Whitchurch Conservation Group

Hampshire and Isle of Wight Wildlife Trust

Review of the Basingstoke and Dean Borough Council 2022 Water Cycle Study: River Test Catchment

Final Report

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This study was conceived and commissioned by Dave George, who is a Subject Matter Expert for Whitchurch Conservation Group. I am grateful to Mr George for provision of information, for discussion during the development of the report and for reviewing the draft report.

CONTENTS

page

APPENDICES

TABLES

FIGURES

ABBREVIATIONS

AA	annual average
AEP	Annual Exceedance Probability
b	below
BAT	Best Available Technology
BAT-AEL	Best Available Technology – Associated Emission Levels
BATC	Best Available Technology Conclusions
BDE	Brominated Diphenyl Ethers
BFI	Baseflow Index
BOD	Biological Oxygen Demand
CC	Climate Change
COD	Chemical Oxygen Demand
DLUHC	Department for Levelling Up Housing and Communities
DWL	Drinking Water Limit
ELV	Emission Limit Value
EPR	Environmental Permitting Regulations
EQS	Environmental Quality Standards
EU	European Union
GL	ground level
HIWWT	Hampshire and Isle of Wight Wildlife Trust
HS	Hazardous Substance
IED	Industrial Emissions Directive
LURB	Levelling Up and Regeneration Bill

MAC	Maximum Allowable Concentration
MDF	Mean Daily Flow
NGR	National Grid Reference
NVZ	Nitrate Vulnerable Zone
OD	Ordnance Datum (Newlyn)
PAH	Polyaromatic Hydrocarbons
PBDE	Polybrominated Diphenyl Ethers
PBT	Persistent, Bioaccumulative and Toxic
RP	Reactive Phosphorus
UP	Unreactive Phosphorus
uPBT	Ubiquitous Persistent Bioaccumulative Toxic
	(mercury, brominated diphenyl ethers (pBDE), tributyltin and certain polyaromatic hydrocarbons)
vPvB	very Persistent and very Bioaccumulative
PHS	Priority Hazardous Substance
PS	Priority Substance
RHS	Relevant Hazardous Substance
SAAR	Standardised Average Annual Rainfall
SGZ	Safeguard Zone
SFRA	Strategic Flood Risk Assessment
SPZ	Source Protection Zone
SP	Specific Pollutant
SRP	Soluble Reactive Phosphorus
SUP	Soluble Unreactive Phosphorus
SVOCs	Semi Volatile Organic Compounds
TOrC	Trace Organic Contaminants
TIN	Total Inorganic Nitrogen
TON	Total Oxidised Nitrogen
TP	Total Phosphorus
TRP	Total Reactive Phosphorus
TSS	Total Suspended Solids
TUP	Total Unreactive Phosphorus
UKAS	United Kingdom Accreditation Service
VOCs	Volatile Organic Compounds
WCS	Water Cycle Study
WFD	Water Framework Directive
WFR	Water Framework Regulations
WNS	Water Neutrality Scenario
WRMP	Water Resources Management Plan
WWTW	Waste Water Treatment Works

UNITS

cumecs	cubic metres per second
d	days
h	hours
ha	hectares
km	kilometres
l	litres
m	metres
m^3/d	cubic metres per day
m^3/h	cubic metres per hour
m^3/s	cubic metres per second
mg/l	milligrams per litre
Ml/d	mega (millions) litres per day
µg/l	micrograms per litre
ppm	parts per million
s	seconds

1 INTRODUCTION

1.1 General

This report presents a technical review (Review) of the Basingstoke and Deane Borough Council (BDBC) Water Cycle Study (WCS), as part of a study regarding the role of the Chalk Aquifer in the quality of water in the River Test.

The WCS was commissioned by BDBC and produced by AECOM in May 2022, AECOM 2022. The WCS was developed to support decision making relating to future development and inform the updated Local Plan (2019-2039), ensuring that development does not adversely impact the water environment.

The Study area for the WCS is the administrative boundary of BDBC, which comprises an area of approximately 634 km^2 and includes parts of the surface water catchments of the Upper Test, River Loddon, and tributaries of the River Kennett including the River Enborne and Foudry Brook. The WCS was based on two housing growth scenarios, a lower growth scenario and a potential maximum growth scenario. There was also a third scenario that was a minor variation of the maximum scenario.

The Review was directed to the coverage of the Upper Test catchment in the WCS. The Review considered the implications of the WCS on future groundwater and surface water quantity and quality in the Upper Test, and the associated effects on dependant ecology and habitat sites.

The report was researched and written by Lawrence Houlden, an independent groundwater and environmental consultant. This work was funded by Hampshire and Isle of Wight Wildlife Trust under a Watercress and Winterbournes Community Grant which is supported by the National Lottery Heritage Fund. The grant was awarded to Whitchurch Conservation Group. We are grateful to HIWWT and the National Lottery for their support.

The remainder of this section summarises the principal findings of the Review and relevant background information.

1.2 Principal Findings

The principal findings were as follows:

General Scope and Content of the WCS

- It is acknowledged that, in general, the WCS is based on appropriate information and used established assessment methodologies to develop its findings.
- However, the WCS lacks technical detail and is not a rigorous scientific assessment of the potential impacts of future housing and population growth on the water environment.

- The WCS should include an assessment of evidence gaps, as recommended by the Environment Agency's Water Cycle Study guidance[a]. The WCS did not adequately identify and consider evidence gaps. As a consequence the WCS did not include an adequate, or arguably any, evaluation of the critical uncertainties in its findings and strategies developed.

Water Supply

- The WCS identifies four Water Neutrality Scenarios (WNS) based on various total water demand growth projections combined with demand efficiency measures in existing and new homes. The Medium WNS was considered to be "*technically and financially feasible*". However, the Medium WNS only delivers 31 to 46% of water neutrality leaving the remainder of the increase in total water demand to be sourced from other measures.

- The High WNS, which delivered 100% neutrality, was considered theoretical and not practically achievable.

- The WCS stated that " *Since development within the study area is not proposed to exceed that for which both South East Water and Southern Water are planning, it is not necessary to evaluate the impacts of water supply in the study area independently of the WRMPs and their assessments*. This meant that the WCS did not include any critical review or verification of the water company Water Resources Management Plans (WRMPs).

- The WRMPs rely on leakage reduction (for Southern Water this is 15% of the current leakage rate by 2025 and 50% by 2050) and consumer demand reduction and other efficiency measures with limited resource development. It is estimated in this Review that leakage reduction of 50% by 2050 would deliver an additional 2.8 Ml/d for the WCS study area, which is approximately 10% of the existing water demand.

- There can be no certainty that leakage reduction and water efficiency measures will meet their respective WRMP targets. The WCS does not provide critical assessments of the water company WRMPs, and therefore significant uncertainty remains as to whether the WRMPs can be delivered. For this reason, although the WCS will inform local planning policy and practice, it does not demonstrate with any degree of confidence that adequate water supplies will be available for either housing/population growth scenario.

Wastewater

- The WCS proposed that the additional volumes of treated effluent discharged from the Wastewater Treatment Works (WWTWs) in the Upper Test Catchment can be accommodated without detrimental effects by adopting the principle of "*load standstill*". This would require that the concentrations of contaminants in the treated

a Water cycle studies - GOV.UK (www.gov.uk) effluent are reduced in proportion to the additional treated wastewater volumes such that the contaminant load discharged to the environment does not increase. There are two fundamental objections to the load standstill principle. Firstly, load standstill does not provide any betterment that may be needed to reverse ecological decline. Secondly, under conditions of reducing low flows, load standstill will result in concentration increases during low flow periods compared to the baseline, and in general it is the concentration rather than load that causes adverse effects. Irrespective of whether load standstill is appropriate for the Upper Test, the methodology described in the WCS is fundamentally flawed for several reasons as follows.

- The WWTW Environmental Permits set emission limit values (ELVs) for several parameters based on (i) annual averages (AA) and (ii) maximum allowable concentrations (MAC). The WCS proposes a proportional decrease in the annual average ELVs for each WWTW but only where existing ELVs have been set in the Environmental Permits. However the WCS does not propose that the ELVs based on maximum allowable concentrations should also be proportionately reduced. Without a reduction in the MAC-based ELVs the contaminant loads will increase under the proposal in the WCS.

- The WCS should, but does not, also propose that the emission controls in the WWTW permits should be upgraded to a common standard, with each WWTW required to meet the same ELVs for the same suite of contaminants. At present all WWTWs have ELVs for BOD[b], TSS[c] and ammoniacal nitrogen, but Whitchurch, Oakley and North Waltham WWTW have ELVs for TIN [d] but not phosphorus/phosphate, and Overton WWTW has ELVs for phosphorus but not TIN. There are no ELVs in the Permits for Hannington and Ashmansworth WWTWs.

- The WCS does not acknowledge that discharges from WWTWs are liable to contain a large number of substances for which ELVs are not set and for which there is very limited, if any, monitoring and in many cases only an emerging understanding of the harm that these substances may cause. These unregulated substances include a large number of Priority Substances (PS) and Priority Hazardous Substances (PHS). In 2019 the WFD status of the River Test and numerous other rivers in England was downgraded to “Fail” because in the case of the Test of the detection of mercury and polybrominated diphenyl ethers (PBDE), both of which are PHS. Any increase in the volume of wastewater discharged would result in a proportional increase in the load of these “unknown” contaminants being discharged to the Chalk Aquifer and then to the River Test, unless any unknown contaminant was fortuitously attenuated by the improvements required to meet the new ELVs for nitrate, phosphorus, etc.

b BOD: biological oxygen demand
c TSS: total suspended solids
d TIN: total inorganic nitrogen

- In the assessment of the effects of increased quantities of wastewater the WCS did not adequately consider the effect of contaminant storage and transport in the Chalk Aquifer.

- Treated effluents from the four larger WWTWs in the Upper Test Catchment are discharged to ground using various infiltration systems. These infiltration systems have been operating for decades, and in the case of Whitchurch WWTW for at least 90 years. The soil and groundwater beneath each infiltration system is inevitably contaminated, and as such should be considered as potentially contaminated land. In effect the WCS proposes an increase of the volume, and changes to the chemical character, of the discharge of treated effluent to contaminated land without any proposals to assess the consequences. In a presentation to BDBC on 1 September 2022 Mr David George explained the likelihood that discharging higher volumes of treated effluent with lower nitrate concentrations would result in back-diffusion of nitrate from storage in the Chalk Aquifer beneath the infiltration system. The consequence of this back-diffusion is that the nitrate loads reaching the River Test would not reduce in accordance with the design under the load standstill approach. In other words the load standstill objective would not be achieved at the River Test. There is a risk that other contaminants have accumulated beneath the infiltration systems and that these contaminants may also be mobilised by the changed operational regimes proposed in the WCS.

- At a regulatory level the obligations placed on the water companies, such as Southern Water, and industry are not on a level playing field. For example, in 2018 Portals Paper Mill near Overton was required, for their discharge of treated effluent to the River Test, to meet the BATC AEL[e] (equivalent to an ELV) for phosphorus, derived from the EU Industrial Emissions Directive (IED), of 0.25 mg-P/l by 2020. In contrast, Whitchurch WWTW does not have an ELV for phosphorus and the WCS does not propose that one should be set.

Flood Risk

- The WCS considered the effects of increased wastewater flows on flood risk only for those WWTWs which discharge to watercourses, and not for those that discharge to ground. All of the WWTWs in the Upper Test Catchment discharge to ground and not direct to a watercourse. Consequently, the WCS did not consider the effect of increased wastewater discharge from the WWTWs in the Upper Test Catchment.

- The flood risk assessments for the WWTWs that discharge to watercourses were based on the 1% annual exceedance probability (AEP) flood event but the WCS does not explain whether the increased wastewater flows included an allowance for climate change or not. Furthermore the derivation of the 1% AEP flood flows is

e BATC AEL: best available technology conclusion – associated emission level included in Appendix H of the WCS but Appendix H is not included in the copy of the report available from the BDBC website.

- The WCS does not provide any assessment of the flood risk effects of additional wastewater discharges to ground, and therefore the Chalk Aquifer, from the WWTWs in the Upper Test Catchment. The Chalk is a fractured rock aquifer where groundwater flow may occur at relatively rapid rates. The infiltration systems at Overton and Whitchurch WWTWs are respectively approximately 100 and 400 m from the River Test. The incremental treated effluent discharges at Overton and Whitchurch WWTWs could, in principle, increase flood risk and therefore an assessment should have been included in the WCS, and all flood risk assessments should have included allowances for climate change in accordance with the NPPF[f].

- The WCS does not consider whether there is sufficient development land in area with low flood risk (Flood Zone 1) to accommodate the growth scenarios. The Environment Agency guidance suggests that a WCS should consider this matter.

- The WCS does not consider the flood risk effects of increased runoff from new housing development. Whilst BDBC's Strategic Flood Risk Assessment (SFRA) should be the primary source for flood risk information, the WCS could have considered flood mitigation in the context of Integrated Water Management[g].

Climate Change

- The effects of climate change are not considered in the WCS, either as a separate issue or within the coverage of each aspect. There is no mention of climate change in the flood risk section (Section 6) of the WCS. These are significant omissions.

Specific Evidence Gaps

- The water supply analysis in the WCS relies on water company WRMPs, but the WCS did not attempt to identify evidence gaps, or otherwise evaluate, the uncertainties contained in these plans.

- There are numerous evidence gaps associated with wastewater proposals in the WCS. For example there are a number of notable evidence gaps in the available water quality monitoring data for the River Test, groundwater in the Chalk Aquifer in the Upper Test Catchment, and the treated wastewater discharges from the WWTWs, but these were not identified or considered in the WCS. These evidence gaps are described in Section 5.4.

f NPPF: National Planning Policy Framework
g CIRIA report C787A, CIRIA 2019

1.3 BDBC Water Cycle Study

1.3.1 Introduction

Water cycle studies were commissioned by BDBC in 2007 and 2009, but these were based on assumptions that the majority of future housing would be located in the Basingstoke area and would be served by Basingstoke WWTW which discharges to the River Loddon.

The 2022 WCS was commissioned by BDBC to support the updated 2019-39 Local Plan. BDBC have now identified two housing growth scenarios for this plan period that assume housing growth spread more widely across the BDBC area, including significant housing growth in the Upper Test catchment. Specifically, new housing is assumed to be located at Oakley, Overton and Whitchurch, with a total of 3861 and 5381 units respectively under growth scenarios 1 and 2. In addition smaller development of 134 units is assumed at North Waltham and 200 units at St Mary Bourne under both scenarios. North Waltham, Oakley, Overton and Whitchurch each have their own WWTW. St Mary Bourne is served by Barton Stacey WWTW.

The objective of the WCS were to identify water-related constraints on planned housing growth, including wastewater drainage and treatment together with protection of sites designated under the Habitats Regulations; water supply and water neutrality; and flood risk from increased treated wastewater flows.

1.3.2 WCS Study Area

Figure 1 shows the BDBC area boundary, the study area for the WCS.

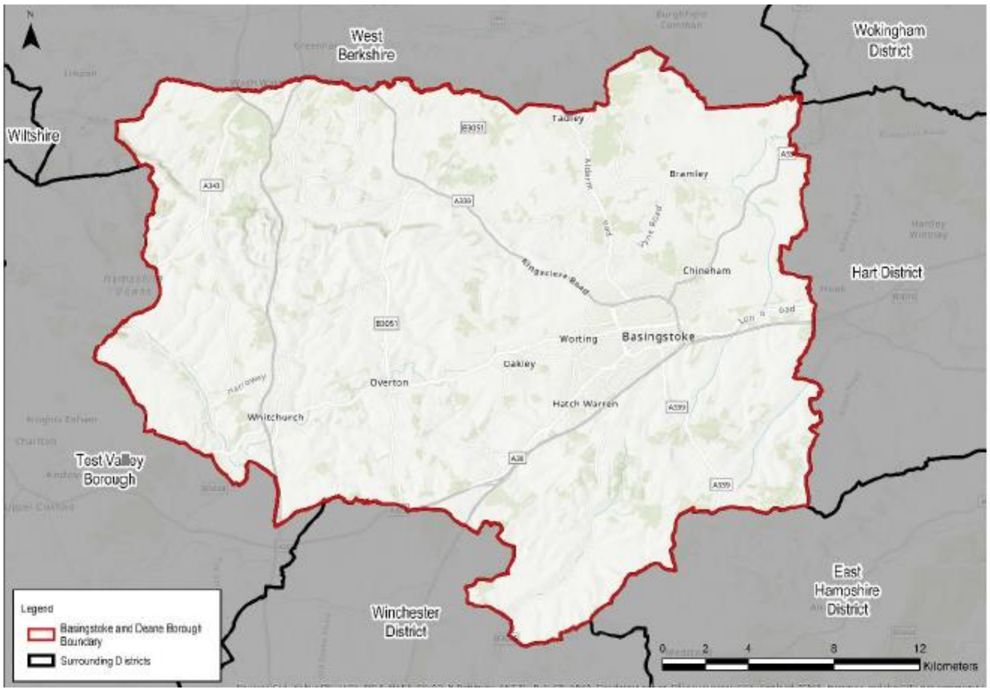


Figure 1 WCS Study Area *Reproduced from AECOM 2022*

1.3.3 WCS Growth Scenarios

The growth scenarios on which the WCS was based are summarised in Table 1. Scenario 1 is a base population and housing growth case and scenario 2 is a potential maximum growth case.

