the Tarrant and Pimperne catchments. The model simulates daily river flows and groundwater levels in the 54-year period 1970 to 2023. The primary location for modelling GWLs is at the Four Acres observation borehole, chosen because of the good availability of recent recorded GWLs, as well as about 6 years of records from 1998 to 2004. The model simulates the GWLs at the sites of other observation boreholes from the modelled GWLs at Four Acres, using best-fit equations between recorded GWLs similar to those shown on

[11] Dealing with impacts of groundwater abstraction on the chalk streams of the Colne and Lea valleys, John Lawson for the Chalk Streams First consortium, February 2023 https://chalkstreams.org/flow-recovery-following-abstraction-reduction/

Figure 9.

For each day, the model calculates groundwater levels and river flows at as follows:

Step 1: Calculate daily aquifer recharge = Daily effective rain (Er) x catchment area (A_R)

Step 2: Change in aquifer storage = (Er x A_R) – Q_R – Q_A – Q_U

Where Er is effective rainfall, A_R is effective catchment area, Q_R is combined river flows at Tarrant Crawford and Coop car park Pimperne, Q_A is abstraction and Q_U is underflow within the aquifer to outside of the catchment. The river flows, Q_R, are calculated from the GWL the previous day and using the relationships between GWL and river flow shown on Figure 9. The underflow, Q_U, is calculated by the equation $Q_U = a \times (GWL - b)$ where a and b are constants obtained by trial and error as part of the process of calibrating the model.

Step 3: Change in groundwater level at Four Acres = Change in aquifer storage ÷A ÷ S

Where A is the topographic catchment area and S is the average specific yield for the catchment. The specific yield was found by trial and error to give best fit to recorded groundwater levels and river flows when modelled with historic abstraction.

Step 4: Calculate new Four Acres GWL and river flow at Tarrant Crawford

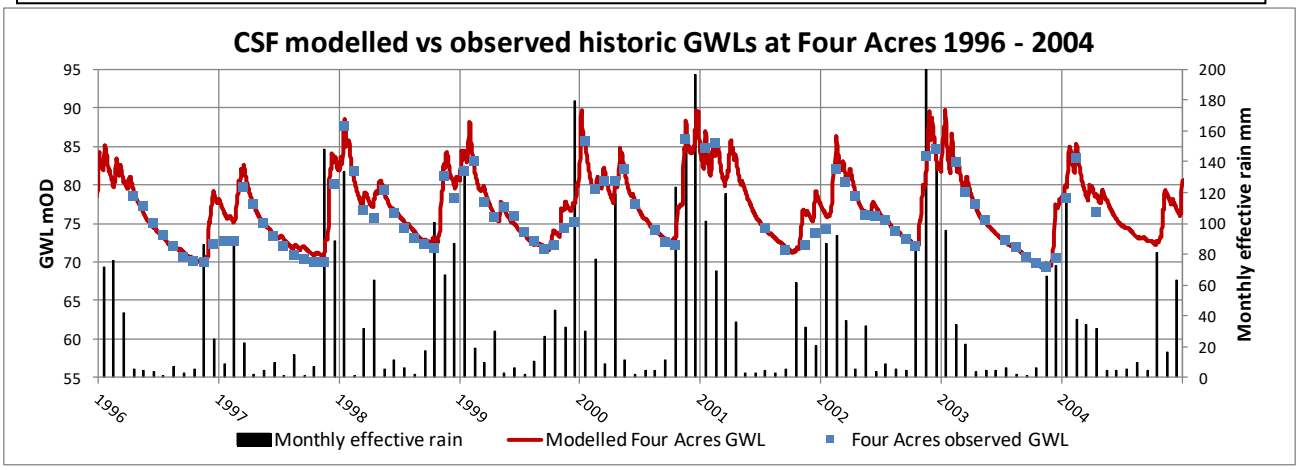
The new Four Acres GWL for the day is the previous day's level plus the increment from Step 3.

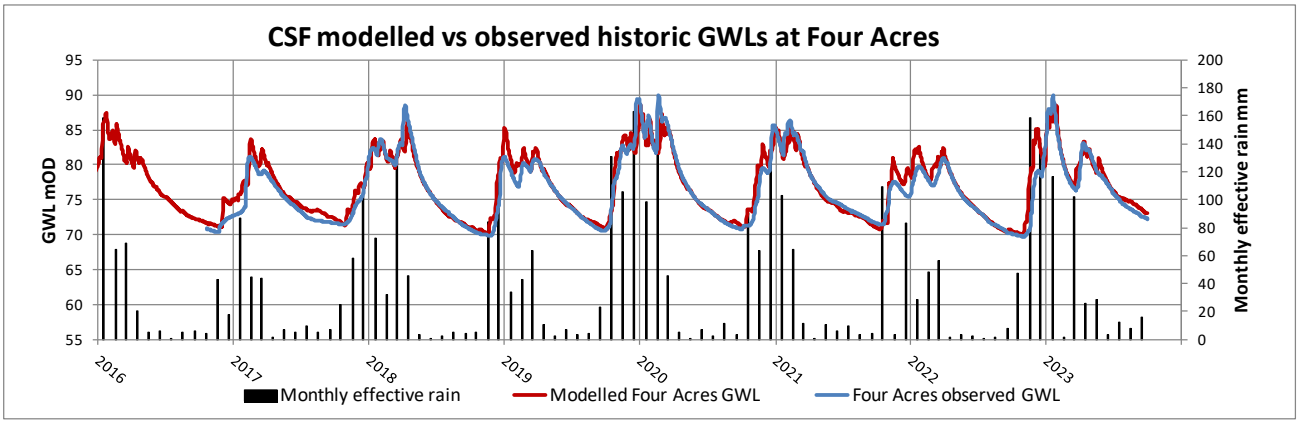
Step 5: Using the new Four Acres GWL, calculate the river flows at other spot gauging locations and the GWLs at other OBH sites, using the correlation equations similar to those shown on Figures 9 and 10. The GWL at Newfield Farm Pimperne is also calculated from the Four Acres modelled GWL and then used to determine the flow at Coop car park Pimperne.

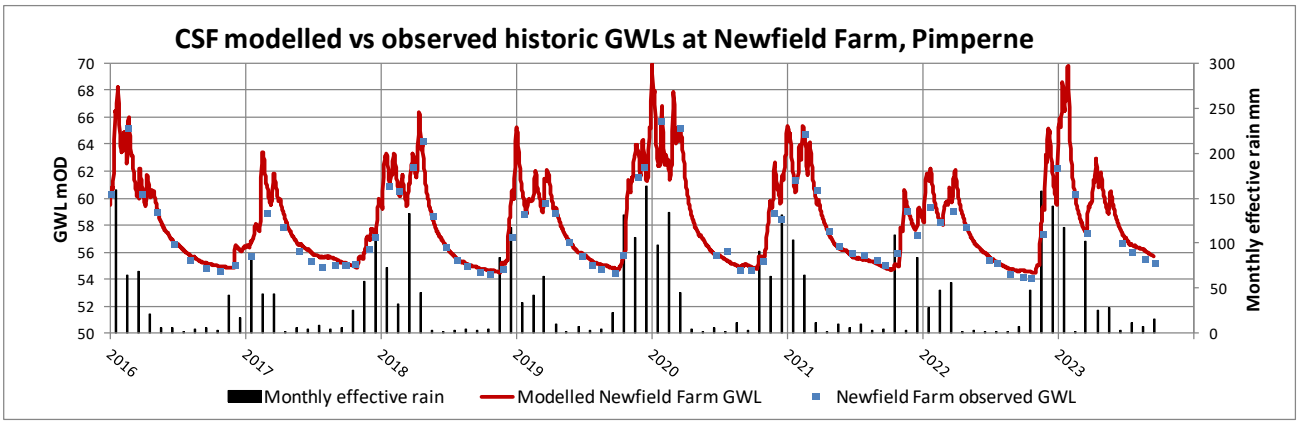
4.3 Validation of the CSF model

The CSF Tarrant-Pimperne lumped parameter model gives good validation fits between modelled and observed historic GWLs in both the Tarrant valley and the Pimperne valley, as shown in the example validation plots below:

Note: Measured GWLs at the Four Acres OBH are available daily from 2016 to 2023 from Wessex Water's records and about monthly from 1996 to 2004. The measured GWLs at Newfield Field Farm, Pimperne and Tarrant Keyneston are available about once per month from EA records going back to 2004.







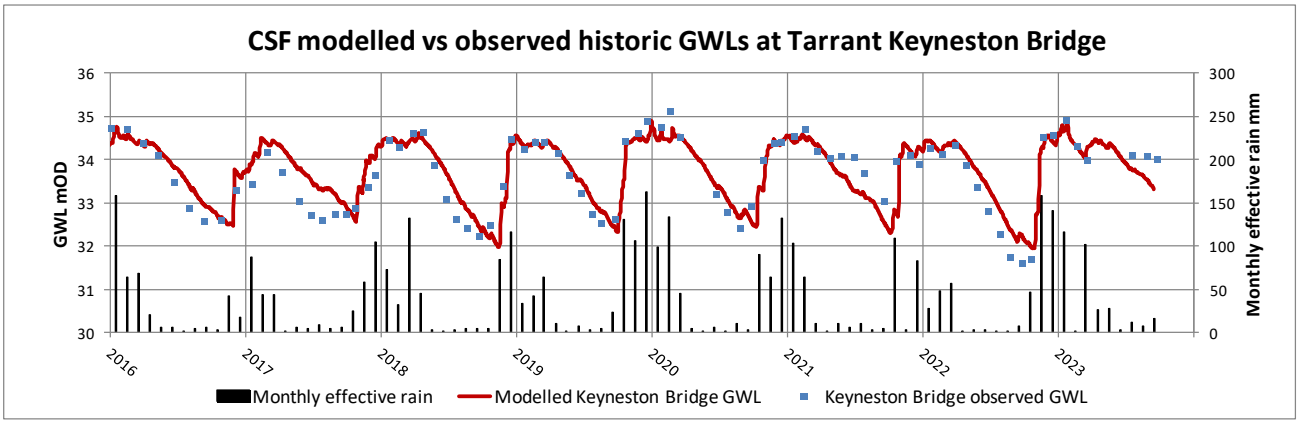
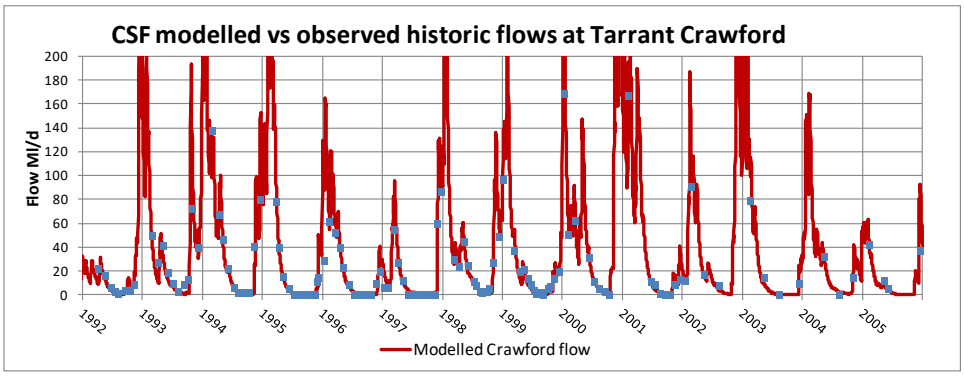


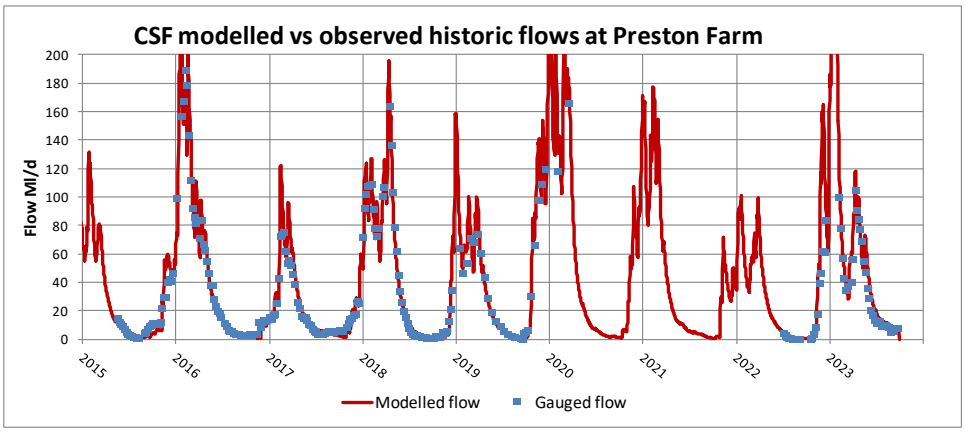
Figure 13 - CSF model validation: modelled vs historic measured GWLs

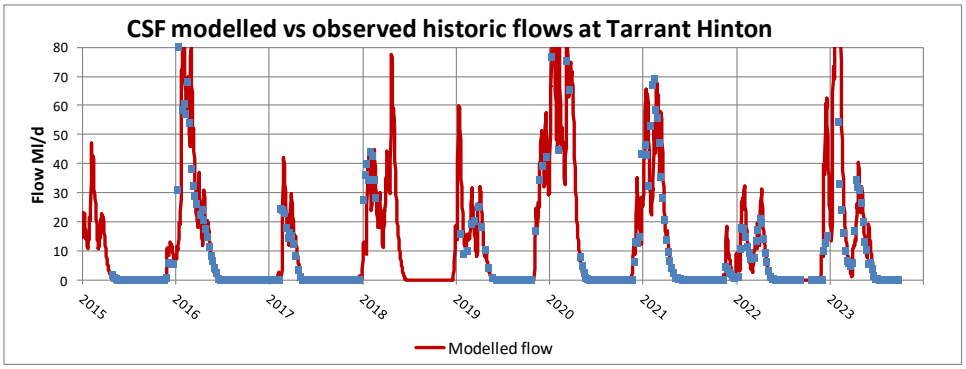
The validation fits shown between modelled and observed GWLs at Four Acres and Newfield Farm, Pimperne are strikingly good throughout the period shown and for other periods when measured GWL data are available. The validation fits for the Four Acres GWLs are of similar good quality for the two well separated periods of available GWL data – 1996 to 2004 and 2016 to 2023. This provides some added confidence to the validity of the modelling.

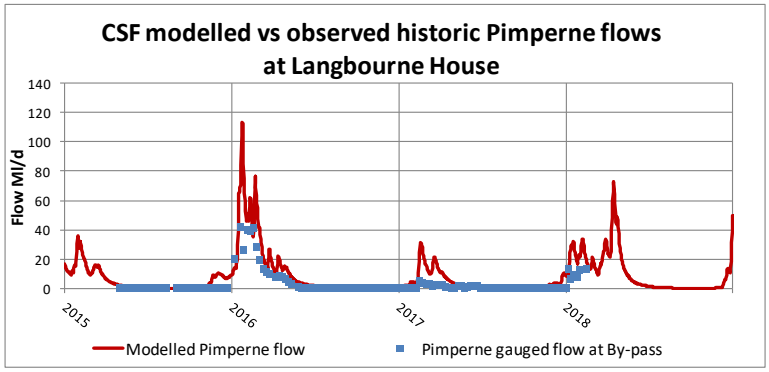
The validation fits for the Keynestone GWLs appear a bit less good on the plot because the range of GWL fluctuation is only about 3 m so the vertical scale has been exaggerated.

Some examples of validation fits for CSF modelled flows are shown below:









Modelled flows are computed daily, but spot flows are mainly weekly, so tend to miss peak flows

Spot flow data for Pimperne Brook are only available from May 2015 to February 2018

Figure 14 - CSF model validation: modelled vs historic measured Tarrant-Pimperne flows

There are close fits between CSF modelled and spot-gauged Tarrant flows at all locations. The periods of the river drying are also simulated quite well. The modelled fits are reasonably good for the limited spot flow data available for the Pimperne Brook, including the prediction of when the stream is dry.

4.4 Comparison of validation of the CSF and Wessex models

The CSF modelling gives validation fits of modelled and observed GWLs and river flows that are as good as or better than the equivalent validation fits from the Wessex model. Some examples of the comparative validation fits for river flows from the two models are shown below:

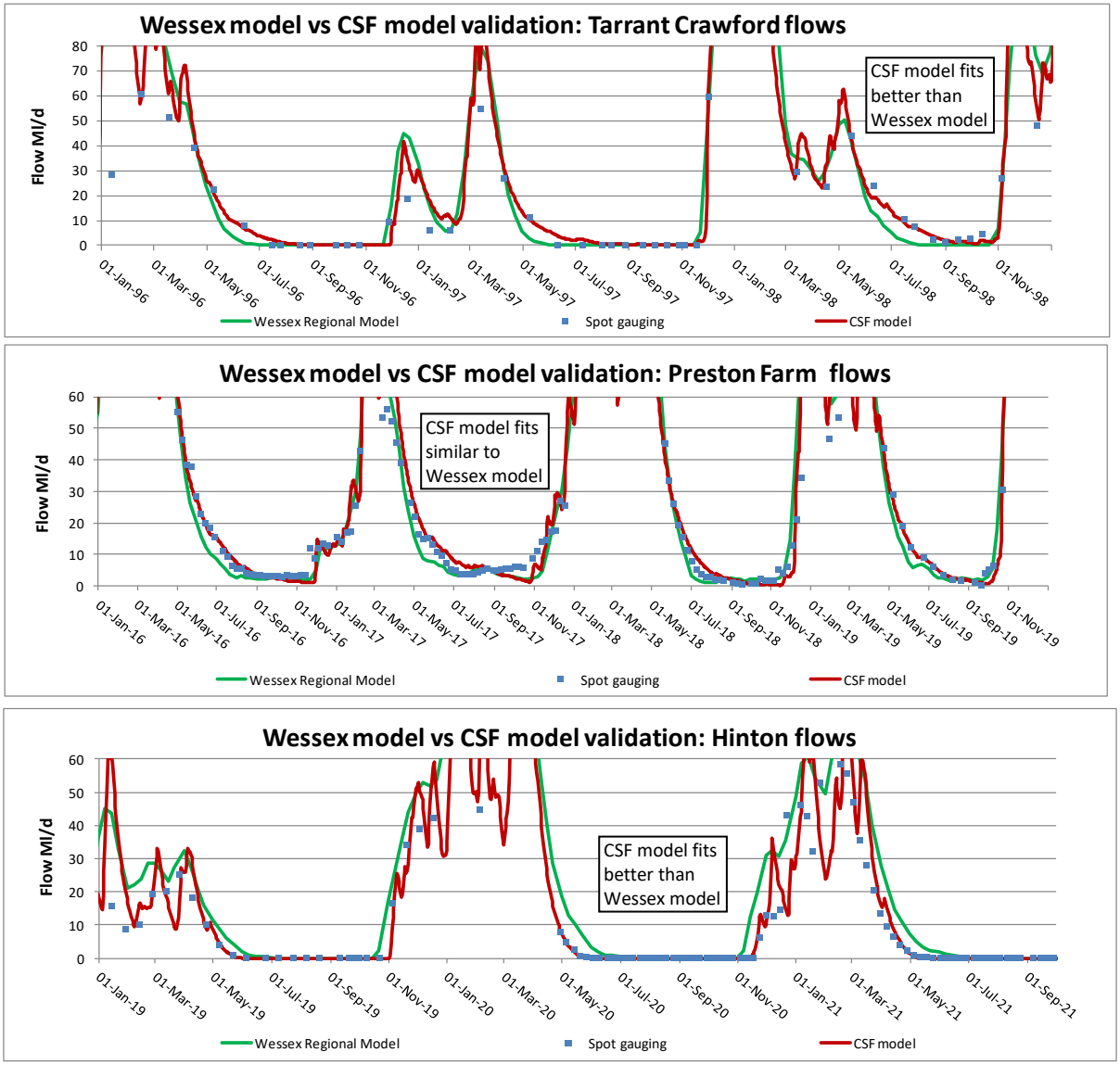


Figure 15 - Flow validation comparison of the Wessex model and the CSF model

Both models capture the magnitude and timing of seasonal flow variations fairly well, but the CSF model provides a better fit in general and a much better fit to the drying of the river. The Wessex model greatly over-estimates the frequency of the drying of the lower river, as is shown later Table 2, which compares the ability of each model to predict when the river actually dried, also using recorded data from the flow signature plots.

No validation data are currently available for Wessex modelling of flows in the Pimperne Brook, but

the 2018 Stour tributaries report said this about the validation[12]:

> *"However, the overall local calibration is poor, meaning that not all the hydraulic control in the valley have been identified by this study. For these reasons, it is considered the model in its current state (Run 427) is not fit for its intended purpose to carry out a reliable impact assessment of PWS abstraction on the Pimperne Brook in relation to Black Lane."*

Further comment on this and its implications for modelling impacts of the Black Lane abstraction on flows in the River Tarrant are given in Section 4.8.

A comparison of the fits of modelled groundwater levels to observed levels is shown below:

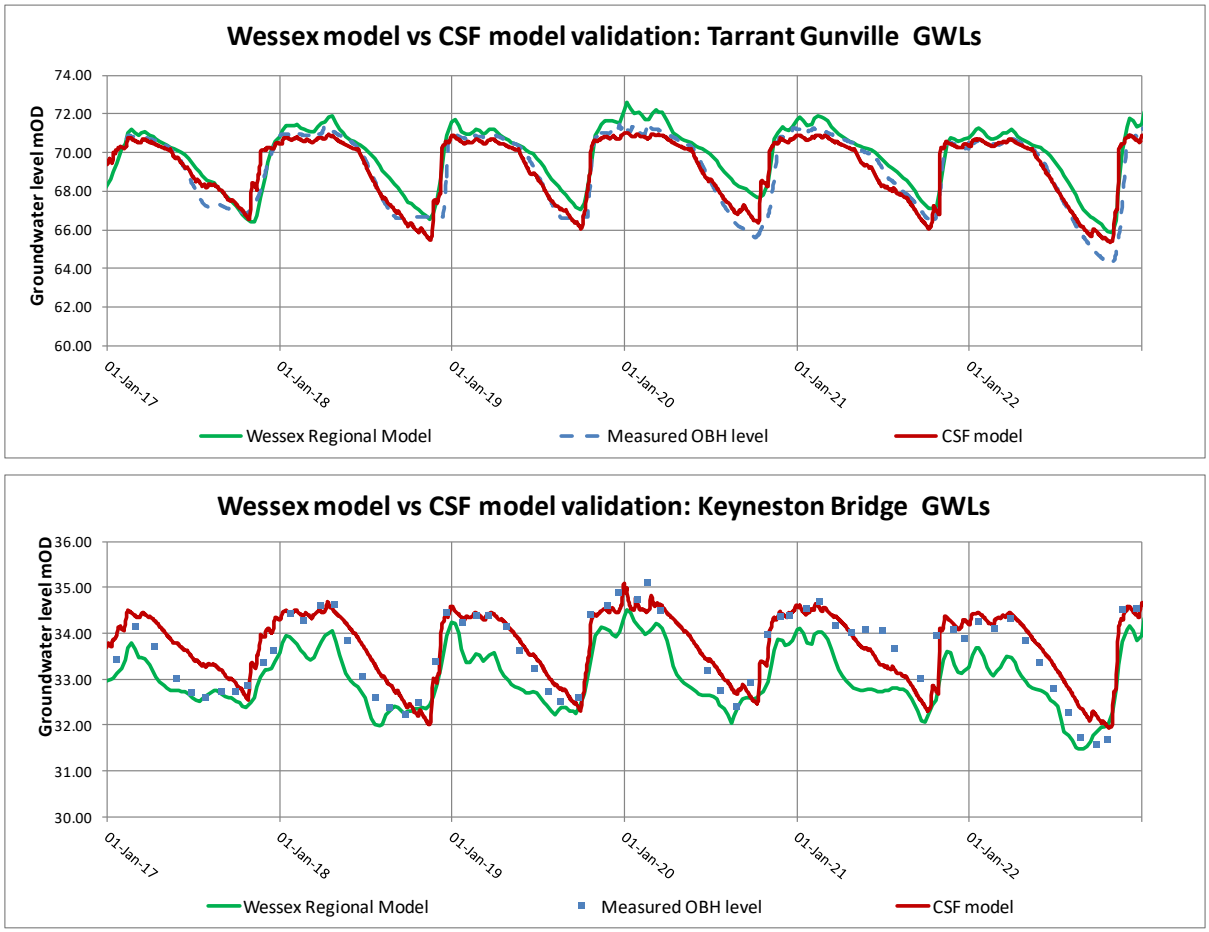


Figure 16 - GWL validation comparison of the Wessex Regional model and the CSF model

As for the modelled flows, both models capture the general timing and magnitude of GWL variations, but from visual inspection of the plots, the CSF model provides a better fit than the Wessex model. The Wessex model persistently under-estimates GWLs at Keyneston Bridge. This may explain why the Wessex model substantially over-estimates the frequency of drying of the lower river.

The ability of the two models to replicate the frequency of drying of the lower river can be tested by comparison of the records of the river drying from the flow 'signature' plots which are available for the two periods 1974 to 1991 and 2015 to 2024, as shown the plots below:

[12] Middle Stour Tributaries Investigation, Draft Final Report, page 56, Wessex Water , 30 March 2018

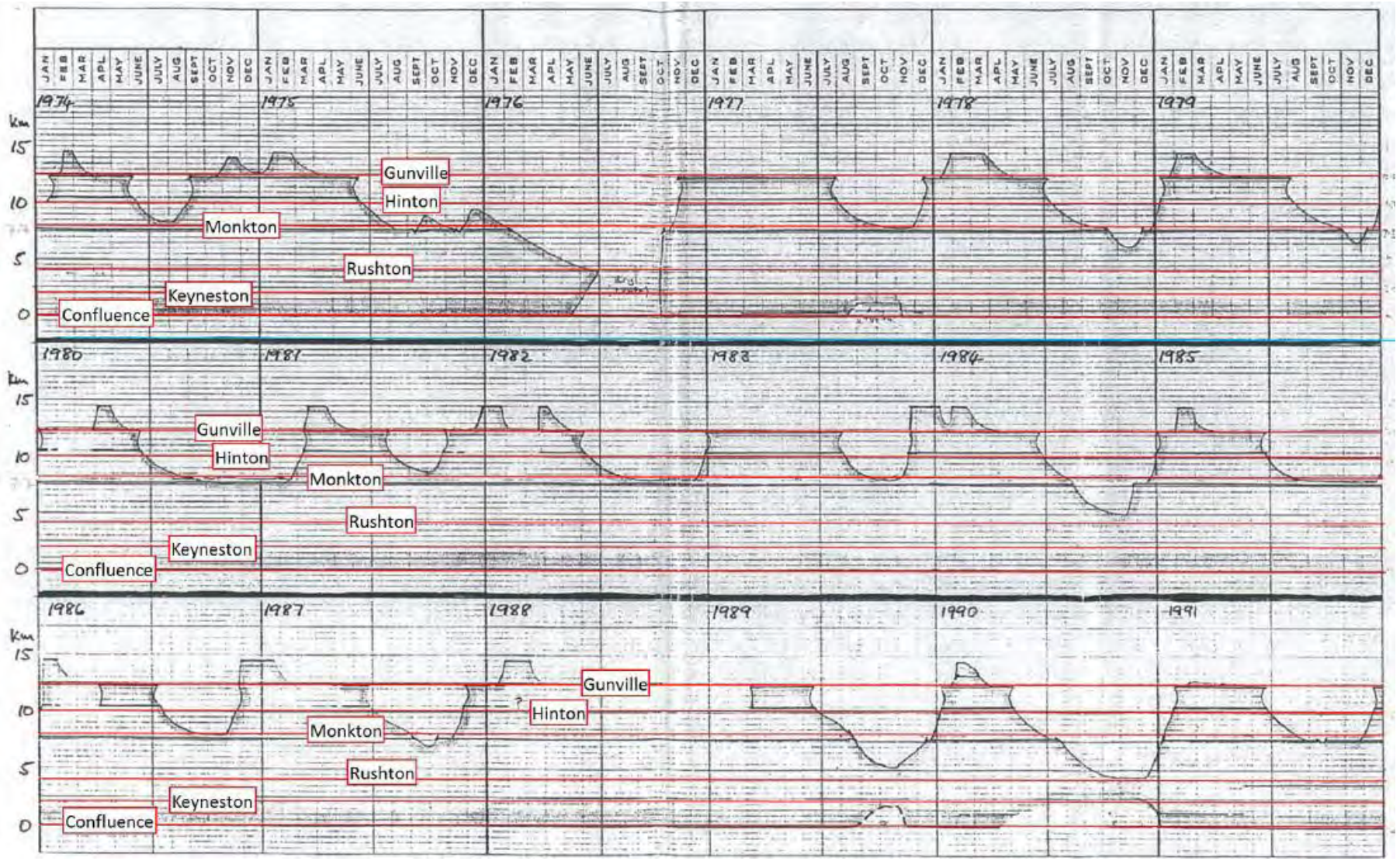


Figure 17 - Tarrant flow signature plot 1974 to 1991

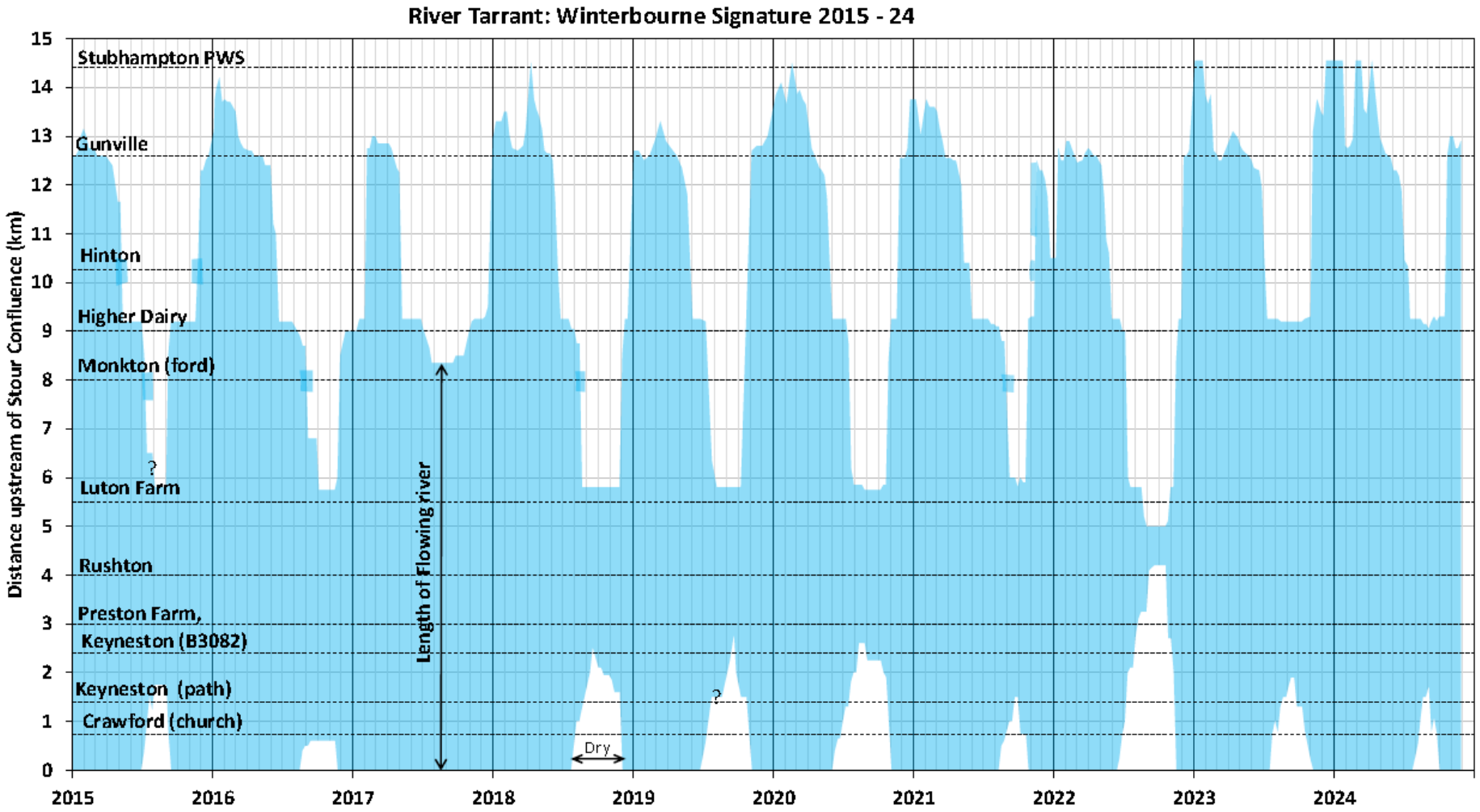


Figure 18 - Tarrant flow signature plot 2015 to 2024

In addition to the signature plots, there are data on the river drying from the spot flow records which are sporadically available from 1995 to 2005. A comparison of the observed frequency and duration of the lower river drying with the modelled data is shown below:

	Keyneston Bridge days dry			Keyneston Weir days dry			Tarrant Crawford days dry		
	Observed	CSF model	Wessex Model	Observed	CSF model	Wessex model	Observed	CSF model	Wessex model
1974	0	0	0	0	0	49	0	0	86
1975	0	0	8	0	0	170	0	0	170
1976	125	0	116	137	44	140	137	55	162
1977	0	0	0	0	0	46	77	0	93
1978	0	0	62	0	4	103	0	32	131
1979	0	0	1	0	0	92	0	0	107
1980	0	0	0	0	0	31	0	0	69
1981	0	0	0	0	0	22	0	0	41
1982	0	0	0	0	0	24	0	0	39
1983	0	0	0	0	21	137	0	36	147
1984	0	51	93	0	81	138	0	89	147
1985	0	0	24	0	9	103	0	35	154
1986	0	0	0	0	0	39	0	0	87
1987	0	0	0	0	0	69	0	12	107
1988	0	0	0	0	17	116	0	24	123
1989	0	28	93	56	60	140	77	74	148
1990	163	96	133	223	132	205	249	149	205
1991	0	0	17	0	0	86	0	14	94
1992	No observed data						0	0	93
1993							0	0	86
1994							0	18	117
1995	74	33	84				131	103	161
1996	0	30	77	135	67	124	135	75	145
1997	0	0	9	33	23	139	174	44	168
1998	0	0	0	0	0	69	0	0	76
1999	0	0	0	0	0	100	30	0	114
2000	0	0	0	0	0	41	15	0	69
2001	0	0	1				37	5	107
2002	0	0	0				0	0	76
2003	0	67	100				125	98	161
No observed data									
2015	0	0	39	53	0	93	58	0	114
2016	0	0	1	0	0	124	84	17	147
2017	0	0	0	0	0	110	0	0	161
2018	15	12	26	114	52	145	119	64	145
2019	27	0	2	106	7	86	99	22	123
2020	0	0	8	122	0	107	140	14	144
2021	0	0	10	38	13	62	53	24	107
2022	99	23	100	137	71	140	137	79	147
2023	0	0	0	61	1	0	46	0	24

Observed data from signature plots

Observed data from spot gaugings

Observed data from signature plots

	Tarrant Crawford days dry		
	Observed	CSF model	Wessex model
Years river dry	19	22	39
% years dry	49%	56%	100%
Average dry days per year	49	28	118

	Keyneston Weir days dry		
	Observed	CSF model	Wessex model
Years river dry	12	15	31
% years dry	38%	47%	97%
Average dry days per year	38	19	95

	Keyneston Bridge days dry		
	Observed	CSF model	Wessex model
Years river dry	6	8	21
% years dry	17%	21%	54%
Average dry days per year	14	9	28

Table 2 - Comparison of observed and modelled frequency of drying of lower river

The Wessex model greatly over-estimates the frequency and duration of drying of the lower river.

The CSF modelled provides a much better fit than the Wessex model to the amount of drying, although it tends to over-estimate the frequency of the dry years, while under-estimating the duration of the river drying in dry years. Overall, the CSF model is a considerably better fit to the observed data than the Wessex model.

With both models, there is a lot of variation from year to year in the quality of fit with the observed data. This is perhaps because a small difference in the groundwater level can effect whether or not the river is dry – when the water table is just above the bed of the river, the river will retain water and will flow; when the water table drops below the river bed, the river will quickly dry. Therefore, the modelled drying of the river is very sensitive to small errors in the modelled groundwater levels.

4.5 Modelled impacts of abstraction on river flows and river drying

Although the CSF model and the Wessex model both give reasonable validation fits when comparing observed and modelled data, there are big differences in the predicted impacts of the abstractions, especially the impacts on drought flows and on the frequency and duration of the lower River Tarrant drying, as shown below:

		% of years the river dries			
		CSF modelling		Wessex modelling	
	Observed	Historic	Natural	Historic	Natural
Keyneston Bridge	17%	17%	0%	60%	60%
Keyneston Weir	38%	40%	0%	94%	94%
Tarrant Crawford	49%	55%	0%	100%	100%

		Average days dry per year			
		CSF modelling		Wessex modelling	
	Observed	Historic	Natural	Historic	Natural
Keyneston Bridge	14	6	0	32	34
Keyneston Weir	38	18	0	99	97
Tarrant Crawford	49	26	0	122	120

Note: the modelled data are for all years in the modelled period 1970 to 2023, but the observed data are only for the years when observations were made, so the observed and modelled data are not strictly comparable.

Table 3 - Modelled impact of abstraction on drying of the lower River Tarrant

The CSF model shows that, since 1970, without abstraction the river would never have dried from Keyneston Bridge down.

In contrast, the Wessex modelling shows that abstraction has made virtually no difference to the drying of the lower river. It shows that the river would have dried every year at Tarrant Crawford, even with no abstraction – obviously wrong as the observed data show that the river only dried at Tarrant Crawford in 19 of the 39 years of available records. This suggests that the Wessex modelling is not a reliable indicator of the frequency and duration of the drying of the lower river.