Details of the effects of the growth scenarios on wastewater treatment are included in Appendix A.

Table 1 Growth Scenarios Considered in the WCS

WWTW	Settlements	Scenario	Number of Proposed New Housing Units	Number of New Jobs Created	Approximate residual wastewater treatment capacity at affected WWTW (m^3/d)
Whitchurch	Whitchurch & Popham	1	2,881	845	-548
		2	3,871	845	-932
Overton	Overton	1	390	nil	7
		2	630	nil	-86
Ivy Down Lane Oakley	Oakley	1	590	nil	-41
		2	880	nil	-153
North Waltham	North Waltham	1	134	nil	79
		2	134	nil	79

1.3.4 BDBC WCS Scope and Content

1.3.4.1 General

The WCS presents water supply and wastewater strategies to accommodate the proposed growth, together with an assessment of the effects of increased wastewater generation on flood risk.

The WCS includes an assessment of surface water and groundwater quality based on information from the Environment Agency's Catchment Data Explorer[h] system which is limited to comparison of monitoring information against WFD objectives. The WCS did not access the detailed quantitative monitoring results on the Environment Agency's Water Quality Data Archive (OpenWIMS)[i] system.

1.3.4.2 Water Supply

The WCS refers to and largely relies on the Water Resources Management Plans produced by South East Water for the period 2020-80 (South East Water 2020)[j] and Southern Water for the period 2020-70 (Southern Water 2019)[k]. Both WRMPs rely heavily on water efficiency measures to reduce demand and leakage reduction in the distribution system in order to meet future water supply demands. Development of additional water supplies from surface water and groundwater is significantly constrained by water resource availability.

h South East River Basin District | Catchment Data Explorer
i Open WIMS data
j Report (southeastwater.co.uk)
k 5025_wrmp_-v11.pdf (southernwater.co.uk)

The WCS provides a strategy for future water supply provision based on a current baseline water consumption in BDBC of 28.39 Ml/d. Four levels of demand growth were postulated:

Projection 1: new homes consume water at the current baseline of 174 l/h/d.

Projection 2: new homes consume water at the Building Regulations rate of 125 l/h/d. The increase in total water demand is 20% and 25% respectively for growth scenarios 1 and 2.

Projection 3: new homes consume water at the of optional Building Regulations rate 110 l/d. The increase in total water demand is 17% and 23% respectively for growth scenarios 1 and 2

Projection 4: new homes consume water at 62 l/d, achieved with grey water recycling and rainwater harvesting. The increase in total water demand is 10% and 13% respectively for growth scenarios 1 and 2

The water supply strategy is then based on a goal of achieving water neutrality, where water neutrality requires that the total demand for water in a planning area after development has taken place is the same, or less, than it was before development took place. Three sets of water neutrality assumptions were developed,

High: theoretical neutrality - Water efficiency measures of (i) retrofitting water meters in 100% of properties and (ii) 50% uptake of water efficiency measures.

Medium: Water efficiency measures of (i) retrofitting water meters in 80% of properties and (ii) 15% uptake of water efficiency measures.

Low: Water efficiency measures of (i) retrofitting water meters in 80% of properties and (ii) 5% uptake of water efficiency measures.

together with the current Baseline. Two sub-sets of assumptions were assessed for the Medium and Low assumption cases.

Water Neutrality Assessments (WNAs) were made for growth scenario 1 (*Table 7-6 on page 76 of the WCS*) and growth scenario 2 (*Table 7-7 on page 77 of the WCS*).

The results were that WNA achievement of respectively 46% and 43% of full neutrality could be achieved by the Medium neutrality assumptions for growth scenarios 1 and 2. WNS achievement was obviously 0% for the baseline, and 21 to 27% for the Low neutrality assumptions. Full neutrality was only achieved under the High (theoretical neutrality) assumptions.

The cost estimates to meet Medium assumption cases were modest at approximately £4.2M for both growth scenarios. However the cost estimate to meet the High neutrality assumptions increased considerably, to £84M for growth scenario 1 and £109M for growth scenario 2.

For planning purposes only the Medium neutrality assumptions can be considered to be technically feasible. Therefore, for all practical purposes there would be a need for approximately 55% of the future water demand to be fulfilled by leakage reduction and/or increasing abstraction and/or by other water supply improvements carried out by the water companies. The WCS does not consider how these additional water resources will be provided.

1.3.4.3 Wastewater

All the WWTWs in the Upper Test Catchment discharge treated effluent to infiltration systems directly above the Chalk Aquifer. Existing permit conditions place limits on the volume of treated effluent and concentrations of a limited number of parameters in treated effluent that can be discharged to the aquifer.

The wastewater strategy for the WWTWs in the Upper Test Catchment is based on a "load standstill" principle. Load standstill means that future wastewater volume increases, caused by development, are accommodated by corresponding reductions in the emission limit concentrations to ensure that loads[1] of controlled contaminants discharged to groundwater do not increase above the current situation. The baseline loads have been determined by multiplying the actual dry weather flows by the current ELV for each substance.

Permits for the WWTW in the Upper Test Catchment variably include emission limit values for BOD, TSS, ammoniacal nitrogen, TIN and total phosphorus (TP). The current and proposed ELVs from the WCS are listed in Table 2.

It is not clear why a consistent set of ELVs have not been enforced, especially as all the WWTWs discharge to the same groundwater body. Logically, each Permit should at the very least include ELVs for TSS, BOD, ammonia, TIN and TP. The inconsistencies are most likely the result of historical anomalies which should have been addressed before now. The WCS did not propose introducing a uniform approach to setting ELVs at WWTWs in the Upper Test Catchment.

There are some anomalies in the WCS:

- The WCS does not include any proposals to amend, or retain the same, ELV for TSS. Therefore TSS loadings will increase resulting in potential adverse operational outcomes because the infiltration systems will likely need more frequent maintenance. Furthermore the greater TSS loads may increase the associated loads of contaminants discharged to the Chalk.

- The WCS does not state how the emission limit values specified as maximum allowable concentrations (MAC) will be amended, if at all. Load standstill cannot be achieved without corresponding reductions in the MACs.

1 Load is the mass of contaminant discharged per unit time, for example in kg per day.

Table 2 Emission Limit Values for WWTWs in the Upper Test Catchment

WWTW; Population Equivalent (PE)	Current (C) or Proposed (P)	DWF (b) m³/d	Emission Limit Values *(mg/l)*							
			TSS	BOD		Ammonia		TIN	TP	Fe
			LUT	LUT	MAC	LUT	MAC	AA	AA	AA
Whitchurch PE:4,757	C	1753	60	40	80	5	20	32	none	none
	P	**3268**	**NP**	**21.5**	**NP**	**2.7**	**NP**	**17.2**	**none**	**none**
Overton PE: 4,477	C	1001	60	40	80	5	20	none	1[a]	8
	P	**1246**	**NP**	**32.1**	**NP**	**4**	**NP**	**none**	**0.8**	**NP**
Oakley PE: 5,051	C	534	60	40	80	5	20	35	none	none
	P	**875**	**NP**	**24.4**	**NP**	**3.1**	**NP**	**21.4**	**none**	**none**
North Waltham PE: 816	C	36	60	40	none	5	none	20	none	none
	P	**88**	**NP**	**16.2**	**none**	**2**	**none**	**8.1**	**none**	**none**
Ashmansworth PE: 20	C	**5**	none	None	none	none	none	none	none	none
	P	**-**	none	None	none	none	none	none	none	none
Hannington PE: 38	C	**10.2**	none	None	none	none	none	none	none	none
	P	**3**	none	None	none	none	none	none	none	none

AA	annual average compliance	NP	no proposal to amend the ELV
BOD	biological oxygen demand	TIN	total inorganic nitrogen
ELV	emission limit value	Fe	total iron
LUT	look-up table compliance	TP	total phosphorus
MAC	maximum allowable concentration	TSS	total suspended solids

a Compliance based on 90%ile of measured data

b Current DWF are actual values, not permit limits, except Ashmansworth and Hannington which are permit values. Future DWFs are based on future populations served.

The WCS also states (page 49) that the ELVs for ammonia and BOD at all the WWTWs discharging to ground are expressed as 95%iles, and that the future ELVs will also be expressed on this basis. According to Table S3.1 of the EPR Permit for Whitchurch WWTW the ammonia and BOD ELVs are based on the LUT method[m,n] but are not specifically expressed as 95%iles in the Permit.

The wastewater strategy in the WCS specifically excluded consideration of priority pollutants:

> *"It should be noted that other wastewater discharge and water quality determinands such as copper, zinc, tributyl-tin and nickel have not been considered as part of this WCS. These have not been reported as an issue by Thames Water or Southern Water for this study area."*

The fact that Thames Water and Southern Water have not reported these and other priority pollutants as an issue should not be a reason to exclude their consideration in the WCS.

m The LUT principle allows a set number of results, for example 2 in 12, to exceed the LUT limit without non-compliance occurring, provided all results are below the MAC. Therefore for Whitchurch WWTW 2 No. ammonia results of 18 mg/l in 12 samples over a calendar year would be compliant provided no other results were higher than 5 mg-N/l (the AA ELV) and no results were greater than 20 mg-N/l (the MAC ELV).

n Site-specific quality numeric permit limits: discharges to surface water and groundwater - GOV.UK (www.gov.uk)

1.3.4.4 Flood Risk

The WCS considers the effects of increased wastewater flows on flood risk only for those WWTWs which discharge to watercourse, and not for the WWTWs in the Upper Test Catchment which all discharge to ground. This approach ignores the potential for rapid flow through the Chalk fissure system that could result in increased flood risk from those WWTWs that discharge to ground; this is discussed in Section 5.2.3.

The WCS does not consider the flood risk effects of increased runoff from development that is discharged to watercourses or ground rather than the drainage system to WWTWs; this is also discussed in Section 5.2.3.

1.4 Guidance on Development of Water Cycle Studies

The National Planning Policy Framework[o] states that strategic policies in development plan documents should make '*sufficient provision*' for infrastructure for water supply, wastewater and flood risk and coastal change management. Planning practice guidance[p] states that a water cycle study can help with planning for sustainable growth, and uses water and planning evidence to understand environmental and infrastructure capacity.

Environment Agency 2021a[q] provides the most directly relevant guidance on development of a Water Cycle Study for planning purposes. This guidance describes a two-stage approach to development of a WCS:

- Stage 1 – Scoping: The scoping stage identifies if the water infrastructure capacity could constrain growth and if there are gaps in the evidence needed to make this assessment. It also identifies the area and amount of development, existing evidence, main partners to involve and evidence gaps.
- Stage 2 – Detailed Study: This stage provides the evidence to inform an integrated water management strategy (IWMS) as described in CIRIA C787A, CIRIA 2019[r]. The aspects that should be included are:

    i. Water supply: whether there is enough water for existing demands and intended growth.

    ii. Sewerage and drainage: whether the existing infrastructure can cope with increased loads, improvements required and the associated/consequent environmental effects.

    iii. Flood risk: sufficiency of development sites in low flood risk areas and effects of higher wastewater flows on flood risk.

    iv. Location-specific environmental risk: biodiversity, conservation and modification of water bodies.

o National Planning Policy Framework (publishing.service.gov.uk)
p Water supply, wastewater and water quality - GOV.UK (www.gov.uk)
q Water cycle studies - GOV.UK (www.gov.uk)
r Item Detail (ciria.org)

v. Climate change: resilience to climate change and mitigation opportunities.

The Environment Agency WCS Guidance, Environment Agency 2021a, emphasises the importance of identifying evidence gaps which, if not addressed, would lead to uncertain outcomes and unreliable plans.

An earlier version of the Environment Agency guidance[s] published in 2009 advised that an effective water cycle study and strategy will achieve the following objectives:

- Urban development only occurs within environmental constraints.
- Urban development occurs in the most sustainable locations.
- Water cycle infrastructure is in place before development.
- Opportunities for more sustainable infrastructure options have been realised.

1.5 Flood Risk Studies

Local planning authorities will have produced Strategic Flood Risk Assessments (SFRA) in accordance with the NPPF. BDBC produced a Level 1 SFRA in July 2021, AECOM 2021[t].

BDBC have not produced a Level 2 SFRA, which indicates that BDBC do not envisage the need for development to occur in high flood risk areas (i.e. Flood Zones 2 and 3)[u].

Hampshire County Council (HCC), as the Lead Local Flood Authority for the BDBC area, has also developed a number of flood risk planning documents[v] which are relevant to development in the BDBC area.

The BDBC Level 1 SFRA is the primary source of flood risk information for the BDBC area. The flood risk content of the WCS should be limited to aspects directly relevant to the WCS, including (i) ensuring that sufficient land is available in low flood risk areas for the proposed development and (ii) understanding the effects of any increase in wastewater flows on flood risk. The flood risk content of the WCS is not intended to replace the local authority SFRA.

1.6 Nutrient Neutrality

In 2018, a ruling, known as the "Dutch Nitrogen case" (CJEU 2018) was made in the European Court of Justice that changed the way legislation is applied to, and limits are placed on discharges of nutrients, specifically nitrogen and phosphorus, to the environment. In response to this Natural England began issuing guidance in 2019 to a number of Local Planning Authorities (LPAs) about the risks posed by development planning

s Water Cycle Studies Guidance Jan 09 v4_A3 (nationalarchives.gov.uk)
t Strategic Flood Risk Assessment (basingstoke.gov.uk)
u How to prepare a strategic flood risk assessment - GOV.UK (www.gov.uk)
v Our responsibilities and strategies | Hampshire County Council (hants.gov.uk)

applications to sites protected under the Conservation of Habitats and Species Regulations 2017 (Habitats Regulations).

Originally, this advice went out to 32 LPAs, those in areas with protected sites considered to be in unfavourable condition due to excessive nutrient concentrations/loads which included protected sites in the Solent. BDBC were one of the LPAs who received this advice because the Test and Itchen discharge to the Solent.

In March 2022, Natural England identified a further 20 protected sites that are adversely impacted by nutrient pollution and informed a further 42 LPAs that developments sites in their jurisdiction would now also be covered by nutrient neutrality advice.

There is evidence that inputs of both phosphorus and nitrogen influence eutrophication of the water environment. However, the principal nutrient that tends to drive eutrophication in the marine environment, including the Solent, is nitrogen.

In July 2022 the Chief Planner at the Department for Levelling Up Housing and Communities (DLUHC) issued a letter to LPAs with further advice on nutrient neutrality, including:

- In autumn 2022, the government will table an amendment to the Levelling Up and Regeneration Bill (LURB). This will place a new statutory duty on water and sewerage companies in England to upgrade wastewater treatment works to the highest technically achievable limits by 2030 in nutrient neutrality areas. Water companies will be required to undertake these upgrades in a way that tackles the dominant nutrient(s) causing pollution in the catchment of habitats sites. The statutory obligation from 2030 will require WWTWs to operate at the technically achievable limit (TAL); for phosphates this was stated to be 0.25 mg/l and for nitrates 10 mg/l. It is assumed this means 0.25 mg-P/l and 10 mg-N/l. Nitrogen is the dominant nutrient for the Test catchment. The legislation has not been published at the time of drafting this report, but it is understood that WWTWs in the Test catchment will be required to meet the TAL for nitrogen but not for phosphorus.
- To ensure mitigation is available for development to demonstrate neutrality, Natural England will establish a Nutrient Mitigation Scheme, working with Defra and DLUHC. Natural England will work with stakeholders to identify mitigation projects in nutrient neutrality catchments with Defra and DLUHC providing funding. Developers can then purchase ‘nutrient credits’ which will discharge the requirements to provide mitigation.

The statutory obligation to upgrade WWTWs in the Test catchment to the 10 mg-N/l standard by 2030 has implications that could not have been considered in the WCS which was published in May 2022. At the time of writing the amendments to the LURB have not been published, and therefore some uncertainties remain. For example the statutory obligation may not extend to smaller WWTWs such as those in the Upper Test and/or the WWTWs that discharge to ground may be excluded.

1.7 Representative Analytical Data

It is important that analytical data collected for investigations, monitoring and other purposes should be fit for purpose. This subject is generally beyond the scope of this report. However, it is relevant to consider the measurement of phosphorus and phosphates in the context of agricultural and wastewater pollution of the River Test.

The freshwater environmental quality standard for phosphorus is set by The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015. Under these Regulations the EQS for phosphorus is the "a*nnual mean reactive phosphorus concentration (in µg per litre)"* which is calculated based on an equation in the Regulations.

The Regulations also state that:

> "*Reactive phosphorus concentration" means the concentration of phosphorus as determined using the phosphomolybdenum blue colorimetric method. Where necessary to ensure the accuracy of the method, samples are recommended to be filtered using a filter not smaller than 0.45 µm pore size to remove gross particulate matter"*

The phosphorus EQS is based on reactive phosphorus because this is the chemical form that is detrimental to ecological receptors. For the purposes of this report the phosphorus EQS for High chemical classification was calculated at 42 µg-P/l in the Upper Test, based on altitude and alkalinity data for the Test at the East Aston sampling point. Table 21 in Appendix D provides the EQS thresholds for all four WFD classes.

By convention filtering the sample before analysis through a 0.45 µm filter removes all particulate matter and the results are considered to be representative of dissolved material only.

It is understood that phosphorus and orthophosphate measurements reported by the Environment Agency are based on filtering using a 0.45 µm filter before analysis, as recommended in the Regulations.

Shaw et al 2021 investigated the effects of analysis of filtered and unfiltered samples for reactive phosphorus (RP) and unreactive phosphorus (UP), based on sampling the River Test and River Itchen. They used 0.22 and 0.77 µm filters to separate samples into three fractions, dissolved, intermediate and particulate, and these three fractions were analysed for reactive and unreactive phosphorus. This resulted in 6 permutations:

- Reactive phosphorus: dissolved, intermediate and particulate fractions.
- Unreactive phosphorus: dissolved, intermediate and particulate fractions.

Their findings are not directly applicable to separation by the single 0.45 µm filter into dissolved and total fractions.

Shaw et al 2021 found from sampling the River Test that soluble reactive phosphorus (<0.22 µm) accounted for over 80% of the total reactive phosphorus in 75% of the samples, but there were outliers where the soluble fraction was a smaller component. It was also found that on average soluble reactive phosphorus was 55% of total phosphorus, where total phosphorus is the sum of all fractions of both reactive and unreactive phosphorous.

This means that the practice of filtering the samples will result in variable under-reporting of both the reactive and total phosphorus concentrations in the samples. The phosphorus concentrations reported by Environment Agency monitoring may represent approximately 55% of total phosphorus in the sample.

1.8 Hampshire Chalk Streams

Chalk streams are globally rare and ecologically rich. They are found only in southern and eastern England, from Dorset to Yorkshire, and in the Anglo-Parisian basin of north west France, together with a very small number near Aalberg in Denmark, CaBA-CSRG 2021, Shaw et al 2021.

Chalk streams are characterised by very high proportions of groundwater discharge to the total stream flow, which can be >90%, with correspondingly high baseflow indices (BFIs). Table 3 lists the BFI of a number of characteristic Chalk streams. The high proportion of groundwater-derived baseflow results in stable temperature, flow and water quality regimes. The relatively slow release of water from storage in the Chalk attenuates rainfall peaks, resulting in subdued hydrographs, with slow recessions after peak flows. Chalk geology creates gravel-rich streambed substrates and high-clarity water. Water quality is slightly alkaline with pH in the range 7.4 to 8 and temperatures of groundwater discharges at approximately 11^{o}C, Mainstone 1999, which warms the streams in winter and cools the streams in summer.

Chalk streams provide habitat for a diversity of plant, invertebrate and salmonid fish species. Fish species include brown trout, Atlantic salmon and grayling. Salmon, trout and grayling are all sensitive to pollution, and will be rare or absent in severely abstracted, eutrophic reaches, CaBA-CSRG 2021.

The Hampshire Chalk Streams are part of a small sub-group of Chalk Streams, see Table 3, the result of the streams flowing over the slope face of the Chalk in landscapes dominated by Chalk outcrop, CaBA-CSRG 2021.

Table 3 BFI of Characteristic Chalk Streams

Stream	Headwater Geology	Water Clarity	Stream Classification *Based on CaBA-CSRG 2021*	BFI
Upper Test at Chilbolton	Upper Chalk	High	Group A Slope Face Chalk	0.97
Upper Itchen at Easton	Upper Chalk	High		0.97
Dorset Frome at Dorchester	UGS, Gault, Lias and Oolites	Turbid after heavy rain	Group B Mixed Geology	0.83
Great Stour at Wye	Weald Clay, Gault, LGS, Chalk			0.57
Chess Stream Henfield, Sussex	Lower and Middle Chalk; Gault	Turbid after heavy rain	Group C Scarp Face Chalk	0.39
Quy Water Cambridge	Middle Chalk			0.82
Upper Wensum at Fakenham	Glacial Till	Turbid after heavy rain	Group D Pleistocene ice-impacted [a]	0.57
Granta at Babraham	Glacial Till			0.55

a Group D class is ambiguous; any stream in Group D typically also has characteristics of either A, B or C.

The River Test flows south over the surface of the Chalk outcrop. Surface geology comprises Chalk (mainly Seaford Formation) at outcrop, with subordinate areas of clay-with-flints or a thin covering of Head Deposits (sand & gravel, locally with silt, clay or peat) over the Chalk. The presence of permeable deposits at the surface results in high rates of infiltration and low rates of runoff. The baseflow index of the Upper Test is 0.97, CEH 2022, which is high even by the standards of the Chalk. The BFI of the Lower Test is 0.94 and the BFI of the River Itchen is in the range 0.91 (Lower Itchen) to 0.97 (Upper Itchen).

1.9 Study Area for this Review

Figure 2 shows the outline of the Upper Test Catchment, the study area for the purposes of this Review, together with the adjacent Bourne Rivulet catchment and the BDBC area.

1.10 Objectives of this Report

The objectives of this report are to:

- Provide a review of the BDBC WCS in relation to the relevant guidance, specifically the Environment Agency guidance[w].
- To assess whether the WCS provides appropriate and adequate evidence to inform development of the BDBC 2019-39 Local Plan.

w Water cycle studies - GOV.UK (www.gov.uk)

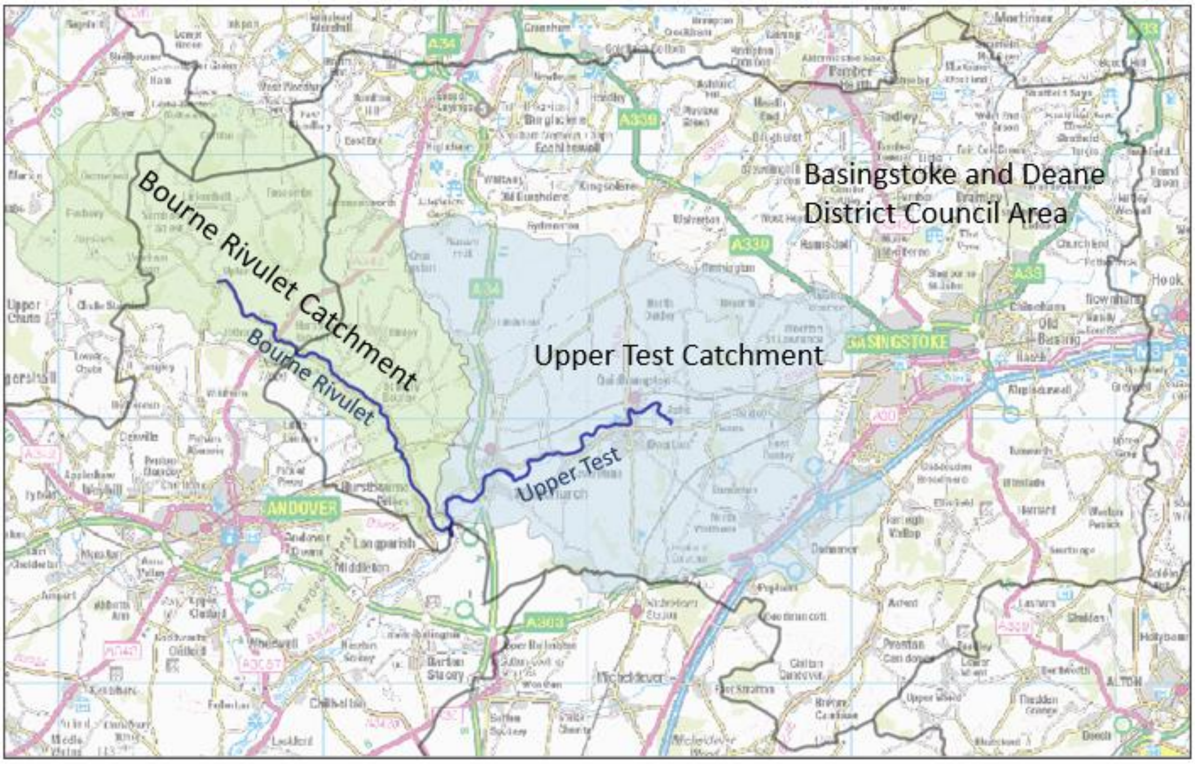


Figure 2 Study Area for this Review

1.11 Organisation of this Report

Section 2 provides a summary of the potential sources of contamination of groundwater in the Chalk Aquifer and surface water of the Upper Test.

Section 3 provides a generic assessment of the hydrogeology of the Chalk Aquifer.

Section 4 describes the environmental setting of, and selected monitoring data for, the Upper Test Catchment.

Section 5 provides a critical review of the WCS.

Section 6 provides conclusions and recommendations.

2 SOURCES OF CONTAMINATION IN THE RIVER TEST CATCHMENT

2.1 Introduction

The Chalk Aquifer and the River Test are vulnerable to contamination from multiple anthropogenic and natural sources of contamination. The most significant are considered to be:

- Agrochemicals used in agriculture: fertilisers containing nutrients and numerous pesticides.
- Treated sewage effluent from WWTWs, containing nutrients (phosphorus and nitrogen in various inorganic and organic forms), organic matter (as measured by BOD, COD, TOC and DOC), volatile fatty acids, trace metals, and numerous organic compounds of natural and manufactured origins.
- Sewage effluent from private sewage treatment plant, septic tanks and leaking cesspools, which can be anything from untreated leakage to treated effluent from package sewage treatment plant. The contaminants potentially present are little different to WWTWs although without the effects of Trade Effluent discharges.
- Industrial WWTWs discharging to watercourses; the most significant in the Upper Test is Portals Paper Mill at Foxdown near Overton.
- Atmospheric deposition, in particular of nitrogen oxides and ammonia.
- Historical Landfill sites.

There are many other possible sources of contamination, of which runoff from roads, pesticide applications for weed control on railway lines, and contamination on industrial land including historical industries, may be of relevance in the Upper Test.

2.2 Agriculture

2.2.1 Sources of Agricultural Pollution

2.2.1.1 Fertilisers

Agricultural fertilisers are a major source of nitrate and phosphate contamination in groundwater and surface water, Foster and Crease 1974, Wellings and Bell 1980, Rivett et al 2007, Stuart and Lapworth 2016.

It became apparent from research started in the 1970s that nitrate has accumulated in the unsaturated zone of the Chalk as a result of application of nitrogen fertilisers and the slow rate of vertical flow of infiltration through the Chalk unsaturated zone. Profiles of high pore water concentrations of nitrate in the unsaturated zone have been measured at many locations, Stuart 2005. Pore water concentration peaks are variable, but have been as high as 40 to 70 mg-N/l. At many locations the pore water peak has not reached the water table and therefore the nitrate load to groundwater in the Chalk is still rising even though current nitrate losses from the overlying soil have been reduced by improved farming practices.

In general the rate of vertical flow of nitrate through the Chalk unsaturated zone is of the order of 0.5 to 1 m/year Wellings 1984, Barraclough 1994, Brouyère et al 2004. Locally and especially where the depth to the saturated zone ("water table") is shallow the rate of vertical flow may be higher.

The effect of the slow transport of nitrate through the unsaturated zone has been described as the "nitrate time-bomb" due to the long delay, which can be of several decades, between fertiliser application and the eventual arrival of fertiliser-derived nitrate at the groundwater surface and in hydraulically-connected surface waters.

The fate and transport of phosphorus and phosphates in the Chalk is significantly different. Phosphorus and phosphates have low mobility in the Chalk due to the effects of adsorption and chemical reactions forming insoluble phosphate minerals including brushite ($CaHPO_4.2H_2O$) and hydroxyapatite ($Ca_{10}(PO_4)_6(OH)_2$), Climawat 2014. Batch laboratory experiments carried out on crushed chalk samples at pH 4.5 and 9.5 indicated that respectively 850 and 400 mg of phosphate can be removed per gram of Chalk, Climawat 2014. The experimental conditions used in the Climawat study will result in a significant over-estimate of phosphorous reactivity under *in situ* conditions. The use of crushed chalk under test conditions generates large effective surface area for surface reactions, especially when compared to groundwater transport through the dual-porosity system of in situ Chalk. In reality, adsorption and precipitation reactions on fissure surfaces will exert a primary control on phosphorous transport, but the available surface area will be much less than the effective surface area generated under the test conditions in the Climawat study. Phosphorus will diffuse from mobile fissure water to immobile pore water in the Chalk matrix in the same way that nitrate diffuses between fissures and matrix, although the diffusion coefficient for phosphorus is about 30% of that of nitrate. Therefore, diffusion from mobile fissure water to the Chalk matrix will further attenuate phosphorus under *in situ* conditions in the Chalk. Overall, the large adsorption/precipitation capacity of the Chalk to phosphorus will result in reduced macroscale mobility of phosphorus.

2.2.1.2 Crop Protection Products

Agricultural application of pesticides is also a source of contamination of Chalk groundwater and hydraulically-connected surface waters, Chilton et al 2005, Lapworth et at 2015. Field and laboratory studies were used by Chilton et al 2005 to assess the main factors that determine the fate and behaviour of agricultural herbicides in the Chalk aquifer of southern England. Field studies using isoproturon, chlortoluron and atrazine showed that leaching of pesticides from normal agricultural use produces concentrations in Chalk groundwater of 0.01–1 µg/l for most compounds, which are comparable with the current UK drinking water standard of 0.1 µg/l. Where significantly higher concentrations were found in groundwater (up to three or four orders of magnitude higher), these are associated with localized 'point' use or disposal, often combined with more rapid preferential transport pathways to the water table.

Studies of the degradation of isoproturon, mecoprop and atrazine showed that these compounds are significantly more persistent in the Chalk than in soils, with half-lives measured in hundreds rather than tens of days.

2.2.2 Quantification of Agricultural Leaching of Pollutants

A preliminary quantitative assessment of the losses of agricultural pollutants was included in this Assessment. Farmscoper Upscale software, ADAS 2021, was run for to quantify the emissions of nitrate-nitrogen, phosphorus and sediment to groundwater and surface water, and of ammonia and methane to the atmosphere.

Farmscoper is a decision support tool used to assess diffuse agricultural pollutant losses on a farm and quantify the impacts of farm mitigation methods on these pollutants. Farmscoper Upscale is a version of Farmscoper commissioned by the Environment Agency to provide catchment-scale estimates of agricultural pollution losses. Farmscoper Upscale estimates losses of nitrate, phosphate, sediment, ammonium, methane, nitrous oxide, pesticides, and faecal indicator organisms (FIOs). Losses of nitrate and phosphorus are assumed to occur as dissolved phase in water distributed in runoff and leaching to groundwater. Losses of ammonium, methane and nitrous oxide are assumed to occur in the gaseous phase to atmosphere.