The modelled impact of abstraction on summer flows in the lower river, when it is still flowing, can be seen by looking at hydrographs focused on summer flows, with and without abstraction. The examples below show some years and locations when spot flow data are available to help judge the realism of the modelled flows:

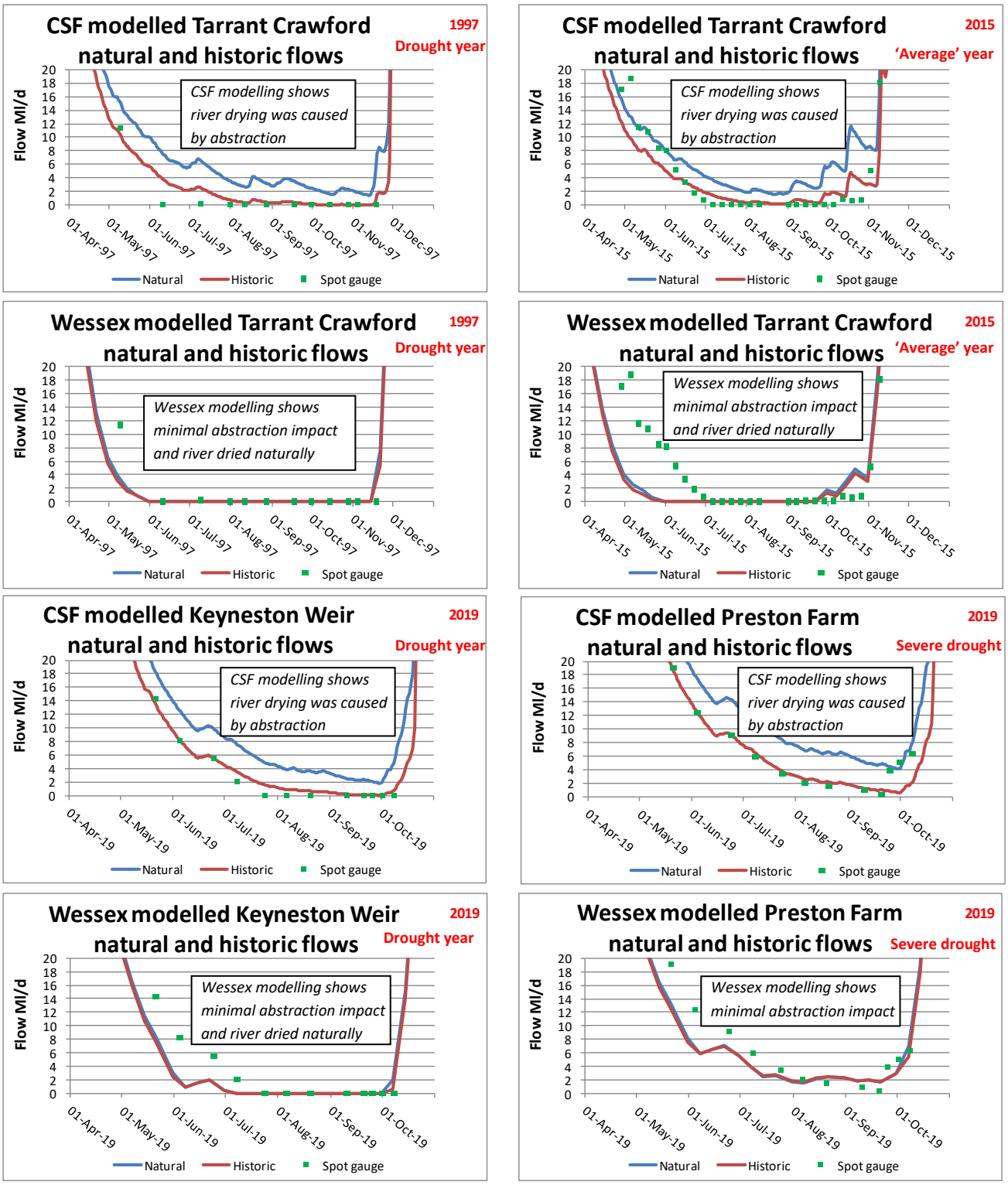


Figure 19 - Comparison of CSF and Wessex modelling of impacts on lower Tarrant flows

The Wessex and CSF modelling of the flow impacts at different river flow levels are compared below:

	Wessex modelled historic flow reductions Ml/d				
	Mean flow	At Q5	At Q50	At Q80	At Q95
Preston Farm	0.99	2.52	0.89	0.03	-0.18
Keyneston Weir	1.00	2.25	1.02	Dry	Dry
Tarrant Crawford	0.99	2.31	1.02	Dry	Dry

	CSF modelled historic flow reductions Ml/d				
	Mean flow	At Q5	At Q50	At Q80	At Q95
Preston Farm	5.63	7.21	5.96	3.98	2.95
Keyneston Weir	5.18	7.67	5.52	2.91	1.57
Tarrant Crawford	5.08	7.84	5.39	2.63	1.23

Note: Q5 is the natural river flow that is exceeded 5% of the time; similarly for Q50, Q80 and Q95

Table 4 - Comparison of Wessex and CSF modelling of abstraction impacts

The plots in Figure 19 and the table above show consistent but very different pictures from the two models. The CSF model shows that drying of the lower river is almost entirely due to abstraction, without which the river would have kept flowing at all times in all years since 1970.

The Wessex modelling suggests that abstraction has had minimal impact on Tarrant flows and that, even without any abstraction, the river would naturally dry every year at Tarrant Crawford and in most years from Keyneston Bridge downwards. This is the same picture as presented by the data in Table 3.

The Wessex modelling's low amount of abstraction impact on Tarrant flows is consistent with the finding of the 2018 Stour tributaries report that Black Lane and Shapwick abstractions have minimal impact on River Tarrant flows. However, the report states that the Wessex model includes 'Horizontal Flow Barriers' to eliminate the Black Lane impacts and the impacts from the Shapwick borehole appear to have been eliminated from the modelling on the grounds of the findings of pump shut-off tests on the Shapwick borehole. There is further comment on the validity of these assumptions in Section 4.8 of this report.

The CSF modelling assumes that the Black Lane and Shapwick abstractions both affect the water balance in the combined Tarrant-Pimperne catchment, so they have a considerable impact on Tarrant flows. There is also more comment on the validity of this in Section 4.8.3.

Both models show the generally accepted effect of abstraction causing a bigger than average reduction in flows at times of high river lows and a lower impact at times of low river flows[13]. Both models show average river flow impacts that are substantially less than the amounts of the abstractions. This is because part of the effect of the abstractions is a reduction of the underflows within the chalk which form part of the catchment water balance.

4.6 Modelled compliance with EFIs

The Environment Agency determines acceptable reductions in river flows using Environmental Flow

[13] Dealing with impacts of groundwater abstraction on the chalk streams of the Colne and Lea valleys, pages 16 to22, John Lawson for the Chalk Streams First consortium, February 2023 https://chalkstreams.org/flow-recovery-following-abstraction-reduction/

Indicators (EFIs) as below[14]:

RIVER TYPE	Q30	Q50	Q70	Q95
ASB3 HIGH SENSITIVITY	24%	20%	15%	10%
ASB2 MODERATE SENSITIVITY	26%	24%	20%	15%
ASB1 LOW SENSITIVITY	30%	26%	24%	20%

2008 EFI STANDARDS FOR ACHIEVING GOOD ECOLOGICAL STATUS FOR CHALK STREAMS GIVEN AS % OF ALLOWABLE REDUCTION OF NATURAL FLOW

Note: Q30 is the natural flow exceeded for 30% of the time, Q95 is flow exceeded 5% of the time, ie a moderate drought

Table 5 - EFI standards for 'Good' Ecological Status

A largely unmodified chalk stream like the River Tarrant should be deemed high sensitivity ASB3, especially in view of the river's importance for spawning of chalk stream salmon and its tendency to very low flows and drying out.

The Wessex modelling suggests minimal flow reductions in the lower river, so the historic flow regime as portrayed by the model would easily comply with the ASB3 EFIs, as shown in the example below for EFI compliance at Preston Farm:

	Wessex modelled flow compliance at Preston Farm			
Natural flow exceedance	Q30	Q50	Q70	Q95
Natural flow Ml/d	55.18	18.38	5.66	0.86
Historic flow Ml/d	53.32	17.50	5.46	1.04
Flow reduction Ml/d	1.86	0.89	0.20	-0.18
Flow reduction %	3.4%	4.8%	3.5%	-20.8%
Allowed reduction for ASB3 EFI compliance %	24%	20%	15%	10%
EFI compliance	**Pass**	**Pass**	**Pass**	**Pass**

The Wessex modelled flow reductions are well within the amounts allowed by the EFIs, so in the WFD assessment the hydrological regime would be classified as 'Supports Good ecological status'

Note: the flow gain at Q95 is understood to be from the model allowing for a small discharge from Blandford Camp STW

Table 6 - Wessex modelled EFI compliance for historic flows at Preston Farm

The modelled reductions in flow at Preston Farm are considerably less than the amounts of the abstractions at Stubhampton. In stark contrast, the CSF modelling suggests large EFI failures in the lower river, as shown in the example for Preston Farm below:

	CSF modelled flow compliance at Preston Farm			
Natural flow exceedance	Q30	Q50	Q70	Q95
Natural flow Ml/d	57.40	26.31	11.33	3.75
Historic flow Ml/d	50.65	20.43	6.81	0.84
Flow reduction Ml/d	6.75	5.88	4.52	2.90
Flow reduction %	11.8%	22.4%	**39.9%**	**77.5%**
Allowed reduction for ASB3 EFI compliance %	24%	20%	15%	10%
EFI compliance	**Pass**	**Fail**	**Fail**	**Fail**

At average and low flows, the CSF modelled flow reductions greatly exceed the amounts allowed by the EFIs, so in the WFD assessment the hydrological regime would be classified as 'does not Support Good ecological status'

Table 7 - CSF modelled EFI compliance for historic flows at Preston Farm

The seasonal timing of EFI failures can be seen on the hydrographs below:

[14] CaBA chalk stream restoration strategy Appendix B2 https://catchmentbasedapproach.org/wp-content/uploads/2021/10/CaBA-CSRG-Strategy-APPENDICES-FINAL-12.10.21-Low-Res.pdf

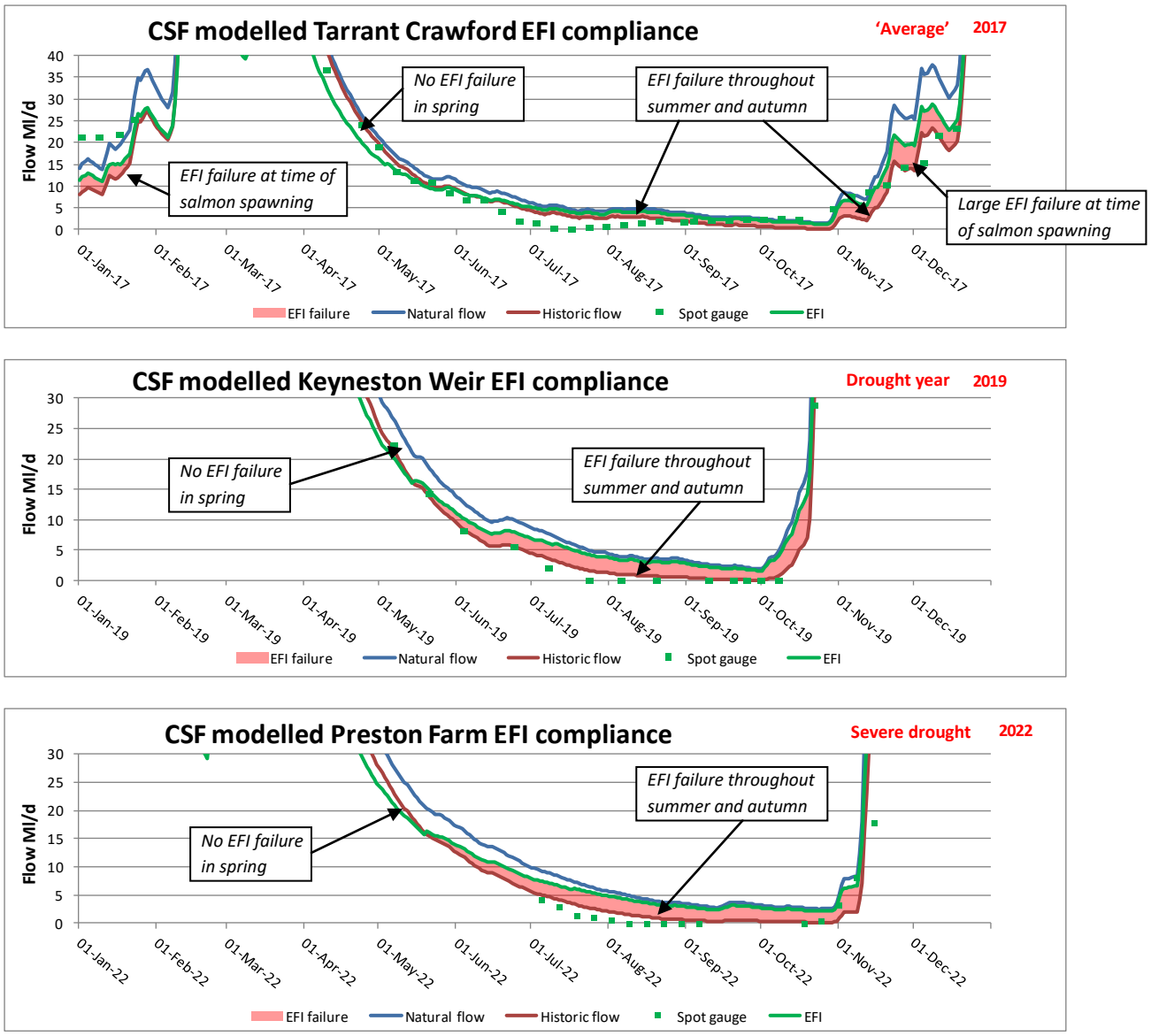


Figure 20 - Examples of EFI flow failures shown by CSF modelling

EFI failures predicted by the CSF model occur at all points in the lower river every year. River flows are mostly compliant with EFIs in spring, when GWLs are usually at their highest. Most of the EFI failures are in the summer and autumn. In dry autumns and winters, there can also be substantial EFI failures, as shown in the above plot for Tarrant Crawford in 2017. Large flow reductions in autumn and winter have big implications for salmon spawning – chalk stream salmon typically lay their eggs in gravel (termed redds) in December-January and the young fish (Alevins) emerge in early spring, so good winter flows are crucial to spawning success. This all supports the conclusion that the hydrological regime status of the River Tarrant should be re-classified to "Does Not Support Good".

4.7 Effectiveness of the AIM scheme

The AIM scheme nominally reduced the abstraction at Shapwick to a maximum of 1.09 Ml/d when Four Acres GWL was less than 79 mOD, during the 5 year period 2019 to 2023. The frequency of AIM use and corresponding Stubhampton abstraction is shown below:

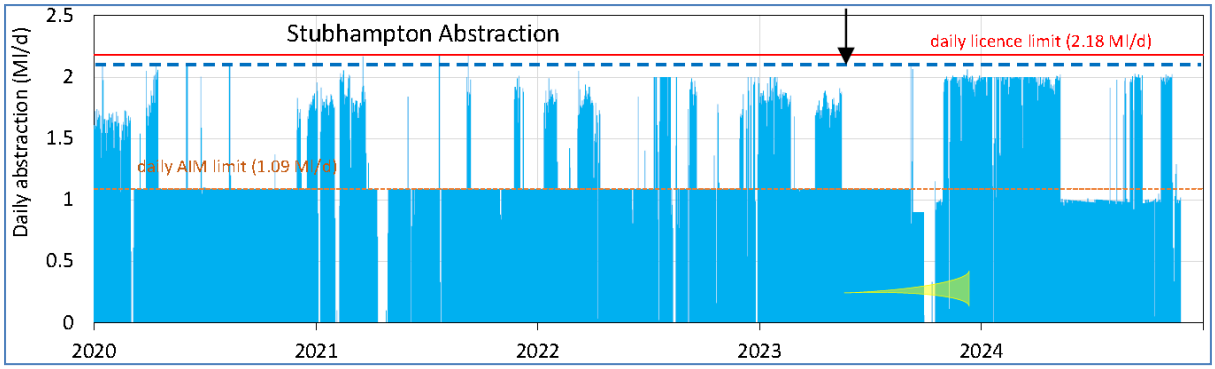


Figure 21 - Stubhampton AIM operation 2020 to 2024

The scheme had only a small effect on River Tarrant flows as illustrated by the example of Wessex modelling of flow at Monkton in the 2022 drought as shown below:

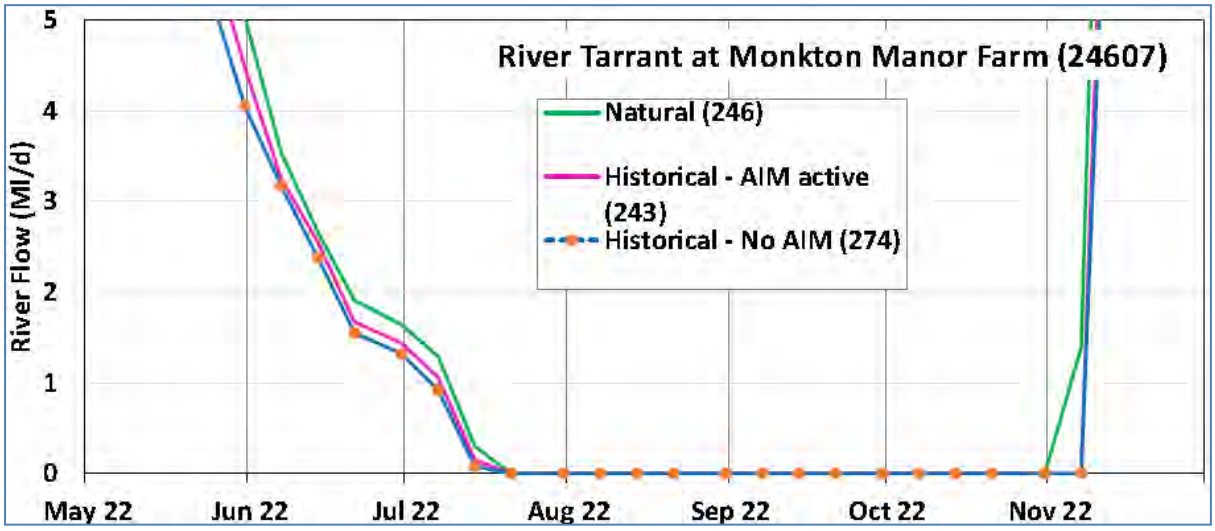


Figure 22 - Wessex modelling of effect of AIM on Monkton flows in 2022 drought

The scheme would have had only minimal benefit to the amount of drying of the lower river. For example the CSF modelling shows that without AIM the duration of the drying of the river at Keyneston would have increased by 4 days from the recorded 137 days to 141 days.

It is understood that the revised version of AIM proposed by Wessex Water for the next 5 years will be triggered by a lower groundwater level at Four Acres, so the benefits will be even less than for the previous AIM scheme. Therefore, it is probably not worth continuing with the AIM scheme and it would, in any case, be unneeded if the solution proposed in Section 5.2 of this report is implemented.

4.8 How reliable is the modelling?

The analysis of modelled impacts of abstraction on river flows, as described in Sections 4.5 and 4.6, has revealed big differences in the Wessex and CSF modelling. This raises the question of how reliable are the models.

4.8.1 Reliability of the Wessex Basin Model

Wessex Water's modelling of the flows and GWLs in River Tarrant uses the Wessex Basin Model (WBM) covering much of Wessex Water's supply area. It is based on an industry-standard groundwater modelling software package. The modelling has been done by the firm WSP, who are leading consultants in the field, and under the direction of Rob Soley who is a prominent national expert in hydrogeology and groundwater modelling. The Wessex modelling has been intensely scrutinised since the RTPS report in 2012, followed by the Middle Stour Tributaries investigation in 2018 and in the review of the Stubhampton AIM use in late 2024. In view of the expertise involved and the scrutiny received, the Wessex modelling of the Tarrant can be considered representative of industry best practice.

That being the case, the Wessex model's poor replication of the frequency and duration of the drying of the lower River Tarrant and its inability to provide credible modelling of the Pimperne catchment raises big concerns over the model's reliability for assessing flow impacts in the lower River Tarrant. This applies particularly to the Wessex modelling of the effect on the Tarrant of the Black Lane abstraction located in the Pimperne valley, as admitted in the previously quoted extract from the 2018 Stour Tributaries report[15]:

> *"For these reasons, it is considered the model in its current state (Run 427) is not fit for its intended purpose to carry out a reliable impact assessment of PWS abstraction on the Pimperne Brook in relation to Black Lane."*

The fact that the amount of river drying is so poorly simulated by the Wessex model does not necessarily mean that there are big errors in the modelled amounts of reduction in flows when the river is flowing. However, the small abstraction impacts shown from the Wessex model arise from a finding of the 2018 Middle Stour Tributaries report which concluded, <u>from hydrogeological analysis rather than modelling</u>, that the Black Lane and Shapwick abstractions have no effect on River Tarrant or Pimperne Brook flows. The justification for this was summarised in the diagram below which from the presentation given to the RTPS in December 2024:

[15] Middle Stour Tributaries Investigation, Draft Final Report, page 56, Wessex Water , 30 March 2018

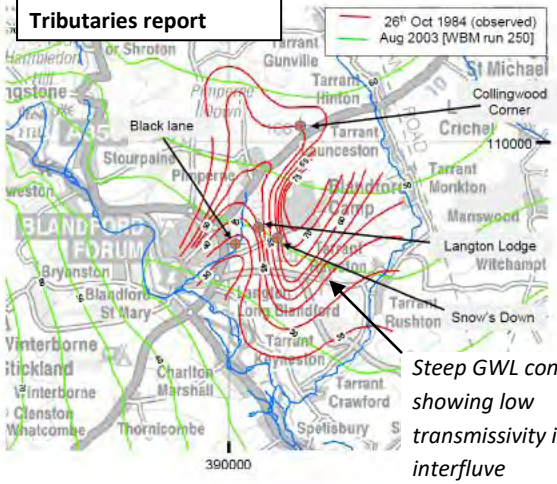
PWS impact on River Tarrant

Wessex Water
YTL GROUP

Black Lane

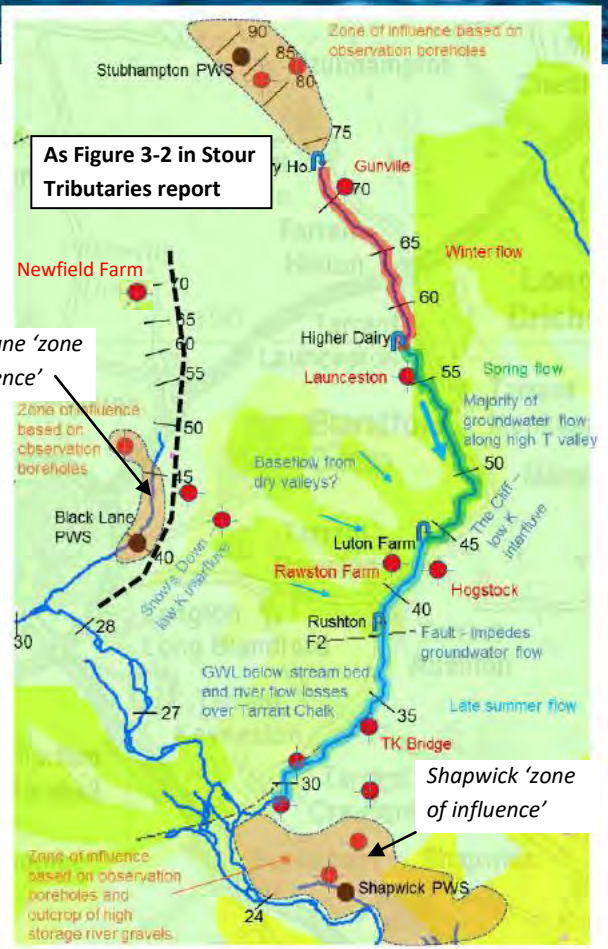
- Influence restricted to Pimperne Valley, intercepting flow to the River Stour
- No impact on Tarrant

As Figure 2-16 in Stour Tributaries report



Steep GWL contours showing low transmissivity in interfluve

As Figure 3-2 in Stour Tributaries report



Black Lane 'zone of influence'

Shapwick 'zone of influence'

Stubhampton

- Influence restricted to Tarrant valley
- Reduces flow to the Tarrant
- 'perennial' flow at Q95 (1970-2016) reduced by <10%
- Natural flow: 140 -300 days per year
- Historical PWS use increase dry period by ~14 days (Gunville-Luton)

Shapwick

- Influence restricted to Stour valley
- No impact on Tarrant's gaining reach

Figure 23 - Wessex Water explanation of lack of impact from Black Lane and Shapwick

The Stour Tributaries Report explains the lack of Tarrant impact from the Black Lane and Shapwick abstractions as follows[16], referring to the report's Figure 3-2 (shown as the central map in the above Figure 23), which describes "zones of influence" for each abstraction:

> *"Groundwater zones of influence have been estimated for PWS sources on Figure 3-2. These are based on groundwater level monitoring, at available observation boreholes, and geological maps, though gaps in understanding still exist.*
>
> *The zone of influence for Black Lane is based observed drawdown of groundwater level at Black Lane BH4 and Hammett's Farm (see section 2.8.4). No discernible drawdown is observed at Langton Lodge or Snow's Down indicating the zone of influence extends along the main valley and up dry valleys rather than radially outwards under the interfluve.*
>
> *The zone of influence for Shapwick is based on observed drawdown of groundwater level at Shapwick EA observation borehole, Clover Close and Middle Field. In contrast, there is no drawdown at Crawford Drove or at boreholes in the lower Tarrant valley. A previous assessment suggests that river gravels in the Stour valley have high storage capacity and are considered to provide significant proportion of yield to Shapwick PWS (Entec, 2008). Therefore, the zone of influence is drawn to (approximately) follow the extent of these deposits."*

Determination of the 'zones of influence' of the Black Lane and Shapwick abstractions was done by looking at observed changes in groundwater levels at observation boreholes during short-term switch-off tests of the boreholes. An extract from the Stour Tributaries report describing the determination of the zones of influence is attached as Appendix C to this report. In essence, the zone of influence of each abstraction was assumed to be the limits of the cone of depression of GWLs around a borehole source, as illustrated below:

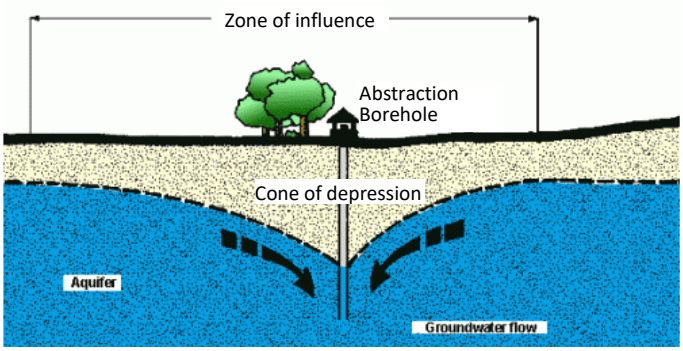


Figure 24 - Conceptual illustration of 'cone of depression' and 'zone of influence'

This interpretation of the effect of abstraction doesn't take account of the long term effect of abstraction on the catchment water balance and regional groundwater levels, as described in Section 4.1 of this report. It is the seasonal fluctuation of regional groundwater level which is the driver of seasonal variation of chalk stream flows. High levels of abstraction cause a faster rate of GWLs falling in summer/autumn and a slower rate of GWLs rising in winter/spring, leading to a long term fall in the average groundwater level. If groundwater levels are lower, river flows will also be lower. The cones of depression around individual boreholes are superimposed on the regional

[16] Middle Stour Tributaries Investigation, Draft Final Report, page 38, Wessex Water , 30 March 2018

fluctuations in the water table, but have only a relatively small and localised effect on GWLs and river flows.

Short term abstraction shut-off tests at boreholes have minimal impact on long term seasonal groundwater level fluctuations – after an abstraction change, it takes several years of seasonal GWL fluctuations before the regional GWLs settle into a new equilibrium. Therefore, the short-term pump shut-off tests at Black Lane and Shapwick do not provide a measure of whether or not continuous abstractions affect flows in the River Tarrant or Pimperne Brook.

The Stour Tributaries report's "no impact" interpretation of the short-term pump shut-off tests has been built into the Wessex modelling of the impact of the Black Lane by the "the i*ntroduction of Horizontal Flow Barriers (HFBs) to hydraulically separate Pimperne-Tarrant interfluve from Black Lane*", as explained in the Stour Tributaries Report[17]. This appears to have artificially ensured that the Wessex model cannot register any impact of the Black Lane abstraction on Tarrant flows and GWLs.

The Stour Tributaries Report also suggests that Tarrant abstraction impacts from the Black Lane and Shapwick abstractions have been constrained in the model by assumptions of low transmissivity in the interfluves (ie hills) between the rivers[18]:

> *"A review of the modelling output shows that abstraction at Black Lane and Shapwick does not impact flows along the Tarrant, a consequence of their abstraction effects being effectively restricted to the high transmissivity valleys in which they are located and low transmissivity beneath the interfluves, which effectively stop inter-catchment transfer of water. Consequently for the Tarrant, only the impact due to Stubhampton is presented."*

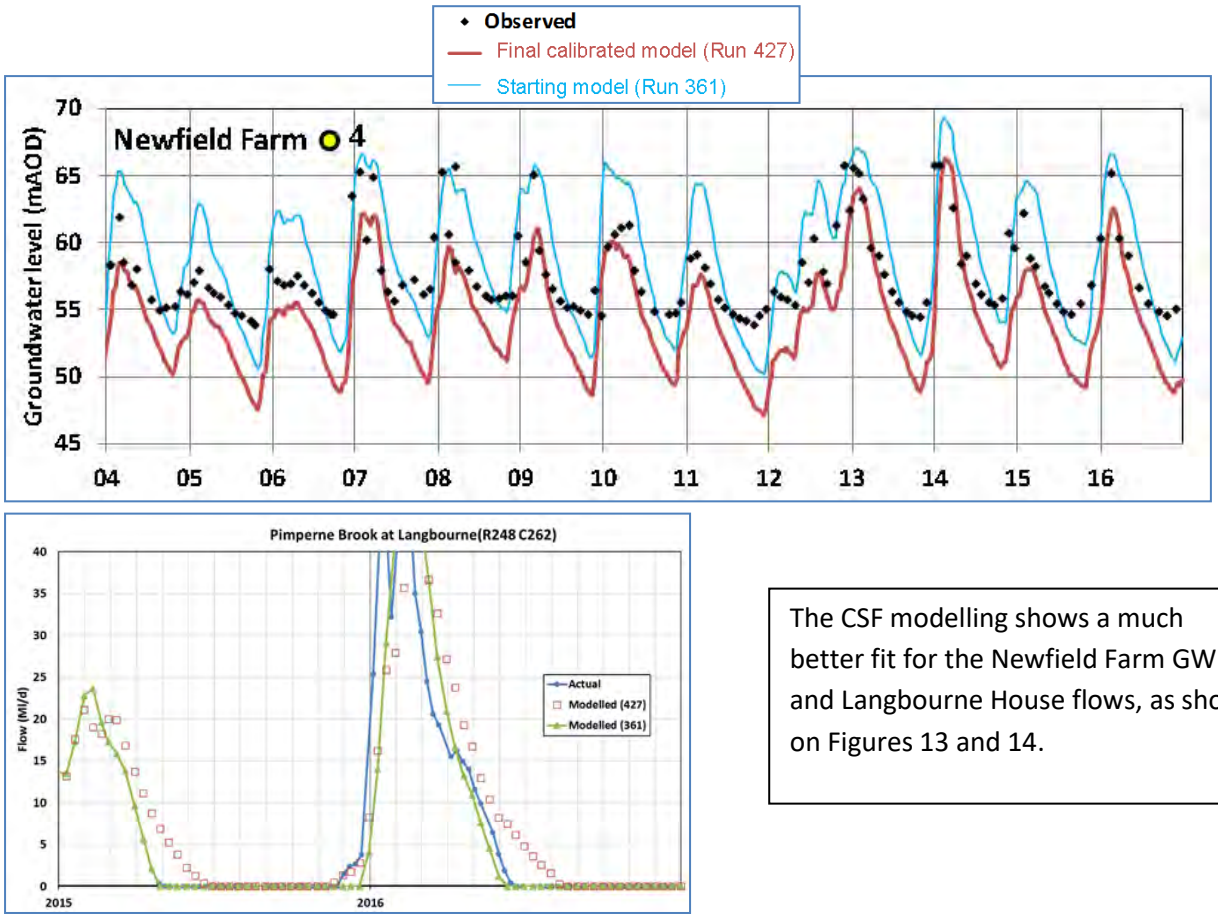
The existence of low transmissivity zones in the interfluves (see GWL contour map on Figure 23) would delay the time it takes for a short term abstraction change to affect the GWLs at the extremities of cones of influence, but low transmissivities will not affect the long term changes to regional GWLs and river flows resulting from long term abstraction changes. It is also noted that the paper on Tarrant history by the NRA geologist WI Stanton in 1991, included as Annex 1 to Dr David Solomon's report in Appendix A, stated that during test pumping of the Shapwick borehole in 1969 "*the cone of depression extended as far as Tarrant Keynston".*

It thus appears that the Wessex model has been set up with a built-in exclusion of the effects of Black Lane and Shapwick abstractions on the Tarrant river flows, based on a questionable interpretation of the results of short-term pump switch-off tests. This casts considerable doubt on the reliability of the Wessex modelling for assessing the Tarrant abstraction impacts from those sources.

4.8.2 Validity of Wessex Water conclusions on Pimperne Brook impacts

The Middle Stour Tributaries report acknowledges that Wessex Water's modelling is not fit for its intended purpose of assessing impacts on the Pimperne Brook[19]. The report recognises the poor fit between modelled and observed GWLs and flows in the Pimperne catchment, as illustrated by the plots below:

[17] Middle Stour Tributaries Investigation, Draft Final Report, page 46, Wessex Water , 30 March 2018
[18] Same report, page 60
[19] Middle Stour Tributaries Investigation, Draft Final Report, page 56, Wessex Water , 30 March 2018



The CSF modelling shows a much better fit for the Newfield Farm GWLs and Langbourne House flows, as shown on Figures 13 and 14.

Figure 25 - Examples of poor validation fits for Wessex model in Pimperne catchment

As commented in the Middle Stour Tributaries Report, the plots above show:

> *"At Newfield Farm some winter fits are achieved, but overall the fit is poor, with summer minima's over 5m too low."*
>
> *"The final calibration model (Run 427) is poor at simulating the flow recession at Langbourne House. In 2016, drying was observed approximately 2 months earlier than predicted by the model. Langbourne House is an important reach because flow continues to accrete here in late spring when the lower reaches are dry and it is just upstream of Black Lane PWS, and therefore at risk of impact."*

Therefore, in view of the poor validation fits achieved by the Wessex model, the Middle Stour Tributaries report chooses not to use the Wessex model to determine abstraction impacts in the Pimperne catchment[20]:

> *"The WBM (Run 427) is not well enough calibrated to the observed river flow behaviour and groundwater levels in the Pimperne Brook valley, to give sufficient confidence to use the model to assess the impact of abstraction i.e. Black Lane on the Pimperne Brook. Instead an empirical approach based on field data has been used, the approach and findings are presented in this section."*

The report provides no information on the modelled impacts of the Black Lane abstraction on GWLs or flows in the Pimperne catchment. Instead, the 'empirical approach' referred to above is based on

[20] Middle Stour Tributaries Investigation, Draft Final Report, page 68, Wessex Water , 30 March 2018

records of the drying of the Pimperne Brook compared to the records of the groundwater levels at the Woodyates and Newfield Farm observation borehole. The report concludes that "*the Black Lane abstraction does not impact the location or timing of the Pimperne winterbourne*." [21] The validity of this conclusion is challenged below in Section 4.9.2.

If the impact of the Black Lane abstraction is confined to the Pimperne catchment, as assumed in the Wessex model's adoption of a low transmissivity barrier between the Pimperne and Tarrant catchments, the recent Black Lane abstraction of about 8 Ml/d is about 33% of the average annual recharge of 23.9 Ml/d for the Pimperne catchment. The A%R of 33% is well above the target of 10% for sustainable abstraction, as suggested in the CaBA chalk stream strategy, and puts the Pimperne Brook amongst the most heavily over-abstracted chalkstreams, as shown below[22]:

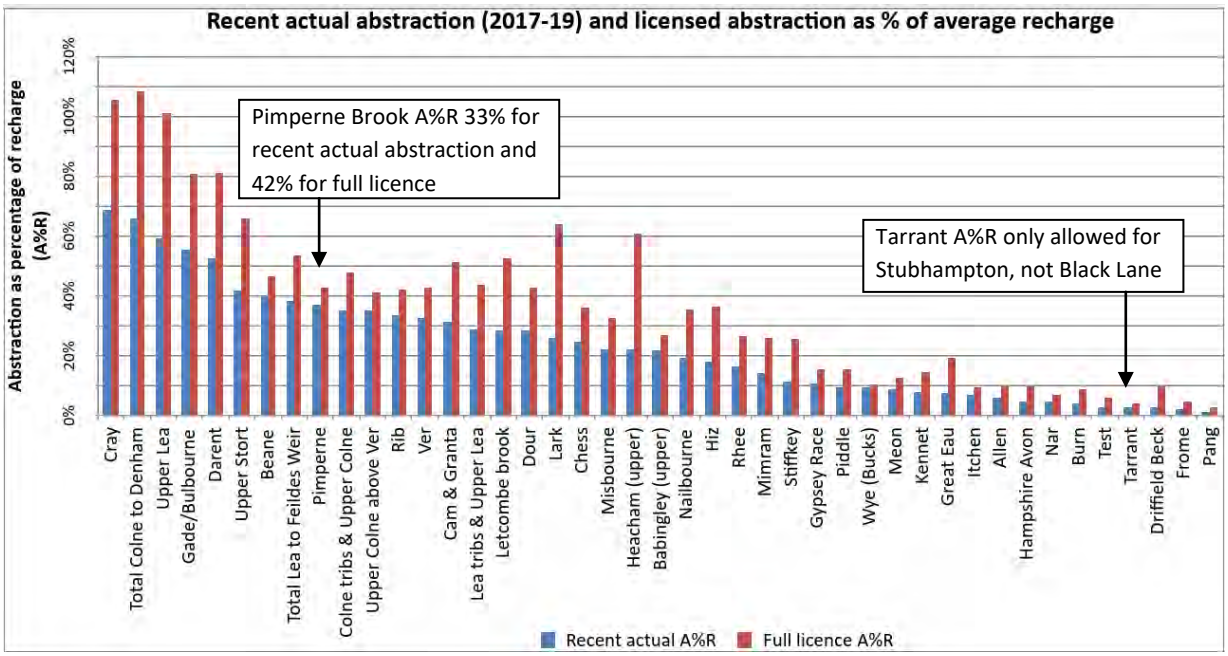


Figure 26 - Abstraction as % of recharge for Pimperne compared to other chalk streams

If the impact of the Black Lane abstraction is confined to the Pimperne catchment, as assumed by Wessex Water, the A%R analysis suggests that the current WFD hydrological regime of the Pimperne Brook must be incorrectly classified as "Supports Good" ecological status. Furthermore, the CSF modelling of the combined Tarrant-Pimperne catchment, which assumes that the Black Lane abstraction is spread across both catchments, shows that the Black Lane abstraction increases the drying of the winterbourne at Langbourne House by an average of about 40 days per year – again not consistent with the WFD classification of "Supports Good".

4.8.3 Reliability of CSF modelling

The reliability of the CSF modelling can also be questioned on various grounds, particularly the hydrogeological assumptions on which the model is based:

[21] Middle Stour Tributaries report, page 69.
[22] CaBA chalk stream strategy, page 41 and diagram on page 45 https://catchmentbasedapproach.org/wp-content/uploads/2021/10/CaBA-CSRG-Strategy-MAIN-REPORT-FINAL-12.10.21-Low-Res.pdf

1. This type of lumped parameter modelling, based on simulating the catchment water balance and the observed river flow-GWL relationships, is a new technique which has not been extensively peer-reviewed.