Farmscoper Upscale contains farm census data at catchment level; for the River Test the catchment is divided in two: (ii) the Lower Test and (ii) the Upper and Middle Test. A Water Framework Directive version, Farmscoper Upscale WFD, contains farm census data for the Upper Test Catchment, WFD catchment No. GB107042022710, allowing an assessment to be made for the Upper Test alone. Farmscoper Upscale WFD was run for the Upper Test catchment using default data; a summary of the input and output data are provided in Table 4.

Table 4 Farmscoper Upscale WFD - Upper Test Input and Results

Total Catchment Area	**Number of Farms**	**Total Area of Farms** (ha)	**Diffuse Pollution Losses – Water** (kg/ha/a, except pesticides)				**Diffuse Pollution Losses – Atmosphere** (kg/ha/a)	
			Nitrogen	**Phosphorus**	**Sediment**	**Pesticides (units/ha/a)**	**Ammonia (volatile)**	**Methane**
177 km^2 17,706 ha	72	13,853 *(78% of catchment)*	29.6	0.10	49	0.03	6.2	16.4

Farmscoper Upscale was also run for the Upper and Middle Test catchment and produced very similar results to those presented in Table 4. The amount of each nutrient lost varies depending on the type of farm; for arable farms (which dominate in the Test catchment) the amount of nitrate-nitrogen and phosphorus losses are respectively 21% and 0.4% of the total applied as fertiliser.

2.3 Wastewater Treatment Works

2.3.1 Operational History and Treatment Technology

Table 5 summarises a review of the history and operations at WWTWs in the Upper Test Catchment; the full review is included in Appendix B.

The review in Appendix B covers:

- Whitchurch WWTW.
- Overton WWTW.
- Ivy Down Lane Oakley WWTW.
- Water Ridges Oakley WWTW (closed).
- North Waltham WWTW.
- Hannington WWTW.
- Ashmansworth WWTW.
- Portals Paper Mill industrial WWTW near Overton.

The River Test is identified as an existing eutrophic sensitive area under the Urban Waste Water Treatment (UWWT) Regulations[x]. Table 2 of Schedule 3 of these Regulations established ELVs for total phosphorus (2 mg-P/l) and total nitrogen (15 mg-N/l). However, these ELVs only apply where the WWTW serves a population equivalent (PE) of 10,000 or more, and none of the WWTWs in the Upper Test exceed this threshold, see Table 5.

All of the WWTWs, except Portals, discharge treated effluent to ground. At Whitchurch WWTW historically untreated effluent was discharged to ground.

At the public WWTWs (Whitchurch, Overton, Ivy Down Lane Oakley, Water Ridges Oakley [closed], North Waltham, Ashmansworth and Hannington) sewage effluent has been discharged to ground, and consequently to the Chalk Aquifer, over prolonged period of between >40 and >90 years. There is therefore the potential for widespread contamination of the Chalk Aquifer.

x The Urban Waste Water Treatment (England and Wales) Regulations 1994 (legislation.gov.uk)

Table 5 Summary Information for WWTW in the Upper Test Catchment

WWTW	DWF (m^3/d)	PE	Date	Historical Treatment	Current Treatment	Recent upgrade	Discharge to
Whitchurch	2,336	4,757	Pre-1930	Primary until 1982	Conventional secondary (TF) 1982 on.	2013: additional infiltration trenches**	Ground – Chalk Infiltration trenches 400m to R Test Direct to Chalk
Overton	1,160	4,477	Pre-1941	Conventional secondary (TF) Expanded pre-1999 & 2011	Conventional secondary (TF)	Upgraded 2011: 2 No. new TFs, 2 No. new HTs, 1 new ST 350 m^3 and a ferric dosing system	Ground – Chalk Infiltration lagoons 150m to R Test Direct to Chalk (thin covering of CwF over Chalk)
Ivy Down Lane Oakley	722	5,051	Pre-1979	Conventional secondary (TF)	Conventional secondary (TF) with N-SAF	2011: N-SAFF to meet 95%ile ammonia ELV of 5mg/l and 2 No. HTs	Ground – Chalk Infiltration trenches 3500m to R Test Direct to Chalk (1.3 to 2m clay over Chalk)
North Waltham	167	816	Pre-1979	Conventional secondary (TF)	Conventional secondary (TF)	2011; N-SAFF to meet 95%ile ammonia ELV of 5mg/l and 2 No. HTs.	Ground – Chalk French drains? 4000m to R Test Direct to Chalk
Hannington	10.2	38	Pre- 1985	unknown	Conventional secondary	Re-built between 1999 and 2005	Ground – Chalk 4700m to R Test
Ashmansworth	5	20	<1979 to 2001; Relocated circa 2001	unknown	Conventional secondary	unknown	Ground – Chalk 5700m to Bourne Rivulet
Water Ridges Oakley (closed)	ND	ND	1966-2009/12	unknown	Conventional secondary (TF)	unknown	Ground – Chalk 4500m to R Test
Portals Industrial WWTW	Max volume: 7000 m^3/d	N/A	Pre-1930	unknown	Activated sludge process	unknown	Pipe to River Test

** Whitchurch WWTW: a proposal made in 2010 to install a methanol denitrification plant and associated sand filters was abandoned and instead additional infiltration trenches were installed.

CwF clay with flints
HT humus tank
N-SAFF nitrifying submerged aerated flooded filters
DWF Permitted Dry Weather Flow
PE population equivalent; data from Southern Water DWMP
SF sand filters
ST storm tank
TF trickling filters

The four larger WWTW have all had some form of upgrade of the secondary treatment system over the last 15 years:

- **Whitchurch WWTW**: a proposal was developed in 2010 to reduce the nitrate concentrations in the treated effluent by installation of a methanol denitrification plant and associated sand filters. However, this was abandoned and instead additional infiltration trenches were constructed in 2013 which approximately doubled the infiltration area. The purpose of the new infiltration trenches was to promote additional denitrification in the ground beneath the site. The new infiltration trenches were built on adjacent farmland which required a change of use planning application. The statement in the planning application supporting document was "*This allows increase natural treatment by the earth, making the nitrate concentration within the groundwater at the nearby monitoring wells within acceptable limits.*" It is not clear whether the revised proposals were supported by technical design studies and/or post-completion verification monitoring.

- **Overton WWTW**: in 2011 the original trickling filters were replaced, and new humus tanks installed, together with a new storm tank. These works were carried out under AMP5. The improvements included two new trickling filters and ferric dosing system to control phosphorus emissions in treated effluent. The phosphorus concentrations in the treated effluent reduced from approximately 6.5 mg-P/l to <1 mg-P/l as a result of the improvements. The current EPR Permit for Overton WWTW sets an ELV of 1 mg-P/l; the reduction in phosphorus in 2011 was the result of the imposition of quantitative ELVs in the Permit. Prior to 2011 the Permit contained only descriptive emission standards. From 2011 the Permit contained quantitative ELVs for TSS, ammonium, total phosphorus and total iron, together with quantitative ELVs for BOD and COD under the UWWT Regulations.

- **Ivy Down Lane Oakley and North Waltham**: similar nitrifying (ammonia oxidation) removal plant (N-SAFF) were installed to meet new ELVs for ammoniacal nitrogen.

Development within the footprint of the existing Southern Water treatments works sites has been carried out under Permitted Development Rights and therefore has been carried out without the need to apply for planning permission. The upgrades at Whitchurch and Overton WWTWs required planning permission because the curtilage of the treatment works was extended on to new land. Limited aspects of the upgrades at Oakley and North Waltham WWTWs required planning permission.

2.3.2 Investigations of the Effects of Sewage Effluent Disposal on Groundwater

Investigations of the effects of sewage effluent disposal on groundwater in the Chalk were carried out at by the former Southern Water Authority (SWA) at Whitchurch WWTW over a period from the late 1970s to post-1982, Baxter et al 1981, Beard and Giles 1990. These investigations were part of a much larger study of the effect of the discharge of WWTW effluent to the Chalk at several WWTWs in Hampshire, Beard and Giles 1990. The investigations carried out by SWA at their Hampshire WWTWs were technically advanced at the time, by the inclusion of analysis for organic substances, installation of monitor wells at multiple depths in the Chalk, use of in situ groundwater samplers, and sampling & analysis of pore water and soil gases from the unsaturated zone, all of which were carried out at Whitchurch WWTW.

The investigations at Whitchurch WWTW included installation of groundwater monitor wells, and sampling and analysis of groundwater and WWTW effluent from the WWTW. A tracer test was also carried out to measure the rate of flow through the unsaturated zone from an infiltration ditch to the saturated zone. The original investigations, Baxter et al 1981 were carried out at a time when untreated sewage effluent was discharged to an earlier infiltration system comprising open infiltration ditches. In 1982 secondary treatment was installed at Whitchurch WWTW and the infiltration ditches were replaced by French drains (i.e. an underground effluent drainage/infiltration system), and further sampling of treated effluent and groundwater was carried out.

The findings from the investigations at Whitchurch WWTW reported by Baxter et al 1981 and Beard and Giles 1990 are summarised in Appendix B. There was evidence of sewage-derived contamination in groundwater approximately 100m downgradient of the infiltration system. Six monitor wells were installed immediately east of Winchester Road and approximately 300m west and south west of the infiltration system, see Figure 3. At the Winchester Road locations there was only on monitor well where there was a minor indication of sewage-derived contamination; groundwater quality in the remainder appeared no different to that in the upgradient monitor well.

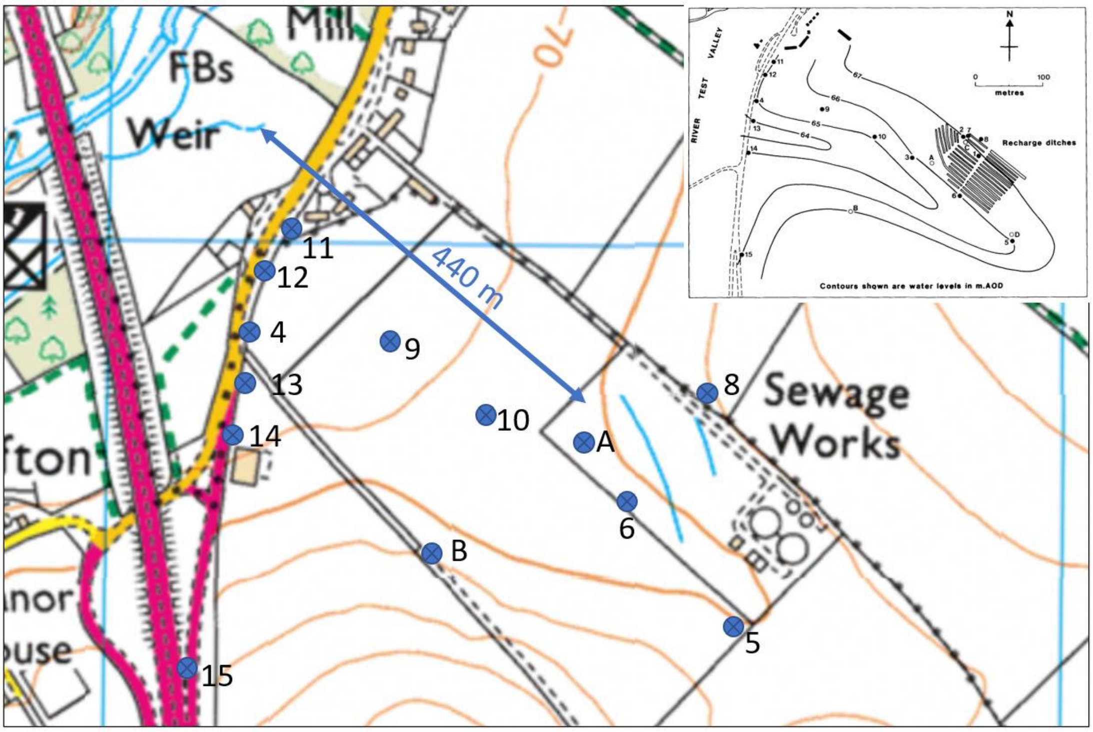


Figure 3 Monitor Wells Installed at Whitchurch WWTW in 1982

It is not known whether either SWA or Southern Water caried out any follow-up investigations at Whitchurch WWTW since 1982, other than monitoring sewage effluent and groundwater as required by the Environmental Permit. A literature search was carried out by the author of this report but no evidence could be found that Southern Water have published any results of investigations at Whitchurch WWTW since the investigations carried out by SWA some 40 years ago.

It is not known whether similar investigations have been carried out at any of the other WWTWs in the Upper Test Catchment.

The WCS does not mention these historical investigations at Whitchurch WWTW and nor does it provide any information concerning any subsequent or other investigations of groundwater quality at Whitchurch WWTW or any other WWTW. As discussed in Section 5 this is considered to be a significant omission from the WCS.

2.3.3 Compliance and Other Monitoring

As indicated in Table 2 the discharges to the Chalk Aquifer from WWTWs in the Upper Test Catchment are controlled by ELVs for BOD, TSS, ammonia, TIN (or TN), TP, and/or total iron. This is a very limited suite of parameters and does not include any Priority Substances (PS) or Priority Hazardous Substances (PHS).

However it is known that at Whitchurch, Overton, and Oakley WWTWs there are additional requirement to carry out monitoring of effluent and groundwater from monitor wells in accordance with the Effluent and Groundwater Monitoring Action Plan (EGMAP) for each WWTW. No details of the EGMAP monitoring methodology and scope or monitoring results were available. It is not clear if the current monitoring programmes for treated effluents, surface water and groundwater at WWTWs are adequate for the purposes of characterising contamination of the Chalk Aquifer in the Upper Test Catchment. **The WCS does not mention the EGMAP requirements at Whitchurch, Overton and Oakley WWTWs, nor does it consider whether the current monitoring programmes for effluent and groundwater are fit for purpose. As discussed in Section 5, these are considered to be a significant omissions.**

For more than thirty years, it has been known that pharmaceuticals, personal care products and other trace organic contaminants (TOrCs) survive conventional wastewater treatment and persist in the environment to varying degrees, Richardson and Bowron, 1985. A UK study, Jones et al 2014, found 40 trace contaminants, including trace metals, pharmaceuticals, polycyclic aromatic hydrocarbons (PAHs), 'emerging' and regulated organic pollutants in sewage sludge. Many of these TOrCs are potentially hazardous substances, including Priority Substances (PS) and Priority Hazardous Substances (PHS).

A study of wastewater treatment performance of TOrCs by Gardner et al 2013 involved 16 UK WWTWs, but all except one were larger works serving population equivalents in the range 12,000 to >200,000. One WWTW serves a PE of 3,400 with a DWF of 740m^3/d and uses conventional nitrifying and biological filtration treatment, and therefore was broadly similar to the WWTWs of the Upper Test. Better treatment performance for TOrCs was achieved by Activated Sludge (AS), Membrane Bioreactors (MBR) and WWTWs with tertiary treatment, but there was performance overlap between Trickling Filter (TF) WWTWs, as found in the Upper Test, and WWTW with higher levels of treatment technology. Some TOrCs were poorly treated (i.e. poorly removed) by all the WWTWs included in the study.

A recent study of the presence of TOrCs in the River Test and River Itchen reported by Robinson et al 2022 is described in Section 4.9.4.

The potential presence of TOrCs in treated sewage effluent on the groundwater and surface water of the Upper Test is not within the scope of the monitoring regimes carried out by either the Environment Agency or Southern Water.

2.3.4 Monitoring Results

2.3.4.1 Monitoring Data

Treated effluent quality monitoring results for the above WWTWs are provided in Figure 4 to Figure 7. The data are limited to the parameters reported and the period of record available from the Environment Agency OpenWIMS system. There are a number of gaps in the data records and different parameters have been measured over varying periods at each of the WWTW.

In the following text and figures all nitrate and phosphate results are expressed respectively as N and as P.

The following trends were noted:

Whitchurch WWTW: TN and TIN concentrations appear stable, but ammoniacal nitrogen and BOD appear to be increasing slowly.

Overton WWTW: BOD and ammoniacal nitrogen appear to have improved over time, phosphate is stable or improving but variable and periodically breaches the Permit ELV (1 mg-P/l); the nitrate record is too short to assess.

Ivy Down Oakley WWTW: all reported parameters appear on stable trends although the concentrations are generally variable compared to the other WWTWs. The effect of the N-SAF plant installed in 2011 is not shown because the record for ammoniacal nitrogen starts in 2012. Over the period 2019-21 the ELV for TIN (35 mg-N/l) was breached frequently.