2. The model assumes that GWLs throughout the Tarrant-Pimperne catchment are inter-connected and rise and fall in unison, albeit with slightly different timing and widely different amounts (more in the valley sides, less close to the river).

3. The model assumes that river baseflows are entirely dependent on groundwater levels.

4. The model assumes that the adjacent Tarrant and Pimperne topographic catchments operate as single groundwater catchment with a single catchment water balance.

5. The model assumes a fixed catchment within the regional aquifer, with a water balance that is independent of adjoining catchments.

6. The model assumes that the Shapwick boreholes affect the Tarrant catchment despite lying slightly outside the topographic catchment boundary.

The CSF model originated from work on the River Kennet and has subsequently been used for work on the Rivers Chess, Ver, Mimram, Bean and Ivel. The original Kennet version was peer reviewed by a consultant for WWF who concluded that the model gave a better fit to measured data than Thames Water's conventional groundwater model and that the abstraction impact assessments were credible.

The Chess, Ver, Bean and Mimram versions of the CSF model were discussed at a workshop attended by a wide range of industry practitioners in October 2022. The consensus was that the model can be used as an initial tool for predicting potential impacts, but that the acknowledged good calibration with measured river flows does not on its own mean it could be reliably used as a predictive tool.

The River Ver version of the model was assessed in an MSc Thesis in 2023[23] under the supervision of Professor Andrew Binley of Lancaster University[24], concluding that:

> *"Overall, the modelling approach provides a useful and informative approach of expressing catchment changes as a result of abstraction.*
>
> *Caution should be taken to fully rely upon this model for accurate assessment of what 'will' happen in the catchment as there is the potential for uncertainty and sensitivity of parameters to overlap in outputs for both current abstractions scenarios and reduced abstractions."*

The CSF model's use on the River Ivel contradicted findings from an earlier conventional groundwater model, and its findings were then mainly supported by a revised version of the conventional regional model (work undertaken by WSP under the direction of Rob Soley).

[23] Modelling the Impact of Groundwater Abstraction in Chalk Rivers: An Appraisal of a Lumped Parameter Approach. Lily Woodward, Lancaster University, September 2023

[24] Professor Andrew Binley https://www.lancaster.ac.uk/lec/about-us/people/andrew-binley

Regarding points 2 and 3 above, the CSF model's underlying assumptions of the inter-connectivity of GWLs and river flows, throughout the Tarrant-Pimperne catchment and the role of the catchment water balance are supported by the measured data and model validation data in this report, particularly:

- The flow vs GWL plots in Figure 9
- The plots in Figure 10 showing strong correlation of GWLs at widely spaced locations in the combined Tarrant-Pimperne catchment
- The excellent fits for the river flow and GWL model validation plots on Figures 13 and 14 which confirm the validity of the water balance basis of the CSF model

The assumption that the Tarrant and Pimperne operate as a single combined catchment, as point 4 above, is supported by the excellent correlation between observed Pimperne and Tarrant GWLs shown on Figure 10 of this report, the excellent validation of modelled Pimperne GWLs on Figure 13 and the reasonably good validation of the modelling of Pimperne flows shown on Figure 14, noting that the Pimperne GWLs and river flows are modelled by correlation with the Four Acres GWLs in the Tarrant catchment.

The assumption that the Tarrant-Pimperne catchment operates independently from adjoining catchments and with a fixed catchment area, as point 5 above, is a potential weakness of the CSF modelling approach. To some extent, the Tarrant-Pimperne abstractions could affect GWLs and flows in adjoining catchments, and abstractions in the adjacent River Allen catchment could be affecting Tarrant flows and GWLs.

Perhaps the most questionable aspect of the CSF modelling is in point 6 above, the assumption that the Shapwick abstraction, lying just outside and downstream of the Tarrant valley, can still affect the Tarrant water balance and, consequently, its GWLs and river flows. Intuitively, the Shapwick abstraction's lowering of GWLs in the Stour valley immediately downstream of the Tarrant must increase the gradient of the downstream slope of the water table within the Tarrant valley, thereby lowering GWLs in the lower Tarrant valley and reducing river flows. However, this effect might not be significant and there are doubts over whether inclusion of the Shapwick abstraction in the Tarrant-Pimperne water balance is a valid means of taking this effect into account.

On the other hand, it is also conceivable that the much larger Sturminster Marshall abstraction of about 15 Ml/d, only about 4 km below the Tarrant confluence, is also lowering the GWLs in the Stour valley, thereby steepening the downstream gradient of the Tarrant water table and reducing the GWLs and flows in the lower river. This effect, potentially larger than any Shapwick effect, is not taken into account by the CSF model, but is considered in Section 4.10.4 of this report.

It is recognised that the inclusion of the Shapwick abstraction in the Tarrant-Pimperne catchment water balance might not be justified, so a version of the CSF model has been calibrated with no Shapwick abstraction. This gives similar model validation fits to those shown in this report and the changes to the modelled amount of natural drying of the lower river are:

- Under natural conditions with no abstraction, the river would have dried at Tarrant Crawford in 1973, 1976, 1990 and 2003, whereas if Shapwick is assumed to affect the Tarrant, the model shows that the lower river would never have dried.

- Under natural conditions, the modelling shows that the river would still never dry at Keyneston Weir or Preston Farm.

In other words, if it is assumed that the Shapwick abstraction has no impact on the River Tarrant, the CSF modelling shows that the river would never have dried naturally at Tarrant Keyneston or Preston Farm since 1970. The CSF model continues to show that the combined effects are probably the cause of the River Tarrant drying between Preston Farm and Keyneston Weir. The lack of drying of the lower river in the absence of abstraction is appears the most realistic conclusion and is consistent with the findings of the historical review in Section 2.

4.9 Measured evidence of Black Lane impacts

4.9.1 Evidence from the Black Lane shut-down in 2016-17

The records of Tarrant flows during the shut-down of the Black Lane abstraction for a pumping station up-grade in 2016-17 provide some evidence of abstraction impacts. The variation in abstraction is shown below (as previously shown in Figure 5):

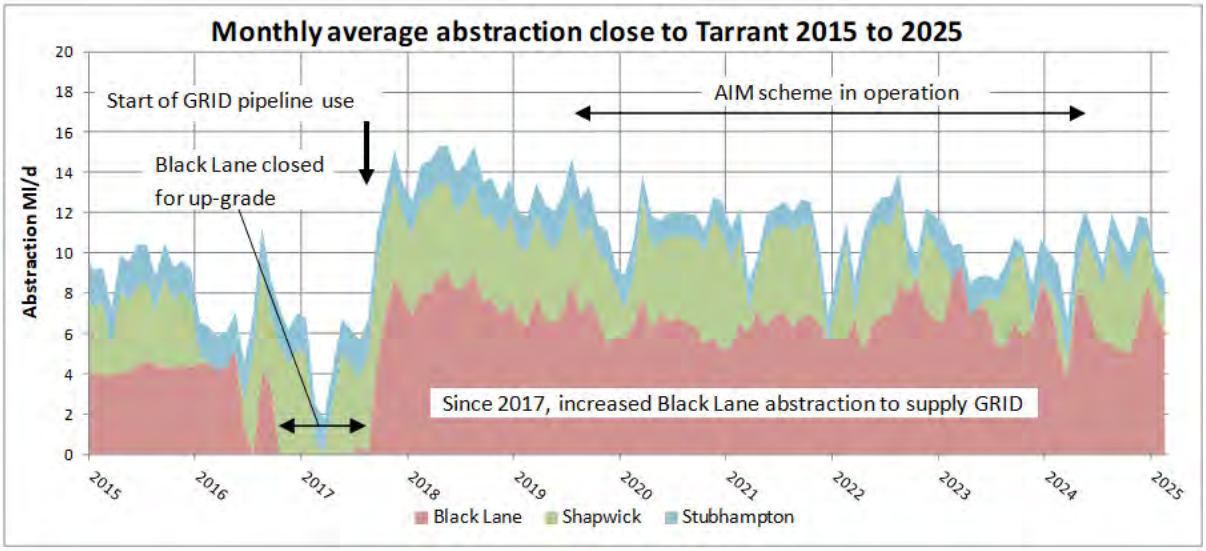


Figure 27 - Abstractions before and after the Black Lane shut-down

The flow signature plots in Figure 18 show that 2017, the year of the Black Lane shut-down, was the only year from 2015 to 2024 that the lower river did not dry at all. The recorded spot flows at Tarrant Crawford and Keyneston Weir in 2016-17 are shown below:

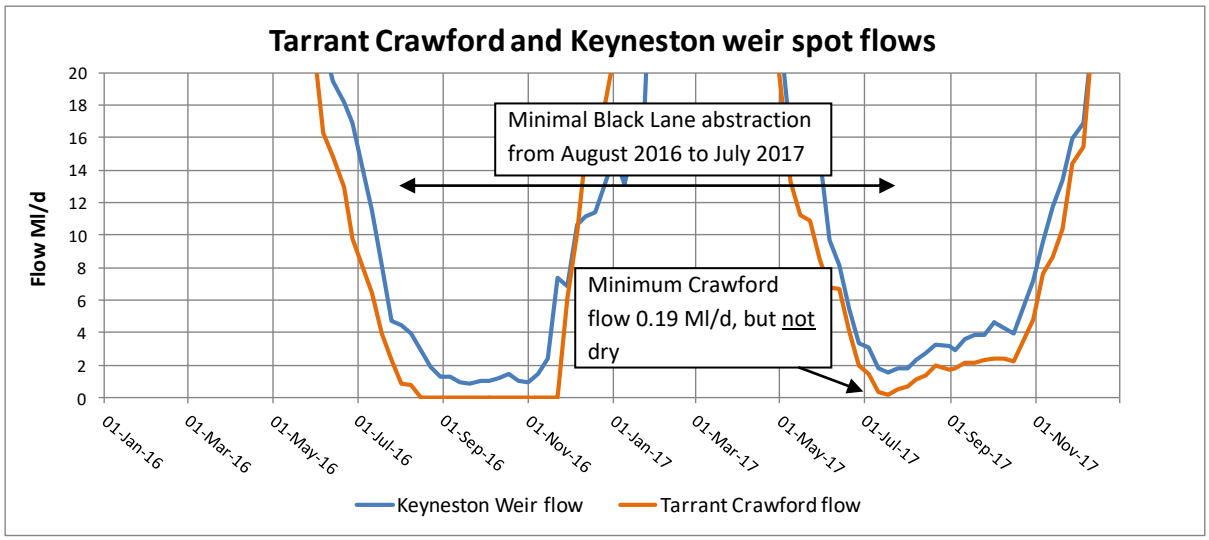


Figure 28 - Lower Tarrant measured flows during Black Lane shut-down

The flow in the lower River Tarrant was maintained throughout 2017, but no other year from 2015 to 2024, despite the effective rain being below average during the hydrological year (October to September) 2016-17 and a lot lower than all the other years 2014 to 2023, when the lower river did dry. The monthly and annual effective rain is shown below (from data used in Wessex and CSF models):

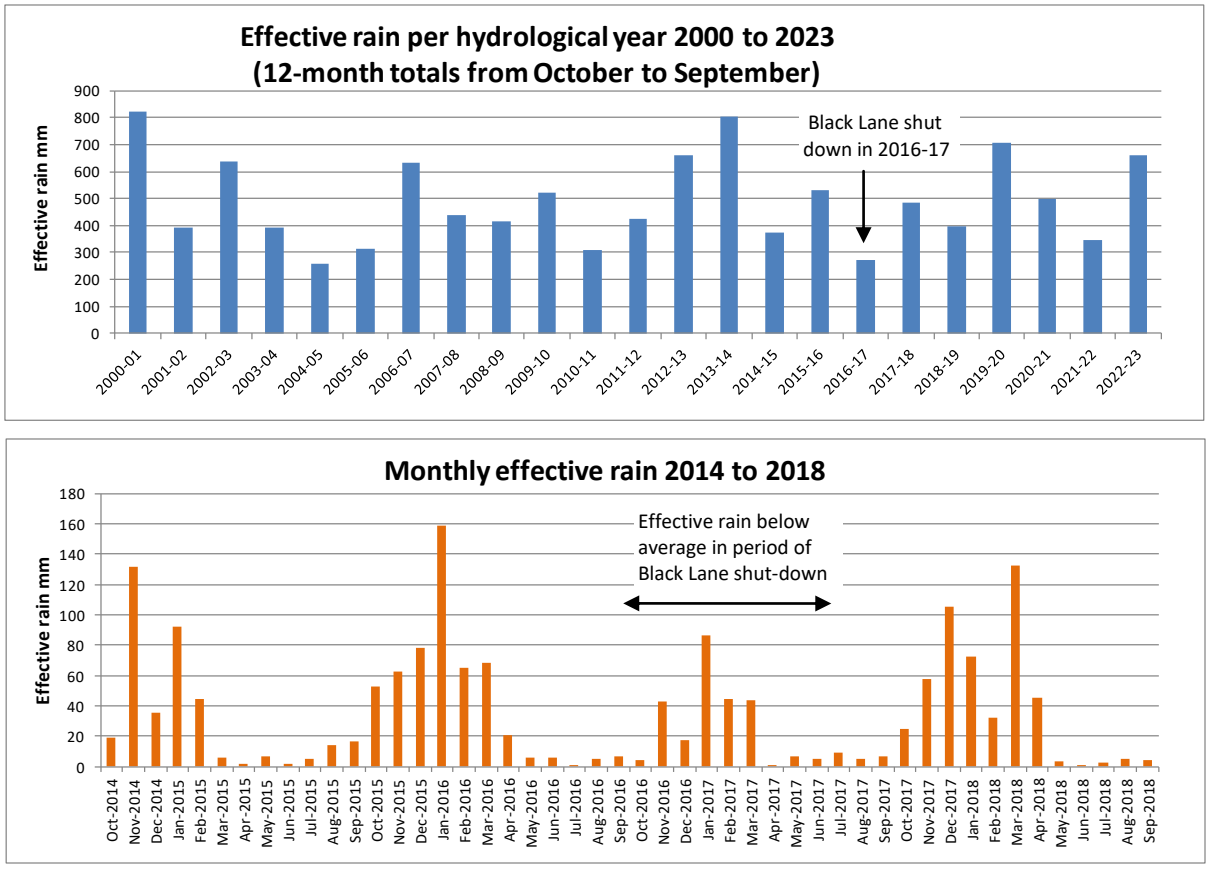


Figure 29 - Effective rain around time of Black Lane shut-down

The maintenance of flow in the lower river Tarrant in 2017, despite the relatively low effective rain,

is compelling evidence that the drying of the lower river in recent years is largely caused by the Black Lane abstraction and has been aggravated by the increased Black Lane abstraction since 2018 to supply Wessex Water's GRID pipeline. It should also be born in mind that it would take several years for groundwater levels to recover after switching off the abstraction, so the natural flows would have been even higher than the flows recorded in 2017.

This evidence provides further validation of the CSF modelling which shows continuous flow in the lower Tarrant with historic abstraction in 2017, but shows the lower river drying in 2017 if abstraction had been maintained at the level of about 4 Ml/d that preceded the shut-down. In contrast, the Wessex modelling erroneously shows extensive drying of the lower river in 2017 with the historic Black Lane abstraction, and almost the same amount of drying with no abstraction.

4.9.2 Use of Woodyates GWLs for impact assessment and model validation

Wessex Water has used observed GWLs at the Woodyates observation borehole (OBH) in their model validations and impact assessments. Its location is shown in Figure 30:

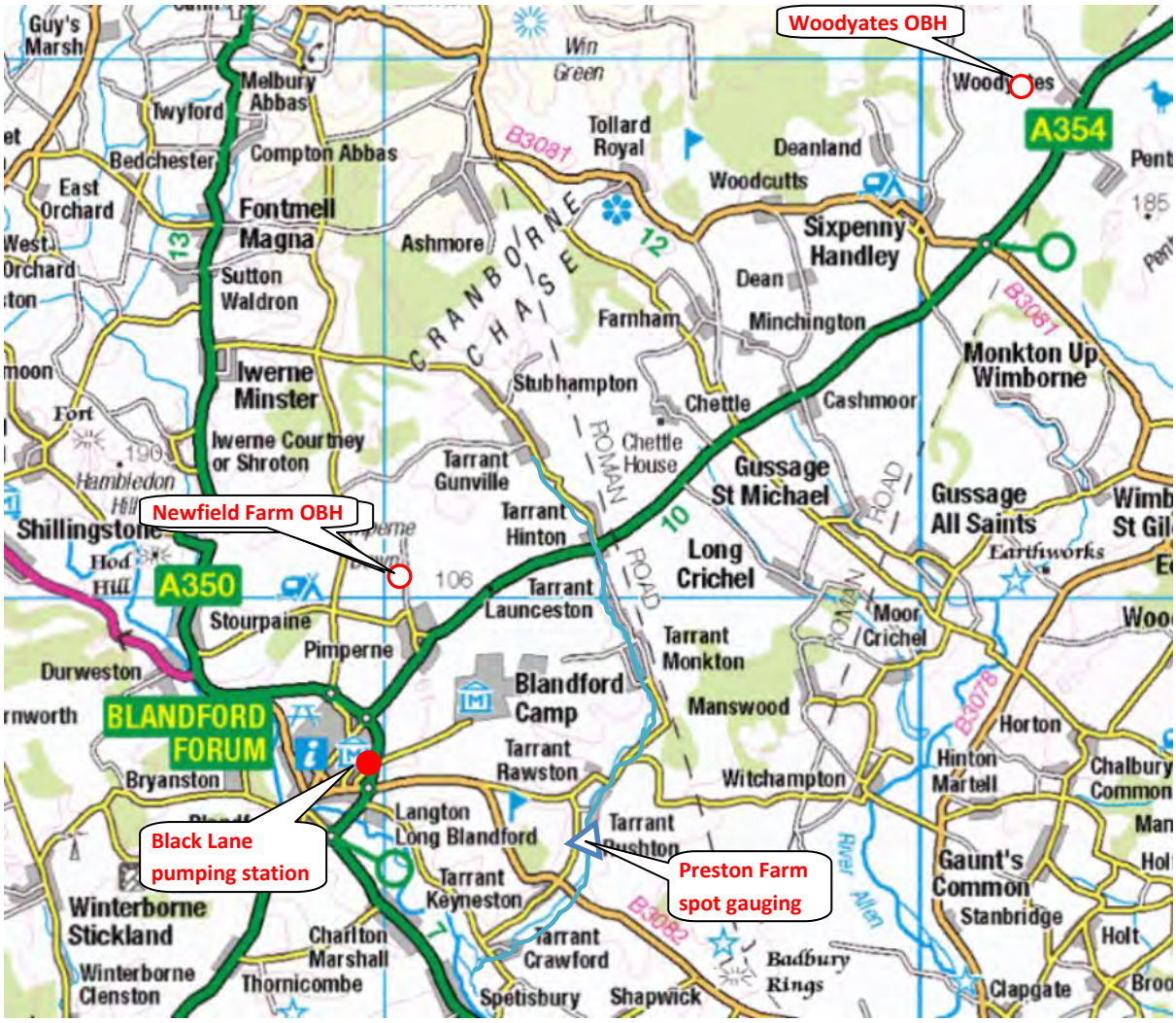


Figure 30 - Location of Woodyates OBH relative to River Tarrant area

Wessex Water have suggested that the relationship between measured River Tarrant flows and recorded groundwater levels at the Woodyates observation borehole (OBH) provides evidence that

the River Tarrant flows are not affected by abstraction at Black Lane in the adjacent Pimperne valley. This is said to be further validation of the Wessex modelling showing no impact of the Black Lane abstraction on the River Tarrant.

The Woodyates observation borehole can be considered to provide a record of natural groundwater levels because it is located well away from any significant groundwater abstractions. In particular, it is about 17 km away from the Black Lane abstraction. Since 2015, the Black Lane abstraction has varied as shown below:

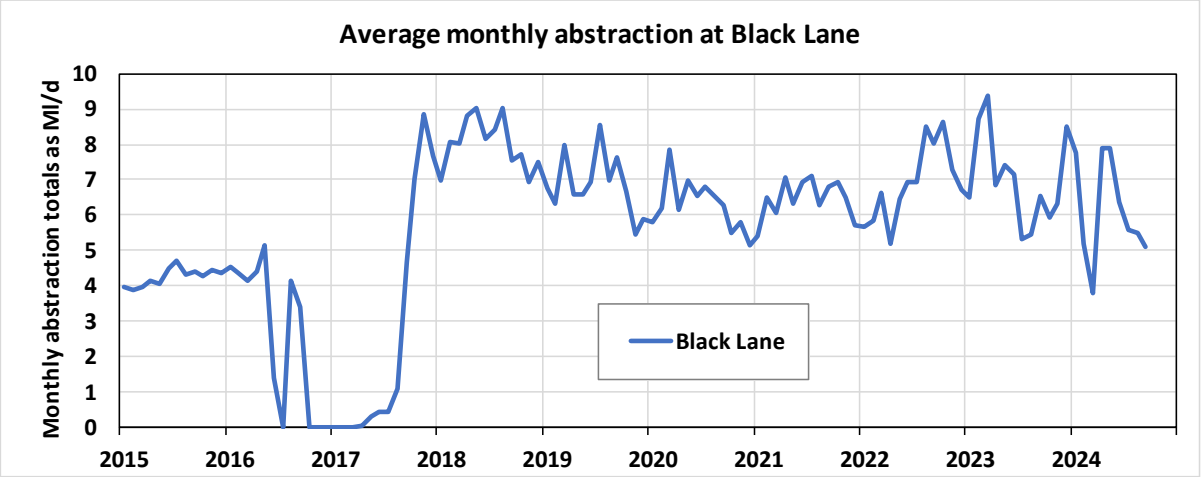


Figure 31 - Average monthly abstraction at Black Lane 2015 to 2024

Therefore, assuming that the river flows are closely related to groundwater levels, if the Black Lane abstraction is affecting flows in the River Tarrant, it could be possible to see changes in the relationship between Woodyates GWL and recorded Tarrant flows at different levels of abstraction.

Wessex Water has compared the relationship between spot gauged flows at Preston Farm and Woodyates GWL at three periods of summer flow/GWL recession with different abstractions at Black Lane to produce the plot shown below, which is said to provide proof that the Black Lane abstraction has no impact on Tarrant flows[25]:

[25] Plot taken from Excel file 'Tarrant flow analysis and leakage to JL.xlsx' worksheet 'Impact analysis 15-17-22' Sent by email from Ian Colley to John Lawson on 22nd May 2025

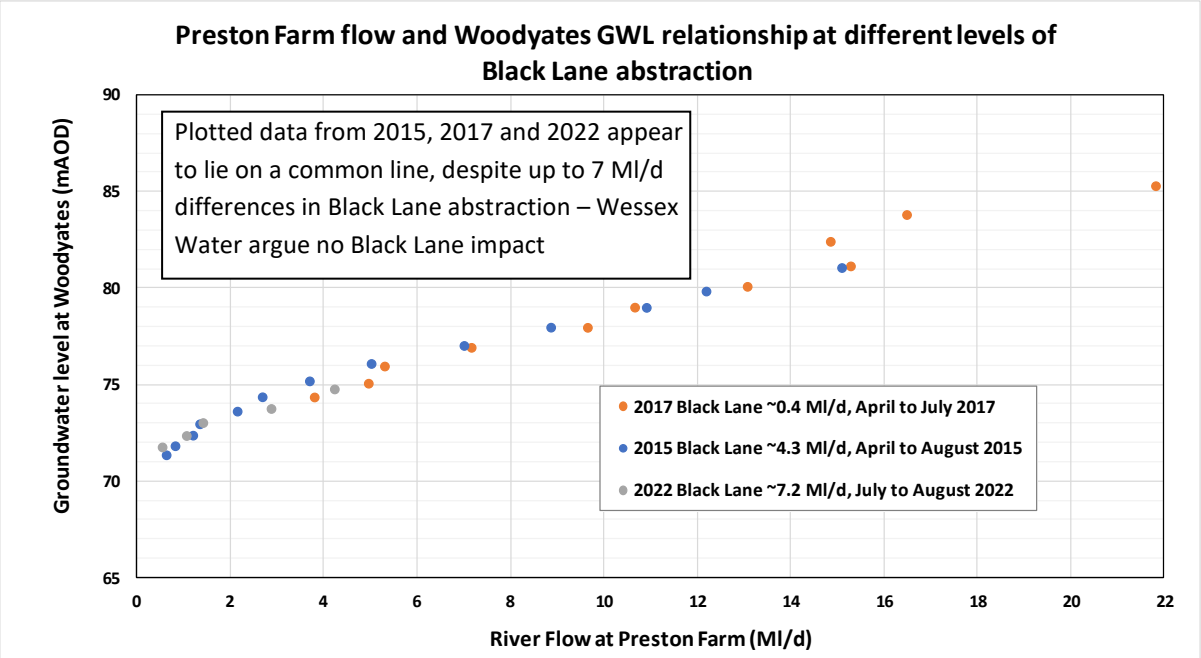


Figure 32 - Wessex Water plot of Preston Farm flows vs Woodyates GWL

On the face of it, this plot seems to show no change in the relationship between the Tarrant flows and Woodyates GWL, regardless of the substantial difference in Black Lane abstraction shown in Figure 31. This could support the conclusion that the Black Lane abstraction has no impact on Tarrant flows. However, this conclusion is not credible for several reasons:

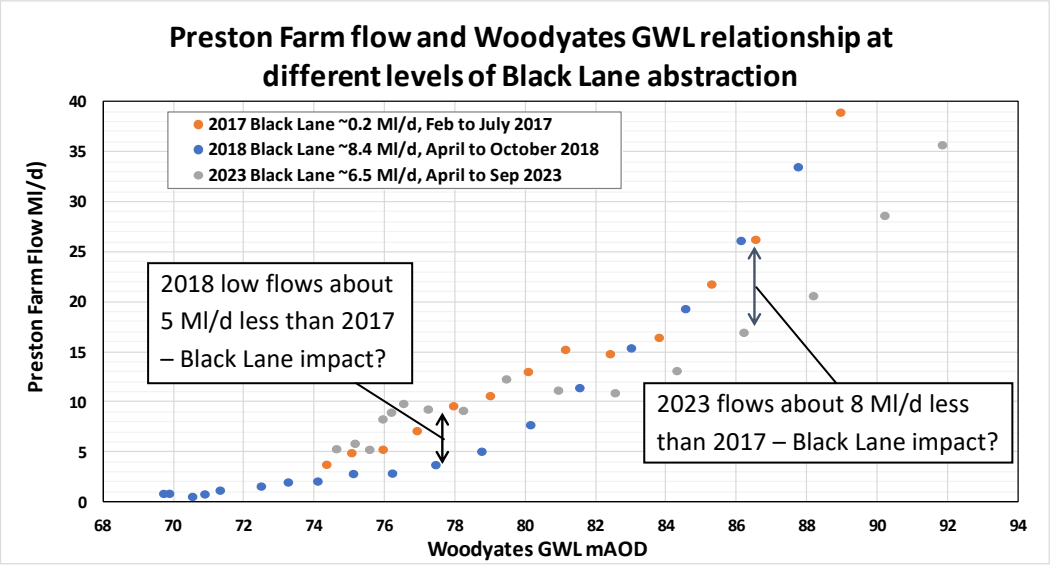
1. The plotted flows and GWLs in the drought of 2022 (the grey dots) only span a flow range of 0 to 4.2 Ml/d in July/August. At these very low flows, the impact of any abstraction on flows in terms of Ml/d will be much lower than at higher flows. The reasons for this that have been explained in investigations of abstraction impacts on Chilterns chalk streams[26]. There are no Preston Farm flow data available for April to June 2022, the early part of the drought when flows would have been a lot higher.

2. Similarly, in 2015 (the blue dots), the highest plotted flow is only 15 Ml/d because there are no Preston Farm flow data available at higher flows

3. The flow records in the Tarrant valley are only spot gaugings at about monthly intervals. Spot gauging in river channels is an inherently inaccurate process, so the flow records may not be reliable, especially at low flows.

If the Preston Farm flow vs Woodyates GWL is re-plotted to include summer recessions from other years with a wider range of gauged flows to compare with 2017, a completely different picture emerges as below:

[26]Dealing with impacts of groundwater abstraction on the chalk streams of the Colne and Lea valleys, pages 25-26, John Lawson, February 2023 https://chalkstreams.org/flow-recovery-following-abstraction-reduction/



Note: Graph axes have been reversed and flow range extended, compared with Figure 32

Figure 33 - Revised plot of Preston Farm flows vs Woodyates GWL, showing different years

From the above, it could be argued that the Black Lane abstraction has had a substantial impact on Preston Farm flows. However, it seems more likely that the plotted differences in the Preston Farm vs Woodyates relationship in both Figure 32 and Figure 33 are merely scatter arising from local rainfall differences, the natural variability in the flow-GWL relationship and, possibly, inaccuracies in the spot-gauged flows.

Therefore, comparison of Tarrant flows with Woodyates GWLs is not a reliable method for determining whether or not the Black Lane abstraction affects flows in the River Tarrant.

Wessex Water has also used the Woodyates GWLs to conclude that the Black Lane abstraction has no effect on the frequency and duration of drying of the Pimperne Brook. The diagram below shows the Pimperne winterbourne signature, Black Lane abstraction and Woodyates groundwater level, highlighting the Woodyates groundwater level when the Pimperne dried in 2015 and 2017[27]:

[27] Copied from Middle Stour Tributaries report, Figure 3-26

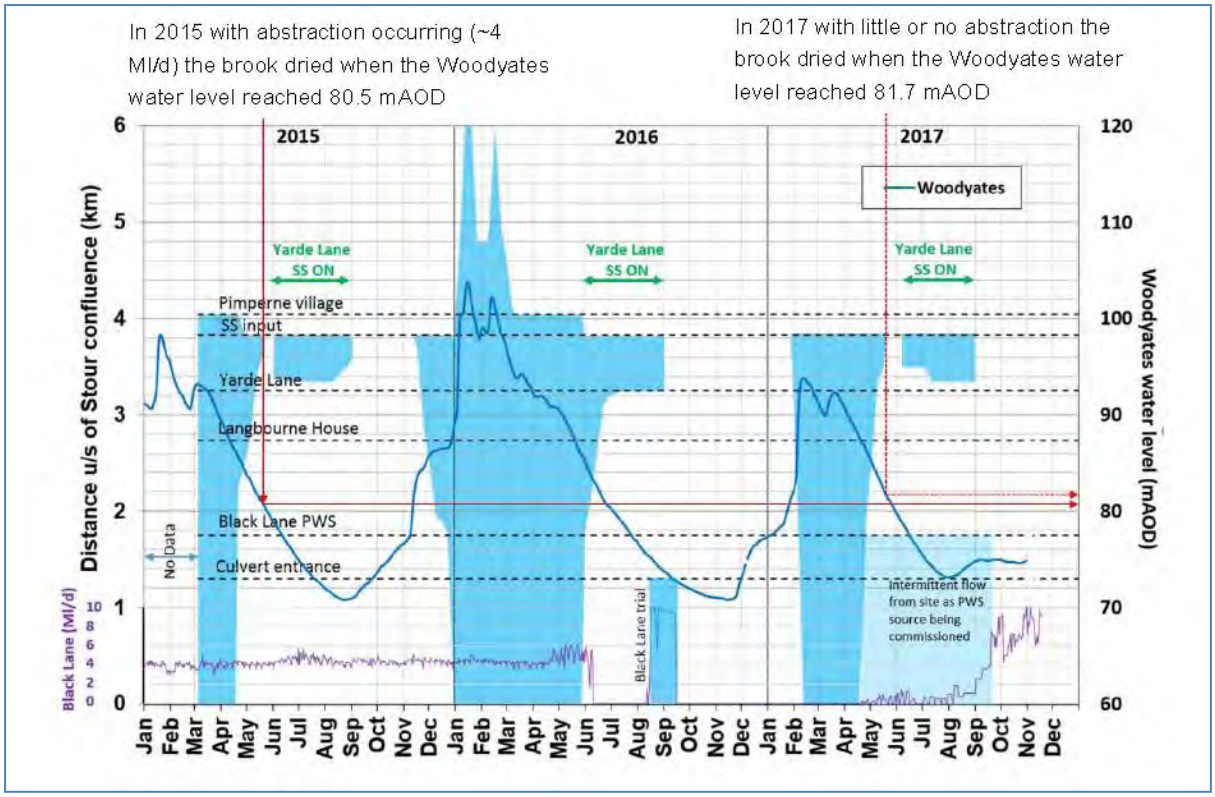


Figure 34 - Drying of the Pimperne Brook relative to Woodyates GWLs

Wessex Water argue that, if the Black Lane abstraction affected the drying of the Pimperne Brook, in 2015 with Black Lane abstraction of about 4 Ml/d, the Woodyates GWL when the river dried should have been higher than when it dried in 2017, when there had been minimal abstraction. Figure 34 shows that when the river dried in 2017 the Woodyates GWL was slightly lower than in 2015 – 80.5 mOD compared with 81.7 mOD. From this Wessex Water conclude that the Black Lane abstraction does not affect the drying of the Pimperne Brook.

Figure 33 shows that Woodyates GWLs can vary by about 3m at the same River Tarrant flow, with no consistent explanation in terms of variation in Black Lane abstraction – the 3 m variation seems likely to be natural scatter, perhaps due to local rainfall differences and natural variations in the GWL/river flow relationship. The 1.2 m difference in the Woodyates GWLs recorded when the river dried at Pimperne Village in 2015 and 2017 is well within the range of the natural scatter, so no conclusions can be reliably drawn from this analysis.

Wessex Water also uses the relationship between Newfield Farm GWLs and Pimperne Brook flows to argue that the Black Lane abstraction has no impact on the Pimperne flows or the river drying. The argument is based on the assumption that the Newfield Farm OBH is located well outside the 'zone of influence' of the Black Lane abstraction, as shown on Figure 23. Wessex Water's reasoning is illustrated by the diagram below[28]:

[28] Middle Stour Tributaries report, page 169, Appendix G

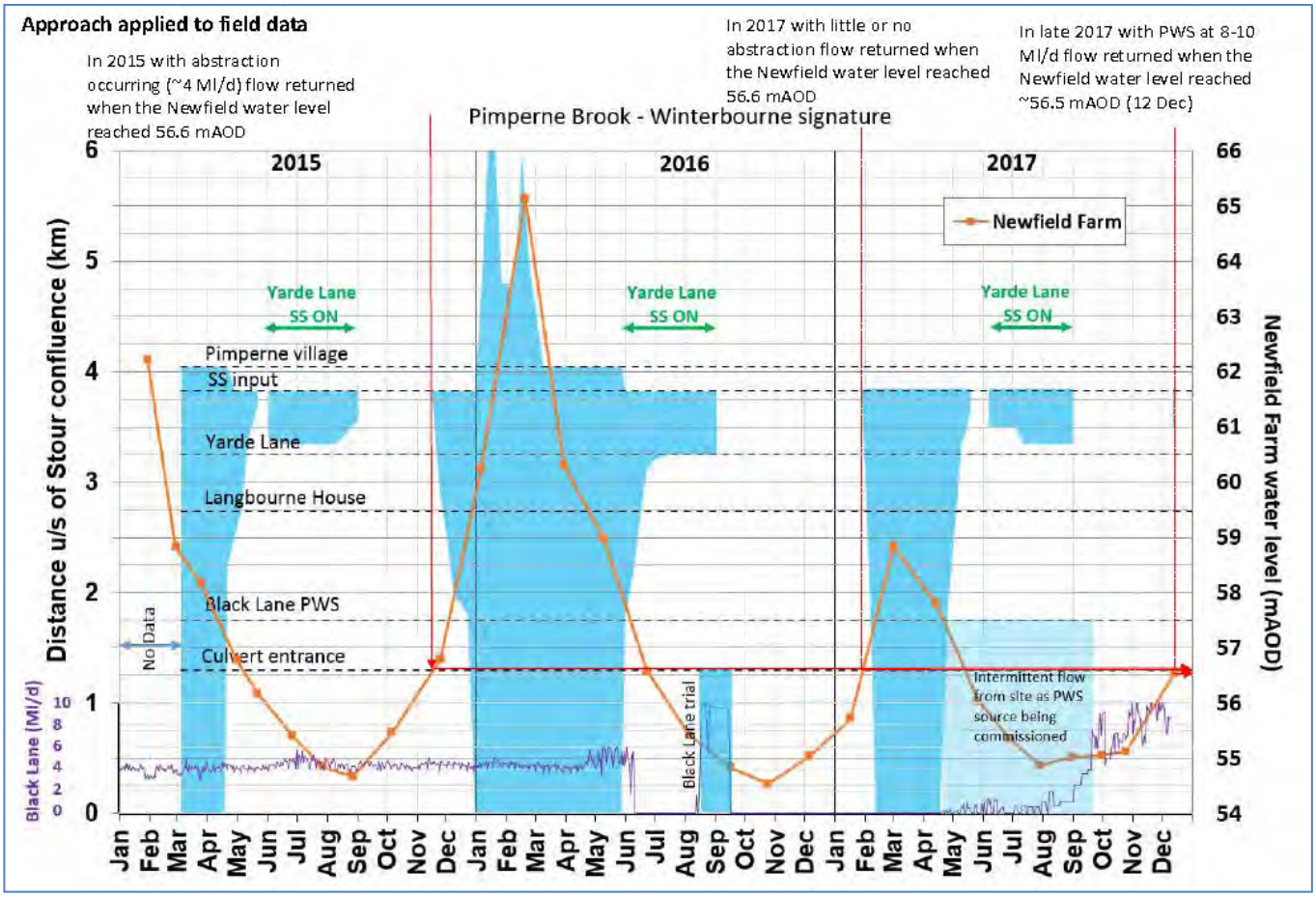


Figure 35 - Newfield Farm GWLs relative to Pimperne drying

Wessex Water argue that, because the Pimperne flow returns in each of the three years at the same Newfield Farm GWL of 56.5 mOD regardless of widely different Black Lane abstractions, the abstractions must have no effect on river flows or the river drying.

This argument assumes that the Black Lane abstraction has no effect on Newfield Farm GWLs, based on the results of Black Lane pump switch-off tests. However, as explained in Section 4.8.1, this interpretation of the short term pump shut-offs doesn't take account of the long term effect of abstraction on the catchment water balance and regional groundwater levels. The cones of depression around individual boreholes are superimposed on the regional fluctuations in the water table, but have only a relatively small and localised effect on GWLs and river flows. Short term abstraction shut-off tests have minimal impact on long term seasonal groundwater level fluctuations across the whole catchment – after an abstraction change, it takes several years of seasonal GWL fluctuations before the regional GWLs settle into a new equilibrium. Therefore, the GWLs at the Newfield Farm borehole, located within the Pimperne catchment and only about 3.5 km from Black Lane, will be affected by the Black Lane abstraction, so should not be used in the manner illustrated in Figure 35.

It is concluded that analysis using comparisons with Woodyates groundwater levels is not a credible means of determining whether or not the Black Lane abstractions affect groundwater levels and river flows in the Tarrant and Pimperne catchments. The comparison should not be used to conclude that the Pimperne hydrological regime supports Good Ecological Status.

4.10 Flow losses in lower River Tarrant

4.10.1 Measured amounts of flow losses, 1996-2004 & 2015-18

The drying up of the lower River Tarrant is the major concern of local residents and the RTPS. Flow losses in the lower river can be seen from the spot flow gauging records which exist for several separate periods: from 1996 to 2006 (EA), from 2015 to 2018 (Wessex Water) and from Wessex Water gaugings in 2024, which were done specifically to focus on lower Tarrant leakage through the river bed. The typical pattern of seasonally varying flow accretion and losses can be seen in the example of the accretion plot shown in Figure 36:

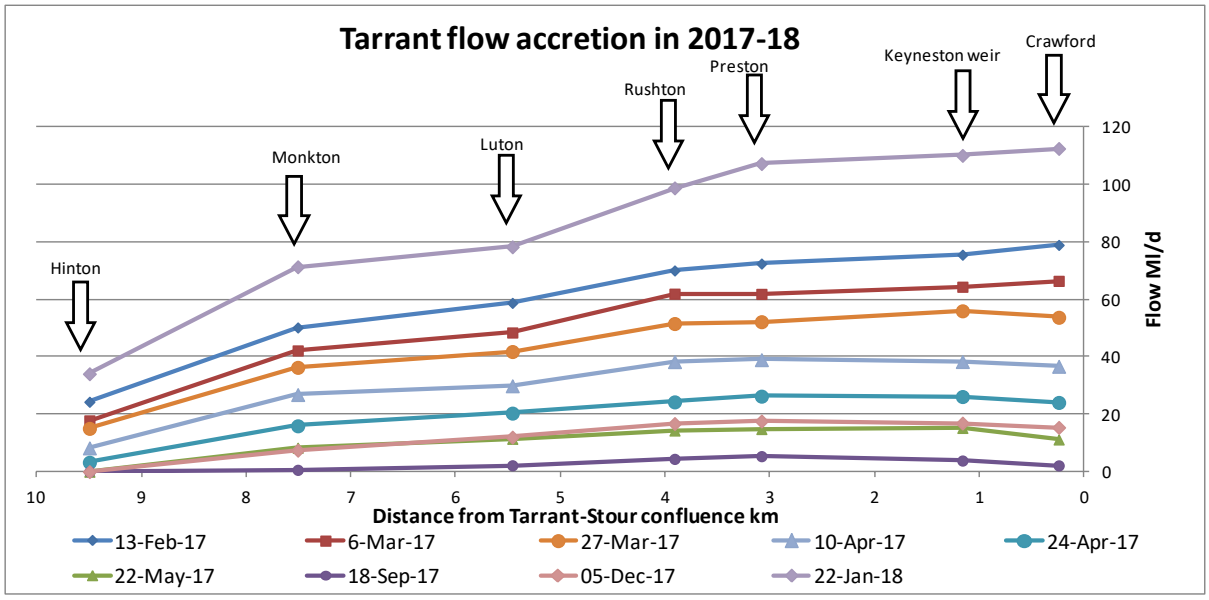


Figure 36 - River Tarrant flow accretion and losses 2017-18

This plot shows flow increasing quite quickly from Tarrant Hinton down to Preston Farm. Below Preston Farm, flows still increase slowly at times of high flow in the winter and spring, but fall at times of lower flows in the summer. It appears from this plot that losses in the lower river cease when Tarrant Crawford flows exceed about 60 Ml/d. The river always flows at Tarrant Crawford when the Keyneston Bridge groundwater level rises above the riverbed level of 33.7 mOD, as can be seen below:

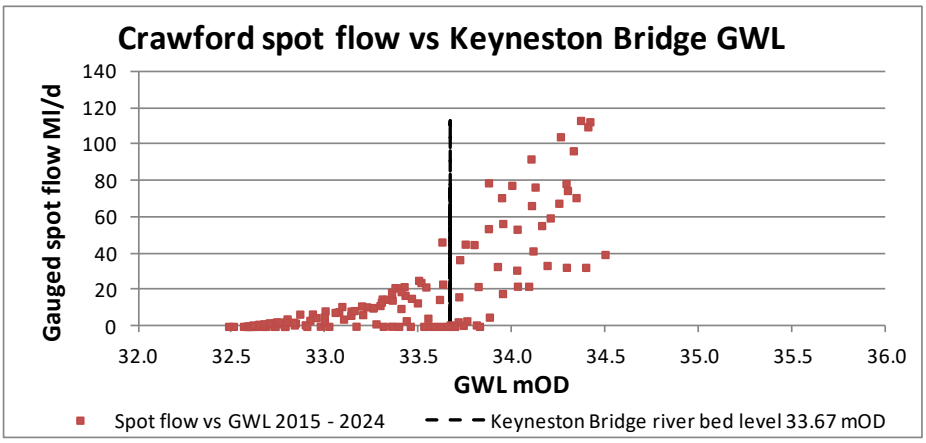
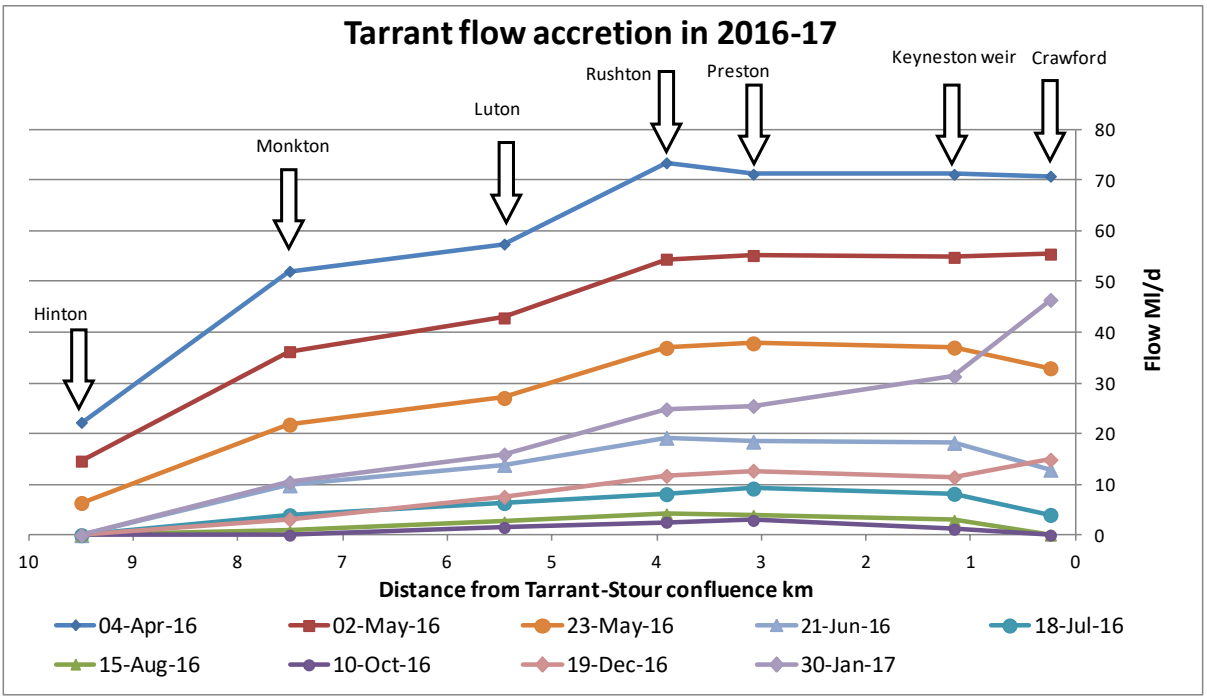


Figure 37 - Crawford spot flows vs Keyneston Bridge GWLs and river bed level

However, the continued accretion of flows in the lower river at times of high flow is less clear in accretion plots for other years as shown in Figure 38:



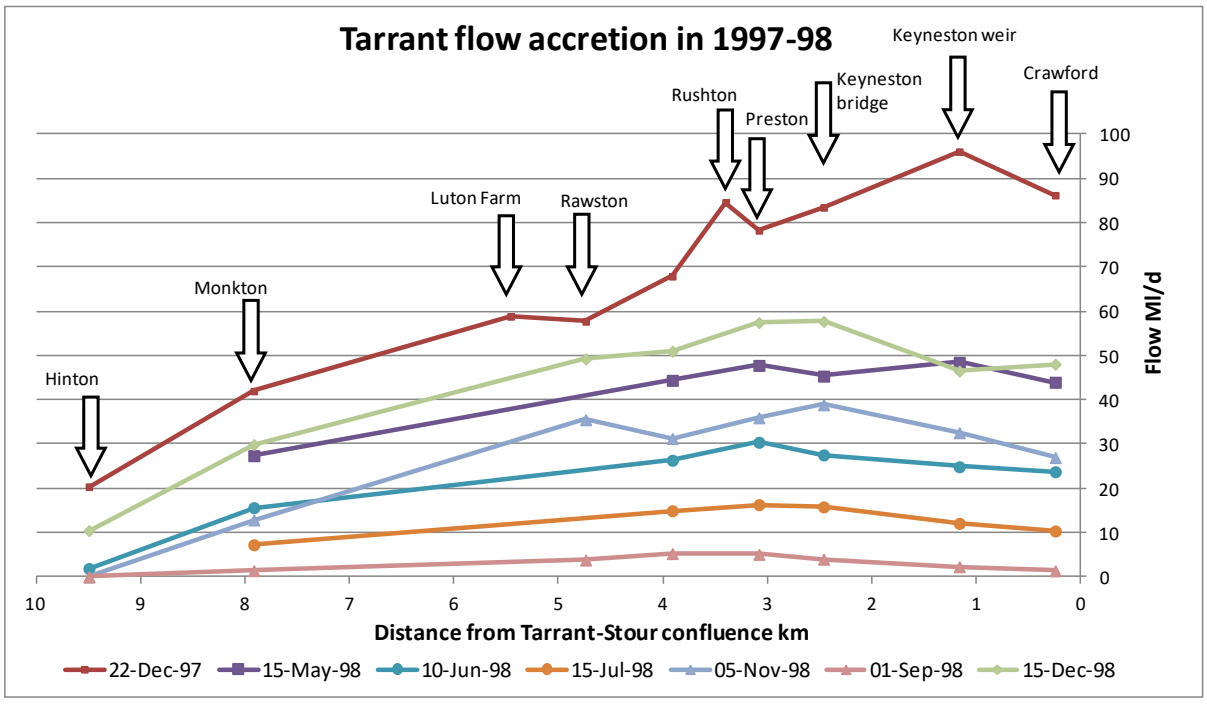
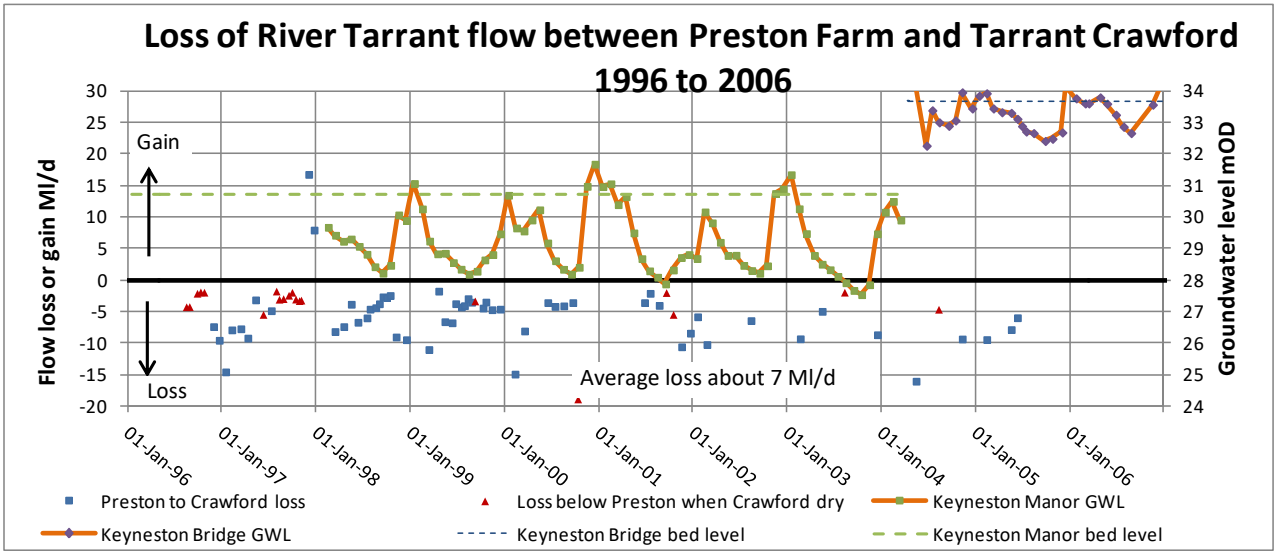
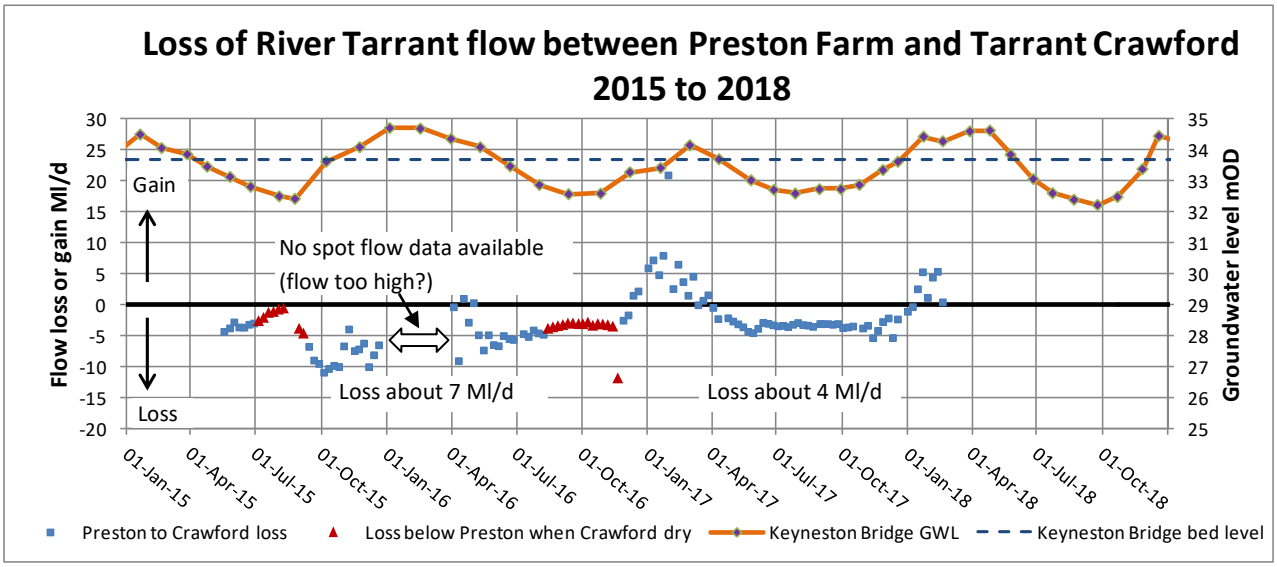


Figure 38 - River Tarrant flow accretion and loss in 2016-17 and 1997-98

The plots in Figure 38 show an inconsistent pattern of accretion and loss in the lower river. This may be due to inaccuracies in the spot gauging, which make it difficult to distinguish relatively small differences in flow. The measured amount of flow loss from the lower river between Preston Farm and Tarrant Crawford is shown below, for the three periods when spot flow data are available, with GWLs and river bed levels shown for comparison:





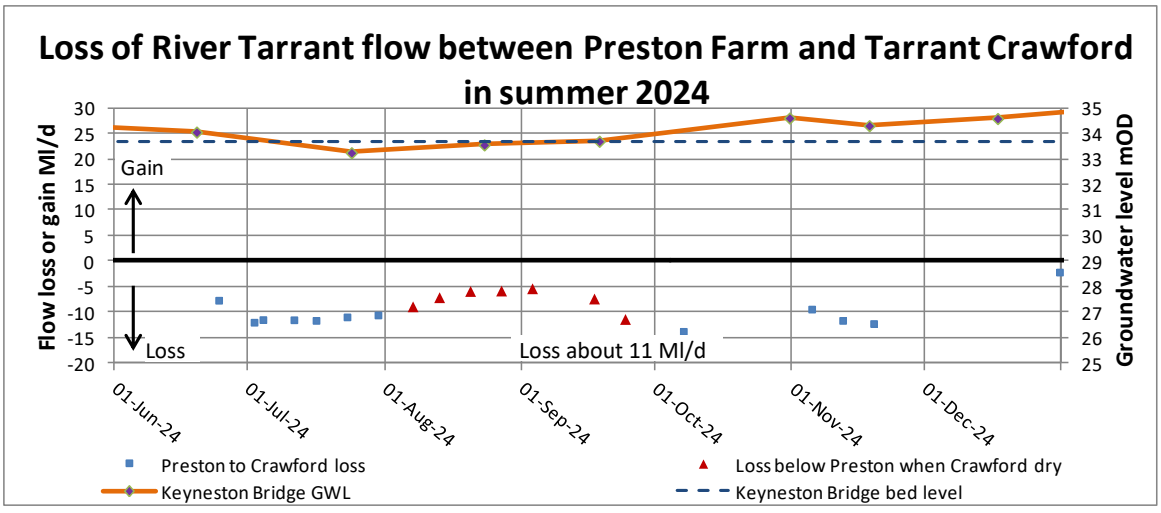


Figure 39 - Gauged leakage losses between Preston Farm and Tarrant Crawford

Spot flow gauging by current meter in small streams is an inherently less accurate process than continuous flow gauging at a purpose built gauging weir. The much larger scatter in the measured leakage shown in the upper plot (using EA spot flow data) compared to the lower two plots (Wessex

Water data), suggests that the EA data were more prone to gauging error.

The plots in Figure 39 suggest that the - flow loss from the lower river has varied over the years:

- The data from 1996 to 2006, suggest an average loss below Preston Farm of about 7 Ml/d, with the scatter in the amount of loss probably due to gauging errors.
- The data from 2015 to 2018 suggest that the losses reduced from about 7 Ml/d in 2016 to about 4 Ml/d in 2017, when the Black Lane abstraction was stopped to allow the pumping station to be up-graded.
- The data from 2024 suggest that the losses were about 11 Ml/d in summer 2024, when the Black Lane abstractions were higher to supply Wessex Water's GRID pipeline.

These data suggest that the flow loss is related to the amount of abstraction at Black Lane and that the increased abstraction to supply Wessex Water's GRID pipeline have made the drying of the lower river worse.

Figure 39 shows that for much of the time in most years, the groundwater levels close to the river are below the bed of the river. There appears to be some relationship between the flow loss or gain and the depth that the GWL is below or above the bed level, particularly in 2015 to 2017 (the middle plot in Figure 36). However, the relationship is not clear cut and appears to vary over time. Conceivably, a variation in loss over time could be caused by human intervention (eg weir removal or dredging), or by natural washing away and re-sealing of a partially calcified river bed.

4.10.2 Measured flow losses in 2024

In 2024, Wessex Water undertook a detailed flow-loss investigation in the lower river, hoping to identify leakage hot spots by flow gauging at the locations shown below:

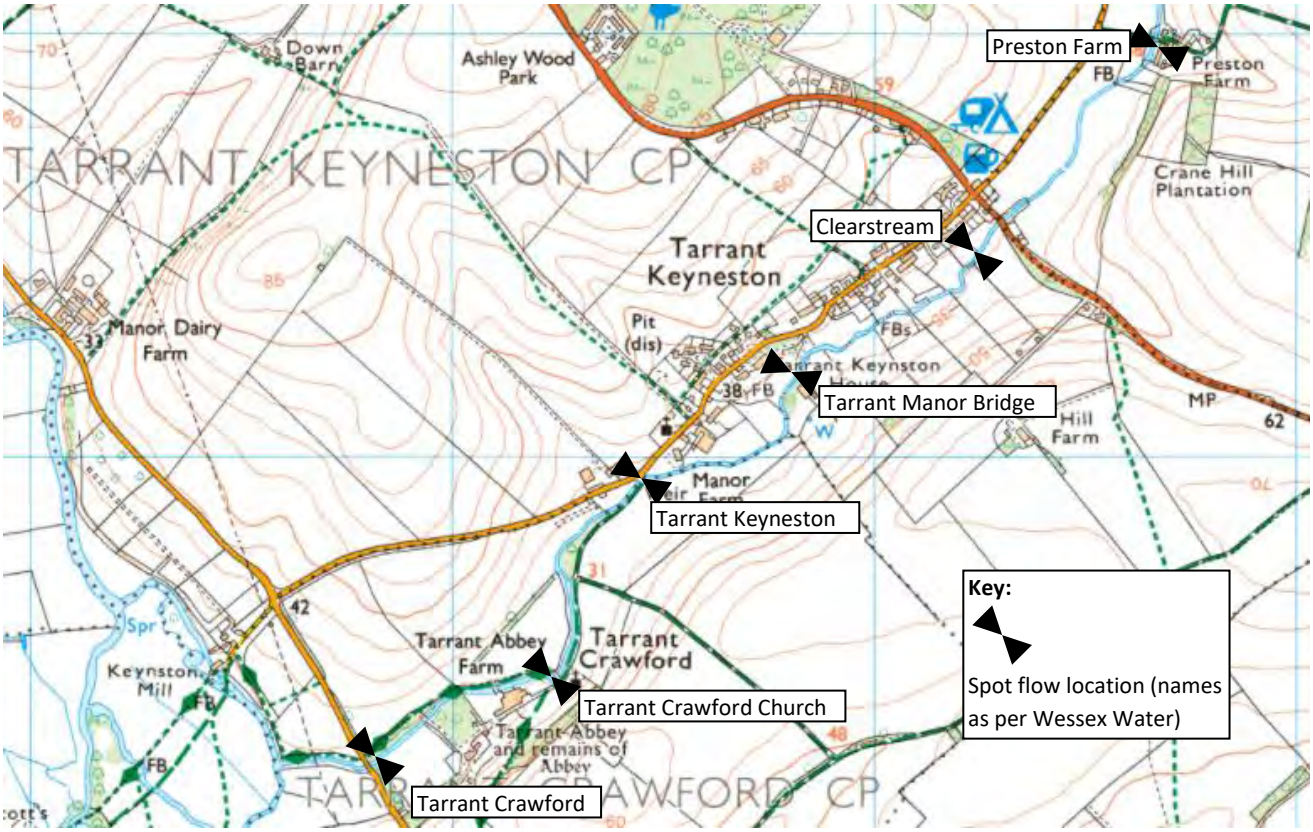
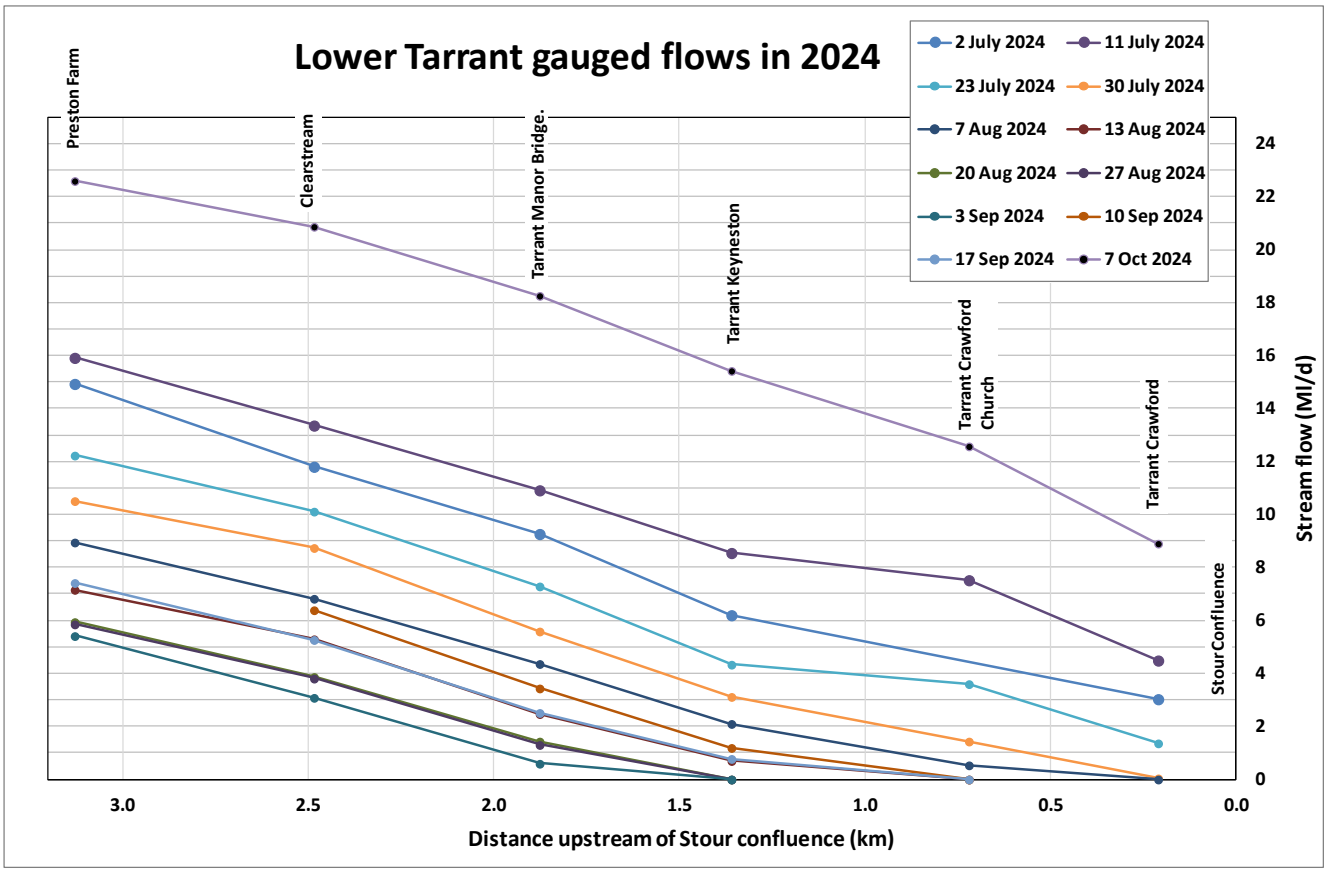


Figure 40 - Spot flow gauging locations for 2024 leakage survey

The gauged flows at each location during the 2024 survey are as below. Flows were also gauged at Luton Farm, 2.4 km upstream of Preston Farm – there was always flow gain between Luton Farm and Preston Farm. Up to the end of July, when the River was still flowing at Tarrant Crawford, the flow loss between Preston Farm and Crawford was about 11 Ml/d, as shown on Figure 39, lower plot. The amounts of flow loss at the various gauged locations, and the losses in each reach are shown below:



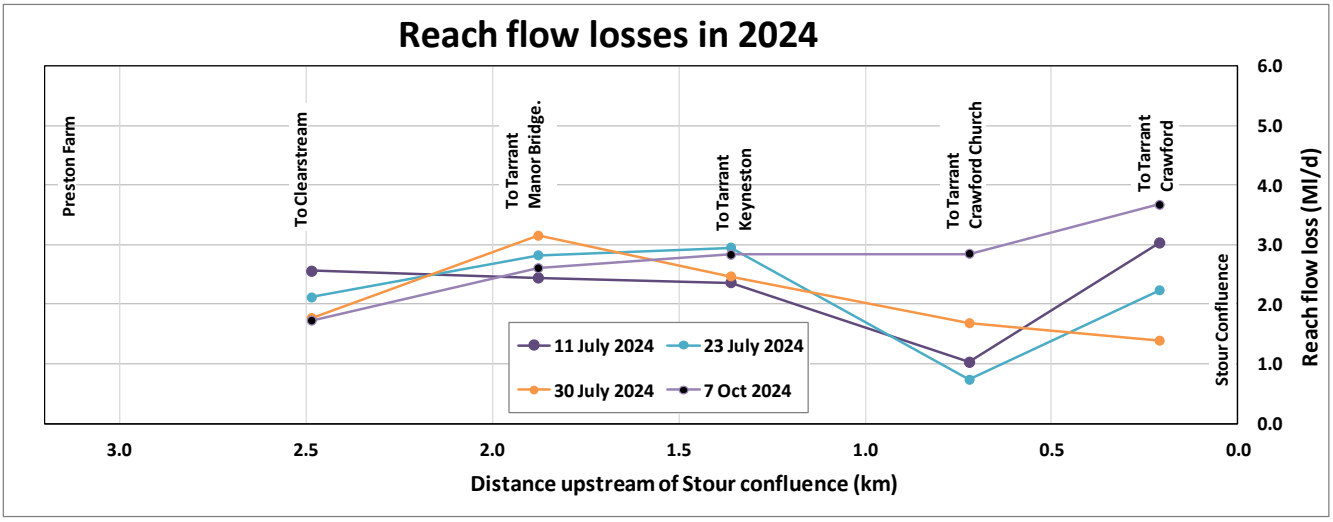


Figure 41 - Measured flow losses in summer 2024

The flow measurements in 2024 showed a consistent pattern of steadily reducing flow from Preston Farm down to the Stour confluence. The amount of loss was quite consistent in each reach and there was no indication of any "leakage hotspots" that might be amenable to local repair of the river bed.

The plot below compares the lower Tarrant flows in 2024 with the flows measured in 2017:

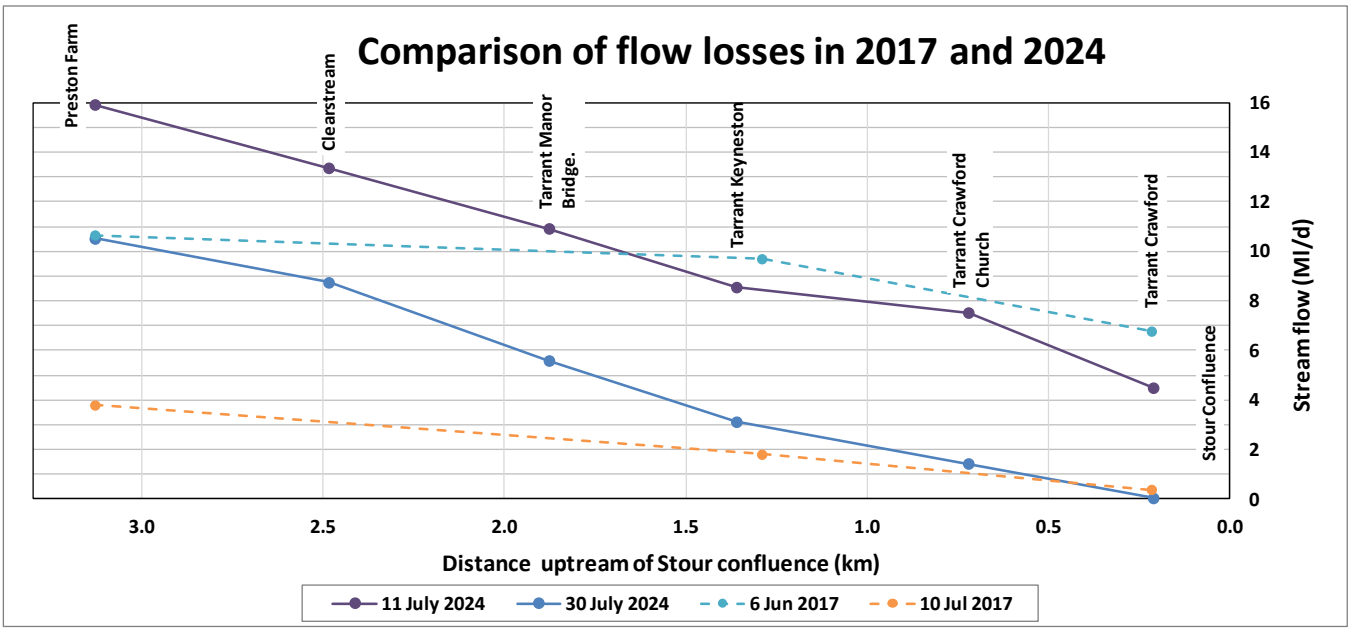
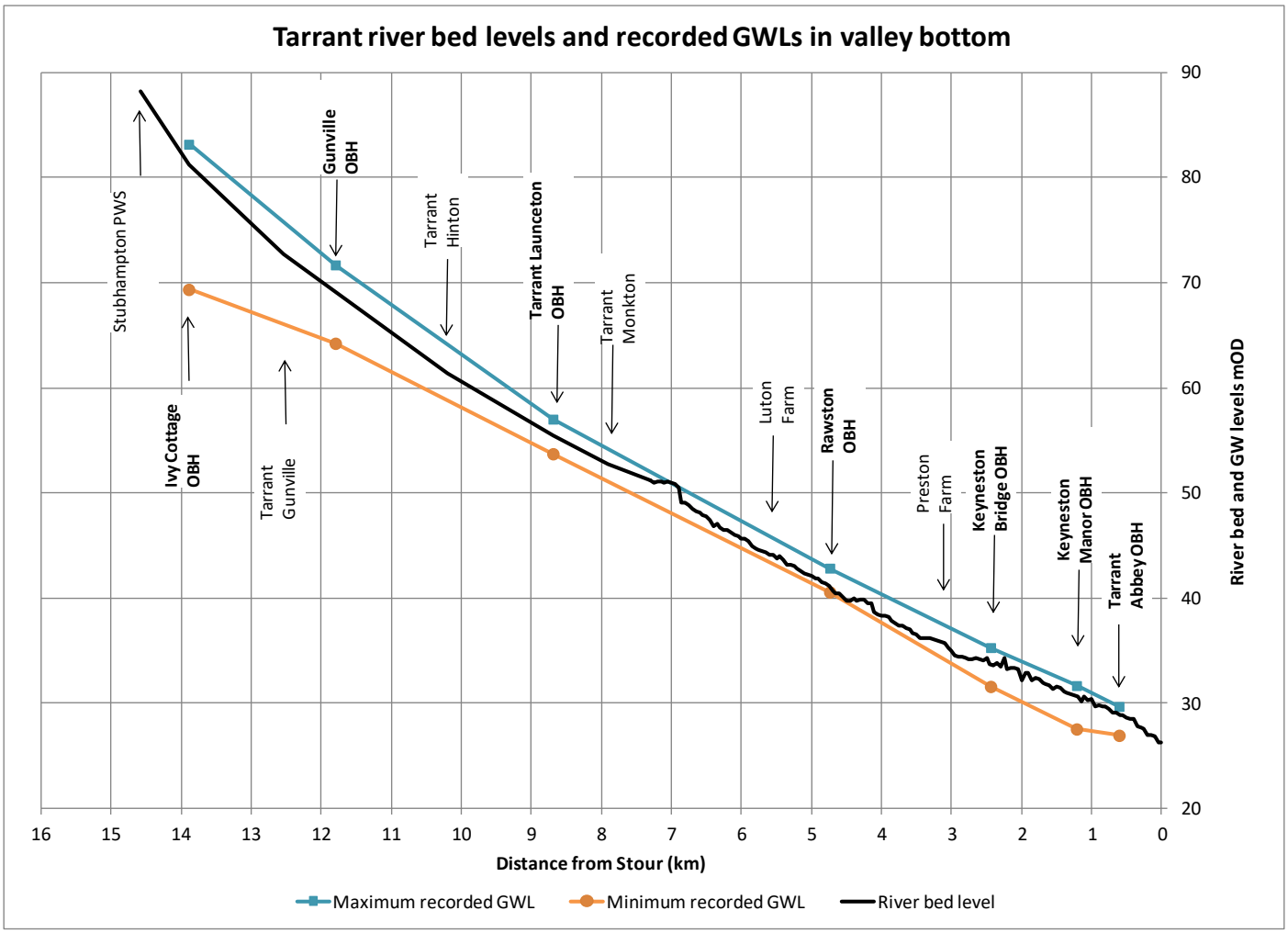


Figure 42 - Comparison of flow losses in 2017 and 2024

The flow losses in 2017 were a lot less than the 2024 losses, but mainly in the last 1.5 km before the Stour confluence and not much loss between Preston Farm and Tarrant Keyneston. The Black Lane abstraction was minimal from August 2016 to July 2017, so the lower losses in 2017 provide more evidence to support the hypothesis that the Black Lane abstraction is affecting GWLs and flows in the River Tarrant.

4.10.3 The relationship between flow losses and groundwater levels

The drying of the river at all locations is broadly consistent with variation of valley bottom groundwater levels relative to the nearby river bed levels, as shown below, comparing the fluctuation in GWLs with the adjacent river bed levels:



Notes:

1. River bed levels up to 7.3 km from Stour are as 1997 survey, otherwise scaled from Wessex 2018 report Figure 2-1
2. The maximum and minimum GWLs shown are for the periods of available OBH records which are 1995 to 2004 for Tarrant Abbey, 1998 to 2004 for Keyneston Manor, 2004 to 2025 for Keyneston Bridge, 1992 to 2006 for Rawston, since 2016 for Launceston and Ivy Cottage, and since 2017 for Gunville

Figure 43 - Variation of valley bottom GWLs relative to adjacent river bed levels

At the top of the valley, the river bed level is close to the top of the range of fluctuation in GWLs, so at most times the GWL is well below the river bed. This is consistent with the frequent drying of the upper river as shown on the flow signature plots on previous Figures 17 and 18. In the middle to lower reaches between Luton Farm and Preston Farm, the river bed level is close to the bottom of the range of GWL fluctuations, consistent with the much less frequent drying shown on the flow signature plots. From Tarrant Keyneston down, the GWLs are more frequently below the river bed, especially at Tarrant Crawford, therefore drying more frequently as shown on the flow signature plots.

However, although the drying of the river is broadly consistent with the concept that the river dries when the GWLs fall below the river bed level, the relationship is not straightforward, as illustrated below:

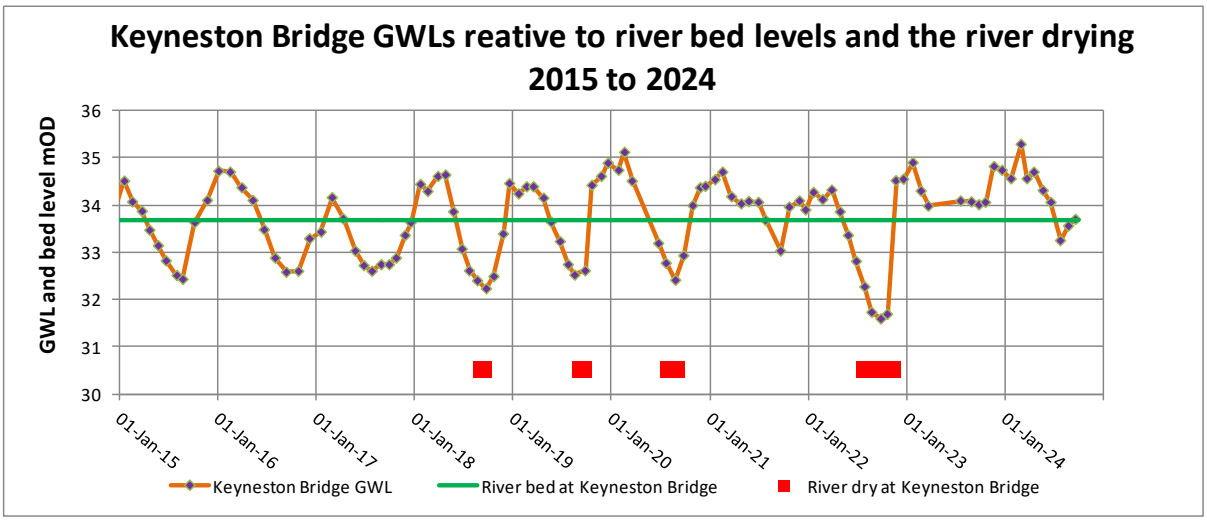


Figure 44 - GWLs, river bed level and the river drying at Keyneston Bridge

From this plot and the signature plots shown on Figures 17 and 18, it appears that:

1. The groundwater level has to drop below the river bed level for several months before leakage exceeds the flow from upstream springs and the river fully dries.