North Waltham WWTW: There appears to be a long term downward trend in the nitrate concentration based on the assumption that most of the TN and TIN is nitrate, and therefore the nitrate-TN-TIN time-series can be viewed as a single concentration trend. Orthophosphate was stable but there are no recent data. Ammoniacal nitrogen has been stable since 2015. Monitoring data was reported as “no flow” from April 2021, which suggests that the WWTW has been closed temporarily.

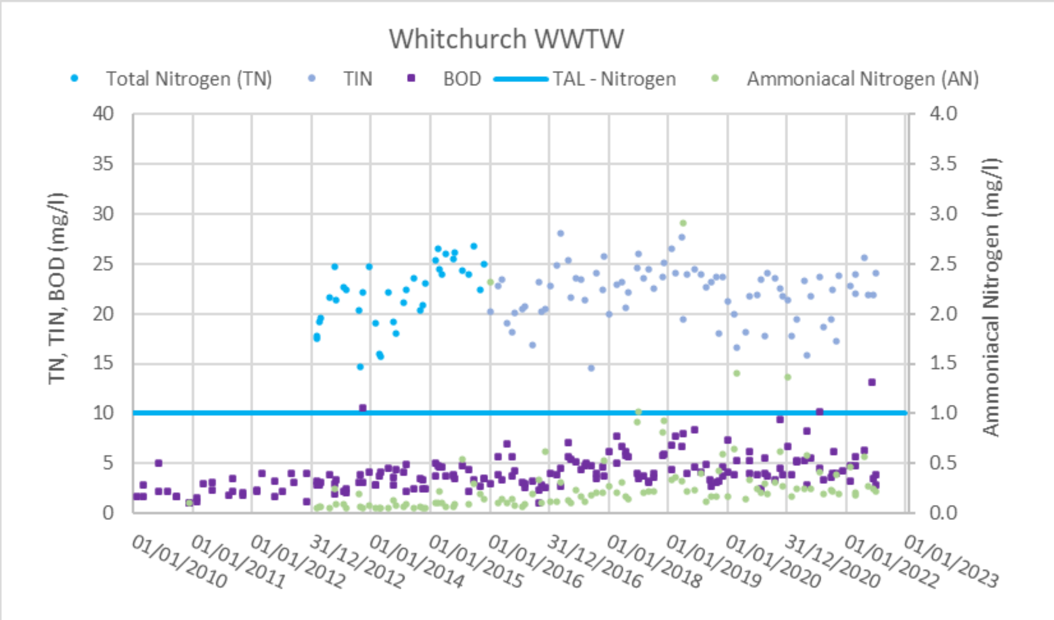


Figure 4 Treated Effluent Quality - Whitchurch WWTW

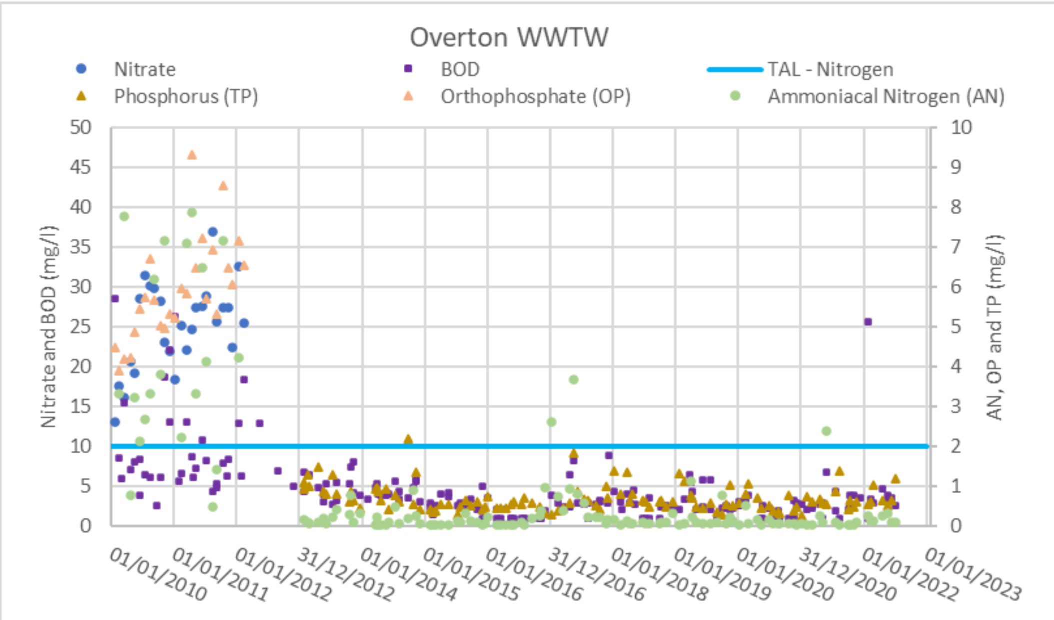


Figure 5 Treated Effluent Quality - Overton WWTW

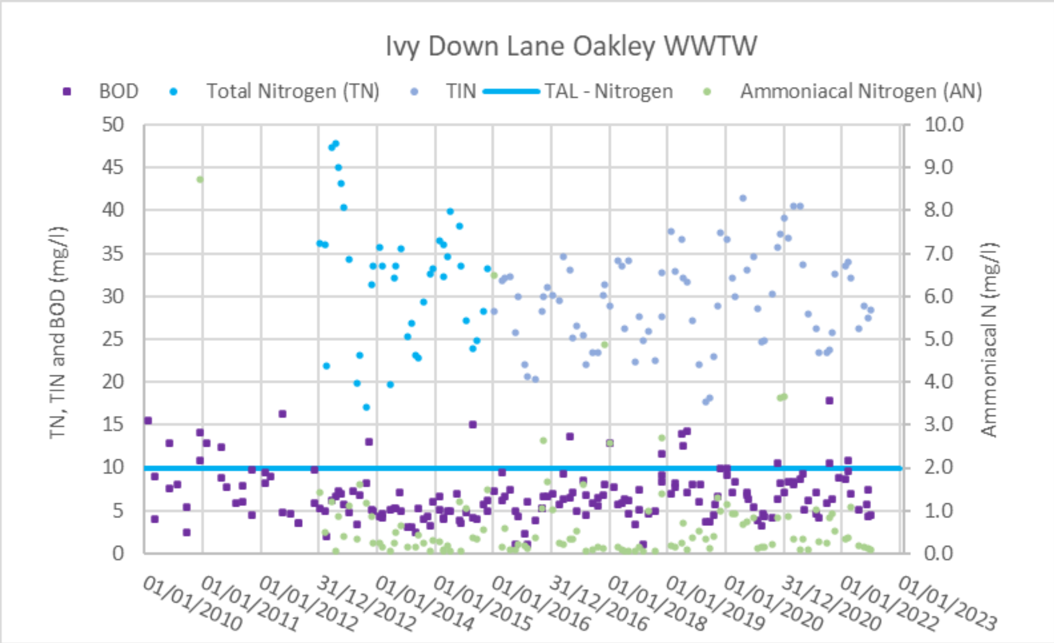


Figure 6 Treated Effluent Quality - Ivy Down Oakley WWTW

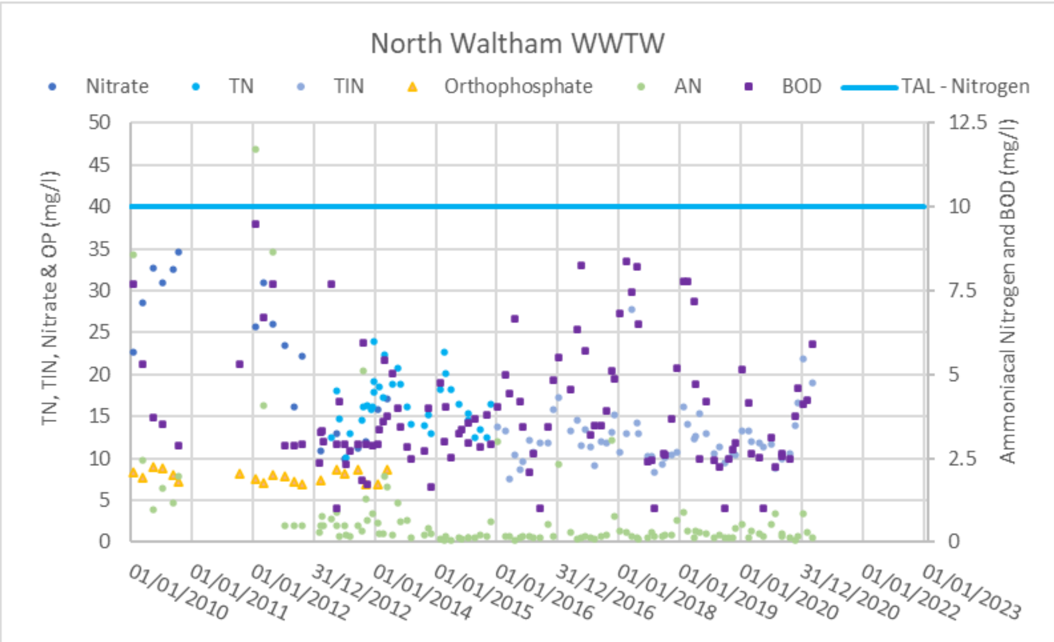


Figure 7 Treated Effluent Quality - North Waltham WWTW

2.3.4.2 Nitrate and Total Nitrogen

The reported nitrate and TIN concentrations in treated effluent were generally in the range 20 to 35 mg-N/l, except at North Waltham where nitrate has recently been reported in the range 10 to 20 mg-N/l. All WWTWs will require investment to meet the TAL of 10 mg-N/l by 2030, also shown on Figure 4 to Figure 7.

2.3.4.3 Phosphorus

Reporting of phosphorus in treated effluent stopped at North Waltham WWTW in 2014 and has never been reported for Whitchurch or Oakley WWTW. The concentration of phosphorus in treated effluent is only reported for Overton WWTW; the current concentrations are circa 1 mg-P/l at Overton WWTW.

2.3.5 Current Actual and Permitted Wastewater Discharges

Table 6 summarises the currently-permitted dry weather flows and actual measured dry weather flows at the WWTWs in the Upper Test Catchment, together with the calculated volume and nutrient load headroom at each WWTW. No phosphorus measurements were available for Whitchurch, Oakley, Ashmansworth and Hannington, and therefore the emission concentrations for phosphorus were estimated from historical measured data at Whitchurch WWTW reported by Beard and Giles 1990.

Table 6 Permitted and Actual Dry Weather Flows at WWTWs

WWTW	Dry Weather Flow (m^3/d)		Volume Headroom (m^3/d)	Actual Emission Concentrations (mg/l)		Nutrient Load Increase from uptake of Volume Headroom (kg/d)	
	Permitted DWF	Actual DWF		Nitrogen	Phosphorus	Nitrogen	Phosphorus
Whitchurch	2,336	1,753	584	22	6.5	12.8	3.8
Overton	1,160	1,001	159	25	0.5	4.0	0.1
Ivy Down Lane Oakley	722	534	188	30	6.5	5.6	1.2
North Waltham	167	36	131	12.5	8	1.6	1.0
Hannington	10.2	3	7	20	6.5	0.14	0.046
Ashmansworth	5	-	-	20	6.5		
Totals	**4,400**	**3,327**	**1,069**			**24.24**	**6.2**

If each of the WWTW received effluent at the permitted DWF the nutrient loads would increase proportionately as indicated in Table 6. Assuming all of the incremental nutrient loads were discharged to the River Test the effect on the concentrations in the River Test at Whitchurch would be increases of 0.18 mg-N/l and 0.05 mg-P/l of nitrate and phosphorus respectively.

Table 22 in Appendix D provides long term annual average nitrate and orthophosphate concentrations and also recent annual average orthophosphate concentrations for the River Test.

There is no EQS for nitrate and therefore WFD objectives would not be compromised by the increased nitrate load. However, nitrate is on an increasing trend at all monitoring locations, see Section 4.9.3, and these trends would be enhanced.

The High WFD quality standard threshold for phosphorus is ≤42 µg-P/l against recent (2022 and 2021) annual averages in the range 24 to 35 µg-P/l. If all of the incremental phosphorus load reached the river the WFD quality standard would reduce to Good and bordering Moderate; the classification may be further degraded by the upward phosphorus trend at the upstream monitoring locations, which is described in Section 4.9.3.2. Attenuation of phosphate in groundwater would probably prevent the WFD quality standard falling below High, but this cannot be guaranteed.

2.4 Wastewater from Non-Sewered Areas

Not all of the housing and non-domestic premises in the study area are connected to the public foul sewer network, with properties in rural areas especially unlikely to be connected. At a national level approximately 96% of the population are connected to the sewer network[y].

Only limited information on the numbers of private sewage treatment plant serving domestic properties was available. The Environment Agency Public Register of Permits issued under the Environmental Permitting Regulations 2016 was accessed to gauge the extent of non-sewered connections in the study area.

It was found that based on a search radii of 3 km centred on Whitchurch and Overton there were respectively 27 and 9 No. private sewage treatment plant serving one or a small number of residential properties. When scaled up over the Upper Test Catchment there are likely to be of the order of 50 private sewage treatment plants serving residential properties. These plant will discharge to the Chalk Aquifer using drainage fields or direct to the River Test, and given the absence of any tributaries of the Upper Test it is expected that the majority will discharge to the Chalk.

The Environment Agency OpenWIMS dataset contains compliance sampling records for the following private WWTWs in or close to the Upper Test Catchment:

- Essebourne Manor Hotel
- Jack Russel STW Faccombe
- Oak Lodge Nursing Home STW Oakley
- Oakley Hall STW Oakley
- Queen Inn STW Dummer

Although the flows from private STW can be small, the contaminant concentrations can be relatively high. For example at Oakley Hall STW the ammonium concentrations in 2022 were 8 and 51 mg-N/l based on two samples only. There is also evidence that the concentrations of phosphorus in treated effluent from modern package sewage treatment plant (PSTP) can be high, with one example reported at 13 mg-P/l from a recently installed state-of-the-art PSTP[z].

y pb6655-uk-sewage-treatment-020424.pdf (publishing.service.gov.uk)
z Development of a Risk Assessment Tool to Evaluate the Significance of Septic Tanks Around Freshwater SSSIs - NECR222 (naturalengland.org.uk)

Based on national statistics, it is likely that the volume of sewage discharged to the WWTWs in the Upper Test Catchment represents <96% of the total domestic foul sewage generated, and that private sewage treatment plant account for the remaining >4%.

Private septic tank and private package sewage treatment systems are subject to little if any regulatory surveillance. There is an increased likelihood of lack of maintenance including removal of sludge from package treatment plant, leakages from poorly managed cesspools and septic tanks, and non-compliance with regulatory requirements. Natural England report that as many as 80% of septic tank systems in England may not be maintained correctly[aa].

2.5 Industrial Sources

2.5.1 General

The Upper Test is largely rural and there are relatively few major industries.

Based on the Environment Agency Public Register, Portals Paper Mill is one of the larger industrial operations and is the only industrial facility in the Upper Test Catchment classified as an Installation under the Environmental Permitting Regulations 2016 (EPR). The WWTW at Portals Paper Mill is described below and in Appendix B.

There is also a large watercress production and salad washing/packing business, Vitacress Salads Ltd (VSL), at St Mary Bourne in the Bourne Rivulet catchment.

There are a small number of agricultural and other businesses that have EPR Permits for discharges to groundwater and surface water.

There are industrial development areas, especially in Whitchurch, but these are likely to be connected to the public foul sewer.

2.5.2 Portals Paper Mill

Portals Paper Mill adjacent to Overton Railway Station is regulated as an Installation under EPR and has a wastewater treatment plant which has operated since the 1930s. Industrial wastewater is treated and then treated effluent is discharged to the River Test at Quidhampton.

It is not known whether Portals WWTW discharged to the Chalk Aquifer during an earlier period of operation. The historical layout of the WWTW does not suggest that treated effluent was discharged to the Chalk.

In 2019, a revised EPR Permit was issued to Portals Paper Mill[bb]. The Decision Document[cc] associated with the revised permit notes that emissions

aa The impact of phosphorus inputs from small discharges on designated freshwater sites - NECR170 (naturalengland.org.uk)
bb RG25 3JG, Portals De La Rue Limited: environmental permit issued - GOV.UK (www.gov.uk)
cc Decision_document.pdf (publishing.service.gov.uk)

of phosphorus from Portals Paper Mill have a significant effect on the concentrations of phosphorus in the Upper Test.