2. The amount of river bed leakage, and hence the river drying, appears to be increasing. This is consistent with:

    - The river didn't dry at Keyneston Bridge in 2015, 2016 and 2017, despite the GWL being similar to the levels 2018, 2019 and 2020, when the river did dry.

    - There was much lower frequency of the lower river drying in the period 1974 to 1991, as shown by the flow signature plots on Figure 17, despite abstraction being similar to current levels, at least since 1979. Unfortunately, there are no observed GWL data close to the river in this period, but modelling shows that the GWLs would have often been below the river bed level:

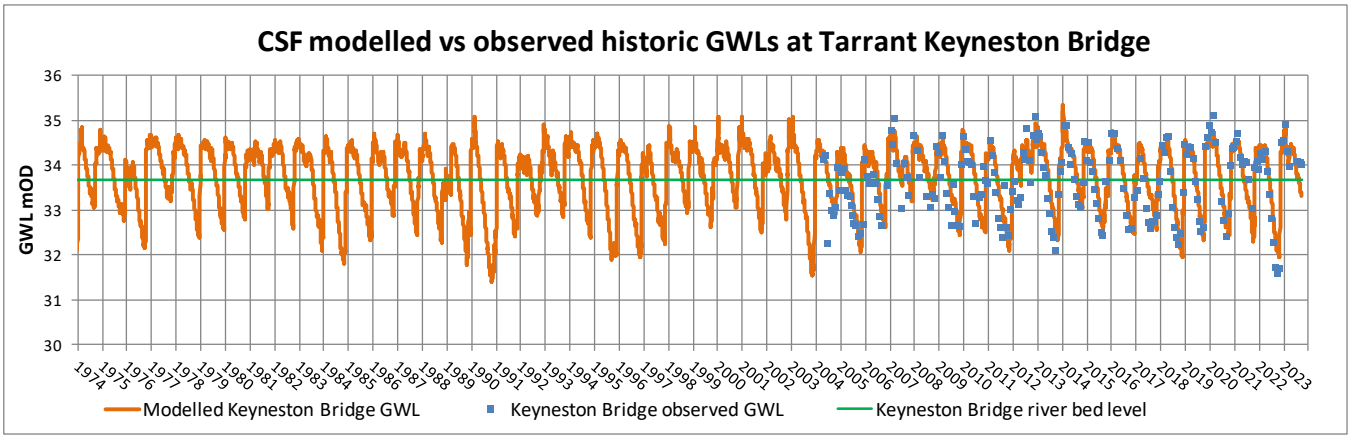


Figure 45 - Modelled GWLs relative to river bed level at Keyneston Bridge

The signature plots on Figure 17 show that, between 1974 and 1991, the river only dried at Keyneston Bridge in 1976 and 1990, despite the modelling showing that the adjacent GWL fell below

the river bed in most years. This suggests that the river bed in the 1970s and 1980s was sufficiently well sealed to allow the river to keep flowing, despite the adjacent GWL being well below the river bed level for lengthy periods in most years. It thus appears that the river bed in the lower Tarrant is becoming increasingly “leaky”.

However, the process of becoming “leakier” does not appear to have been continuous. The plots of flow losses shown in Figure 39 suggest that average losses in the lower river were about 7 Ml/d in both 1996-2004 and 2015-16. The measured leakage of only 4 Ml/d in 2017 suggests that the “leakiness” can reduce due to natural processes of silting up flow paths or re-calcification of the river bed.

Nevertheless, amount of flow loss in the lower river and the frequency of the river drying does seem to depend on the amount and time that adjacent GWLs are below the river bed. The lack of the river drying in the 1980s and 1970s, despite abstraction amounts similar to recent levels, suggests that natural sealing of the river bed allowed the river to keep flowing, “perched” well above the GWLs beneath the river bed. Over time, the natural seal of the river bed appears to have been breached by the additional pressure exerted on the seal by the lowered GWL beneath. The process of breaching the seal appears to have been gradual and there is some evidence that re-sealing can take place naturally, as shown by the reduction in leakage between 2016 and 2017.

4.10.4 Influence of Stour valley abstractions on Tarrant GWLs and flows

The longitudinal section river bed levels and GWLs in the River Tarrant illustrated on Figure 43 shows that the gradient of the water table and GWLs at the lower end of the Tarrant are likely to be controlled by the GWLs in the Stour valley, which are probably affected by the large groundwater abstractions downstream of the Tarrant confluence. The map below shows the locations of the major abstractions and observation boreholes in the Middle Stour valley:

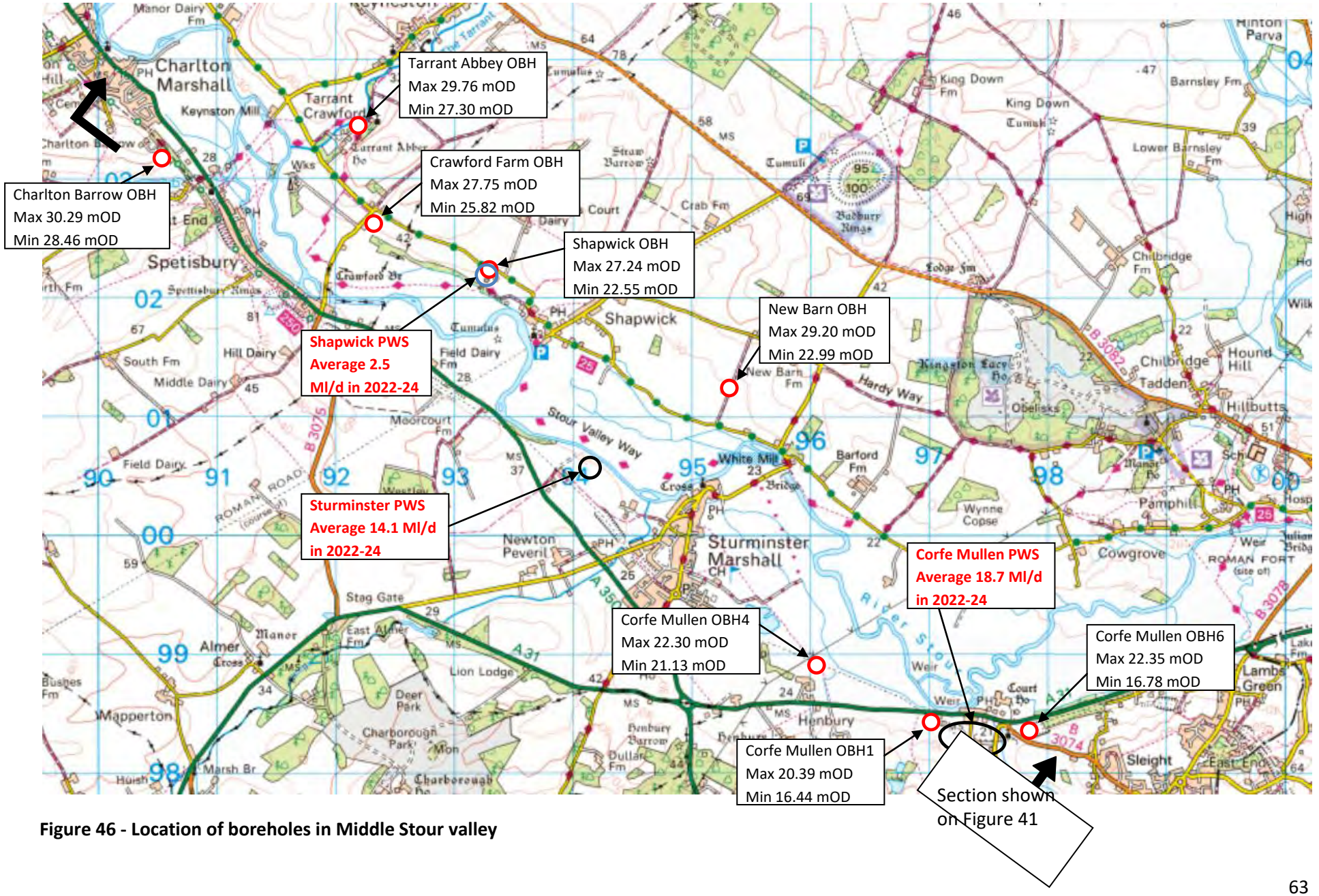


Figure 46 - Location of boreholes in Middle Stour valley

The recorded minimum GWLs in the observation boreholes in the Stour valley are shown below:

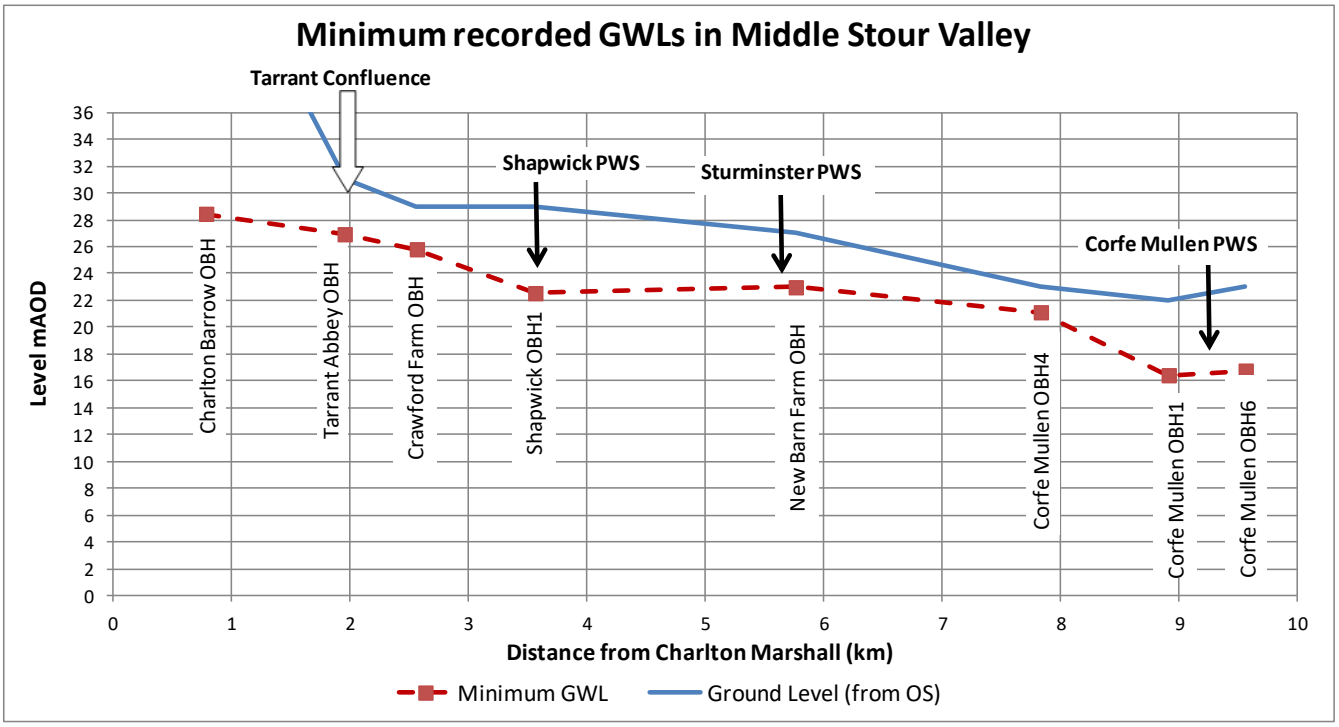


Figure 47 - Minimum recorded GWLs in the Middle Stour valley

The Tarrant Abbey observation borehole is in the Tarrant valley about 500 m upstream of the Stour confluence. The recorded minimum GWL at Tarrant Abbey aligns with the GWLs in the Stour valley upstream and downstream of the confluence.

There is about 35 Ml/d of total abstraction at Shapwick, Sturminster and Corfe Mullen, so it would seem likely that the water table in the Stour valley will have been lowered significantly, with consequent impact on the lower Tarrant GWLs and frequency of drying. There is some evidence to support this in the history of abstraction changes as below:

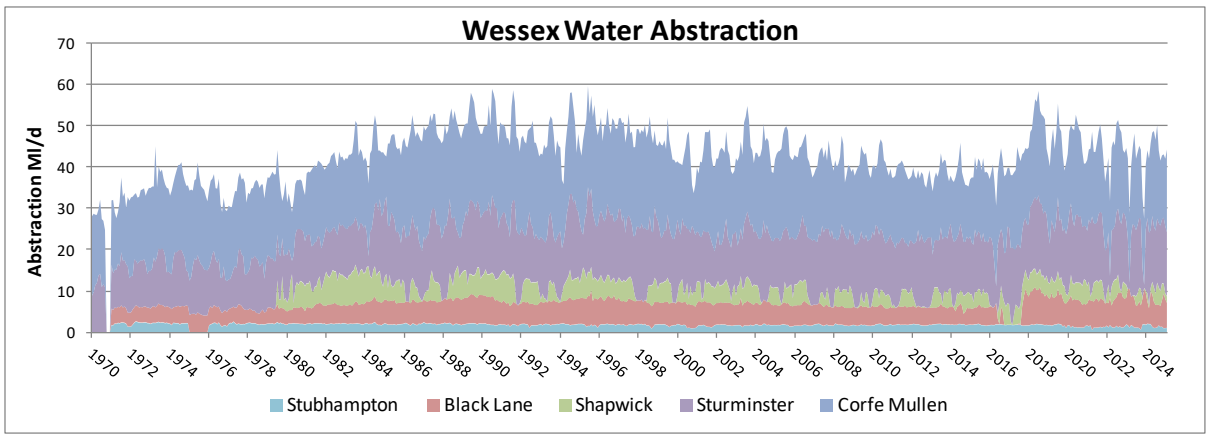


Figure 48 - Changes in Middle Stour abstraction since 1970

Up to 1979, the total abstraction was about 15 Ml/d lower than in the 1990s. This could explain the general lack of the river drying in the 1970s, apart from the very severe drought of 1976. The higher abstraction after 1979 could have led to a gradual breakdown of the natural seal in the river bed,

leading to the higher leakage and frequency of drying measured in the late 1990s. The lower abstraction in the period 2010 to 2017 is consistent with the reducing amount of flow losses between 2015 and 2017. The higher losses and more river drying in 2018 could be due to the markedly higher abstraction in 2018.

The CSF modelled impact of abstraction on Tarrant Keyneston GWLs is shown below:

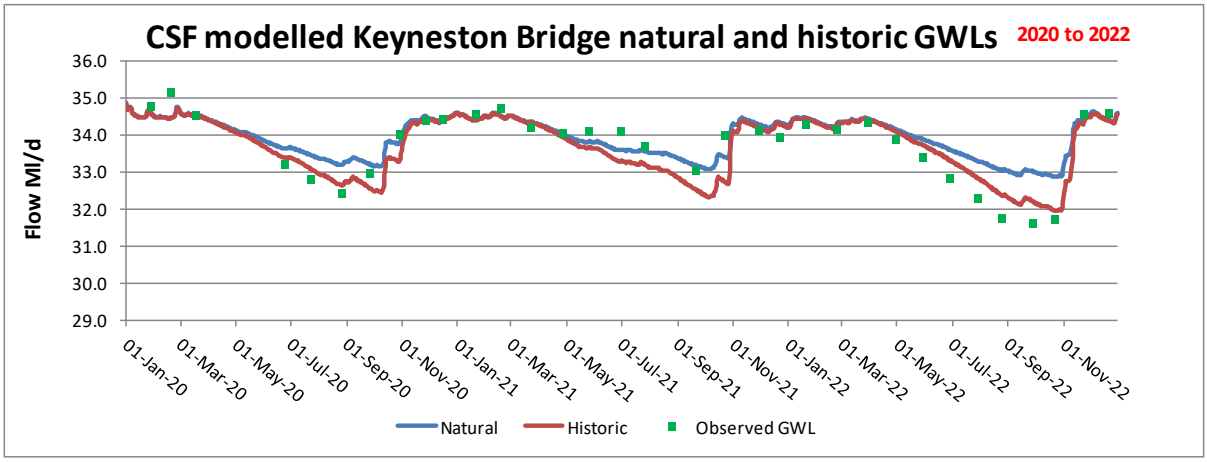


Figure 49 - CSF modelled impact of abstraction on Tarrant Keyneston GWLs

The CSF modelling assumes that the Tarrant GWLs are affected by the Black Lane, Stubhampton and Shapwick abstractions, but not the Sturminster or Corfe Mullen abstractions. Nevertheless, the modelling shows GWLs at Keyneston Bridge reduced by about 1 m in late summer. This alone would substantially increase the amount and duration of leakage and the Sturminster and Corfe Mullen abstractions are likely to make this worse.

4.11 Conclusions from the review of abstraction impacts

4.11.1 Conclusions from the modelling of abstraction impacts

The conclusions from the CSF modelling of abstraction impacts and the review of Wessex Water's modelling are:

1. When simulating historic river flows and groundwater levels both models provide a reasonably good match to the observed records in the Tarrant valley, although the CSF model outputs provide a better fit to observed records than the Wessex model.

2. The CSF model also provides a reasonably good match to observed flow and GWL records in the Pimperne valley. The Wessex model is unable to provide a credible simulation of the Pimperne valley, but has built in an assumption that the Black Lane abstraction does not affect the Tarrant, based on a questionable interpretation of short-term pump shut-off tests.

3. The Wessex modelling greatly over-estimates the frequency of drying of the lower river. The CSF model provides a much better match to historic records of drying, although still with some considerable differences.

4. The difference in effectiveness of the two models in prediction of the lower river drying is particularly evident in the modelling for 2017, the year in which the Black Lane abstraction

ceased to allow the pump station up-grade. The recorded data show that the lower river did not dry at all in 2017, but the Wessex model predicts it would have dried for 110 days at Keyneston Weir and 161 days at Tarrant Crawford. The CSF model correctly predicts no drying of the lower river in 2017, but that it would have dried with the normal amount of Black Lane abstraction.

5. The Wessex modelling suggests that abstraction has had minimal effect on the lower river, either on the frequency of drying or in reduction of flows.

6. The CSF modelling shows that, without any abstraction, since 1970 the river would not have dried anywhere in the lower River Tarrant.

7. The CSF modelling shows that the existing abstractions are causing extensive drying and failures of EFIs in the lower river, mainly in the summer/autumn, but also in dry winters, when the reduced flows and extended drying of the river has serious implications for the spawning of chalk stream salmon.

8. Even assuming that the Shapwick abstraction does not affect the Tarrant, the CSF modelling shows that most of the drying of the lower River Tarrant is caused by the Black Lane and Stubhampton abstractions – the lower river would only have dried naturally in 1973,1976, 1990 and 2003, not almost every year as shown by the Wessex model.

9. Wessex Water's use of comparison of Woodyates GWLs with Tarrant/Pimperne GWLs and flows is not a valid means of assessing abstraction impacts.

There are considerable uncertainties in both sets of modelling. The Wessex modelling seems flawed by built-in assumptions that Tarrant flows are not affected by the Black Lane and Shapwick abstractions, based on questionable interpretations of the results of pump shut-off tests. The CSF model also has some questionable assumptions, but they are reasonably well supported by the available hydrogeological data and the good model validations in both the Tarrant and Pimperne valleys.

It is concluded that, although the CSF model does have some questionable underlying assumptions, it is a more reliable indicator of abstraction impacts in the lower Tarrant than the Wessex model.

The CSF modelling shows that the Wessex Water abstractions at Black Lane, Stubhampton and, probably, Shapwick are causing extensive and unnatural drying of the lower River Tarrant. The CSF modelling shows that without abstraction the lower River Tarrant would flow perennially every year since 1970. The modelling shows that abstractions are causing substantial failures of EFIs in the lower river.

Both models show that the Tarrant AIM scheme has provided only minimal benefit to river flows and the amount of drying of the lower river. For example the CSF modelling shows that without AIM the duration of the drying of the river at Keyneston would have increased by 4 days from the recorded 137 days to 141 days. It is understood that the revised version of AIM proposed by Wessex Water for the next 5 years will be triggered by a lower groundwater level at Four Acres, so the benefits will be even less than for the previous AIM scheme. Therefore, it is probably not worth continuing with the AIM scheme and it would , in any case, be unneeded if the solution proposed in Section 5 of this report is implemented.

4.11.2 Conclusions from measured evidence of abstraction impacts

The measured Tarrant flows during and after the Black Lane pumping station shut-down from August 2016 to July 2017, provide strong evidence that the flows in the lower Tarrant are affected by the Black Lane abstraction. The maintenance of river flow throughout 2017, despite the relatively low effective rain, implies that the drying of the lower river in recent years is largely caused by the Black Lane abstraction and has probably been aggravated by the increased Black Lane abstraction since 2018 to supply Wessex Water's GRID pipeline.

Although the relationships between Woodyates GWLs and Tarrant flows in 2015, 2017 and 2022 appear to provide evidence of no impact of the Black Lane abstraction, the scatter in the relationship between these GWLs and flows in other years shows that no conclusions can be reliably drawn from this analysis.

4.11.3 Conclusions from review of River Tarrant losses

The lower River Tarrant now consistently loses flow from Preston Farm down to the Stour confluence. The flow data suggest that the amount of flow loss is quite evenly spread along the length of the lower river, with no leakage "hot spots". The leakage occurs when the groundwater levels in the valley bottom fall below the river bed, causing the river channel to be "perched". The groundwater level has to drop below the river bed level for several months before leakage exceeds the river flow from upstream springs and the river fully dries.

The evidence of spot flow gauging and flow signature records show that the lower river flow loss has varied over the years, but is generally increasing:

- From 1974 to 1991, little flow loss and the lower river only drying in the severe droughts of 1976 and 1990.
- The data from 1996 to 2006, suggest an average loss below Preston Farm of about 7 Ml/d, with scatter in the amount of loss probably due to gauging errors.
- No data on losses between 2006 and 2015.
- The data from 2015 to 2018 suggest that the losses reduced from about 7 Ml/d in 2016 to about 4 Ml/d in 2017, when the Black Lane abstraction was stopped to allow the pumping station to be up-graded.
- No data from 2018 to 2024.
- The data from 2024 suggest that the losses were about 11 Ml/d in summer 2024, when the Black Lane abstractions were higher to supply Wessex Water's GRID pipeline.

The data since 2015 suggest that the flow loss is related to the amount of abstraction at Black Lane and that the increased abstraction to supply Wessex Water's GRID pipeline has made the drying of the lower river worse.

The records of the river drying suggest that the river bed in the 1970s and 1980s was sufficiently well sealed to allow the river to keep flowing, despite the adjacent GWL being well below the river bed level for lengthy periods in most years. It thus appears that the river bed in the lower Tarrant is

becoming increasingly “leaky”. The amount of flow loss and the frequency of the river drying seem to depend on the amount and time that adjacent GWLs are below the river bed, made worse by the increased Black Lane abstraction.

Over time, the natural seal of the river bed appears to have been breached by the additional pressure exerted on the seal by the lowered GWL beneath. The process of breaching the seal appears to have been gradual and there is some evidence that re-sealing can take place naturally, as shown by the reduction in leakage between 2016 and 2017.

4.11.4 Conclusions on the WFD status of the hydrological flow regimes

The CSF modelling of River Tarrant flows shows extensive failures of the EFIs which are used to determine the WFD classification of the rivers’ hydrological regimes.

The CSF modelling of the Pimperne catchment, which assumes that the Black Lane abstraction is spread across the Pimperne and Tarrant catchment, shows that the Black Lane abstraction increases the drying of the winterbourne at Langbourne House by an average of 40 days per year – again not consistent with the WFD classification of “Supports Good”.

If the impact of the Black Lane abstraction is confined to the Pimperne catchment, as assumed by Wessex Water, the A%R analysis shows that the recent abstraction is about 33% of average annual recharge, putting it amongst the most heavily over-abstracted chalk streams the in the country.

The Water Framework Directive classification of the hydrological regimes of the River Tarrant and Pimperne Brook should be changed to ‘Does not support Good’. When combined with the present ‘Poor’ classification of the ecological status of the River Tarrant, this should be grounds for urgent investigations into means of reducing the abstractions impacts.

4.11.5 Conclusions on the need for action to reduce abstraction impacts

Although there are conflicts over the conclusions drawn from Wessex Water’s modelling and the CSF modelling and doubts over the validity of both models, the weight of modelling evidence points towards over-abstraction being the main cause of the drying of the lower River Tarrant in most years. The analyses of the causes and frequency of the drying of the lower river, also point towards abstraction being the primary cause of increased drying.

Compelling evidence of the impact of the Black Lane abstraction on lower Tarrant flows is provided by the lack of drying in 2017 when there was minimal abstraction at Black Lane – this is the only year that the lower River Tarrant hasn’t dried since the start of detailed flow monitoring in 2015.

The modelling and hydrological analyses together make a strong case for re-classification of the WFD hydrology regimes of the Tarrant and the Pimperne Brook to “Does Not Support Good”.

When combined with the historic and fisheries evidence of increased drying of the river, there is an urgent need to seek better ways of using the water resources of the Middle Stour and its tributaries, reducing impacts to acceptable levels whilst maintaining public water supplies.

5. Potential solutions

5.1 Types of potential solutions

Any reduction in abstraction in and around the Tarrant-Pimperne catchment will require replacement water sources to enable Wessex Water to continue to meet its legal obligation to supply water to customers, including customers now supplied via the regional GRID pipeline. The options for replacement sources fall into two categories:

1. Taking more water from sources further down the Stour valley, potentially making use of the additional flow in the River Stour arising from the reduced abstractions around the Tarrant-Pimperne area. This is in keeping with the Chalk Streams First principle of shifting abstraction downstream, thereby giving the upper chalk stream first use of the water. If feasible, a solution of this type could be implemented quite quickly and without major cost.

2. New water sources to replace some or all of the Stubhampton, Black Lane and Shapwick sources – perhaps up to 16 Ml/d of lost deployable output. Water resources in Dorset are already scarce and this would be a costly solution, maybe of the order of £50 to 100 million, and it would be hard to justify on a benefit/cost basis. Such a solution would also take many years to plan, gain approval and build. Nevertheless, it would be useful to consider what such options might be, if only to appreciate what might be involved in delivering them.

5.2 Making best use of existing River Stour supplies

5.2.1 Existing supplies in the Stour valley

The sources of public water supplies in the Stour valley below Blandford are shown Figure 50 on the next page. All the sources are groundwater sources owned by Wessex Water, except for the Longham sources which are owned by South West Water for supplying Bournemouth. The supply amounts shown for each source are the annual licensed amounts:

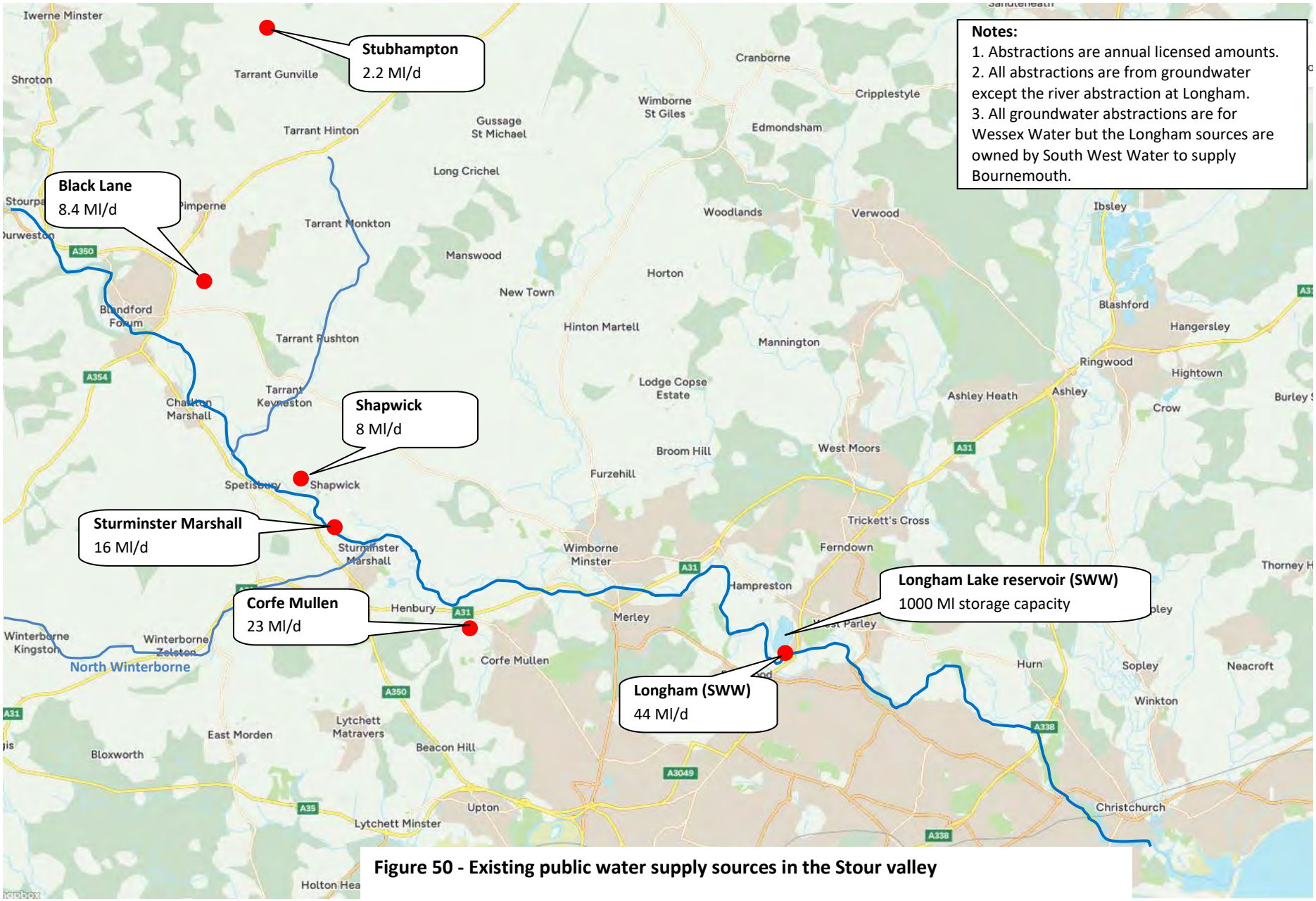


Figure 50 - Existing public water supply sources in the Stour valley

The outputs of Wessex Water's Stour sources under various conditions are shown below:

	Source outputs in Ml/d					
	Recent abstraction 2022-24		Existing licensed amounts		WRMP deployable outputs in dry year	
Source	Average	Maximum monthly	Annual average	Daily maximum	Annual average (DYAA)	Critical period (DYCP)
Stubhampton	1.37	2.04	2.18	2.27	1.25	2.17
Black Lane	6.73	9.40	8.38	12.00	8.00	9.44
Shapwick	2.45	5.36	8.00	9.09	4.28	4.27
Sturminster Marshall	14.13	18.33	15.95	20.00	15.95	22.52
Corfe Mullen	18.72	23.19	22.79	32.96	22.80	27.84
Totals	**43.40**	**58.32**	**57.30**	**76.32**	**52.27**	**66.24**

Note: 1. Recent abstraction and deployable output data as supplied by Wessex Water
2. Licence data as supplied by Environment Agency in 2021 for A%R work

Table 8 - Outputs of Wessex Water sources

The presence of a lot of existing sources downstream of the Tarrant-Pimperne catchment, opens the opportunity for the Chalk Streams First type of solution to the over-abstraction that has been proposed for some Chilterns Chalk Streams[29]. The approach is being encouraged by the Environment Agency and Ofwat. There is work in progress to implement a CSF type of solution on the River Ivel[30] and the concept forms part of the CaBA chalk stream strategy[31].

5.2.2 Proposal for a CSF-type of scheme to minimise Tarrant-Pimperne impacts

The simplest way of reducing abstraction impacts on the Tarrant and Pimperne catchments would be to minimise the abstractions at Stubhampton, Black Lane and Shapwick and to take water instead from Wessex Water's Sturminster Marshall and Corfe Mullen boreholes. The combined recent average abstraction from the Stubhampton, Black Lane and Shapwick sources in the three year period 2022 to 2024 is 10.5 Ml/d. It is proposed that most of this water is taken instead from the Sturminster Marshall and Corfe Mullen sources, with the Tarrant supplies only used to serve local areas with no connection to other sources.

Comparing the dry year critical period (DYCP) deployable outputs of the sources with their average outputs in 2022 to 2024, the data in Table 8 show that the additional water potentially available from these existing sources is:

- From Sturminster Marshall boreholes (22.52 – 14.13) = 8.39 Ml/d
- From Corfe Mullen boreholes (27.84 – 18.72) = 9.12 Ml/d

Assuming that the dry year critical period DOs are the maximum output capacity of the existing boreholes in droughts, it appears that there is a total unused capacity of 17.5 Ml/d from the

[29] Chalk Streams First Proposal https://chalkstreams.org/chalk-streams-first/
[30] River Ivel alleviation of low flows report and follow-up report by WSP for Anglian Water both available here https://www.revivel.org/resources-reports/
[31] CaBA Chalk stream strategy, page 45 https://catchmentbasedapproach.org/wp-content/uploads/2021/10/CaBA-CSRG-Strategy-MAIN-REPORT-FINAL-12.10.21-Low-Res.pdf

Sturminster Marshall and Corfe Mullen sources – well in excess of the combined recent output of 10.5 Ml/d from the combined Tarrant/Pimperne sources. Therefore, there is sufficient spare output capacity in the existing Sturminster Marshal and Corfe Mullen sources to replace all of the recently used supplies from the Stubhampton, Black Lane and Shapwick sources. The presence of the Wessex GRID pipeline also means that there is probably sufficient flexibility in the existing distribution system to allow the Corfe Mullen and Sturminster Marshall supplies to reach most, if not all, of the areas currently supplied by the Tarrant/Pimperne sources. This all needs to be confirmed by Wessex Water.

However, at present the amount that the Sturminster Marshall and Corfe Mullen sources can be used to replace the Tarrant/Pimperne supplies is constrained by the existing licences, as shown below:

	Licensed amounts in Ml/d		
	Sturminster Marshall	**Corfe Mullen**	**Total**
Daily licence	20.00	32.96	52.96
Recent max monthly	18.33	23.19	41.52
Additional available within daily licence	**1.67**	**9.77**	**11.43**
			0.00
Annual licence	15.95	22.79	38.74
Recent annual amount	14.13	18.72	32.85
Additional available within annual licence	**1.81**	**4.08**	**5.89**

Table 9 - Licence constraints on additional water from Wessex Water lower Stour sources

Although the 11.43 Ml/d headroom in the existing daily licensed amounts is enough to allow full replacement of all of the recent Stubhampton, Black Lane and Shapwick abstractions of about 10.5 Ml/d, there is insufficient headroom in the annual licensed amounts.

Therefore, it is proposed that Wessex Water's licensed abstraction amounts for its five Stour sources should be changed as shown in Table 10:

	Source outputs in Ml/d					
	Recent abstraction 2022-24		**Existing licences**		**Proposed licences**	
Source	**Average**	**Maximum monthly**	**Annual average**	**Daily maximum**	**Annual average**	**Daily maximum**
Stubhampton	1.37	2.04	2.18	2.27	0.50	2.27
Black Lane	6.73	9.40	8.38	12.00	2.00	10.00
Shapwick	2.45	5.36	8.00	9.09	2.00	8.00
Sturminster Marshall	14.13	18.33	15.95	20.00	22.80	22.80
Corfe Mullen	18.72	23.19	22.79	32.96	27.84	32.96
Totals	**43.40**	**58.32**	**57.30**	**76.32**	**55.14**	**76.03**

Table 10 - Proposed licence changes to reduce Tarrant-Pimperne abstraction impacts

The reasoning behind the proposed licence change amounts is as follows:

1. A combined annual average capacity of 4.5 Ml/d is retained in the Stubhampton, Black Lane and Shapwick sources to allow them to continue to be used for local demands that can only be met by these sources.

2. The proposed annual licences for the Stubhampton, Black Lane and Shapwick sources follow the A%R guideline for average abstraction to be no more than 10% of average annual recharge and ideally less than 5% for highly sensitive chalk streams[32]. For the combined Tarrant-Pimperne catchment, the total of 4.5 Ml/d is about 5% of the combined catchment average annual recharge of 89.7 Ml/d. The Back Lane annual licence of 2 Ml/d would be 9% of the average recharge for the Pimperne catchment on its own.

3. The maximum daily licensed amounts for the Stubhampton, Black Lane and Shapwick sources are set at roughly existing licensed levels to allow these sources to be used at full capacity for short periods in emergencies. The annual licensed amounts for the licences are equivalent to about 10 weeks use per year at the maximum daily rates. However, it is proposed that there should be an operating agreement that the use of the Stubhampton, Black Lane and Shapwick sources is kept to a minimum during normal operation on a "best endeavours" basis[33].

4. The proposed new annual average licences for the Sturminster Marshall and Corfe Mullen sources are set at the dry year critical period (DYCP) deployable output levels in Wessex Water's latest Water Resource Management Plan (as shown in Table 8). It is assumed that the existing source works have the output capacity to supply the DYCP outputs.

5. The total annual and daily licensed amounts for the five Wessex Water sources are about the same as in the existing licences, so there will be no reduction in water available for downstream supplies, particularly for South West Water's Longham supplies for Bournemouth.

Increasing the Sturminster Marshall and Corfe Mullen abstractions could have an impact on flows and ecology of the North Winterborne (location on Figure 50), although the Middle Stour Tributaries Report concluded that the impact of the existing abstractions is small and will not affect the winterbourne ecology[34]. However, Wessex Water's 2024 Water Resource Management Plan suggests that there are still some concerns over the impact of the Sturminster Marshall abstraction, which will be further investigated in AMP8 (2025 to 2030).