Under the 2019 revision of the EPR Permit, Portals Paper Mill were subject to more stringent emission limit values for the discharge of treated effluent to the River Test. The revised emission limit values were based directly on the BATC-AELs (Best Available Technology Conclusions – Associated Emission Levels) derived for the Pulp and Paper Sector under the Industrial Emissions Directive (IED), as described in the Best Available Technology Reference Document (BREF) and BAT Conclusions[dd].

A derogation was issued to the operator that permitted emissions of Total phosphorus (TP), total nitrogen (TN) and chemical oxygen demand (COD) above the BATC-AELs until 2020 after which the operator was required to comply with BATC-AELs.

The change in emission limit values for TP were as follows:

- Pre-2016: TP 2 mg-P/l.
- 2019-20: TP 0.5 mg-P/l as an annual average.
- 2020 on: TP 0.25 mg-P/l as an annual average.

The BATC-AEL is therefore 8 times lower than the pre-2016 emission limit value for TP.

The current ELVs are listed in Table 7. It is notable that the operator is required to monitor for a range of trace organic substances several of which have low Environmental Quality Standards (EQS), for example the EQS of nonylphenol is 0.3 µg/l.

Table 7 ELVs at Portals Paper Mill

Parameter	Process Water Inlet	Process-based Limits *(kg/tonne pulp)*	WWTW Discharge
Treated wastewater	-	none	7000 m^3/d
COD	-	0.3 to 5	none
TSS	-	0.1 to 1	25 mg/l
TN	-	0.015 to 0.4	none
TP	-	0.002 to 0.04	AA: 0.25 mg-P/l MAC: 0.5 mg-P/l
Absorbable organically bound halogens (AOX)	-	0.05	
Ammonia	-	none	2 mg-N/l
Mercury and cadmium	-	none	Monitoring required, no ELVs
Organic substances, including pentachlorphenol, organo-tin as tin, TBT, nonylphenol and nonylphenol ethoxylates; chlorpyriphos, cypermethrin and endosulphan (A&B).	Monitoring required, no ELVs	none	Monitoring required, no ELVs

dd Production of Pulp, Paper and Board | Eippcb (europa.eu)

Monitoring data from the Environment Agency OpenWIMS system for the process waste discharge to the WWTW is shown in Figure 8. No post-2014 data were available.

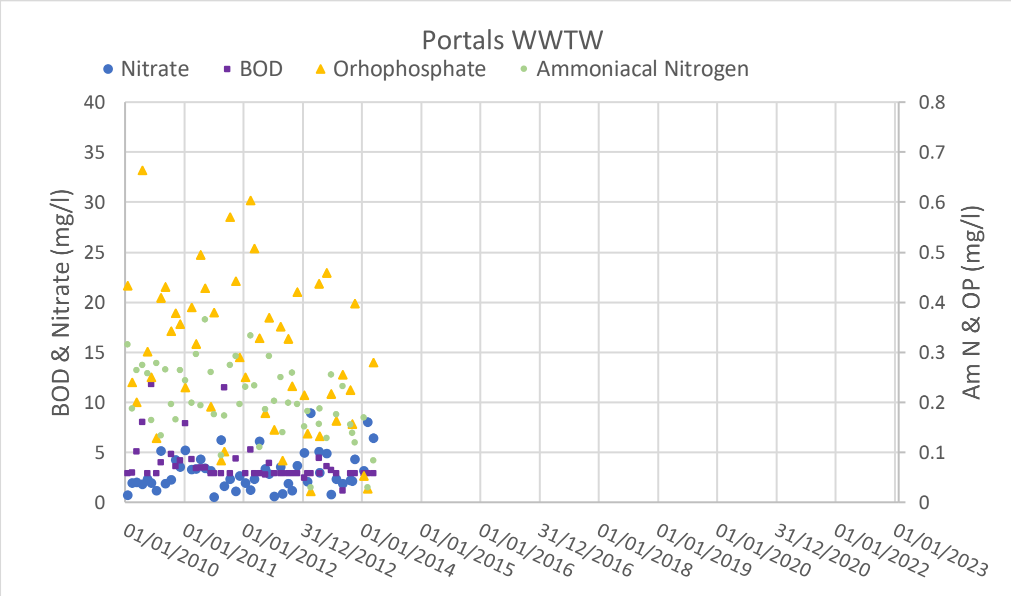


Figure 8 Portals Process Wastewater Monitoring Data

It is understood that Portals facility at Overton is scheduled to close in 2022, and therefore this discharge will cease.

2.5.3 VSL Factory

Vitacress Salads Ltd operate a watercress farm and processing factory near St Mary Bourne between the Test and the Bourne Rivulet. They have two discharge consents which have operated since 1995 or earlier.

VSL have applied for planning consent for development of a constructed wetland system comprising 15 ponds. VSL plan to improve the quality of discharge waters and sediment control by delivering a series of wetland areas. The wetland pond systems involve a series of simple vegetated pond-based systems which will function by mimicking the water treatment properties of natural wetlands. The application had not been determined at the time of preparing this report.

The planning application was supported by an Environmental Statement, RMA 2021, which contains information relevant to this report. VSL monitor the quality of water entering and leaving watercress beds, with analysis for ammoniacal nitrogen, nitrate, TN, phosphate and orthophosphate together with other substances. The monitoring records cover the period 2015 to date. Additional sampling and analysis at various locations was carried out to support the ES. Groundwater from the on-site abstraction borehole, surface water in the watercress beds and factory process water were sampled and analysed for a number of substances including pesticides. A number of pesticides were detected at relatively low concentrations in factory process water, but not in groundwater or surface water.

2.6 Atmospheric Deposition of Nitrogen

Dry and wet deposition of nitrogen oxides (NO_x) from vehicle emissions and industrial sources, and agricultural emission of ammonia, contribute to the soil and water nitrogen balances.

According to data provided by the Air Pollution Information System (APIS), the 2018-20 deposition rate for atmospheric nitrogen in the Upper Test Catchment is approximately 21 kg-N/ha/a [ee]. This is typical of deposition rates over England.

Most of the atmospheric nitrogen deposition is likely to be utilised by vegetation. Assuming 10% of this nitrogen load is eventually discharged to the River Test via transport in surface runoff and groundwater, the resulting concentration in the River Test would be, by mass balance, 0.2 mg-N/l using the catchment area and mean daily flow data in Table 12.

2.7 Historical Landfill Sites

The Environment Agency records of historical landfill sites [ff] include a total of five sites in the Upper Test Catchment of which three landfill sites were formerly operated by Portals Ltd. The Environment Agency Public Register records one closed landfill in the Upper Test Catchment, also formerly operated by Portals Ltd. Details are provided in Table 8.

It is likely that the wastes deposited by Portals would contain phosphorus and nitrogen because they are described as sludges and are likely to be paper process waste sludges and waste water treatment sludges. There is the possibility that the paper mill wastes contained other contaminants although they were classified as inert. However the quantity of waste deposited and site engineering details are unknown. Further investigations would be needed to determine whether any of the identified historical landfill sites presents a risk of contamination of the River Test.

Table 8 Landfill Sites in the Upper Test Catchment

Site Name	Operator	Location	Grid Reference	Status	Operational	Waste Type	Liquid/Sludge Waste	Distance to River Test
Apple Dell	Portals Ltd	Tirrell Hill Farm, Overton	SU 510 483	Closed	1945 -	Inert	Yes	1500m
Apple Dell Extension	De La Rue International Ltd		SU 5106 4834	Closed	1979 - 2019	Inert		1500m
Brick Kiln	Portals Ltd	Brick Kiln, Overton	SU 509 490	Closed	1977 - 1979		Yes	700m
Kennel Plantation	Portals Ltd	South of Kennel Plantation, Quidhampton	SU 522 504	Closed	1977 -	Inert	Yes	<100m
Disused Cutting, Whitchurch Station	ND	North of Whitchurch Railway Station	SU 463 489	Closed	ND	Household waste	No	800m
Land at Weston Down Clump	Gleeson Civil Engineering	Freefolk Land, Micheldever	SU 507 436	Closed	1981	Inert	No	7 kms

ee www.apis.ac.uk
ff Historic Landfill Sites - December 2021 (data.gov.uk)

2.8 Catchment Nitrogen Balance

Table 9 provides an approximate anthropogenic nitrogen balance for the Upper Test. The atmospheric nitrogen inputs are based on the assessment in Section 2.6. The agricultural inputs are based on the Farmscoper Upscale results presented in Section 2.2.2.

The WWTW inputs in Table 9 were based on the WWTW dry weather flows and nitrogen concentrations from recent monitoring data. An additional 4% allowance was added to account for non-sewered wastewater inputs to the Chalk Aquifer. The nitrogen load from Portals was based on the maximum permitted discharge volume and TN concentration.

These anthropogenic inputs are superimposed on a pre-industrial baseline which is likely to be of the order of 1 mg-N/l, Limbrick 2003, Buss et al 2005.

Table 9 Catchment Nitrogen Balance Estimates

Parameter	Units	Atmospheric	Agriculture	WWTW	Total
Source of estimates:		APIS data	Farmscoper Upscale WFD (*see Section 2.2.2*)	DWF: Table 1 Concentrations: *Section 2.3*	
Diffuse load to surface from atmosphere or agricultural application rate	kg-N/ha/a	21	45 to 140		
Attenuation in soil	-	90% (*estimated*)	*As modelled by Farmscoper*		
Net load to river	kg-N/ha/a	2.1	29.67		
Catchment area	Ha	17,706	13,853		
Total load to river	kg-N/a	37,183	401,160	47,662	
Mean daily flow of River Test at Whitchurch	m^3/a	69,568,115			
Calculated concentration in River Test	mg/l	0.53	5.91	0.69	**7.13**

Notes:

1 Attenuation of atmospheric loads in soil estimated across all land uses.

2 Agricultural loads estimated using Farmscoper Upscale, and representative of current rather than historical farming practices.

3 WWTW loads based on permitted DWF (Table 1) and recent measured concentrations of nitrate and TIN. Total WWTW load includes an estimate of the nitrogen load from unsewered discharges and Portals Paper Mill consented discharge.

4 The derivation of the nitrogen loads from WWTW is provided in Appendix G.

It is important to note that the nitrogen concentrations in Table 9 are based on estimates of current agricultural and wastewater loads, and are not representative of historical loads:

- A large part of the historical agricultural nitrogen load remains in storage in the unsaturated zone and in groundwater in the Chalk Aquifer, including nitrate that has diffused into the pore space of the Chalk matrix. The current discharges of nitrate from groundwater to the River Test is an artefact of historical farming practices and fertiliser inputs and as shown in Section 6 is still increasing. Even after nitrogen loads entering the Chalk groundwater from the unsaturated zone decrease due to improved farming practices there will be a long period, measured at least in decades, over which reverse-diffusion from the Chalk matrix in the saturated zone will maintain high nitrate concentrations in mobile fissure water in the Chalk.
- Historical inputs of nitrate to the Chalk aquifer beneath WWTW infiltration systems will have caused nitrate to diffuse into the pore space of the Chalk matrix. It is likely that a large mass of nitrate is stored in the pore water of the Chalk matrix in the zone beneath each infiltration system and in the downgradient aquifer. There will be a long period, measured in decades, over which back-diffusion from the Chalk matrix in the saturated zone will maintain high nitrate concentrations in mobile fissure water in the Chalk.

Therefore, the effects of historical inputs of nitrate and other nitrogen compounds to the Chalk Aquifer from agricultural and WWTW sources will continue for many decades into the future.

3 HYDROGEOLOGY OF THE CHALK AQUIFER

3.1 Introduction

This section provides a brief summary of the state of knowledge of the hydrogeology of the Chalk Aquifer in England. This is intended to serve the purposes of this report and is not a complete summary of the hydrogeology of the Chalk.

The Chalk Aquifer is an important source of public water supply in southern and eastern England providing 40% of public water supplies in this area, and up to 80% in local areas, Downing 1998.

In much of southern and eastern England the Chalk provides the majority of river flows and therefore is critically important to dependant ecosystems.

Chalk groundwater resources are heavily exploited and a large proportion of Chalk groundwater bodies are over-abstracted.

The Chalk has been contaminated by diffuse and point sources of contamination. The main source of diffuse pollution is agricultural, especially nitrate from agricultural fertiliser application. Point sources include industrial and public and private wastewater treatment systems.

The understanding of the hydrogeology of the Chalk has developed over the last 50 years. Advances have been made in the understanding of groundwater flow and storage; groundwater recharge and unsaturated zone storage & transport; the availability of groundwater resources; and fate and transport of a wide range of contaminants especially nitrate.

3.2 Geology and Stratigraphy of the Chalk

The previous and well-established division of the Chalk into Lower, Middle and Upper zones has been revised in recent years, Bristow et al 2008, Mortimore 1986, as summarised in Table 10.

Table 10 Chalk Sub-Divisions

<table>
<tr><th>Group</th><th>Previous Divisions</th><th>New Formation names</th></tr>
<tr><td rowspan="6">White Chalk sub-group</td><td rowspan="3">Upper Chalk</td><td>Newhaven Chalk</td></tr>
<tr><td>Seaford Chalk</td></tr>
<tr><td>Lewes Nodular Chalk</td></tr>
<tr><td rowspan="2">Middle Chalk</td><td>New Pit Chalk</td></tr>
<tr><td rowspan="2">Holywell Chalk</td></tr>
<tr><td rowspan="3">Lower Chalk</td></tr>
<tr><td rowspan="2">Grey Chalk sub-group</td><td>Zig Zag Chalk</td></tr>
<tr><td>West Melbury Marly Chalk</td></tr>
</table>

3.3 Physical Properties

The Chalk is a micro-porous pure limestone formed from the skeletal, coccolithic remains of marine algae. Coccoliths are individual plates of calcium carbonate formed by single-celled algae which are arranged around them in a coccospheres. The coccoliths and component plates give the rock matrix an open porous structure.

Hancock 1975 describes the petrology of the Chalk in detail. Nearly all the sediment was deposited as low magnesium calcite which is stable at surface temperatures and pressures. Unlike most limestones, the low Mg-calcite of the Chalk meant that early post-deposition re-crystallisation and lithification did not occur, and the Chalk retained a high matrix porosity. The Chalk generally contains approximately 1% clay minerals, although the Chalk Marl at the base of the Chalk, and thin (1 cm scale) marl horizons and lenses within the Chalk, contain up to approximately 30% clay minerals.

The grain size of the matrix is circa 1 micron, derived from the size of the coccoliths, with 10 to 25% larger fragments in the range 10 to 100 microns. The characteristic pore size of the Chalk is in the range 0.2 to 1 micron. The matrix porosity is in the range 20 to 45% and the matrix hydraulic conductivity, consistent with the grain size, is 10^{-9} to 10^{-7} m/s, Price et al 1993, in the range typical of fine silt and clay.

A fracture (fissure) system, enlarged by solution, has developed, which results in a macroscale rock mass hydraulic conductivity orders of magnitude higher than the matrix hydraulic conductivity. The porosity of the fissure system is typically 0.1 to 3%.

It has also been established that hydraulic conductivity reduces with depth in the saturated zone, but also tends to be higher in river valleys and lower in interfluves where the depth to groundwater is higher and can be 40m or more. This results in non-linear transmissivity, Rushton 2003.

3.4 Dual Porosity and Groundwater Flow

A dual porosity conceptual model of the Chalk has become established, in which the majority of groundwater storage occurs in the micro-porous matrix, but groundwater flow in the saturated zone is dominated by relatively rapid fracture/fissure flow. This is represented conceptually by a system of a microporous matrix, where each block can be considered to act similarly to a sponge, divided into blocks by the fracture system which provide rapid groundwater flows.

Under conditions of a falling or rising groundwater potentiometric surface (i.e. water table) the release from or refilling of storage is controlled by the fissure system storage (0.1 to 3%) because the matrix remains saturated when the rock is drained.

The Chalk is characterised by large seasonal water table fluctuations at distances from watercourses, which can be tens of metres in the interfluves.

It is common for Chalk groundwater catchments that feed to watercourses and abstraction wells to be disconnected from the associated surface water catchments. Groundwater divides do not coincide with surface water divides and/or dry valley systems are either not replicated by groundwater contours or represented by subdued contour replications.