All the potential reductions in sources supplying Wessex Water's Southern GRID pipeline are shown in the table below, copied from Wessex Water's recent water resource management plan[35]:

[32] CaBA chalk stream strategy, page 39 https://catchmentbasedapproach.org/wp-content/uploads/2021/10/CaBA-CSRG-Strategy-MAIN-REPORT-FINAL-12.10.21-Low-Res.pdf
[33] Legal meaning as here https://acuitylaw.com/best-endeavours-or-reasonable-endeavours/
[34] Middle Stour Tributaries Report, pages ii and 117
[35] Un-redacted version of Table 4-3 in Wessex Water's WRMP24 Supply Forecast Annex, as supplied by Ian Colley in email to John Lawson on 27th July 2025

Supply reductions in Ml/d

South Grid Sources	Catchment	Proposed year of licence/DO reduction	Investigation type			Reductions in DO - DYAA			Reductions in DO - DYCP		
			Environmental Destination	No Deterioration	Regular Investigation	Low	Central	High	Low	Central	High
Black Lane	Dorset Stour	2035/36	AMP8			0	0	0	0	0	0
Briantspuddle	River Piddle	2035/36	AMP8	AMP8	AMP8	0	4.05	4.68	0.95	9.0	9
Corfe Mullen	Dorset Stour	2035/36	AMP8	AMP8	AMP8	0	0	0	0	0	0
Dewlish	Devil's Brook	2042/43	AMP8			0	0	2.08	0	0	0
Fonthill Bishop	River Nadder	2040/41	AMP8	AMP8	AMP9	0	0	0.99	0	0	1.53
Milborne St Andrew	River Piddle	2042/43	AMP8			0	0	0	0	0	0
Shapwick	Dorset Stour	2035/36	AMP8	AMP8	AMP8	1.86	4.28	4.28	4.3	4.3	4.3
Stubhampton	Dorset Stour	2042/43	AMP8			0	0	0	0	0	0
Sturminster Marshall	Dorset Stour	2035/36	AMP8	AMP8	AMP8	0	1.21	10.49	5.76	12.89	18.06
Total						**1.9**	**9.5**	**22.5**	**11.0**	**26.2**	**32.9**

Table 11 - Planned reductions in South GRID supply sources in Wessex Water's WRMP24

The possible future reduction of up to 18 Ml/d in the licensed Sturminster Marshall abstraction throws doubt on the acceptability of using the Sturminster Marshall source to replace some of the Tarrant-Pimperne abstractions. The concerns over impact of the Sturminster Marshall source appear to be mainly related to flows in the River Stour, bearing in mind the Middle Stour Tributaries Report's conclusion of lack of impact of the source on the North Winterbourne (see reference 34). However, the flows in the River Stour will be enhanced by the proposed reductions at Black Lane, Stubhampton and Shapwick, off-setting any impact of increased abstraction at Sturminster Marshall.

Also, any additional impact could be minimised by taking more of the extra abstractions from Corfe Mullen, rather than Sturminster Marshall, noting that there are no planned reductions in the Corfe Mullen licence.

It is also noted that future water abstraction impacts will be less because Wessex Water expect that their total supplies of water will reduce, particularly over the next 25 years. This is because the planned reductions in leakage and per capita consumption more than offset the planned additional supplies needed for an increased population. This is shown in Figure 51[36]:

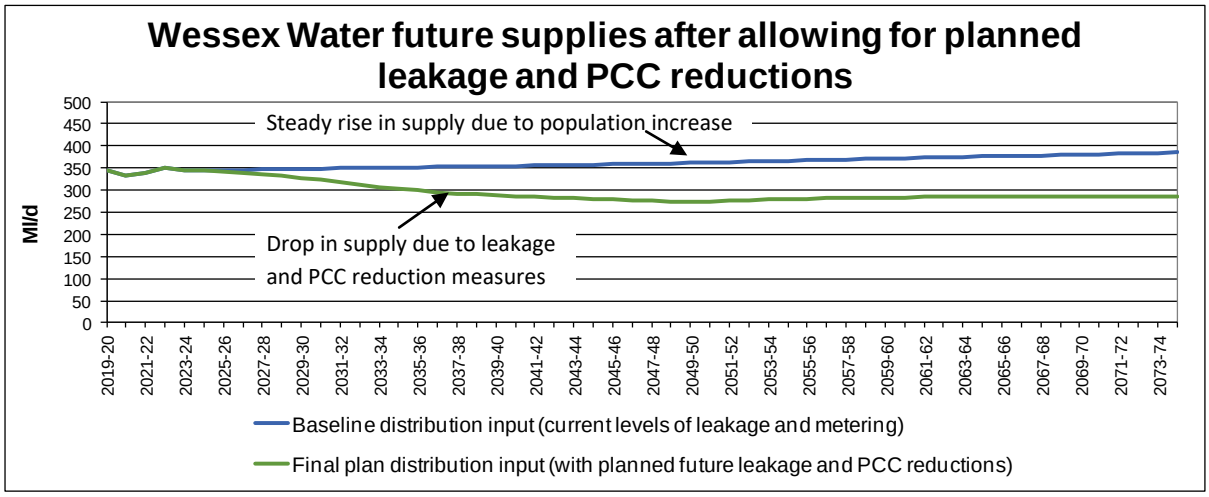


Figure 51 - Wessex Water planned reduction in future supplies

[36] Data from Wessex Water final WRMP tables, rows 85 and 175 on WXWWSX tab

The reduction in future supplies due to Wessex Water's planned investment in leakage reduction and smart metering should ensure that the proposed changes in the Stour licences will meet the Water Framework Directive requirement for "no deterioration".

It is proposed that, in the first instance, the licence changes shown in Table 10, should be time limited for a period of 42 months, including three full hydrological years, ie three periods of winter recharge followed by three periods of summer recession. This should be sufficient time for recovery of groundwater levels in the Tarrant-Pimperne catchments to close to their natural levels and, hence, a proper evaluation of the effectiveness of the changes in re-establishing a near permanent flow in the lower River Tarrant.

5.2.3 Investigation of proposed redistribution of abstraction from Middle Stour sources

More detail of the AMP8 investigations of impacts of the Sturminster Marshall, Shapwick and Corfe Mullen sources referred to in the above Table 11 are given in the table below, which has been extracted from an Environment Agency spreadsheet of WFD-related actions needed in the Wessex region during the AMP8 period, 2025 to 2030:

Unique_ID	**Action_Name**	Action_Description	Tier_1_Outcome
08WW100050d	**River Stour Environmental Destination Investigation**	Defining long term sustainable abstraction in the Dorset Stour catchment	Enhancing water environment to meet outcome of regional plan
08WW100091a	**Middle Stour sources WFD ND investigation (Corfe Mullen)**	Investigate effect of abstraction from Wessex Water's sources (Corfe Mullen) on WFD status of the River Stour	Preventing deterioration from current status within a catchment
08WW100091b	**Middle Stour sources WFD ND investigation (Shapwick)**	Investigate effect of abstraction from Wessex Water's sources (Shapwick) on WFD status of the River Stour	Preventing deterioration from current status within a catchment
08WW100091c	**Middle Stour sources WFD ND investigation (Sturminster Marshall)**	Investigate effect of abstraction from Wessex Water's sources (Sturminster Marshall) on WFD status of the River Stour and North Winterbourne	Preventing deterioration from current status within a catchment

Table 12 - Planned AMP8 Middle Stour WFD over-abstraction investigations due by end of 2026

It is noted that the EA's spreadsheet contains no mention of investigations into over-abstraction in the Tarrant or Pimperne water bodies. This is disappointing, but consistent with disputed classification of the hydrological regime in these water bodies as "Supports Good". It is proposed that, in the light of this report, the AMP 8 investigations should include the River Tarrant and Pimperne Brook.

Each of the investigations shown in Table 12 is described in the EA's spreadsheet as:

- complex investigation involving multiple surveys and or monitoring locations, and or complex modelling
- investigation to inform PR29 (ie for possible implementation after 2030)
- investigation to be completed by 31st December 2026

It is proposed that the investigations into the Corfe Mullen, Sturminster Marshall and Shapwick

abstractions should include consideration of the acceptability of the re-distribution of Middle Stour abstractions proposed in Table 10. The investigation reports should make recommendations for the optimum use of all the Middle Stour abstractions to minimise ecological impacts on the affected water bodies, including the River Tarrant and Pimperne Brook.

If the AMP8 investigations are completed by the end of 2026 as currently planned, the proposed 42 months of trials of the changed abstraction licences could start in 2027. The trials should include an extensive programme of monitoring of river flows, groundwater levels and duration of the various streams drying (flow signature plots). It would be particularly important to do spot flow gauging at reasonably close intervals down the river reaches that have been subject to flow losses and drying. This would improve understanding of why the amount of lower Tarrant river bed leakage seems to vary. Solutions to the problem of flow losses and the river drying could include some form of river bed sealing, possibly replicating the process of natural sealing of the river bed which has allowed the lower River Tarrant to keep flowing at times when the groundwater levels are well below the river bed.

5.2.4 Possible use of South West Water's Bournemouth sources

If the proposed 42-month trial of changed abstraction licences does not give the expected large reduction in the frequency of drying of the lower River Tarrant, it is likely to be because the increased groundwater abstractions at Sturminster Marshall and Corfe Mullen have caused a general lowering of groundwater levels in the Stour valley (see Section 4.10.4). This could lead to reduced groundwater levels in the lower Tarrant valley and, consequently, little improvement in the river bed losses and drying of the lower river.

In that case, there would be options to take water to replace the Tarrant-Pimperne sources from the River Stour, rather than from the existing Sturminster Marshall and Corfe Mullen groundwater sources. One option would be to use South West Water's existing Longham source which supplies the Bournemouth area. The Longham source is a surface water abstraction from the River Stour. The licensed amount of 44 Ml/d is scheduled to be reduced by 12.5 Ml/d in 2028, as explained in South West Water's Water Resource Management Plan[37]:

> *"Our abstraction licence on the River Stour at Longham includes a time limited component of 12.5 Ml/d. This expires in 2028 when we must reduce our total daily average abstraction to 31.82 Ml/d. We have assumed that this component will not be renewed because of the risk of deterioration in the WFD status classification and EFI deficits in the River Stour."*

The "risk of deterioration" would seem minimal, because the future supplies into the Bournemouth area are expected to reduce due to South West Water's planned investments in leakage reduction and in smart metering to lower per capita consumption. This can be seen on Figure 52 which shows SWW's forecast supplies into the Bournemouth zone, with and without the planned leakage and per capita consumption (PCC) reductions[38]:

[37] South West Water, Water Resource Management Plan 2024, Appendix 1: Supply Forecasting, page 18 https://www.southwestwater.co.uk/siteassets/documents/about-us/wrmp/revised-wrmp/sww-dwrmp24-appendix-1-supply-forecast.pdf

[38] South West Water, Water Resource Management Plan 2024, WRMP revised tables, rows 75 and 185 on SWWBNM tab

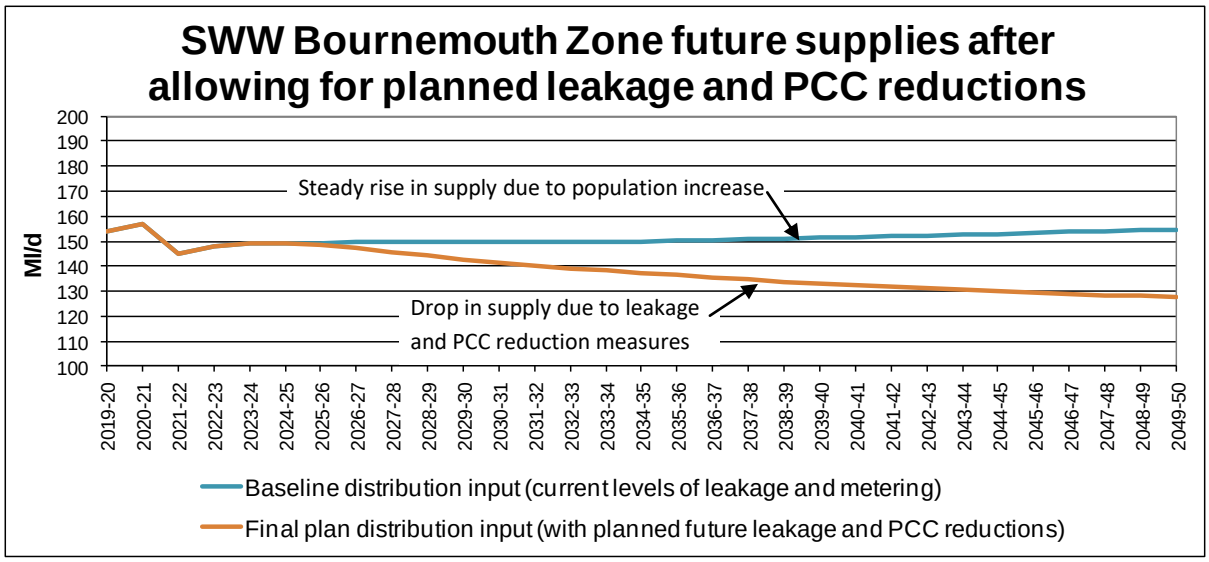


Figure 52 - Forecast reduction in SWW's supplies into the Bournemouth zone

The plot above shows that any rise in Bournemouth supplies due to forecast population increase will be more than offset by the planned leakage and PCC reductions, leading to an overall fall in required supply of about 17% by 2050. Therefore, there would appear to be no risk of deterioration from the continued use of the time limited 12.5 Ml/d component of the Longham source. The additional water abstracted at Longham could be transferred to Wessex Water to replace the lost Tarrant-Pimperne supplies. The River Stour between Blandford and Longham would benefit from the additional flow arising from the reduced Tarrant-Pimperne abstractions.

An alternative to South West Water abstracting the enhanced Stour flow at Longham would be for Wessex Water to abstract the enhanced flow just downstream of Corfe Mullen. This would require a new surface water pumping station on the River Stour and a short pipeline connecting to the regional GRID pipeline. This option is likely to be less costly and quicker to implement than the pipeline transferring water from Longham to Corfe Mullen and it would avoid the need for an inter-company transfer agreement.

A potential difficulty with this Chalk Streams First type of solution is that the flow benefits from the 10 Ml/d Tarrant -Pimperne abstraction reductions would be higher in winter and lower in droughts – the extra flow at Longham would be a lot less than 10 Ml/d when it is most needed. However, the scheme could operate in conjunction with the 1000 Ml/d of storage in the Longham lakes reservoir, storing some of the water from the Tarrant-Pimperne reductions when it is not needed and using it in droughts.

5.3 Possible new sources to replace Tarrant-Pimperne supplies

Some potential replacement sources for the Tarrant-Pimperne supplies have been identified from a review of Wessex Water and Southern Water's 2024 water resource management plans (WRMPs). From Wessex Water's WRMP, its main potential new source for replacement of the Tarrant-Pimperne supplies would appear to be:

- The c. 30 Ml/d Mendips quarry reservoir scheme which was planned to supply regulation releases to the River Stour for the benefit of Wessex Water's Stour valley supplies and South

West Water's Bournemouth zone. This scheme was considered feasible, but not selected in final WRMPs. It could be re-considered.

- The Poole sewage effluent recycling scheme, supplying 10 Ml/d, with possibly more to South West Water – could this be made larger to replace Tarrant-Pimperne supplies?

South West Water's water resource management plan includes a number of potential new sources that appear to be potentially capable of replacing the Tarrant-Pimperne supplies into Wessex Water's strategic grid:

- An aquifer storage and recovery scheme at Longham supplying 10 Ml/d is already planned – could this be made larger?
- Mendips Quarry reservoir as above?
- Cheddar 2 reservoir, supplying 6 Ml/d is considered feasible, but it was not selected during the WRMP optimisation process.

These are all options that could be considered as replacements for the damaging Tarrant-Pimperne abstractions, if the 'Chalk Streams First' type of solutions proposed in Section 5.2 turn out not to be feasible. However, these options would be very costly and would take a long time to plan, promote and build. They would probably be very hard to justify on cost-benefit grounds.

6. Next steps

6.1 Review of this report by the EA and Wessex Water

This report provides strong evidence that flows in the River Tarrant have been substantially reduced by abstraction and that the lower river nowadays dries far more frequently than occurred before the chalk groundwater was extensively used for public water supplies. Although there will always be uncertainty over the extent of abstraction impacts, it is believed that the evidence is strong enough for an immediate re-classification of the hydrological regimes of the Tarrant and Pimperne Water bodies to "Does Not Support Good". This would then justify serious consideration of ways to reduce the abstraction impacts, at the very least on a precautionary basis.

Therefore, the Environment Agency and Wessex Water are urged to review this report from the perspective of actively looking for a quick solution to the abstraction impacts, rather than continuation of the arguments over the extent the impacts.

In particular, the Environment Agency and Wessex Water are asked to focus on the solution put forward in Section 5.2 of this report – re-distributing the abstractions amongst the five existing sources, minimising use of the groundwater abstractions at the Stubhampton, Black Lane and Shapwick sources, and taking the water instead from the Sturminster Marshall and Corfe Mullen sources. A trial of this solution could start in 2027. It would incur minimal capital costs and would only require adjustment of abstraction licences, with the total amount allowed to be taken from the five groundwater sources remaining unchanged.

It is proposed that, after allowing time for consideration of the report, there should be a meeting focusing on the proposed solution and addressing questions such as:

- What infrastructure changes to the existing sources, treatment and distribution networks would be needed, if any, to allow the abstractions to be re-distributed amongst the five sources?
- What temporary adjustments would be needed to existing abstraction licences and how long would the process take?
- How should investigation of the proposal be integrated with the existing AMP8 investigations of the Sturminster Marshall, Shapwick and Corfe Mullen sources that are due to be completed by the end of 2026.
- How to communicate with stakeholders about this proposal, recognising that some will be concerned by it?
- Is the proposed 42-month period of the trial licence changes long enough to determine the effectiveness of the proposal and identify any unwanted environmental impacts?
- Does there need to be an operating agreement covering how total abstraction is distributed between the five sources on a day-to-day "best endeavours" basis, in addition to the temporary licence changes?

The outcome of this meeting should be a plan for taking forward the proposed solution.

6.2 Review of geomorphological evidence

A study of the geomorphology of the River Tarrant could provide more evidence that the river used to flow perennially. This has been suggested by Charles Rangeley-Wilson in the email copied below:

> *"I think there is more science that we can add. David Sear [Professor of Physical Geography at Southampton University[39]] and I have been talking a lot about winterbourne and headwater morphology and how chalk streams evolve.*
>
> *We've discussed how the headwaters of many chalk streams that were naturally ephemeral have been unnaturally extended far up catchments through ditching - giving the impression that channels once existed when they probably didn't. Natural and reliably ephemeral reaches may not have consisted of very distinct channels, but rather shallow dishes through which the groundwater seeped / flowed at high GWLs. The ditching has corralled that flow into straight, man-made channels (these probably drain the aquifer unnaturally quickly too).*
>
> *Conversely, it seems unlikely that meandering floodplain channels would or could evolve in reaches of the valley that were naturally ephemeral. Chalk stream channels are inherited from the post glacial phase (when multiple channels would have braided across a barren glacial outwash valley floor) around which the floodplain surface has accreted over time as the planet warmed. Peat will only form – and create the distinct, stable, single-thread channel – in areas that are perennially wet.*
>
> *Thus core samples can tell us a lot about valley history. There won't be any peat in a natural winterbourne reach. On the other hand, if there is peat, the stream must have been reliably perennial. Core samples are not cheap, but can be done by David Sear's colleagues at Southampton University.*
>
> *The meander pattern and natural channel dimensions (cross section and width to depth ratio) can tell us a lot too, given that these are all largely determined by the flow regime. It must be possible to look at recent actual (abstracted) flow regimes and legacy channel dimensions and determine the degree of fit or misfit.*
>
> *Similarly, if a straightened channel has been left alone for a decent length of time a meander pattern will start to express itself (see the attached photo of a mill-leat on the Wycombe stream). It would be potentially interesting to correlate emerging channel dimensions (where they can be found) in abstracted streams with relic channel dimensions and see if there is any difference.*
>
> *There is lots of good map and Lidar data suggesting natural meanders in the Tarrant upstream as far as Tarrant Launceston. Perhaps this area upstream of Tarrant Launceston marks the transition from natural ephemeral to naturally perennial? On the other hand the Tarrant names continue on up the valley, perhaps suggesting that even up here the natural river may have flowed more often than not? There are Roman villa remains north of Tarrant Hinton. In Norfolk Roman villas seem to coincide with the spring-line and certainly reliable sources of water."*

The geomorphological investigation suggested above could provide powerful evidence that the

[39] Professor David Sear https://www.southampton.ac.uk/geography/research/staff/ds5.page

lower River Tarrant used to flow perennially and add weight to the need to develop the proposed solution put forward in this report.

Appendix A – Dr David Solomon report on historical and fisheries aspects

Contents

1. Background

2. Direct observations on flows in the Tarrant

3. Evidence from the existence of water mills

4. Evidence from fish rescues

5. Evidence from River Tarrant fishery records

6. River Tarrant and the Water Framework Directive (WFD)

7. Summary of historical evidence of flow deterioration

Annex 1 – WI Stanton (NRA) note on Tarrant history

References

Report on historical aspects of the River Tarrant, with special reference to fisheries.

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1. Background

This report covers a number of issues concerning flow in `the River Tarrant. These include the history of flows (including the extent to which different reaches have dried out during drought); and the use of the stream by salmon for spawning and rearing. This latter issue requires a consideration of Stour salmon in general to put it into context; this is provided. The WFD Assessment for the Tarrant is also discussed.

Figure 1 is a map of the lower Tarrant showing the sites mentioned in the text.

2. Direct observations on flows in the Tarrant

Here a number of historical observations on flow and drying of the Tarrant are presented, gathered from local press reports and elsewhere. This is by no means an exhaustive analysis of flows, it is offered to support the observations and modelling undertaken in recent years, and other general memories of local residents.

The first useful observations are from 1929 (Swanage Times and Directory, July 19 1929):-

The drought was responsible for a unique experience which befell a local resident who with two companions strolled through Monkton, one of the Tarrant villages, on Wednesday. They came to a bridge by the roadside and were astonished to see innumerable trout splashing dangerously near the surface.

Disaster had overtaken the fish, the water had gradually receded from beneath the bridge, leaving the tunnel dry. For the next half hour of so the passers-by must have been astonished to see three young men dashing along the road and across the field with bathing costumes that heaved spasmodically. Swift transfer to another and purer pool, however, was the only means of saving the unfortunate little victims, and the rescue work, although slippery was doubtless in some measure effective, accomplished, though it was, with walking sticks for rods and bathing costumes as improvised fishing nets!

The Prolonged Drought – Serious Effects in North Dorset. The water shortage generally throughout Dorset, but more particularly in this and adjacent areas, is becoming extremely serious. Cottage wells are drying up, and hundreds are relying on the generosity of neighbouring farmers who, profiting by the experience of the 1921 drought, have had their wells deepened on many farms; but even this has in only a small degree lessened the difficulties now being experienced in agricultural circles. The Tarrant stream is dry, and villagers are having the unique experience of walking over the bed of the rivulet at Tarrant Monkton dry shod, a circumstance without parallel for a very prolonged period.

And in 1933, Hampshire Advertiser (December 2 1933):-

In the Tarrant valley the river that gives it its name has disappeared during the summer, and hundreds of fish, including fine trout, were left in a few pools where they were netted before they died in the brackish water.

The situation is causing grave concern amongst the inhabitants of the villages, who are dependent upon the meagre supply from the few wells which have water and increased demands are having their effect.

An article in "The Field" by Warren (1997) contains some useful observations by long-term local residents at that time. One lady who had lived in Tarrant Monkton since 1951, recalled that in the 50s and early 60s there was enough water throughout the summer for children to paddle or even swim; it "now" (1997) dries there every summer. Another resident of the village since 1939 stated that he could not recall the river drying in the summer at Tarrant Monkton until the sixties. A third long-term resident, this time living in Tarrant Launceston since 1933, stated that flows before 1950 were occasionally low enough there to kill trout. After about 1970, there were no trout present and the river dries out regularly.

Of great interest is a two-page document "River Tarrant – Historical Summary" covering 1926 to 1991 (file reference WPC2/5206/4). This was written by geologist Dr William Iredale Stanton, who worked for the National Rivers Authority until his retirement in 1995. Entries of interest include:-

1970. *Shapwick boreholes test pump report says that the Tarrant "in its upper reaches is a winterbourne drying annually u/s of Tarrant Monkton and in the drier years u/s of Tarrant Rushton. In exceptionally dry years the river is dry just above the confluence with the Stour, although there may be flow between Tarrant Rushton and Tarrant Keynston". This refers to the Tarrant as known in 1969. Testing appeared to show groundwater flowing beneath the Tarrant to the Stour. The report also says that "although the cone of depression extended as far as Tarrant Keynston; the lower Tarrant would not be generally affected because it was already influent (ie it loses water into its bed). (NRA would not agree with this statement).*

1989. *Extremely dry summer. On 15.08.89 NRA noted the Tarrant rising at Tarrant Monkton, increasing to Tarrant Keynston, then shrinking to almost zero flow at confluence with River Stour.*

These two extracts shows that it was only in exceptional drought that the river dried in its lowermost reaches, in sharp contrast to the present-day situation of drying almost every year.

3. Evidence from the existence of water mills

There have been a number of water mills operating on the Tarrant over the past thousand years. Clearly such mills require an abundant supply of water to operate, so what can we learn from the history of these mills with regard to the historic flow regime? Their locations are shown in Figure 1;



Fig 1. Lower Tarrant showing sites of fisheries interest mentioned in the text. Blue grid lines at 1 km spacing.

At least eight waterwheel sites have been identified (six corn mills, two water pumps) in the Tarrant parishes, but at least one of these, Tarrant Keyneston Mill, was in fact of the River

Stour and should be disregarded. Some detail of this mill is nevertheless provided here to allow clear identification and isolation of information on this site; in the past some confusion has arisen (of which more later). Details of all eight sites are provided in Table 1.

Table 1. Details of water mills in the Tarrant Parishes, working upstream.

	Name	Watercourse	NGR	Earliest ref	Rent 1086	Purpose
1	T. Keyneston	Stour	915 035	1086	1000 eels	Corn
2	T.K'ston	Tarrant or Stour	Unknown	1086	30 shillings	Corn
3	T. Crawford	Tarrant	922 035	1086	5 shillings	Corn
4	"Tarrant"		Unknown	1086	4 shillings	Corn
5	T.Rushton (1)	Tarrant	937 049			Water pump
6	T.Rushton (2)	Tarrant	937 060	1855		Corn
7	T. Rawston	Tarrant	941 066			Water pump
8	T. Monkton	Tarrant	949 081 (a)	1086	5 shillings	Corn

Footnotes. (a) Domesday mentions a mill at Tarrant Monkton, but this NGR location is just conjecture; there are the remains of an old head-retaining structure here which are reminiscent of a mill, but t there is no indication of a mill here on OS maps from the 19th Century

The historic presence of several mills on the Tarrant strongly suggests that the stream once had a more reliable flow regime. However, their presence in not absolute proof of perennial flow.

First, if a stream with a winterbourne tendency is the main potential water resource available, it is not really a matter of where to site your mill as to whether to build it at all. "Winter mills" (*molinum hiemale*) are mentioned in Domesday for a number of locations (though this description is not used for the Tarrant sites). A mill that has a reliable flow regime for perhaps two thirds of the year may be a much better alternative than no mill at all. The "unreliable" season could have been covered by hand milling, stones operated by animals such as horses or donkeys, or by having essential grain processed at a nearby reliable site (such as, in the case of the Tarrant, the larger mills on the nearby Stour). Or it may have been possible to plan a milling strategy based upon relying only on certain times of year; grain could be stored as easily and satisfactorily (possibly more so) than flour. At a time when transport was difficult, expensive and slow, great ingenuity was used to "keep things local".

The demise of the working mills on the Tarrant was not of course caused or hastened by any flow changes due to abstraction; all the corn mills had ceased operation by about 1900. Their demise was down to quite different developments. At the beginning of the 19th century, small mills like those on the Tarrant were doing what they had been doing for hundreds of years, serving an important role in the local community. The lack of infrastructure for the cost-effective transport of raw material and finished product meant that the relative inefficiency of such small-scale milling was not a threat to their operation. However, towards the middle of the century things started to change in ways that represented a serious challenge to the business model of local mills (Solomon 2020). First, improved transport, especially the development of railways, meant that both grain and processed products could be transported significant distances more quickly and relatively cheaply. The introduction of steam power to supplement water power improved the reliability and economics of mills

large enough to warrant it; this did not apply to the Tarrant mills. However, this development hastened the decline in viability and eventual demise of the smaller mills.

The repeal of the Corn Laws in 1846 allowed the import of grain and flour from Europe and North America. Although this had little impact at first, by about 1870 larger and faster ships were bringing huge quantities of grain across the Atlantic. Large and efficient mills developed near the places of import, such as Avonmouth and Plymouth. The harder North American wheat grain, preferred as a source of flour by the bread-making industry, could not be ground effectively using traditional stones, and new steel and ceramic roller mills were developed. While some existing larger mills invested in the new machinery, it was not economically feasible for smaller local mills. A survey in 1887 identified 8,814 flour mills in the UK, and while only 461 were fitted as roller-only mills, they accounted for 65% of the country's total output of flour. For the twenty years 1850 to 1870 the price of wheat had averaged 52/- (£2.60) per quarter (28 lb), but in 1886 it fell to 31/- (£1.55), and for the rest of the century never got back above 40/- (£2.00) .

All of this was very bad news for local millers. Not only was their livelihood dwindling, but the capital value of their assets was eroding too. As already mentioned, all the Tarrant mills (apart from the water pumps) had ceased operation by about the turn of the 20th century.

Perhaps the most compelling mill evidence comes from that sited at Tarrant Abbey, in Tarrant Crawford. This was a substantial structure with a dedicated head-retaining structure and mill leat etc (Figure 2). This must reflect a historically reliable flow regime; whereas in recent years (eight out of nine years) this site has been dry for a period, ranging from 46 to 140 days**.** In addition, there is likely to have been a period at either end of the dry spell when flows would have been too low for effective operation. This would not be a good basis for operation of a mill.

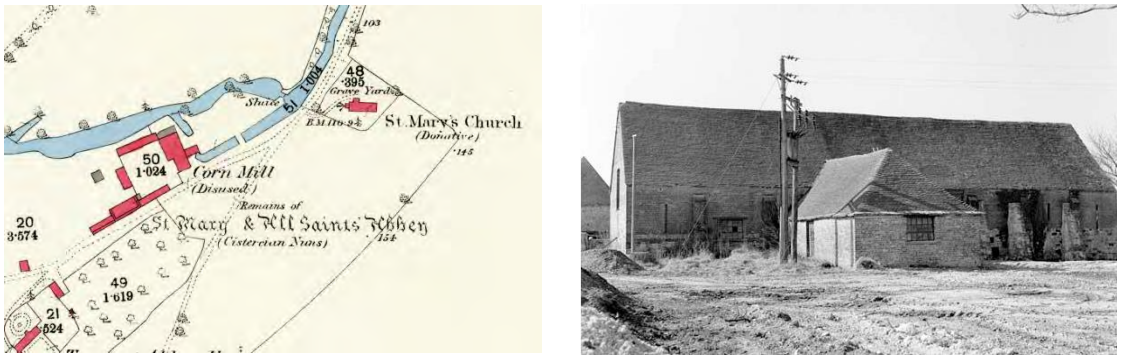


Figure 2. Tarrant Crawford Abbey Mill. Left. OS 25" map, surveyed 1887. Right:- View from ENE, dated 1964. The mill wheel is believed to have been housed in the single-story extension on this side of the building. The mill leat has been filled-in (probably only shortly before this picture was taken), and ran from the foreground to the electricity pole.

So while not representing conclusive proof, the presence of mills on the Tarrant strongly suggests that the stream once had a much more reliable flow regime, especially in the lowermost reaches.

4. Evidence from fish rescues

Here is presented all information that could be located on the history and conduct of fish rescues on the river Tarrant.

Rescuing fish, especially trout, which have become stranded by falling levels and drying out of reaches of the River Tarrant, has a long history. The earliest records, albeit of an impromptu effort by concerned bystanders in 1929 and 1933, have already been described.

Before this, it is likely that stranded trout were considered "fair game" for taking by local residents by whatever means they had at their disposal; if they did not take them, they would die anyway and be consumed by scavenging animals such as rats and crows. The most effective method for authorities to remove fish from streams, electric fishing, had only really developed in the 1950s.

July 1929. The impromptu rescue of a number of trout stranded at Tarrant Monkton has been recorded in the main report.

September 1961. From the Avon and Dorset River Board Annual Report for 1961-62:-

> *... on the Chitterne Brook , the Board's fisheries staff removed 1390 trout in three days fishing... Similar operations were carried out on a tributary of the River Allen (54), the Fonthill Stream (218) and side streams of the River Avon at Charford (30), but by far the largest total was obtained on the Tarrant Brook where, between the 6th to 25th September over 5,500 trout were rescued including a fish weighing 4½ lb. While a number of sizeable fish were taken here the majority (including a catch of over 1,000 taken from some 300 yards) were 0+ fish. It thus appears that the earlier notions that trout drop back as the water level falls were quite mistaken. Henceforth, these bournes must be regarded , in drought, as a sink down which a large proportion of the trout stock on main river is annually poured; and the fish will be annually rescued by electric fishing. It seems certain that these small streams are highly efficient nurseries for fry since food is abundant and predators are scarce. It may well be worth the Board's while considering their use as a nursery streams for salmon.*

A report of part of this rescue appeared in the Portsmouth Evening News on September 9 1961:-

500 trout saved. *Five hundred trout have been rescued from the dried-up River Tarrant near Spetisbury, Dorset, by the Avon and Dorset River Board bailiffs.*

September 1962. From the Avon and Dorset River Board Annual Report for 1962-63:-

Despite the generally low flows of 1962 the bournes did not run dry to anything like the same extent as in 1961 and rescue work was therefore more limited. Nevertheless, a total of 1,661 trout were removed from small streams and transferred to larger waters elsewhere. The largest transfer was 901 trout which were moved from the Tarrant Brook between the 2nd and 9th August 1962. All these fish were taken with the electric fishing machine.

1951-1974. The above rescues in 1961 and 1962 were the only two detailed in the Annual Reports of the Avon and Dorset River Board and River Authority between 1951 and 1974. The annual fisheries reports were detailed and followed a similar format year on year. They were all written by the Chief Fisheries Inspector, J D Brayshaw, one of the most experienced and respected fisheries officers in the industry, and an acknowledged expert on chalk streams. In view of the fact that the only contemporary press coverage of a Tarrant fish rescue coincides with one of these detailed reports, it is suggested that this silence probably reflects a lack or scarcity of (and a lack of need for) major fish rescues in the Tarrant in the other years during this 24 year period.

1973 to 1994. No details available. It is known that there was extensive drying of the stream in the drought years of 1976 and 1989, with some fish rescues and some stranding and deaths.

August 1995. Evidence from this year is provided by an article by Charles Rangeley-Wilson in an article in "Trout and Salmon" (October 1995 edition). Between them, he, the NRA and the Game Conservancy rescued almost 2000 fish during August, though ,many others perished in drying reaches and pools.

1995 onwards. Better detail is available for these more recent years, courtesy of the Environment Agency. Checks on flows and stranding are made every year, and rescues mounted when conditions suggest. Blank years are generally when rescues were deemed unnecessary. The numbers of trout rescued from the river upstream and downstream of Tarrant Rawston are shown in Table 2. The number of juvenile salmon rescued is also shown – all these would have been from the lower river. In addition, small numbers of other fish are involved, most abundantly bullhead, minnow and stone loach.

Strandings/rescues involving large numbers of trout (2000 or more) occur in years apparently satisfying two criteria:-

1. Good flows in the winter before, encouraging and enabling adult fish to enter and spread through the stream; and
2. Rapidly falling flows through the summer, making emigration by both spawned adults and juveniles essential but trapping many fish in pools and sumps.

So what can we glean from this history of fish rescues? Unfortunately, the consistency of the data is not good enough to allow a statistical examination of trends and relationships. It is not possible to determine if the lack of fish rescued in particular locations in particular years is a true reflection of differences between years and sets of conditions.

Table 2. Results of fish rescues on the Tarrant, 1995 to date.

Year	Trout u/s Rawston	Trout d/s Rawston	Total trout	Salmon parr
1995			2,000	
1996				
1997		159		
1998				
1999				
2000				
2001	500	?	?	
2002	325	630	955	
2003	750	1120	1870	
2004				
2005	none	600	600	
2006	none	56	56	
2007				
2008				
2009				
2010				
2011		111	111	
2012	2322	452	2674	7
2013	1249	916	2165	
2014				
2015	400	1524	1924	
2016	370	215	585	29
2017				
2018			2100	75
2019	75	?	?	
2020	121	400	521	
2021			C800	18
2022	325	630		25
2023			Very few	
2024			Very few	

Nevertheless, a number of features are apparent. Fish rescues appear to have become much more frequent in recent decades – not just in the frequency of operation (which may merely reflect a more consistent allocation of manpower) but also in terms of large-scale results (say, over 2000 fish rescued in a particular year). This is a strong indication that stream drying has become more frequent, especially with respect to the lower part of the stream (from Tarrant Rushton downstream).

5. Evidence from River Tarrant fishery records

5.1 Juvenile fish surveys

Unfortunately, no part of the River Tarrant has been included in the routine fish monitoring programme operated by electric fishing by the Environment Agency and its predecessors over the past fifty years or more

Table 3. Sites on the Tarrant used for fish surveys

Name	Date	NGR	Who	Area (m^2)	Trout (n)[a]	Trout/ 100 m^2	Salmon (n)
Tarrant Rushton	1964-66[a]	936 056	FBA	270	53	19.6	present
Charlton Cottage	19/9/03	936 051	EA	105	18	17.1	0
	12/9/07	936 051	EA	440	93	21.1	0
	28/8/12	936 051	EA	321	6	1.9	0
	19/6/18	936 051	EA	462	40	8.7	0
T'Abbey	29/7/10	923 370	EA	440	80	18.2	7

Footnote. ([a]) Most of the surveys involved only a single run through electric fishing, ie they were only semi-quantitative (catch per unit effort) indicators. Therefore only the first or only run figures are used here for all the EA surveys. The figure for the FBA site is the estimate of total population; results for the separate "runs" were not available. This figure is likely to be of the order of 1.5 to 2 times a notional single-run figure, so needs to be reduced for comparison with the EA surveys. The FBA site was surveyed on several occasions. The figure presented here is based on results from August 1.

However, three sites have been fished on an *ad hoc* basis by the EA and others. Details are shown in Table 3. In the early 1960s, biologists from the River Laboratory in East Stoke (on the Frome u/s of Wareham) looked at the fish populations in many Dorset streams. A single site was included for the Tarrant at Tarrant Rushton (NGR ST 936059) (LeCren 1969, Mann and Orr 1969, Mann 1971). Productivity of trout was high at about 12g/m^2 per year, but that of bullheads was much greater at around 43g/m^2. Le Cren (1969) commented that the overall productivity, at around 60 g/m^2 per year, "must be one of the highest levels of natural fish production so far recorded". Juvenile salmon were noted as present at the single site.

Although not included in the EA cycle of regularly-surveyed sites, two locations on the stream have been surveyed on an *ad hoc* basis by the EA in recent years; the results are included in the NFPD database.

The first, at Charlton Cottage downstream of Tarrant Rushton, was sampled on four occasions between 2003 and 2018.

Somewhat surprisingly, no juvenile salmon were recorded at the Charlton Cottage site in any of the years. The other site, at Tarrant Abbey (NGR ST 923 037) yielded seven 0+ salmon when sampled in July 2010 (NFPD data).

So what can be gleaned from these observations? The figures are too few to allow any identification of trends. The variation in calendar date of the surveys (June 19 to September 19) covers a period when the population of the numerically-dominant age class of trout, 0+ (young of the year) is falling significantly naturally; the estimate for the FBA site fell from 100 for June to 20 for September. The extent to which this was due to mortality or emigration is unknown. For the surveys for which sufficient detail is available, the age

structure of the populations is indicative of a perennial site (populations found in, emigrating from or rescued from, true winterbourne sites comprise only 0+ fish – those born on the site - and mature fish –those that migrated upstream into the site to spawn – and fish aged 1+ are generally absent).

Small numbers of eels have been recorded at times in the Tarrant, but their presence says little if anything about the reliability of the flow regime. However, it is rather surprising to note that Darby and Welldon Finn (1967), in an assessment of Domesday entries, allocate an eel rent of 1000 eels to a mill on the River Tarrant; their map puts this well up the stream, above Tarrant Monkton. This would appear to be a confusion; this eel rent is believed to have applied to Tarrant Keyneston Mill, which is on the Stour. This is an altogether more plausible interpretation, with this mill exploiting the eel production of the whole upper half of the Stour catchment.

5.2 Salmon in the River Tarrant

There is a long history of salmon in the Tarrant, from a number of sources. Most are "one-off" observations rather than the result of regular surveys, but they do build-up into a coherent picture of the stream being a significant spawning and nursery area for Stour salmon.

The earliest record comes from correspondence in "The Field" in 1866-67. Specific records are:-

:and in some of them, the Tarrant for instance, many what are called salmon, and which I believe to be so, are, or rather used to be, observed in the autumn. But in addition to my own knowledge of this fact, I have questioned the man who was for many years gardener at the rectory of Tarrant Keyneston, and who was more conversant than myself with the, to him, too often advantageous resources of the stream. He says that the old salmon came up the stream during the months of November and December, and evidently spawned in the shallows. (Letter from John H Austen, The Field, June 18 1866).

I know that fish came up this season to spawn in the Tarrant just below Blandford. (letter from E.P., The Field, April 20 1867

Such (salmon) were seen and caught as high up as Tarrant Rushton in January last, 1867. (letter from John Austen, The Field, May 11 1867).

Two salmon from the radio-tracking programme on the Avon were observed in the Tarrant in December 1986 in a spot check. The first was a two-sea-winter fish which was netted at Mudeford and tagged on June 3 that year, when it weighed 10.5 lb. It passed the automatic listening station at the tidal limit at Iford on June 18, and was located by on-foot search near Longham road bridge on occasions between August 4 and October 6. It was again recorded at Iford on October 27 and 28. It was last located by an on-foot search on December 19 upstream of Tarrant Rushton at NGR ST 937 062 (Figure 1).

The second was a grilse tagged on June 13 at Mudeford. It was recorded by the Iford automatic listening station on June 16, and not recorded again until found by an on-foot search on December 19 at NGR ST 938 064 (about 200 m upstream of the other radio tagged fish located – Figure 1).

Of the 15 radio-tagged salmon tracked extensively in the Stour between 1986 and 1990, five (33%) were recorded passing, or were observed upstream of, Shapwick. It is quite possible that all these fish entered and spawned in the Tarrant (two were located by foot searches there as detailed above).

As already described, the Tarrant has a long history of fish being trapped by falling flows, to die or be rescued and transferred elsewhere. More detailed notes are available from the EA for more recent years. The EA were able to supply brief details of the fish recued in seventeen years since 1995 (were these the only years when rescues were mounted?). Salmon were reported among the fish rescued in only five of the seventeen years (2010, 2016, 2018, 2021, and 2022). It is interesting to note that salmon were recorded in five of the ten years since 2010, but not once in the seven years before that.

In conclusion, spawning salmon and juvenile salmon have been recorded in the Tarrant on many occasions over the past 160 years. It is suggested that they have spawned, and continue to spawn, within the stream in most years. Salmon generally spawn in the stream, and general reach of the stream, from which they themselves originated, ie they represent a discrete sub-stock representing a specific zone of the catchment. If this stock is denied access to the zone eg by drought flows, they will spawn somewhere fairly close though generally the output from that year-class will be significantly reduced eg by competition with another sub-stock. In fact, the sub stock, if in an otherwise healthy state, can withstand the complete failure of a spawning year-class as the spawning stock is typically made up from individuals born in up to four separate years (one and two year smolts, one, two and three sea winter adults), but a series of poor spawning years can add up to being disastrous. Another factor that can "rescue" a juvenile year-class from drought effects is the tendency of the parr to drop downstream about six months before the smolt emigration, to occupy territory less likely to be adversely affected by drought. This appears to be a functional migration over and above the "stream evacuation" procedure followed by (or partially followed by) juvenile trout in winterbournes, and may take place due to stimuli well short of the "stream is failing" signal needed to shift the latter species. This may explain why salmon are recorded in relatively few of the Tarrant fish rescues.

5.3. Salmon in the Stour

While there was little angling for salmon in the Stour before the 1870's, fish were recorded from the river over many years. In 1866, John Austen of Ensbury House[40] wrote a long letter to the Dorset County Chronicle describing the history of the Stour as a salmon river, and making suggestions for its restoration. He described how there were many salmon forty to fifty years earlier; for example catches of up to 25 fish in a single haul of a net below Throop

[40] Ensbury is a small village on the Stour near Kinson, between Throop and Longham.

Weir, although they had been purposely penned there by aggressive operation of the sluices. His grandfather had also netted at Ensbury. Strong summer weed growth, including rushes growing from bank to bank, meant that most fish remained for many months seawards of Wimbourne, where they were vulnerable to poachers (for example just upstream of Longham, where the fish remained for long periods in "congenial pools" and were seen jumping frequently). He suggested that many salmon spawned in the Tarrant, and quoted the gardener at the rectory at Tarrant Keyneston, as saying that *"the old salmon came up the stream during the months of November and December, and spawned in the shallows".* Austen stated that millers at Keyneston and Spetisbury annually received a present from Christchurch to ensure their turning free the salmon fry which were caught at the eel traps at those mills. Although Austen suggested that salmon stocks were reduced by the time he was writing, they were still ascending the Stour. He reported catching two in his net at Ensbury in 1866 weighing 14 and 31 pounds, and on June 10th and 22nd that year heavy fish were seen struggling up the shallows at Longham.

There was an interesting correspondence in "The Field" in April 1867, enlivened by the ill-informed statements by well-known fishing journalist and artist John Greville Fennel that the Stour was not, and never would be, a viable salmon river. This brought more evidence from John Austen and other correspondents, including "E.P" who wrote:-

I have lived on the banks of the Stour for the greater part of my life, and have taken my share in the attempts to carry out on the Stour contemplated by the salmon Acts of 1861 and 1865, and I can tell you that, far from its being the fact that "very few if any" salmon go up the river, there have always been fish passing up to the best of their ability through the many obstructions on the river. The men at the mills on the lower part of the river would tell "Falcon" (another doubter with respect to the Stour) *that the "fish have not rejected the Stour as quite unsuitable;" and I know that fish came up this season to spawn in the Tarrant below Blandford."*

The lack of rod catches at that time is very interesting. The difficulty of passage, due to mills and the overgrown nature of the stream, may have stopped the fish from distributing through the middle reaches until the autumn. Although there were a number of fish passes, they were considered to be of poor design and ineffective (Anon 1874). A fish of 32lb, caught in March 1872 below Throop Weir, was suggested to be the first ever to be known taken by a rod there. Grimble (1925) suggested that this capture was in fact made in 1873, and that it resulted directly from the owner of the Throop fishery, Lord Malmesbury, having cut a way through the rushes from the tidal limit at Wick all the way to Throop, a total distance of the order of 10 km. Susan, Countess of Malmesbury, writing in 1895 suggested that work to extract iron ore at Hengistbury Head around the 1870s altered the gravel bars at the mouth of the joint estuary of the Stour and Avon and made entry to the Stour much easier for the salmon. Whatever the reasons, angling catches became much more abundant; *"the Stour, in that part of it only which lies between Iford and about a mile above Throop Weir, now began to produce about eighty fish in a season….. the fish were mostly very heavy and in splendid condition"* (Malmesbury, 1895). Grimble (1913) stated that the average weight of salmon

caught on this fishery was 21¾ lb. The largest fish he reported were 36 and 40 lb. Wentworth (undated, about 1960) records a Throop fish of 42½ lb caught by S W Tomkins.

The reported annual rod catch for the Stour, from 1908 to 1992, is shown in Figure 3. From 1993 onwards the Stour catch was no longer listed separately, and is believed to have been minimal.

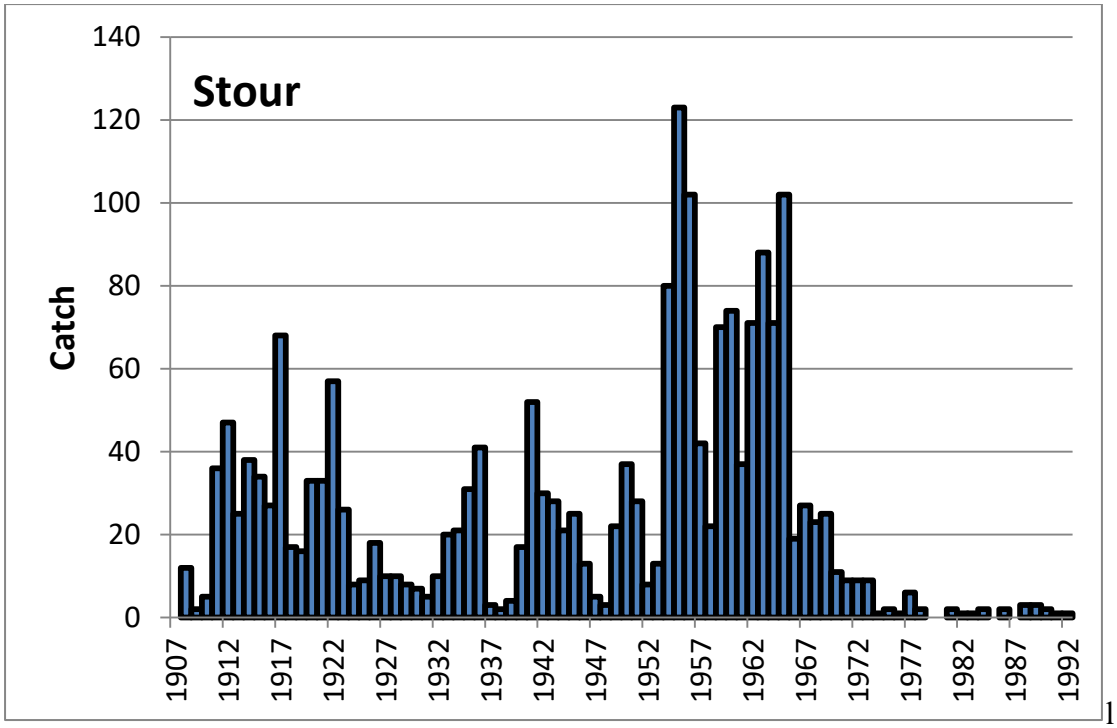


Fig 3. Annual declared rod catch of salmon from the River Stour, 1907-1992. Sources:- Bledisloe (1961) for 1907-1959, and Russell *et al* (1995) for the later figures.

In the 1960's, well-known coarse fisherman Dave Steuart fished for salmon in the Wimbourne area (Julian's Bridge) during the coarse fishing close season. He averaged of the order of one fish per two trips. The fish were there to be caught by someone who knew where they were and how to go about targeting them.

The radio-tracking investigation on the Avon in 1985-90 (Solomon *et al* 1999) provided some insight into Stour salmon. A total of 437 adult fish were netted, fitted with radio transmitting tags, and released at "The Run" at the mouth of the joint estuary of the Avon and Stour. Although the focus of the study was the relationship between flow and salmon migration in the Avon, the opportunity was taken in some years to locate recording equipment on the Stour. The following is reproduced from Solomon *et al* (1999):-

In 1986, three tagged fish were located well up the Stour system by spot checks. Five others were recorded at or just seawards of Iford Bridge, and in the absence of an ALS (Automatic Listening Station) network upstream of Iford in that year it is not possible to say whether any or all ascended the river further. Given the limited scale of the search that located three fish, it is likely that more had in fact ascended the river. In 1987, five tagged fish were recorded in the river by the five ALS located there. Again in 1988, five fish were recorded having

penetrated well into the system. In 1989, only two were recorded well up the Stour, both having first ascended some way up the Avon. No fish were recorded in the river above the tidal limit in 1990, though many fish were recorded in the tidal reaches from Iford Bridge downstream.

The small numbers of observations preclude detailed analysis, though generally the pattern of movements in the Stour appears to be broadly similar to that on the Avon. Some fish ascend the river to the Wimborne area in their initial migration in the summer, but many do not enter the river until the autumn. The river has a lower base flow than the Avon, and Stour fish appear even more vulnerable to the problems of low flow and associated poor survival in the estuary. The low numbers of fish entering the river in the dry years of 1989 and 1990 were, it is suggested, as a result of virtually the whole run being denied access to the river during the summer. Of the two ascending in 1989, one had in fact spent the summer/early autumn in the Avon, upstream of Knapp Mill. In October it continued up the Avon to Ringwood area, before returning seawards and ascending the Stour, where it was recorded by successive ALSs up to Shapwick.

It appears that the potential run up the Stour in the years of the study was of the order of a few hundred fish per annum. In average to wet years, many of these fish ascend the river in the summer, and exhibit a high survival. At lower flows, an increasing proportion appear to remain in tidal water through the summer, where they experience a high mortality in the same manner as the Avon fish exhibiting the same behaviour. However, as the Stour is more prone to low flows in dry years, the impact on the well-being of the stock appears to be greater, with an overall very low survival in 1990. Summer passage past Throop gauging station was associated with flows in excess of 5m³/sec. It is stressed that these observations are based on relatively few data.

Although the ALS array gave a fair picture of the dispersion of fish through the Stour system, the small numbers involved did not justify extensive foot searches to locate spawning areas. Of the fifteen fish, five were recorded passing/having passed upstream of Shapwick, five more passed Canford, four more passed Throop, and one remained downstream of Throop. In addition to the main river, the main spawning tributaries are considered to be the Tarrant (upstream of Shapwick – two tagged fish were located here in 1986), the Allen (between Canford and Shapwick – one tagged fish was located here in 1986) and the Moors River (downstream of Throop).

The 15 radio-tagged fish recorded upstream of the tidal limit on the Stour compare to the 262 detected passing the tidal limit on the Avon. This suggests that the Stour run of fish was of the order of 6% of that on the Avon. Based upon the calculation of a mean run into the Avon in the years of study of 3,467 fish (mark-recapture calculation on the tagged fish), the mean run on the Stour for those years is calculated at about 200 adults. The total reported rod catch for those five years combined was just ten fish, indicating a rod exploitation rate of around 1%. This contrasts with a calculation of 15.6-19.3% for the same five years on the Avon.

The Environment Agency and its predecessors have conducted a long time series of fisheries surveys (by electric fishing) throughout England and Wales, including the Dorset Stour. The locations and results of this monitoring programme are available on-line on the National Fisheries population Database (NFPD; website address https://www.data.gov.uk/dataset/823e7de7-33a2-4fc6-9a79-4c7672130094/freshwater-fish-surveys-nfpd). A total of 120 sites in the Stour catchment have been involved, including those sampled only once or just occasionally, in addition to those that are fished regularly. These sites are spread throughout the main river and the tributaries. Of the 120 sites, 37 have yielded juvenile salmon on one or more occasions. Most of these are on the main river, or on the River Allen and Tarrant. None were located upstream of Blandford, so salmon spawning has been limited, in recent decades at least, to the lower half of the Stour catchment. Only one site has been sampled more than once on the Tarrant; the results for this are described elsewhere.

In summary, it would appear that the Stour has had a small run of salmon for hundreds, probably thousands of years, persisting up until the present. This is likely to be genetically distinct from the stock in the Avon and other surrounding rivers, and genetically adapted to the conditions prevailing in the Stour. The main spawning areas appear to have been the main river between about Longham and Blandford, and the chalkstream tributaries the Tarrant, Allen and Moors River (River Crane). The Stour stock would appear to be particularly depressed at present (no rod catch, few reports and southern stocks generally under great pressure), and is likely to be reduced to a few tens of individuals each year. In these circumstances the fact that salmon are persisting in the Tarrant (juveniles present in both the last two fish rescues) means that this tributary might be disproportionately important to the future of the Stour stock, and would warrant particularly sensitive management.

6. River Tarrant and the Water Framework Directive (WFD)

The Tarrant and its catchment represent the entirety of a single WFD waterbody. Some extracts from the entry in the DEFRA catchment Explorer website are shown below.

Classification Item	2019	2022
Ecological	**Poor**	**Poor**
Biological quality elements	**Poor**	**Poor**
Fish	**Poor**	**Poor**
Invertebrates	**High**	**High**
Macrophytes and Phytobenthos Combined	**Good**	**Good**
Macrophytes Sub Element	**Good**	**Good**
Physico-chemical quality elements	**High**	**High**
Ammonia (Phys-Chem)	**High**	**High**
Dissolved oxygen	**High**	**High**
Phosphate	**High**	**High**
Temperature	**High**	**High**
pH	**High**	**High**
Hydromorphological Supporting Elements	**Not high**	**Not high**
Hydrological Regime	**Supports good**	**High**
Chemical	**Fail**	**Does not require assessment**
Priority hazardous substances	**Fail**	**Does not require assessment**
Benzo(a)pyrene	**Good**	
Dioxins and dioxin-like compounds	**Good**	
Heptachlor and cis-Heptachlor epoxide	**Good**	
Hexabromocyclododecane (HBCDD)	**Good**	
Hexachlorobenzene	**Good**	

RNAG in Tarrant with fish classification element

Cycle 3

ID	SWMI	SWMI certainty	Activity	Activity certainty	Category	Category certainty	Business sector	Classification element
669434	Physical modification	Confirmed	Barriers - ecological discontinuity	Confirmed	Other	Confirmed	Not applicable	Fish

Objectives

Classification Item	Status	Year	Reasons
Ecological	**Poor**	2021	Disproportionately expensive: Disproportionate burdens
Biological quality elements	**Poor**	2021	Disproportionately expensive: Disproportionate burdens
Fish	**Poor**	2021	Disproportionately expensive: Disproportionate burdens
Invertebrates	**Good**	2015	
Macrophytes and Phytobenthos Combined	**Good**	2015	
Physico-chemical quality elements	**Good**	2015	
Ammonia (Phys-Chem)	**Good**	2015	
Dissolved oxygen	**Good**	2015	
Phosphate	**Good**	2015	
Temperature	**Good**	2015	
pH	**Good**	2015	
Hydromorphological Supporting Elements	**Not high**	2015	
Hydrological Regime	**Supports good**	2015	
Supporting elements (Surface Water)	**Not assessed**	2015	
Specific pollutants	**Not assessed**	2015	
Chemical	**Good**	2063	Natural conditions: Chemical status recovery time

It will be seen that the fish assessment is “poor” for both 2019 and 2022; this in turn forces the Biological Quality Elements and the Ecological Assessments, of which fish form part, to be “poor” also on the “weakest link” principle. This highlights one of the weaknesses in the WFD process, which confuses the “reasons” for failure with the “causes” of the failure. The EA was approached for clarification of the RNAG for fish and the response was that the

failure was driven by the lack of minnows and stone loach in the fish survey at Charlton Cottage in 2018. Oddly, in the table which accompanied the response, there were several other species that were recorded as absent, but which were allocated higher "expected density" scores than minnow and stone loach; these included roach, pike, perch, lamprey, gudgeon, grayling, dace, chub, and even rudd and bream! It must be said that none of the other absent species had a higher "expected prevalence" score that the minnow and stone loach; the significance of the difference between "expected density" and "expected prevalence" is obscure.

In 1969, Le Cren wrote of a survey site just 500 m upstream of the Charlton Cottage site; "this must be one of the highest levels of natural fish production so far recorded". Species present were trout, salmon, bullhead, minnow, three-spined stickleback, stone loach, eel, brook lamprey and pike (though still no bream or rudd!). This is indicative of a productive, balanced community of fish occupying a perennial reach of stream. This situation would surely have warranted a "High" fisheries assessment. Fast forward to 2018, the year of the survey used for Tarrant WFD fish assessments in recent years, and the population is judged as "Poor". This would appear to be a valid assessment, albeit based upon a rather strange criterion of a lack of minnows and stone loach.

The "Reason for not attaining Good" (RNAG) since 2018 is given as "Barriers – ecological discontinuity". This is assumed to refer to the problem of fish becoming stranded as parts of the stream dry out. Thus this, coupled with the Hydrological Assessment of "Supports Good" (2019), and "High" (2022), overlooks completely the probability that decreased streamflow (for whatever reason, abstraction or increased bed leakage) is implicated. Further compounding of this very unsatisfactory situation comes from the fact that the "Objective" for fisheries is given as poor for the reason "Disproportionately Expensive; Disproportionate Burdens". This suggests that the Environment Agency (which is responsible for administering the WFD) considers the situation to be as good as it is going to get, and that no further action can be justified. This is clearly a quite unacceptable situation.

What has changed since the halcyon days of the 1960s and the suggested "High" fisheries status? One thing that has changed very little is the physical barriers to fish movement. Most are in the form of old mill and watermeadow weirs, and deeper parts of the stream bed, either natural such as the usual pool and riffle configuration and deeper glides on the outside of bends; or left over from long-discontinued agricultural activities such as milling and meadow-watering. The main thing that has changed is the flow regime of the stream, making flow much less reliable and causing much more frequent and extensive drying-out, leading to major harm to the fish community. It is suggested that the hydrological regime should be marked as "poor" or "bad", and not "supports good" (2019) or "high" (2022).

7. Summary of historical evidence of flow deterioration

The historic and fisheries evidence of the deterioration of river flows is summarised below, with cross references to the relevant report sections:

1. **Old press reports**. Local press reports from 1929 and 1933 refer to drying-out of parts of the upper Tarrant in the years of exceptional drought. In 1929 one report said that *"the villagers are having the unique experience of walking over the bed of the rivulet at Tarrant Monkton dryshod, a circumstance without parallel for a very prolonged period"*. This is nowadays an annual phenomenon. No mention is made in these old press reports of drying-out of the lower river; if it happened, it would surely be a more newsworthy story than drying of the upper reaches. (Section 2)

2. **Long-term residents' observations**. A lady resident in Tarrant Monkton stated that in the 50s and 60s there was enough water for children to paddle of even swim; but "now" (1997) it dries there almost every summer. There are a number of other similar observations. (Section 2).

3. **NRA historical summary**. This note was penned by NRA geologist Dr William Stanton in about 1991, and included the statement that "in exceptionally dry years the river is dry just above the confluence with the Stour". In contrast, this reach has dried out in eight of the past nine years. (Section 2).

4. **Water mills**. Clearly watermills require a reliable supply of water to function effectively; there have historically been several on the Tarrant in the past thousand years. Tarrant Abbey Mill, in the lowermost reaches of the river, incorporated extensive river engineering for the head-race, and a brick-built building. Nowadays, the flow here is intermittent; in eight of the last nine years the river here has been dry for a period ranging from 46 to 140 days, with a period of low flow before and after this. This would not be a good basis for operation of a mill. (Section 3).

5. **Fish rescues**. Fish rescues have been mounted in most of the last 20 years, with numbers of trout being saved from pools on the drying stretches ranging from a few to more than 2000. There appear to have been many fewer such rescues required fifty years ago. One major rescue was reported in September 1961, with a smaller operation a year later. These were the only rescues mentioned in the very detailed fishery sections of the River Board/River Authority Annual Reports between 1951 and 1974 (Section 4).

6. **Juvenile fish surveys**. The Water Framework Directive fish status of "Poor" is based upon the lack of minnows and stone loach at the site downstream of Tarrant Rushton used for assessment. The EA suggest that this is due to obstructions to upstream movement preventing recolonisation following eradication by low flows. A nearby site investigated by the Freshwater Biological Association in the early 1960s showed a good mixed fish community (including minnows and stone loach), was said by one of the researchers as representing *"one of the highest levels of natural fish*

production ever recorded". The presence of topographical features representing potential hindrance to up and downstream migration has changed very little in the past sixty years. The deterioration of the fish community from showing "one of the highest levels of natural fish production" to "Poor" is shocking and almost certainly due to the deteriorating flow regime (Section 5).

Annex 1 – WI Stanton (NRA) note on Tarrant history

RIVER TARRANT - HISTORICAL SUMMARY

1926	"In the Tarrant Valley, the water level is close to ground level, and good supplies may be got by sinking shallow wells. 'Winterbourne' conditions exist in this area .... The Tarrants cluster along the small stream .... They all get adequate supplies of good water from shallow wells in the chalk ..." (Wells and Springs of Dorset, pp 17-18).
Pre-1946	In very wet weather River Tarrant rises up-valley of Stubhampton. A well at Stubhampton Farm, 400m d/s of Stubhampton borehole, overflows.
1946	Stubhampton borehole drilled to 142m depth (Chalk and Upper Greensand) but because "fine sand" was drawn from the U.Gs it was plugged with concrete and gravel below 78m depth. All the water then came from the chalk. Borehole No 2 was drilled to 72m depth.
1948	June. Test pumping for 7 days at 2.2Ml/d of the Stubhampton borehole produced water that showed a "very moderate degree of pollution", thought to be domestic effluent from 3 cottages, the closest 60m from the borehole. A well in the chalk at this cottage was severely polluted. (Chemist's report to Shaftesbury Rural District Council, 1950). The test pumping also showed that the water table in the chalk sloped down towards Tarrant Gunville, and that the pumping formed a cone of depression of 900m radius. Pumped water sank into the dry bed of the River Tarrant within a few metres of the discharge point.
1950	Stubhampton borehole authorised to supply 2.2 Ml/d, but not in use because of pollution. Water supply to Shaftesbury Borough limited to 11 hours per day.
1951	Engineer's report says the Stubhampton borehole site was chosen as best to supply both Tarrant Valley and the Shaftesbury area. The Tarrant Valley demand was estimated at 0.41 Ml/d, to be supplied by gravity as far as Tarrant Crawford.
1951	Population of Tarrant Valley (including Farnham and Chettle) estimated to be 1400. Built environment consists of 305 houses, 29 farms, 9 churches, 4 public houses and 7 other buildings (Sanitary Inspector's report to Public Inquiry).
1952	January. Public inquiry held into Tarrant Valley water supply scheme. Evidence of Senior Sanitary Inspector, Blandford RDC, shows that all villages are supplied by private wells or small estate or farm wells. There is no mains sewerage. Effluent from Blandford Camp discharges into the Tarrant Valley between Tarrant Monkton and Tarrant Rawston. 45 raw water samples were taken in the Tarrant Valley, 1950-51, and only 28 were bacteriologically satisfactory. Severs laid to take domestic effluent from Stubhampton to treatment works at Tarrant Gunville.
1957	Regular abstraction begins from Stubhampton boreholes.
1966	Stubhampton boreholes abstraction of 2.2 Ml/d, 796 Ml/a given Licence of Right under Water Resources Act 1963.

WPC2/5206/4

1968 Poole and East Dorset Water Board construct 2 boreholes at Shapwick, (152m and 107m deep, in chalk).

1969 October 12-27 Shapwick boreholes test pumped at c.9.6.Ml/d.

1970 Shapwick boreholes test pump report says the Tarrant "in its upper reaches is a winterbourne drying annually u/s of Tarrant Monkton and in the drier years u/s of Tarrant Rushton. In exceptionally dry years the river is dry just above the confluence with the Stour, although there may be some flow between Tarrant Rushton and Tarrant Keynston". This refers to the Tarrant as known in 1969. Testing appeared to show groundwater flowing beneath the Tarrant to the Stour. The report also says that "although the cone of depression extended as far as Tarrant Keynston; the Lower Tarrant would not be greatly affected because it is already influent" (ie loses water into its bed). (NRA would not agree with this statement).

December. Shapwick boreholes licensed to abstract 9.1 Ml/d, 3319 Ml/a.

1971 West Wilts Water Board granted temporary licence to abstract an extra 0.32 Ml/d from Stubhampton boreholes to meet growing demands (to lapse after 3 years).

1973 Heavy rain causes flooding at Stubhampton.

7 September. Tarrant Valley Water Protection Association (TVWPA) formed, states that the River Tarrant is/was a good breeding river for trout and sometimes salmon. TVWPA argues it is wrong to abstract water high in the valleys and pipe it to coastal towns or out of the catchment area. Increased pollution of streams and rivers calls for greater, not smaller flows if the water quality is to be maintained.

1974 West Wilts Water Board advises TVWPA that Stubhampton abstraction is back to original licensed amount.

1989 Extremely dry summer. On 15.08.89 NRA noted the Tarrant rising at Tarrant Monkton, increasing to Tarrant Keynston, then shrinking to almost zero flow at confluence with River Stour.

1991 12 valid private water abstraction licenses in Tarrant Valley, 11 groundwater, 1 river water (spray irrigation), totalling 1.5 Ml/d, 108 Ml/a.

W I Stanton

WPC2/5206/3

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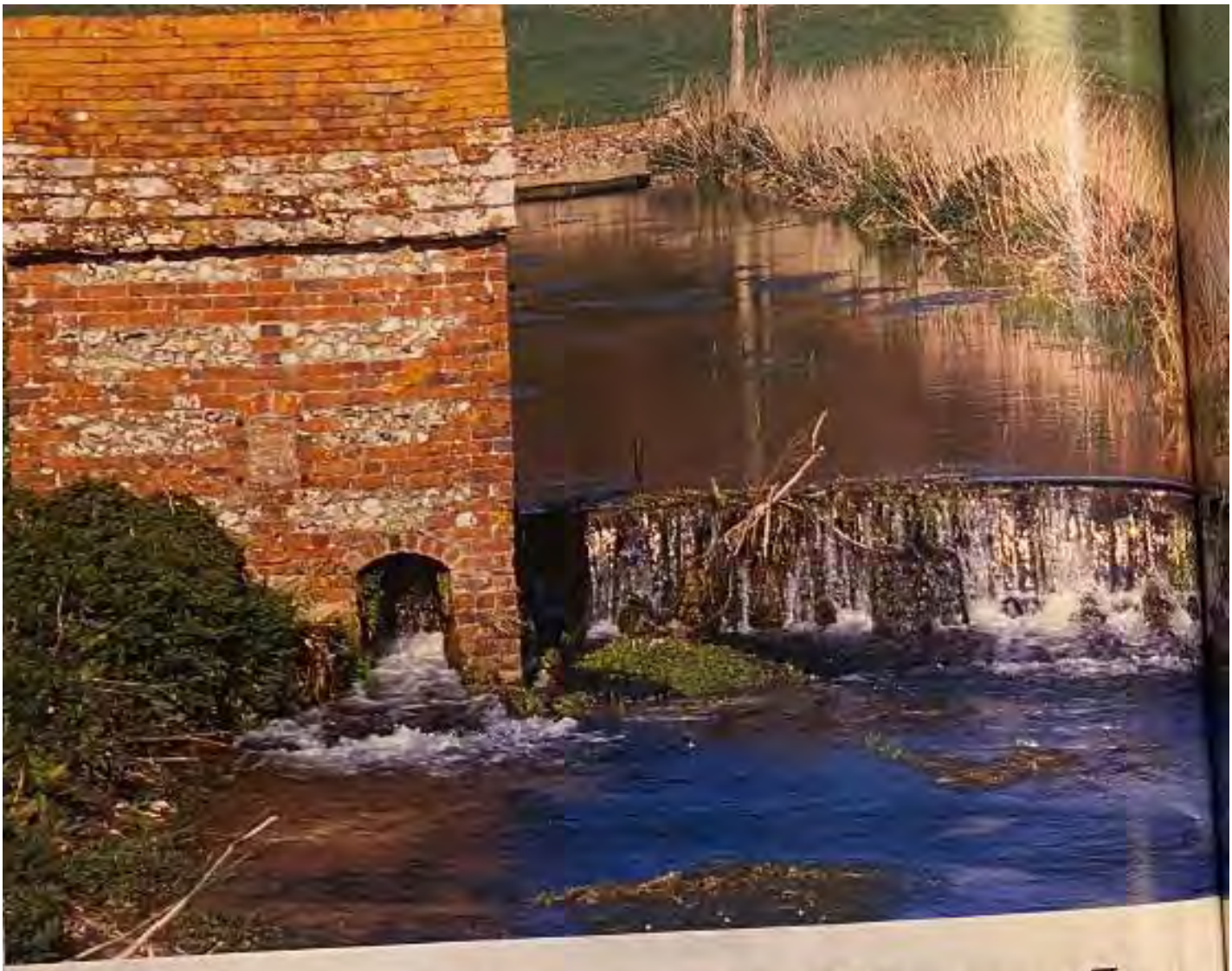
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Appendix B – Article on Tarrant from Field magazine, 1997



A Land Where No Water Is

England's rivers are being sucked dry. Victoria Warren highlights the problem with a case study of Dorset's River Tarrant

TWO summers ago, when a small chalkstream in Dorset dried up almost completely, it was hardly news. Nevertheless, while all the media attention was focused on the drought in Yorkshire there was quiet despair in the Tarrant valley as water vanished into the river-bed. What is most upsetting is that this sight, once rare, has now become almost normal. Similar stories are emerging all round the country and there seems to be little that anyone can do about it.

Charles Rangeley-Wilson had fly-fished the Tarrant for three years. Nothing, let alone the wet winter which preceded it, could have prepared him for the August before last. "The farmer phoned to tell me that there had been a fish-kill of 50 or so. I went to the river immediately and found them lying below the water splash. For several days I tried to move as many surviving trout as possible downstream to the Stour. During the three wet years I had known it the Tarrant had been glassy and full of healthy weed growth – at its worst just low, overgrown in July and August. Now the pools had become puddles of mud with 2lb or 3lb trout hiding in black liquid a few feet wide."

The Tarrant is a tributary of the Stour which runs east of Blandford for up to 15 miles through a beautiful, green valley. Tarrant Gunville, Tarrant Hinton, Tarrant Launceston, Tarrant Monkton, Tarrant Rawston and Tarrant Rushton testify by their names to their long-standing dependence on the little river. Once, with its



where flocks of lapwing used to breed. There were kingfishers, water voles and other wildlife. All of this has now been destroyed."

She is not alone in her memories of a different River Tarrant. John Bugg, a farmer in the valley at Tarrant Monkton since 1939, cannot recall the river drying up in summer before the Sixties. "They tell us now that the river naturally dries up in summer, but the Tarrant was never a winterbourne except in its uppermost reaches." After mains water arrived his 24ft well dried completely. It used to supply all the farm's needs.

Jim Strange, another Tarrant farmer, has known the stretch at Tarrant Launceston since 1933. He remembers how, before 1950, it was occasionally low enough to kill trout, but since about 1970 there have been no trout there at all. Now the river dries, not as it used to, but fully and very suddenly. It disappears every year within a week. "No one thought back then," he says, "that the pumps could have been so powerful or the pipes that big, to take so much water away."

"No one thought back then that the pumps and pipes could be powerful enough to take so much water away"

A borehole upstream at Stubhampton began to abstract the groundwater which feeds the river when mains water arrived in 1957. In 1979 further abstraction started from two more boreholes at Shapwick, below where the Tarrant meets the Stour. Together these boreholes are licensed to remove 11.3 million litres per day.

"It is definitely abstraction which kills this river," says Rangeley-Wilson. "I know at least three other small Dorset chalk-streams which stay healthy all summer: the Cerne, the Sydling and the Fontmell Brook, none of which is abstracted."

The Tarrant Valley Water Protection Association (TVWPA) was founded in 1973. Far from objecting to all abstraction, it argued with the local water authority that it was wrong to take water from the top of the river system out of the catchment area to coastal populations and elsewhere. Since that discussion started, the responsibility for guarding the water environment was passed on to the National Rivers Authority which became part of the Environment Agency (EA). Now, 24 years later, not only is the abstraction continuing exactly as before, but no official body will say that it is damaging. Geoff Hardwicke, EA Area Water Resource Manager, who was sent to address the TVWPA in April last year, could tell the members neither how much water was actually being abstracted nor where it was being pumped to. In 1991 an EA hydrometric investigation began taking the river flow measurements once a month (nowadays, when the river dries it does so within a week), and only the events of the summer of 1995 persuaded the investigation team to intensify monitoring and make groundwater measurements continuous near the two abstraction points.

The people who have known and watched the river are not scientists, and while any ▷





There is no abstraction from the Fontmell Brook (right) but the abstracted Tarrant (above and far right) can dry completely in a matter of days

wells, it comfortably supported 15 dairy herds and a more permanently resident population. Rose Mainwaring-Burton, who has lived there since 1951, remembers what the river was like as far upstream as Tarrant Monkton where it now dries every year.

"During the Fifties and early Sixties the river flow remained high enough in the summer months for our children to paddle and even swim in it. We had a boat which gave endless pleasure. Fish were abundant, and one of the games was to drive the trout upstream to the pipe under the splash and catch the largest as they came through. At that time people would go to watch the salmon jumping the weir at Tarrant Keyneston. Salmon redds were observed and the Tarrant was claimed to be the best trout breeding ground for the Stour. The water meadows provided an early bite,

number of measurements could now be taken, there will never be any data from the past with which to compare them. The original authorities were supposed to prove before they pumped that the process would do no harm. Thanks to their neglect, the situation has now become open to interpretation. To local people the low flows, faster and more frequent drying of the Tarrant and the downstream shift in its spawning salmon all fit the picture of a river suffering from abstraction; but then each symptom can also be explained away by some other factor.