Three phase porosity models have emerged more recently. Haria et al 2003 presents a three phase model based on identification of an additional intermediate porosity system, partly based on an investigation site in the River Test catchment. Price et al 2000 provide several lines of evidence that irregularities on the surfaces of the fissure system provide additional storage when matrix potentials are too low to support fissure flow. Price et al 2000 noted that the volumes of water draining from some Chalk catchments in recessions are greater than can be explained by gravity drainage from fissure porosity alone, with an unidentified storage component of circa 0.3%. The additional storage from the fissure irregularities provided the required additional 0.3% of storage under drainage conditions.

3.5 Chalk Unsaturated Zone and Recharge Mechanisms

Wellings 1984 showed that the majority of vertical flow of recharge through the unsaturated zone occurs as slow matrix-flow and that flow in the fractures in the unsaturated zone only occurs when matrix potentials are higher than -5 kPa. Where the unsaturated zone is tens of metres thick the rate of flow in the unsaturated zone of the Chalk has been measured by pore water profiling and tracer tests at of the order of 0.5 to 1 m/year.

However, where groundwater is shallow the effect of higher pore pressures and increased saturation of the unsaturated Chalk results in by-passing of the slow matrix transport route, with rapid flow of recharge through the fissure system and/or coarser grained matrix porosity, Haria et al 2003. The rate of flow in the unsaturated zone above a shallow water table will be much faster, at rates of the order of metres per day or metres per month.

As described in Section 2.2 the pore water nitrate profiles include nitrate peaks of as much as 40 to 70 mg-N/l which originated as soil losses decades ago and are still slowly moving towards the water table. Therefore whilst farming practices have reduced nitrate losses from the soil zone, the maximum nitrate load to groundwater has not yet occurred in some areas with thicker unsaturated zones.

3.6 Contaminant Fate and Transport

The dual porosity and hydraulic conductivity distribution characteristics of the Chalk have a profound effect on transport of dissolved contaminants and microorganisms (bacteria and viruses):

- Unreactive contaminants, such as nitrate and chloride, transfer from mobile fissure water to the matrix by diffusion-controlled transport. Thus diffusion into matrix storage and back-diffusion from the matrix control the transport of unreactive contaminants. The high porosity of the matrix provides high storage capacity for these substances. Once a contaminant has diffused into the matrix, which may occur over prolonged periods, reversing the process by flushing, with uncontaminated or more weaky contaminated water, will be very slow because of the reliance on back-diffusion rates.

- Contaminants that react with the aquifer matrix by ion exchange, adsorption and precipitation reactions are likely to be preferentially distributed on surfaces associated with the zones of groundwater flow in the saturated zone i.e. the fissure system and larger pore spaces. These contaminants are likely to be relatively immobile in the unsaturated zone due to the adsorption and precipitation capacity of the Chalk matrix where unsaturated flow is concentrated. Reactive contaminants include phosphorus/phosphate, ammonium (NH_4^+), many trace metals, and some organic substances.

- Bacteria and protozoa are generally too large to penetrate the Chalk matrix and are probably concentrated as biofilms on fissure surfaces and in the larger pore spaces, and as filtration deposits in clogged pore space. Viruses are 0.01 to 0.25 microns in diameter and are small enough to enter the Chalk matrix pore space.

- Vertical pore water profiles in the unsaturated zone can show large variations in contaminant concentrations at metre or smaller scales, which relate to the history of contaminant entry at the surface.

- The effect of seasonal fluctuation of the groundwater surface (water table) results in flushing in the zone of water table fluctuation.

3.7 Site-specific Contaminant Fate and Transport Aspects in the Upper Test

3.7.1 Inorganic Contaminants

In his presentation David George, George 2022, highlighted the differences in transport of nitrate and phosphate/phosphorus in the Chalk, where treated sewage effluent is discharged to infiltration systems at the WWTWs in the Upper Test. The high flows and point-source nature of these discharges to the Chalk will result in rapid flow through the unsaturated zone because effluent infiltration rates are almost certainly in excess of the flow capacity of the Chalk matrix beneath the infiltration systems.

3.7.2 Nitrate

Nitrate as a non-reactive contaminant will have, and will continue to, transfer by diffusion to the Chalk matrix. The Chalk beneath and around these infiltration sites will contain a very large mass of nitrate in storage, representative of the decades, >90 years in some cases, of disposal of sewage effluent to the Chalk.

The concentrations of nitrate and other unreactive contaminants in the matrix are in equilibrium with the concentration in the mobile water in the fissure system. The rate and direction of diffusion will respond to changes in input concentrations affecting the flow system. Wherever WWTW treatment technologies have been improved in the past, or are improved in future, and contaminant concentrations in effluent are reduced by these technologies, the Chalk system will respond in potentially complex ways. A future improvement at the WWTWs to meet the technically achievable limit of 10 mg-N/l, compared to the current concentration of circa 30 mg-N/l, will not result in a directly proportionate reduction in nitrate concentrations and mass transport to the River Test. When exposed to lower nitrate concentrations in the mobile water in the fissure systems, nitrate stored in the matrices will back-diffuse into the fissure system, controlled by concentration gradients. Therefore the input nitrate concentrations in the treated effluent entering the ground will be counter-attenuated by mass diffusion back from the matrix, resulting in higher concentrations flowing to the River Test compared to the concentration in the treated effluent. The back-diffusion of nitrate mass to the mobile fissure water will continue for a prolonged period, probably measured in years.

A preliminary assessment of the storage of nitrate in the Chalk has been made in this Review to inform the understanding of the fate and transport of nitrate between the WWTW infiltration systems and the River Test. It is stressed that this is only a preliminary assessment and that further work, including data collection and dual porosity groundwater modelling, is required to provide an adequate understanding. Information that should be available from the "*Effluent & Groundwater Monitoring and Action Plan*" obligations at Whitchurch, Overton, Oakley and North Waltham WWTWs (see Tables S1.2 and S3.4/S3.5 of each Permit) should inform such a study.

The storage estimate is as follows, based on Whitchurch WWTW:

- The matrix of the Upper Chalk has a porosity of approximately 39% by volume with a corresponding dry density of 1650 kg/m^3, Allen et al 1997.
- A 1 cubic metre block of Chalk would contain approximately 390 litres of water in matrix storage.
- The nitrate concentration in the Chalk matrix of the saturated zone is likely to be in the range 4.5 to 9 mg/l based on: (i) data for the Oakley Farm monitor well, see Section 4.9.2; (ii) a nitrate concentration of 7.2 mg-N/l measured at the spring shown in Figure 9 in October 2022; and (iii) the investigations at Whitchurch WWTW in 1981 when nitrate was measured in the oxidised plume in the range 6.3 to 9.6 mg/l, with an upgradient concentration of 7.4 mg-N/l, see Appendix B1.3.
- At a nitrate concentration of 7.5 mg-N/l, a 1 cubic metre Chalk block would contain approximately 0.003 kg of nitrate as N. This assumes that the nitrate concentration in the matrix is in equilibrium with the nitrate concentration in mobile groundwater in the fissure system.
- The aerial extent and depth of the plume emanating from the infiltration system at Whitchurch WWTW is unknown. Any attempt to estimate the plume dimensions would be conjectural at this stage. For this reason the mass of nitrate in the plume has not been estimated.

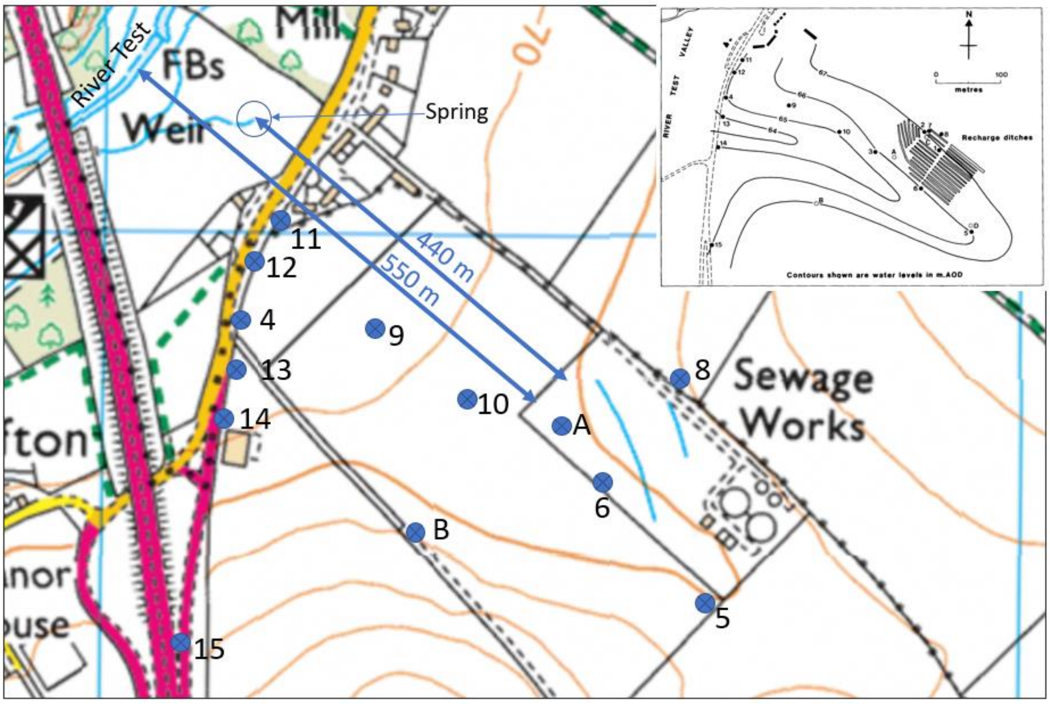


Figure 9 Whitchurch WWTW Monitor Well Network and Transport Path to River

An estimated 51 kg/d of nitrogen is discharged to the Chalk from the infiltration system at Whitchurch WWTW, see Appendix G. Assuming steady state conditions, negligible or no denitrification, and that the entire nitrate load reaches the River Test, this load would cause the nitrate concentration in the River Test at Whitchurch to increase by approximately 0.4 mg-N/l based on the estimated mean flow in the river from Table 12. Given the assumptions made this is the maximum incremental concentration that could be predicted. The 2010-22 average nitrate concentration at Town Mill Whitchurch, upstream of Whitchurch WWTW, is 7.37 mg-N/l and the downstream 2010-22 average concentration at East Aston is 7.59 mg-N/l, a difference of 0.22 mg-N/l. Whilst this increment could be caused by nitrate loading from Whitchurch WWTW, there could be multiple influences on nitrate concentrations between Whitchurch and East Aston.

The 1981 investigation indicated that the nitrate concentrations in the plume at Whitchurch WWTW were only a maximum of 3 mg-N/l above the upgradient background, see Appendix B1.3. This increase is very small and is not consistent with such a large loading suggesting that nitrate was undergoing considerable de-nitrification in the unsaturated zone at the time. However, these measurements were made before secondary treatment was installed at Whitchurch WWTW. The discharge of nitrified effluent since 1981 may have resulted in significant changes to nitrate fate and transport since that time.

The lack of recent groundwater monitoring data at Whitchurch WWTW severely restricts the understanding of nitrate fate and transport.

3.7.3 Ammonium

The ammonium ion NH_4^+ is a reactive contaminant which is attenuated by adsorption and cation exchange. Ammonium will diffuse into the Chalk matrix and therefore behave similarly to nitrate, with back-diffusion likely whenever fissure concentrations are lowered. In addition, ammonium may be desorb and/or be subject to reverse cation exchange in response to changing concentrations in fissure water. Therefore there is the potential for ammonium to be mobilised from storage if the concentrations of ammonium in treated wastewater discharged to the Chalk are lowered to allow increased wastewater volumes to be discharged.

3.7.4 Phosphorus and Phosphates

Transport of reactive contaminants such as phosphorus in phosphates is also controlled by equilibrium reactions. Under conditions of constant input concentrations phosphorus will attenuate by adsorption and/or precipitation as phosphate mineral such as hydroxyapatite. However, this is an equilibrium reaction itself and the phosphorus concentration in the mobile groundwater is likely to be higher than under the uncontaminated baseline.

The attenuation capacity of the Chalk for phosphorus is high, Climawat 2014, and therefore it is likely that a significant proportion of the phosphorus mass historically discharged to the Chalk at WWTWs in the catchment remains in storage in the Chalk. There is a likelihood that any improvement in treatment technology at WWTWs to reduce phosphorus concentrations discharged to the Chalk will result in re-mobilisation of phosphorus from storage due to the effect of back-diffusion. Therefore, similarly to nitrate, the concentration of phosphorus in groundwater migrating to the River Test may not reduce in direct proportion to the reduction in concentration in the input treated effluent. Again, the timescales for complete reverse mass transfer will be very long and measured in years or decades for phosphorus.

4 ENVIRONMENTAL SETTING AND CONCEPTUAL MODEL

4.1 Introduction

This section describes the environmental setting and characteristics of the Upper Test Catchment.

Land use, rainfall and hydrological data were obtained from the National River Flow Archives (NRFA) held by CEH, CEH 2022[gg]. Geological and hydrogeological data were obtained from BGS public domain data. Water quality data was obtained from the Environment Agency Water Quality Archive (WIMS system)[hh].

4.2 Land Use

Table 11 summarises the land use distribution in the Upper Test Catchment based on data from CEH 2022.

Table 11 Land Use Distribution of the Test

Subdivision	Land Use Distribution (%)				
	Woodland	Arable and Horticulture	Grassland	Heath	Urban
Upper Test	13.5	50.4	29	0.1	3.4
Lower Test	14.9	46.2	30.8	0.2	4.4

Source: CEH 2022, Catchment Info for 42024 - Test at Chilbolton Total (ceh.ac.uk)

4.3 Topography

Topography comprises rolling Chalk downs dissected in a ENE to WSW direction by the River Test. The landform is also characterised by a significant number of dry valleys with intervening interfluves. The dry valleys can be appreciated from the map of superficial geology, Figure 13, where the dry valleys appear as narrow lineaments of superficial deposits including River Terrace, Head, and alluvium.

The topographic elevation varies from 65 to 95m OD through the valley of the River Test, and rises to a maximum of 296m OD in the higher ground.

4.4 Climate Data

The 1961-90 standardised average annual rainfall (SAAR) in the Upper Test is 801 mm, see Table 12. According to CEH data[ii] the mean annual rainfall within the catchment varies from approximately 700 mm/a in the Test valley to approximately 850 mm/a in the high ground to the north east.

gg Catchment Info for 42024 - Test at Chilbolton Total (ceh.ac.uk)
hh Open WIMS data
ii Catchment Info for 42024 - Test at Chilbolton Total (ceh.ac.uk)

4.5 Hydrology

The Upper Test extends from the confluence of the Test with the Bourne Rivulet to the source, see Figure 10, and Figure 32 in Appendix C.