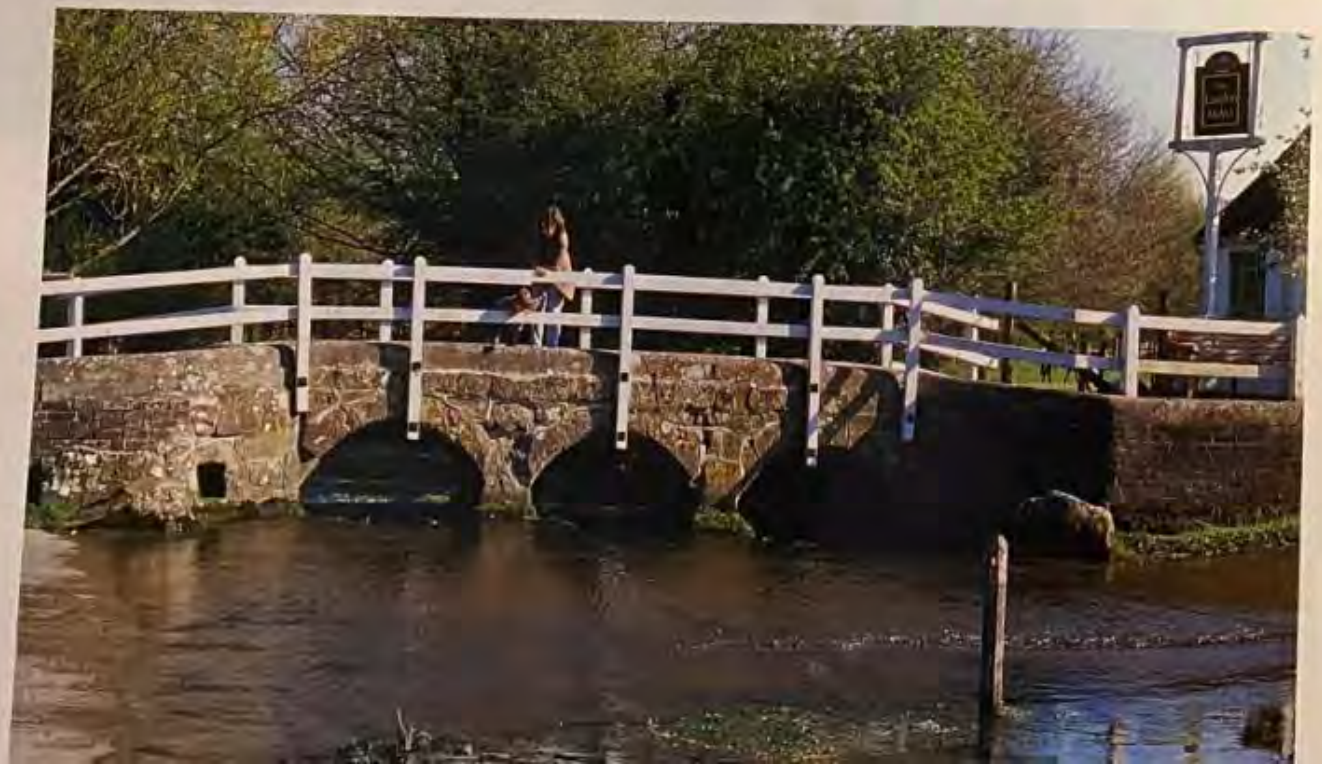
"River maintenance and land use have changed a lot over time," says Hardwicke. "You can swim in water flowing at only one litre per second if you use railway sleepers to make a pool. Water levels can be deceptive and the important factor is water flow, which is much harder to measure."

The reduction in salmon numbers is part of a general trend in the Stour system and throughout the southern chalkstreams. The few fish to spawn in the Tarrant now are seen only in its lower reaches. I asked Dr Graham Lightfoot of EA's south-west region whether abstraction might have been responsible for this change. It might, he agreed. However, the end of upstream spawning "could be for any number of reasons. Salmon tend to spawn where they were spawned; it is possible that the only fish to have survived the drop in numbers just happened to be fish who were spawned downstream." He could not then think of any of the other reasons.

Richard Slocock, who runs a fishery on another Dorset chalkstream, the Piddle, knows how long the process of proving damage can take. He campaigned for 12 years and finally won. Six years ago computer models were made to demonstrate what the abstraction does to flows in the river. Two separate graphs clearly illustrate how the Piddle follows the same pattern annually of high and low flows whether abstracted or not, but the second graph, tracing the flow of the river under its abstraction regime, is lower at every point than that of the natural river and always crashes into the horizontal axis in summer when the first graph hovers just above it. Put simply, this means that abstraction causes the River Piddle to dry up completely in August or September when otherwise it would be low but not dry.

"And that seemingly small difference," says Slocock, "is absolutely crucial, because it is the difference between species of plant, insect and fish life living or dying. The river's ecology will change with its flow regime and





The Tarrant flowing through Tarrant Rushton (right) and Tarrant Monkton (below) once supported 15 dairy herds. Nowadays its trout need to be rescued





there are rivers in Kent, for example, which because of abstraction are now simply no longer chalkstreams. It is only because we made such nuisances of ourselves that we stopped the same happening to us." The case against abstraction has been proven, though only, it seems, for that one river.

In the meantime, while the TVWPA is being kept quiet by the long, drawn-out process of scientific research, the researchers themselves are manacled by the restricted powers of the EA. In the unlikely event of their being able to prove "significant damage" to the Tarrant, what can the EA do? "We can either start negotiations with Wessex Water or use our authority to revoke their licence to abstract. Unfortunately, in the latter case we run up against problems because the water is still going to have to come from somewhere and, what is more, Wessex Water can claim compensation for their losses," says Hardwicke.

Proving that the damage from abstraction is significant is clearly the less comfortable of the two possible conclusions of research because it means that the EA would have to solve the problem. Four years of protracted negotiations with Wessex Water about the Piddle have led to elaborate and costly systems to limit some of the pumping at times of low flow, and put compensation water back into the river. Slocock is pleased with the results but resigned to the fact that, "When you analyse everything they are doing, all it really means is a guarantee that the flows shouldn't get any lower than they are already, but at least that's something."

Hose lock sales soar as an increasingly affluent society leaves the plates in the new dishwasher and takes up gardening

Neither negotiation nor compensation looks pleasant for the EA, so it is in its interest to prove that the Tarrant is in a healthy state, scientifically rubber-stamping an end to the discussion. The more positive alternative is for the EA to avoid reaching either conclusion and to recommend further research, thus stalling the argument, keeping itself busy and appearing to be doing something. Meanwhile, time may be running out for the river's ecology.

The memories of people in the Tarrant Valley are largely being discredited. The picture seems to be getting less clear for everyone as they weary of the issue and give in to the view that the experts know best. But the scientists involved are not working from a neutral position. It is the job of the EA both to prove the damage and to deal with it, without having much power to do so.

The experience of the Tarrant Valley community would be just as affecting if they were exceptional, but they are not. There is a larger national water crisis brewing. Dry winters seem set to happen more often, and it is not just the climate which is changing.

In four years hose lock sales have doubled, as an increasingly affluent society leaves the dirty plates in the new dishwasher and takes up gardening. When the population has spread itself out over the next 20 years, to fill 23 per cent more houses than now, each person will be using more water than ever before. By 2021, Wessex Water expects consumption to have increased by 45 per cent over its 1990 level. Water companies have to plan ahead to deal with the upsurge in demand as new sources take between 10 and 20 years to develop. With Ofwat to guide them, they are certain to want to abstract their maximum allowance from the licensed boreholes they already have before spending money on expensive, environment-saving alternatives.

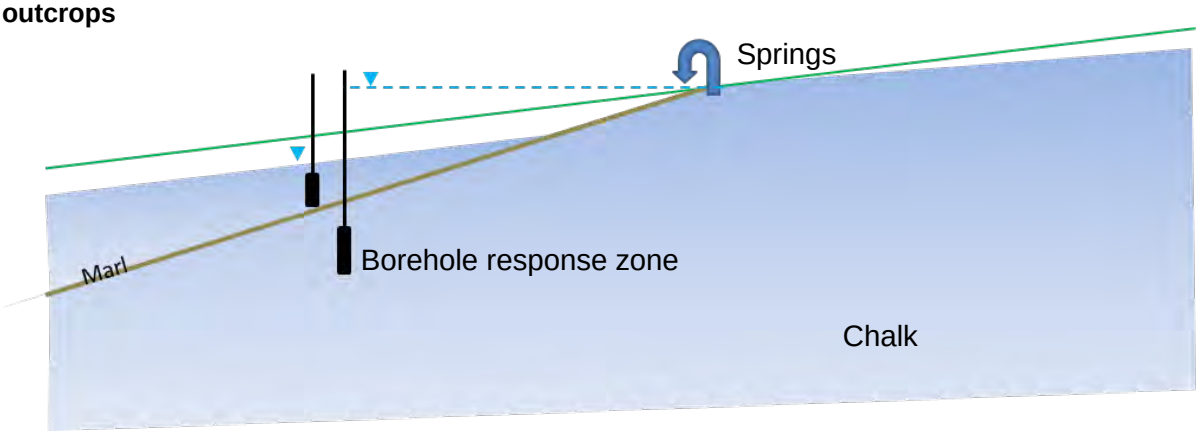
The River Tarrant dried downstream again last year and local people were splashing in the mud to rescue the many brown trout which as yet persist in believing that it is not a winterbourne. Simultaneously, a consultant who had been analysing data collected by the EA was recommending further study and, according to Hardwicke, the conclusion of the research so far is that: "There is no clear indication yet of groundwater abstraction significantly affecting surface flows in the Tarrant." □

Appendix C – Extracts on determining abstraction zones of influence from Middle Stour Tributaries report

2.8.2 AMP6 investigation – Tarrant valley boreholes

Winterbourne surveys were undertaken between 1974 and 1991 and more recently as part of this AMP6 investigation, as described in Section 2.7.1. These indicate that during the spring months there are longer-lasting springs at Tarrant Gunville and during summer there are long-lasting springs at Higher Dairy, just north of Tarrant Launceston i.e. the winterbourne head 'holds' at these locations for a period of time, even though the stream flow is recessing. A hypothesis to explain this behaviour was that outcropping marl seams within the Chalk may impede the south-easterly flowing groundwater so that the water backs up and forms springs. This is illustrated in Figure 2-15.

Figure 2-15: Schematic cross-section to show hypothesis of springs occurring at marl outcrops



Two new boreholes were drilled within the Tarrant valley, one at Tarrant Gunville and another at Tarrant Launceston (locations shown on). Geological logging indicates that the Tarrant Gunville borehole was drilled entirely within Seaford Chalk. No marls were found.

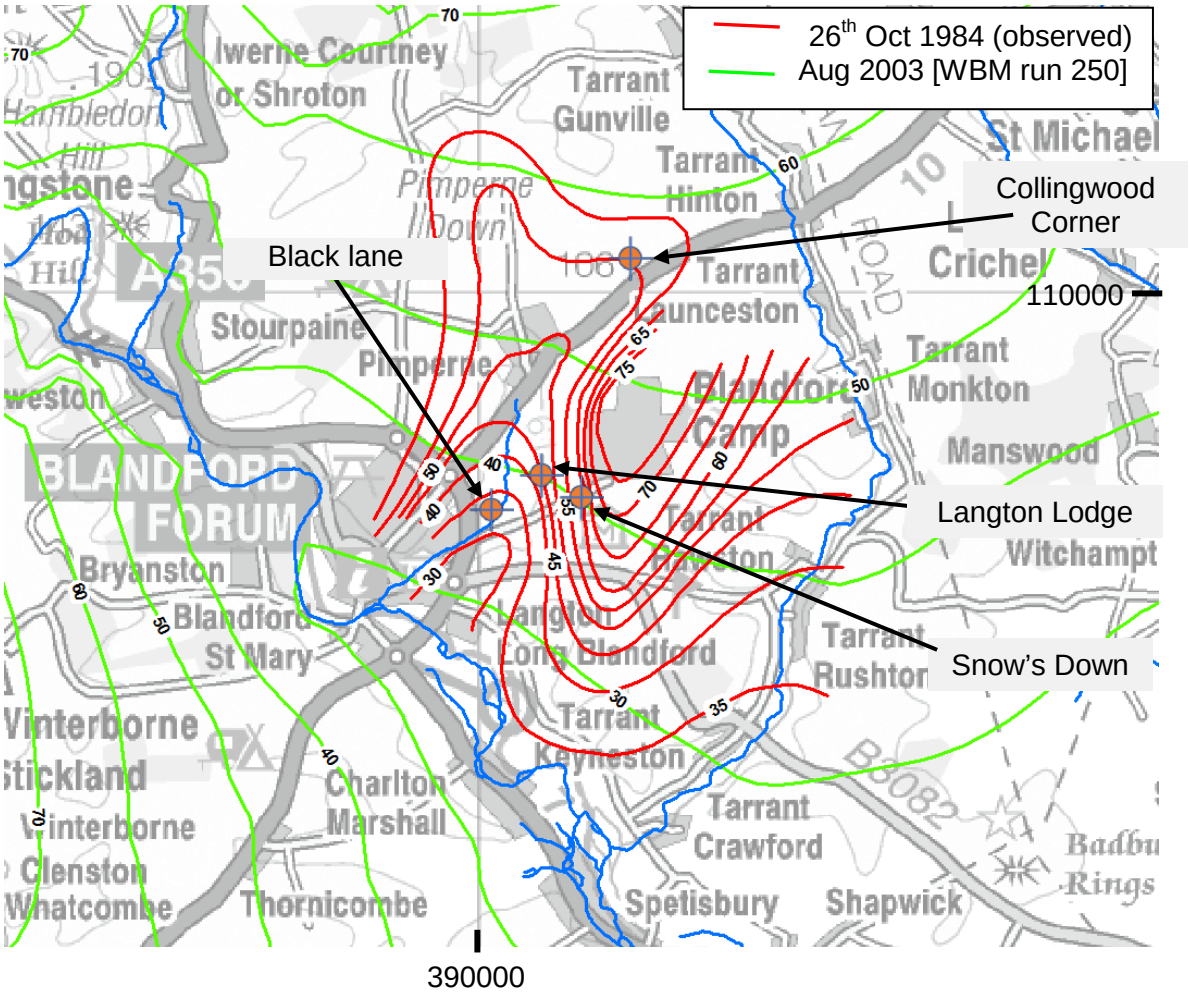
Several marl seams were identified at Tarrant Launceston, which was drilled in the Newhaven Chalk and into the upper few meters of Seaford Chalk. However, the marl seams were thin and there was no evidence of confined groundwater (water under pressure). Summary borehole logs (geology and construction) are provided in Appendix C.

Groundwater levels have been recorded in each borehole since July 2016. These data are being compared with other groundwater level observations and winterbourne surveys to provide valuable insights into the behaviour of the River Tarrant (see Section 3).

2.8.3 AMP6 investigation – Pimperne/Tarrant interfluve

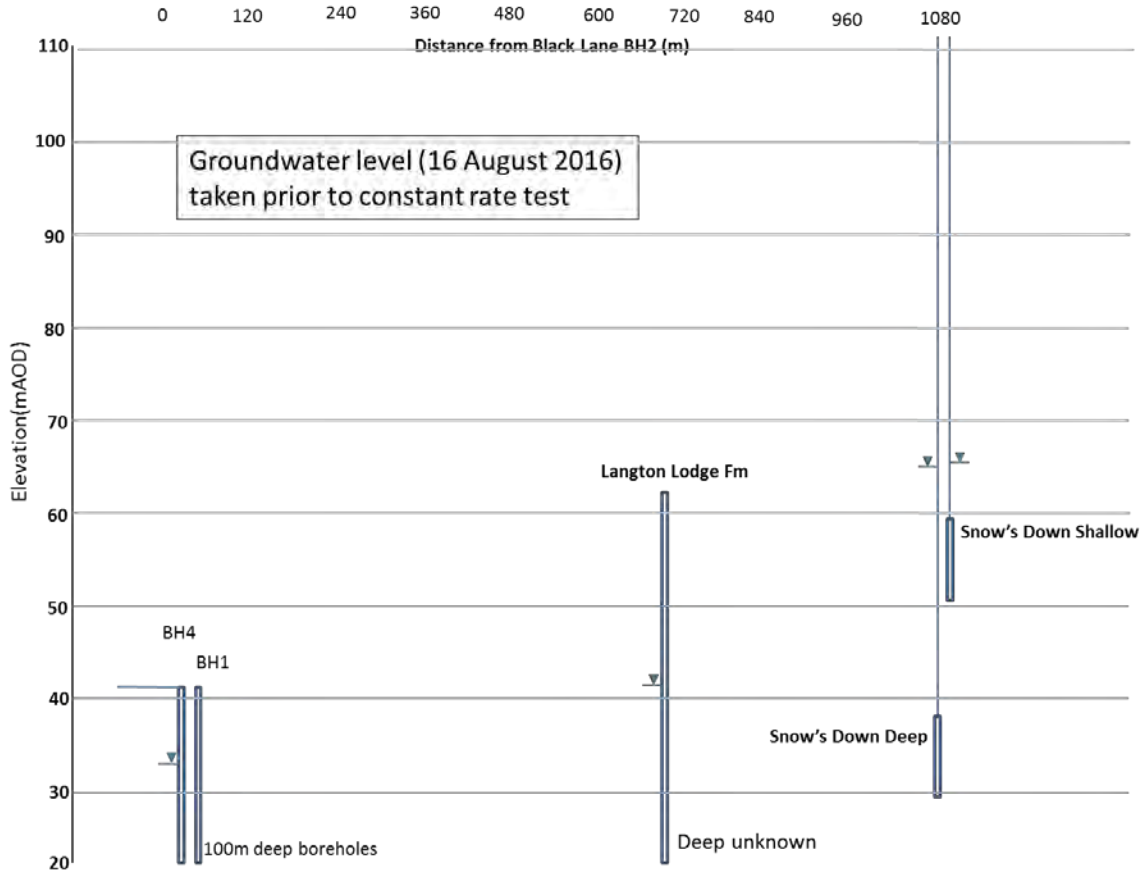
Groundwater contours are presented within the Pimperne Valley Investigation report (Wessex Water Authority, 1985). Figure 2-16 compares these to model groundwater contours from the WBM Run 250 (historical calibrated model run). Whilst the timing of the contours is different they both represent periods of low groundwater levels. The model is significantly underestimating the high groundwater levels along the Pimperne – Tarrant interfluve. And the marked ridge (close spaced contours) of groundwater near Blandford camp is not predicted by the model.

Figure 2-16: Groundwater level contours presented in the Pimperne Valley Investigation compared to model contours (WBM Run 250)



New boreholes were drilled at Snow's Down and Collingwood Corner to verify the high groundwater levels. The results, combined with monitoring at Langton Lodge and Black Lane confirm that groundwater levels on the Pimperne – Tarrant interfluve are 25 m to 30 m above the Pimperne valley (Figure 2-17).

Figure 2-17: Groundwater levels at Snow's Down, Langton Lodge and Black Lane



These data suggest very low transmissivity chalk underlies Pimperne – Tarrant interfluve. Plus other hydraulic controls may be in operation.

Two boreholes were drilled to different depths at Snow's Down (Deep and Shallow) to test the hypothesis that there may be two water tables. A water level in the Seaford Chalk that flows towards the Pimperne and a perched (upon a marl band) water table in the Newhaven Chalk; with the regional dip meaning the water flows towards the Tarrant. Consequently cored boreholes were drilled to investigate this hypothesis.

Snow's Down Deep is screened between 75 and 82 m below ground level (bgl). Snow's Down Shallow is screened between 44 and 54 m bgl. Groundwater levels in the shallow and deep boreholes indicate groundwater is in hydraulic connection; the cores from the Snow's Down Deep did not reveal any significant Marl band which would support a water table. Therefore, no evidence for a perched water table was identified.

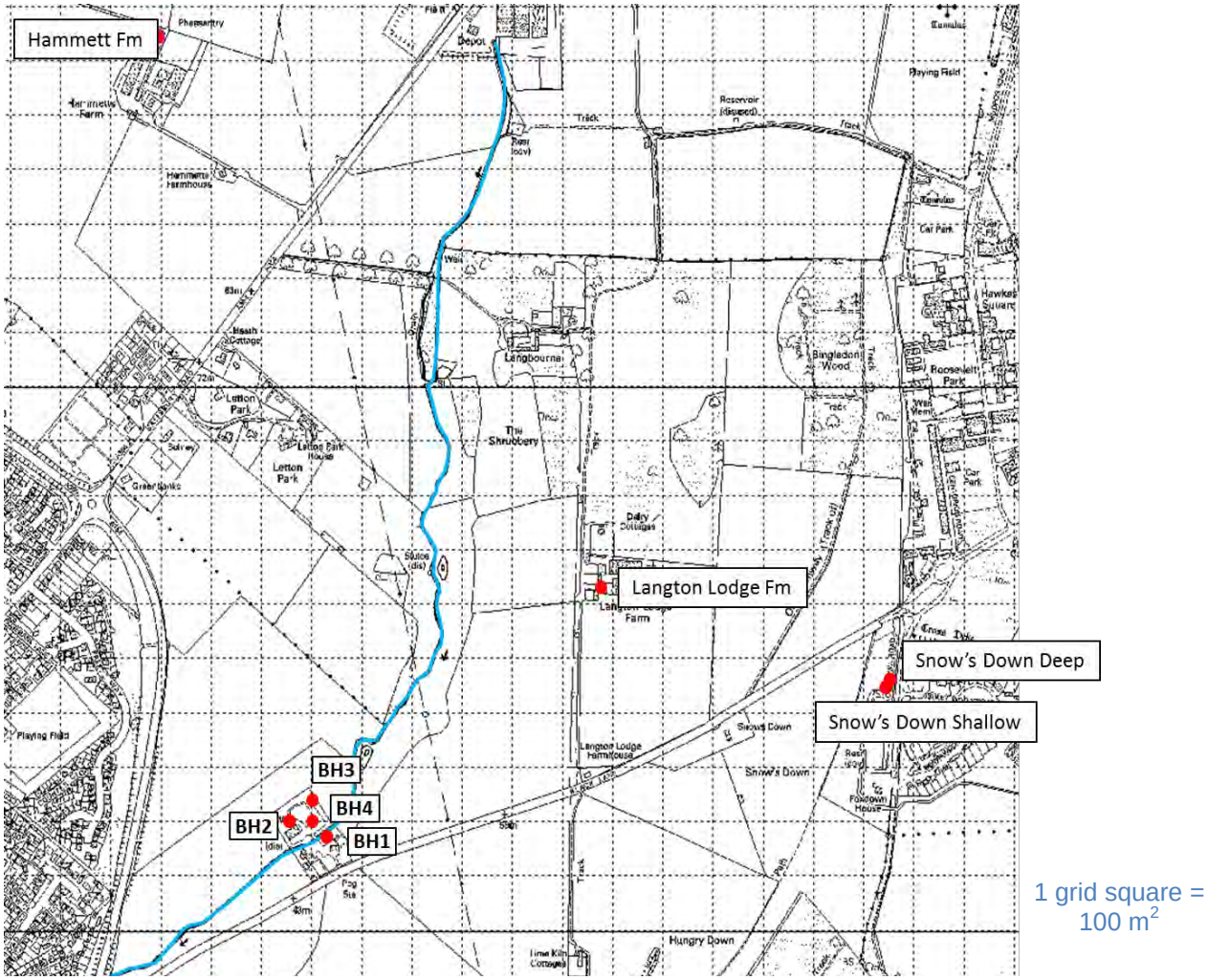
Another possibility is that a fault acting as a zone of low permeability lies between Snow's Down and the Pimperne valley. Rock cores and geophysical logging indicate that the Newhaven Chalk Formation is thicker than expected in the Snow's Down boreholes. This may be due to faulting and/or a channel that was filled by the Newhaven Chalk. Further details are provided inAppendix D.

2.8.4 AMP6 investigation – Black Lane PWS pumping trial

A previous pumping test in 1984 determined that there were no measurable impacts at almost thirty boreholes within the Pimperne and Tarrant catchments (Wessex Water Authority, 1985). However, the pumping test involved increasing the pumping rate by just 2 Ml/d (from 5.5 to 7.5 Ml/d) and there was significant rainfall during the test period, which may have obscured any impacts. Furthermore, detailed results of the test were not included with the report and so re-evaluation of the test was not possible.

A pumping and switch-off trial of Black Lane PWS was carried in late summer/autumn 2016. Prior to the 2016 trial Black Lane PWS boreholes were abstracting at a daily average rate of ~5 Ml/d. The source was switched off for just under 10 weeks between 9th June and 15th August 2016. This was followed by the pumping test; continuous pumping at a rate of around 9.5 Ml/d for 30 days (from Borehole 3) from 16th August until 15th September. The boreholes were then switched-off again until May 2017. Figure 2-18 shows the boreholes monitored during the 2016 Black Lane pumping trial.

Figure 2-18: Boreholes monitored during the 2016 Black Lane pumping trial



The full set of charts covering the 2016 trial are presented inAppendix E. The key findings of the trial are:

- Black Lane PWS boreholes show a clear response (Figure 2-19). After 30 days of pumping at a rate of around 9.5 Ml/d, drawdown in borehole No4 (not pumped) was only ~4 m, which indicates the high transmissivity of the Chalk aquifer.
- At the end of the pumping test on 15thSeptember there is a clear recovery at Hammett's Farm (Figure 2-20).
- The increase in groundwater level of almost 1 m at Hammett's Farm is markedly greater than at Langton Lodge Farm (Figure 2-20), where there is no discernible impact, despite being 770 m further away from Black Lane.
- Groundwater levels at Snow's Down gradually increased by almost 0.5 m after the second switch-off on 15th September,initially it wasuncertain whether this is due to recovery from pumping or a response to rainfall. However, it is now considered that the gradual rise is due to recharge from almost 60 mm of rainfall between 9th September and 3rd October (Figure 2-21). The full groundwater level dataset from Snow's Down shows that the Chalk responds quickly to rainfall, despite 40 m of unsaturated zone (Appendix E).
- The rise in groundwater level at Snow's Down is also markedly greater than at Langton Lodge Farm despite being almost 500 m further away from Black Lane. None of the boreholes are in dry valleys.

Figure 2-19: Groundwater levels at Black Lane PWS boreholes during the 2016 trial

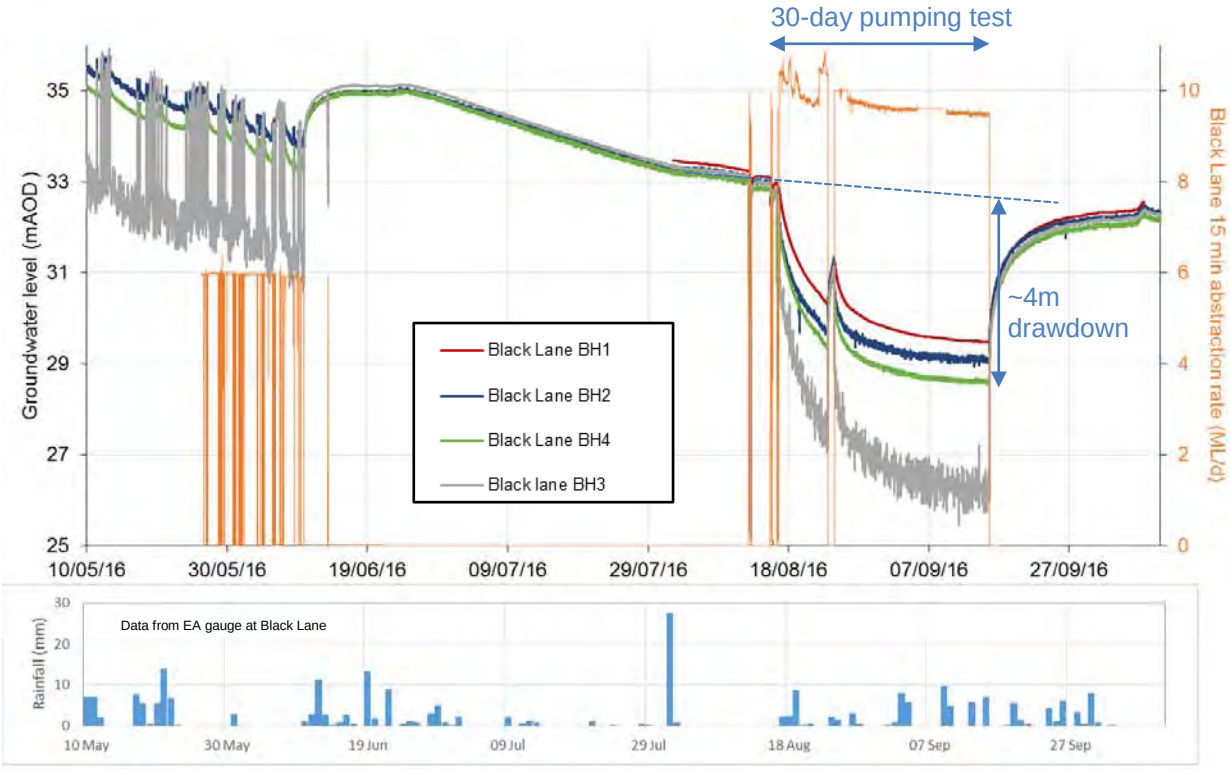


Figure 2-20: Groundwater levels at Hammett's Farm and Langton Lodge

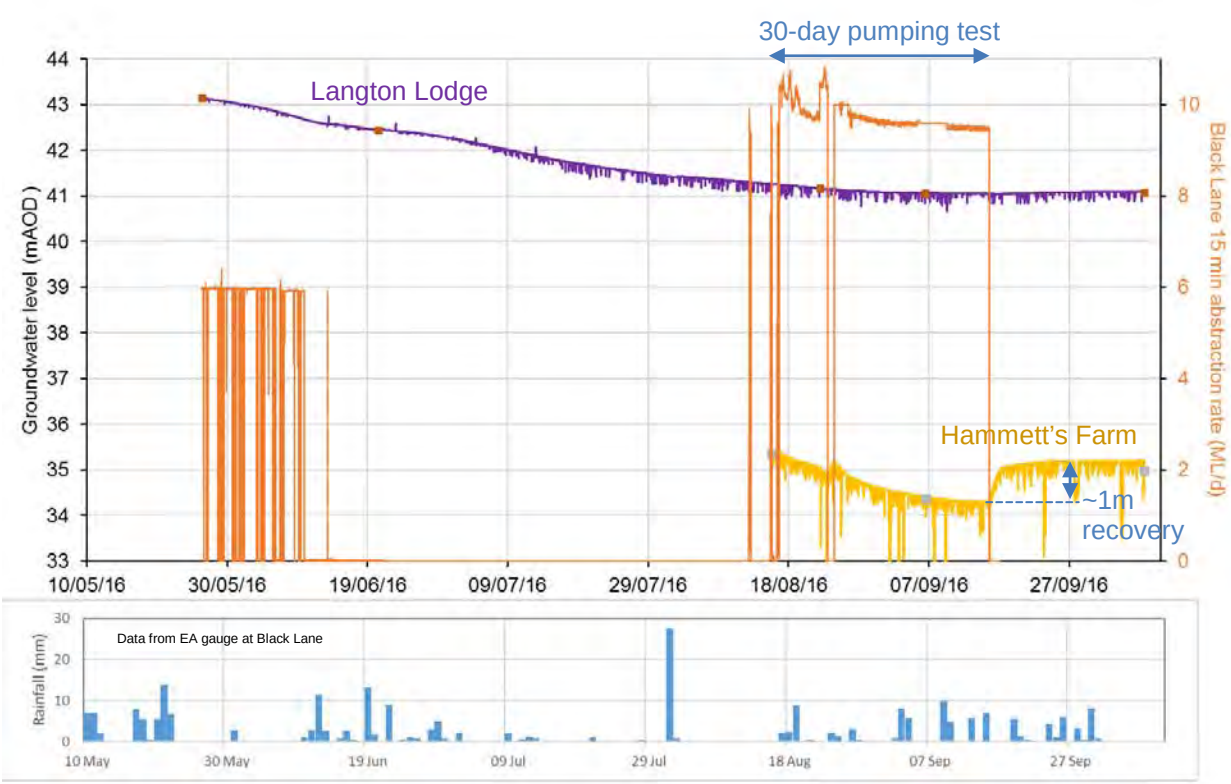
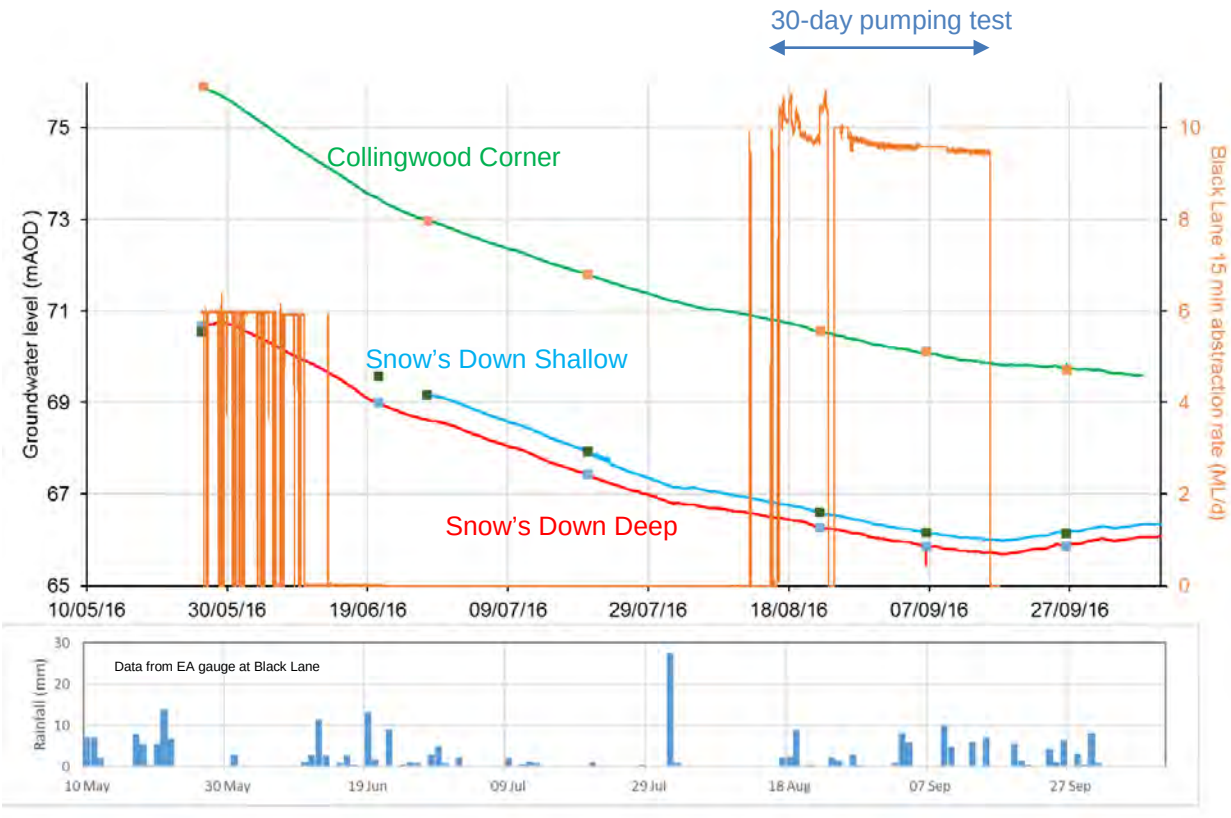


Figure 2-21: Groundwater levels at Snow's Down and Collingwood Corner

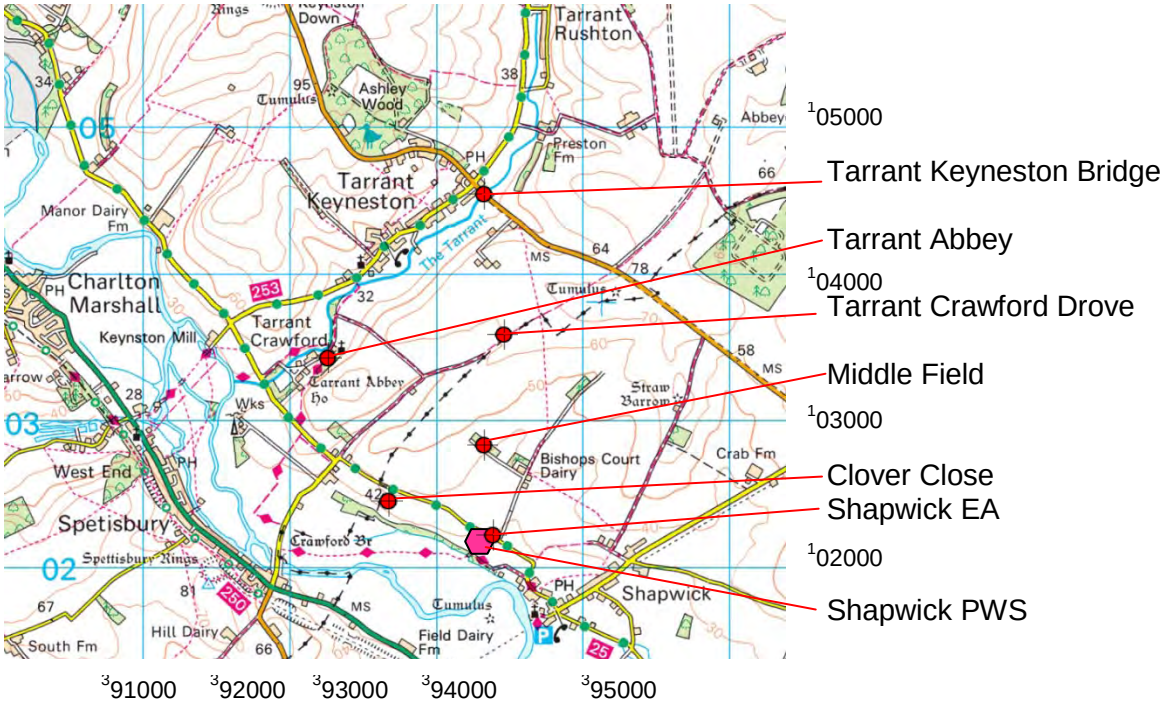


2.8.5 AMP6 investigation – Shapwick PWS impact

A pumping test was undertaken by the Avon and Dorset River Authority in October 1969 following completion of two boreholes at the Shapwick site (Avon and Dorset River Authority, 1970). Both boreholes were pumped during the test at a combined average abstraction rate of 9.6 Ml/d for a period of 15 days. The data from this test showed drawdown along the Stour valley, but it was not clear whether there was an impact along the lower reaches of the Tarrant valley.

During the AMP6 period continuous groundwater level monitoring was established at observation boreholes surrounding Shapwick PWS. Monitoring borehole locations are shown in Figure 2-22. As well as boreholes along the Stour valley and lower Tarrant valley, a new borehole was drilled at Middle Field and used in conjunction with an existing (EA) borehole at Tarrant Crawford Drove to determine whether the effect of Shapwick pumping extends northwards towards the Tarrant valley.

Figure 2-22: Boreholes monitored during the 2017 Shapwick PWS switch-off



A switch-off of Shapwick PWS boreholes occurred in early July 2017, lasting 8 days. Groundwater level responses in the observation boreholes are shown in Figure 2-23. When the Shapwick PWS boreholes stopped pumping, there was a clear recovery of groundwater levels at Shapwick EA, Clover Close and Middle Field observation boreholes. There is no discernible response on the interfluve at Crawford Drove, or at any of the Tarrant valley boreholes; Tarrant Abbey, Keyneston Manor and Keyneston Bridge. These data suggest that the impact of Shapwick PWS does not extend into the Tarrant valley. This conclusion is consistent with a previous assessment, which suggests that river gravels in Stour valley have high storage capacity and are considered to provide a significant proportion of yield to Shapwick PWS (Entec, 2008).

The Shapwick PWS abstraction most likely takes its water from a combination of groundwater storage and flow through the Chalk aquifer, and groundwater release from the Stour valley river terrace deposits.

Figure 2-23: Groundwater levels during the 2017 Shapwick PWS switch-off