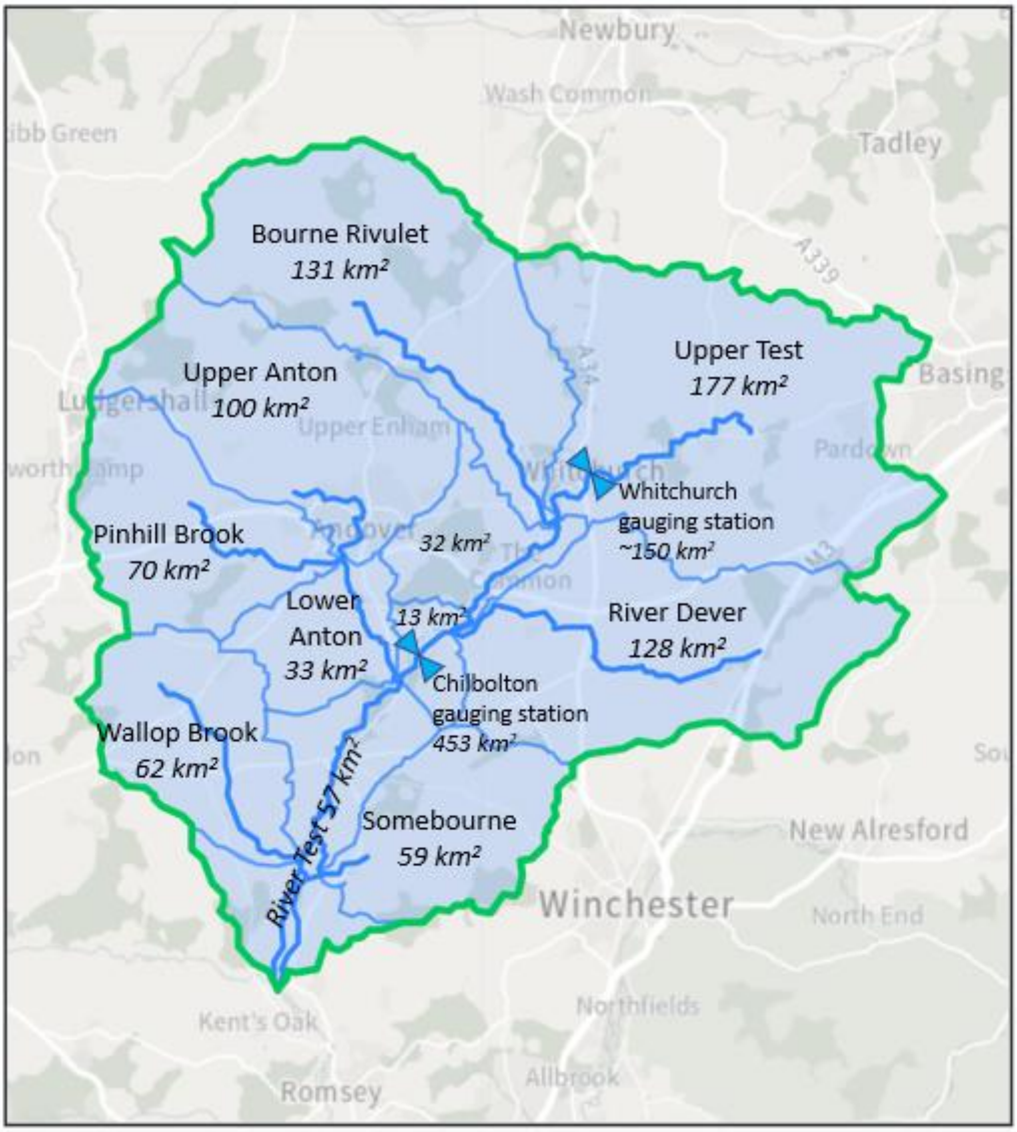


Figure 10 Catchment Boundaries and Areas

According to Environment Agency data[jj] the Upper Test Catchment covers an area of 177 km^2, with a stream length of 14.8 km. The River Test is the only permanent watercourse present in the catchment, resulting in a very low drainage density of 0.084 m^{-1}.

Limited gauging data was available for the Upper Test from periodic spot sampling of the main and side channels at Whitchurch. Gauging records were available for the main channel and for the side channel, with a longer period of flows records for the main channel, 1955-2013, than for the side channel, 1990-2013. The 1990-2013 measured total mean daily flow is

jj Test (Upper) | Catchment Data Explorer | Catchment Data Explorer

1.56 m^3/s, but this is likely to be an underestimate because high flows were not recorded.

River flow and rainfall data were obtained from the national River Flow Archives held by CEH[kk]. The Middle Test is gauged at Chilbolton which is some 12 km below Whitchurch and below the confluences with the Bourne Rivulet and the River Dever, see Figure 10. Greater than 30 years of daily flow data are available for the Middle Test at Chilbolton. According to CEH the flow regime in the River Test at Chilbolton is "sensibly natural", meaning that there are little or no artificial influences on river flows. The combined dry weather flows of the WWTW works upstream of Chilbolton is 0.07 m^3/s and therefore only 1.3% of the mean daily flow at Chilbolton.

There is also a flow gauging station on the River Dever at Bransbury close to the confluence with the Test. Flow data for the River Dever are provided in Table 12.

Table 12 summarises the available stream flow data.

Table 12 Hydrological Data for the Upper and Middle River Test

Gauging Station and Location	Area (km^2)	Period of Record	N	MDF[a]	95%ile Flow (m^3/s)	BFI	Elevation Range (m OD)	SAAR 1961-1990 (mm)
River Test at Whitchurch SU 464 479	Circa 150	Periodic spot gauging, 1990-2013	237	1.56 m^3/s 1076 $m^3/d/km^2$	0.82	ND	67 to 296	ND
River Dever at Bransbury SU 421 422	122	Daily data, 2000-2021	7,943	1.096 776 $m^3/d/km^2$	0.39	0.95	49 to 182	780
River Test at Chilbolton SU 385 393	453	Daily data, 1989-2021	11,814	5.64 879 $m^3/d/km^2$	2.99	0.97	40 to 296	801

Source - Chilbolton data: CEH 2022 Search Data | National River Flow Archive (ceh.ac.uk)

Source - Whitchurch data: Environment Agency

BFI baseflow index; MDF mean daily flow

N number of daily flow measurements; ND no data

SAAR standardised average annual rainfall

a mean daily flow per unit catchment area is based on the surface water catchment area

Figure 11 shows the river flows at Chilbolton from January 1989 to September 2021, with groundwater elevations for the Clapgate Cottage monitor well near Litchfield 4 km north of Whitchurch for comparison. Figure 12 shows the river flows for the Upper Test at Whitchurch, Dever at Bransbury and Middle Test at Chilbolton.

kk Search Data | National River Flow Archive (ceh.ac.uk)

The very high peak, 21 m^3/s at Chilbolton, in February 2014 occurred at a time of widespread flooding in south east England[ll,mm]. The highest flows occurred at Chilbolton on 15/02/2014 and at Bransbury on 12/02/2014.

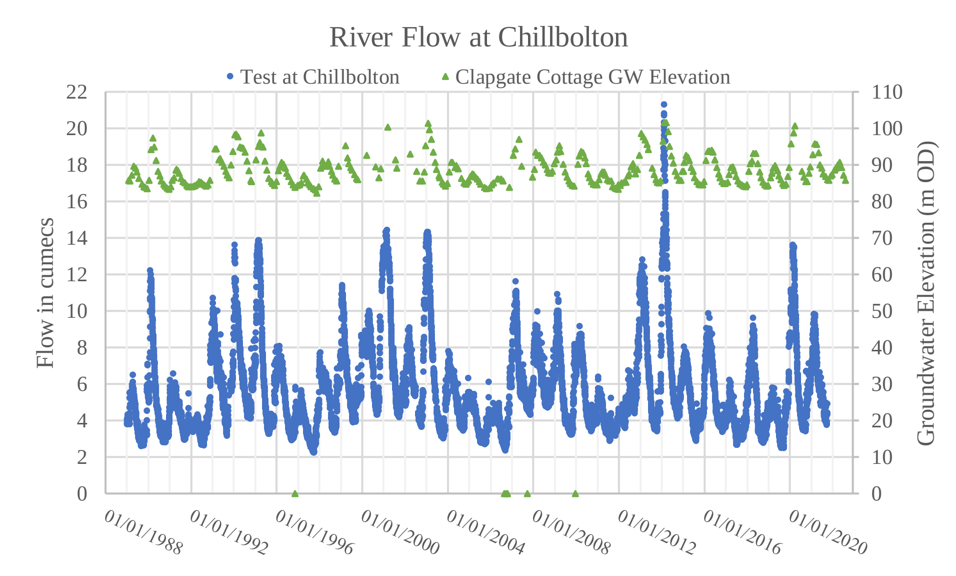


Figure 11 **Flow Hydrograph for the Middle Test at Chilbolton**

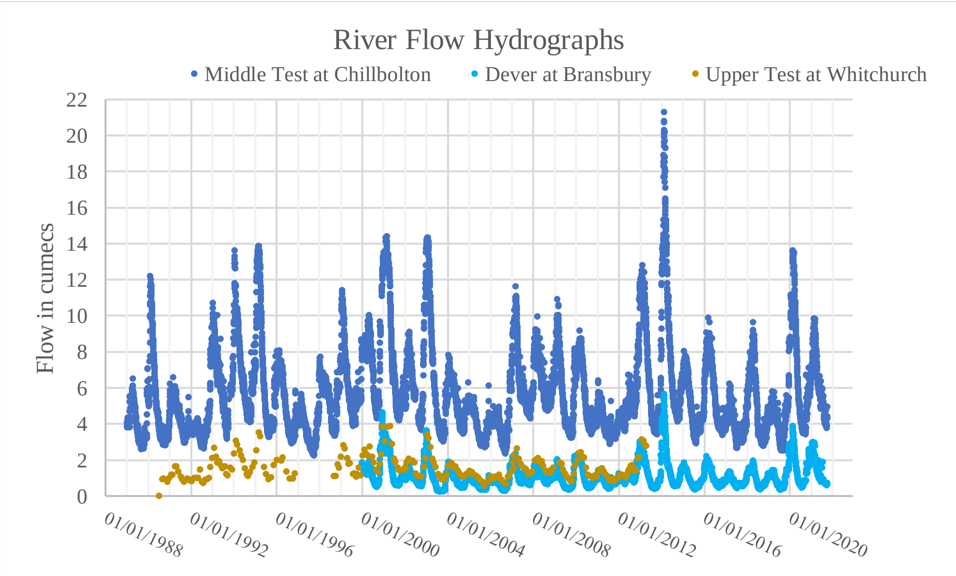


Figure 12 **River Flow Hydrographs for the Upper & Middle Test and Dever**

4.6 Geology

As shown in Figure 13 above the outcrop geology over the catchment is mainly Chalk, with subordinate areas of clay-with-flints on the interfluves and River Terrace and Head deposits in the valleys, including the dry valleys.

ll The costs and impacts of the winter 2013 to 2014 floods - GOV.UK (www.gov.uk)
mm winter-storms-january-to-february-2014---met-office.pdf (metoffice.gov.uk)

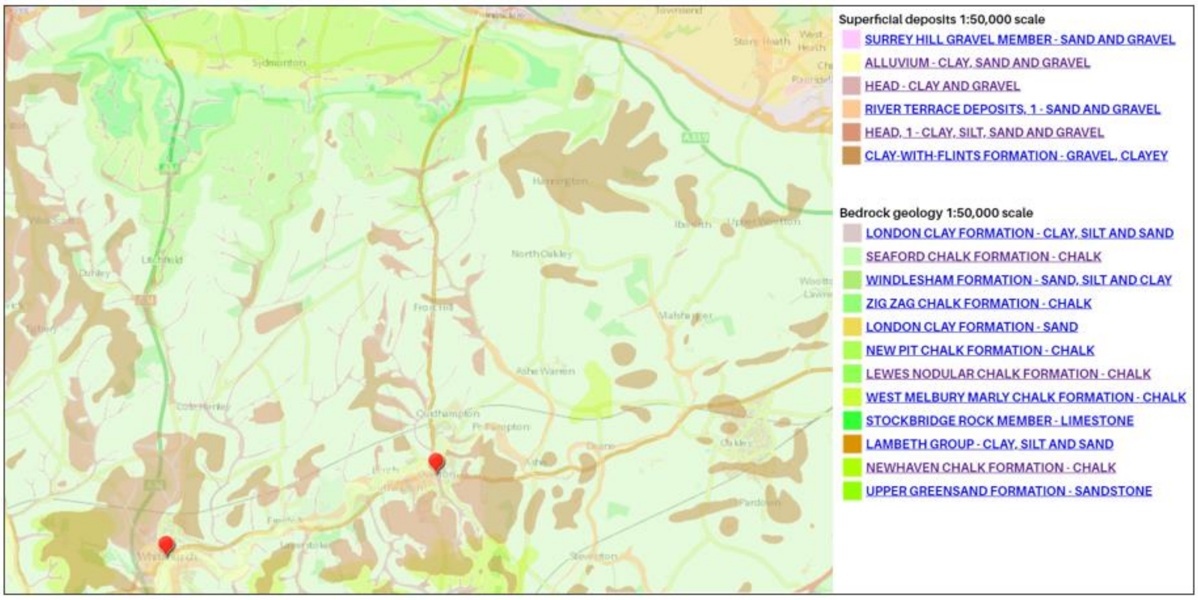
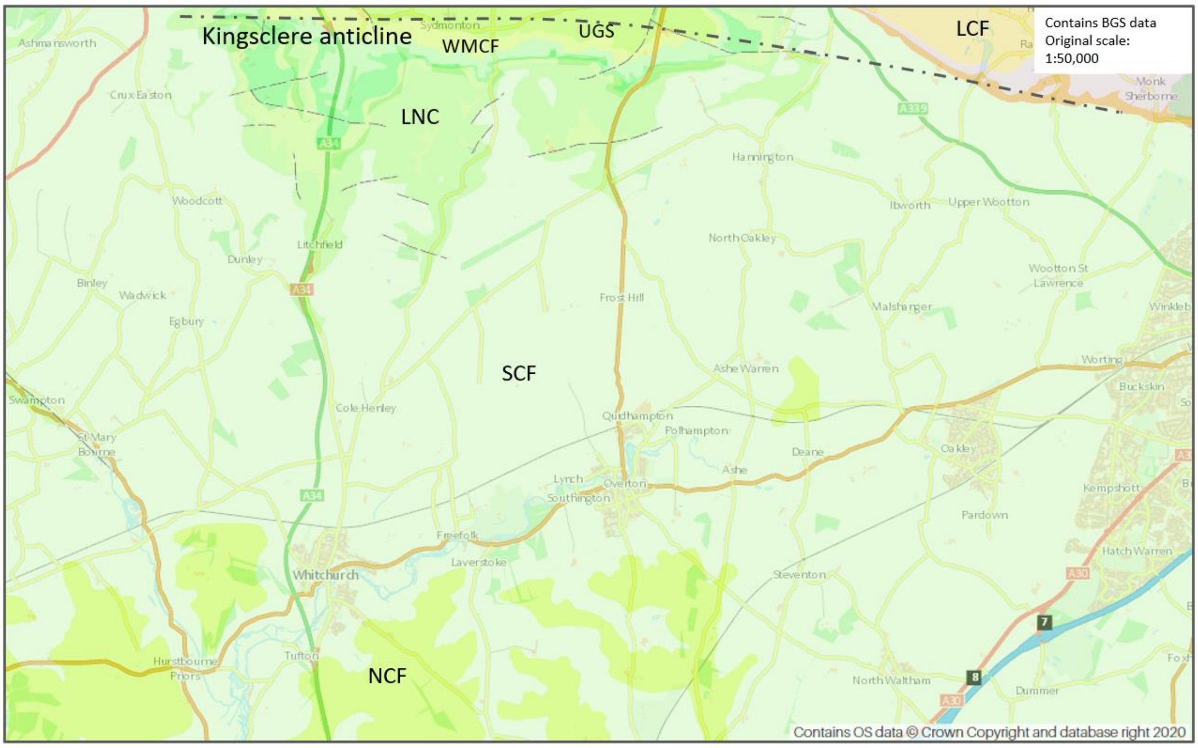


Figure 13 Superficial Geology of the Upper Test

The bedrock geology in the Upper Test mainly comprises Seaford Formation (formerly Upper Chalk), see Figure 14.

To the north of the catchment, on the high ground in the vicinity of Ladle Hill and Cottington's Hill, there is an east-west anticlinal structure, the Kingsclere Anticline. In this area surface geology comprises the entire underlying Chalk formations (Lewes Nodular Chalk, New Pit Chalk, Holywell Chalk, Zig Zag Chalk and Wets Melbury Chalk), together with the underlying Upper Greensand. The east-west trending Micheldever syncline runs through Barton Stacey and Micheldever in the southern part of the Upper Test Catchment.

The Chalk dips south over most of the Upper Test Catchment, with a number of east-west tending faults.



Bedrock geology 1:50,000 scale

- LONDON CLAY FORMATION - CLAY, SILT AND SAND
- SEAFORD CHALK FORMATION - CHALK
- ZIG ZAG CHALK FORMATION - CHALK
- LONDON CLAY FORMATION - SAND
- NEW PIT CHALK FORMATION - CHALK
- LEWES NODULAR CHALK FORMATION - CHALK
- WEST MELBURY MARLY CHALK FORMATION - CHALK
- STOCKBRIDGE ROCK MEMBER - LIMESTONE
- LAMBETH GROUP - CLAY, SILT AND SAND
- NEWHAVEN CHALK FORMATION - CHALK
- UPPER GREENSAND FORMATION - SANDSTONE

Figure 14 Solid Geology

Contains BGS information © British Geological Survey 2022

4.7 Hydrogeology

4.7.1 Aquifer System

The Upper Test Catchment is entirely underlain by the Chalk Aquifer, a Principal Aquifer.

There are only very limited areas of superficial deposits in the Upper Test. The alluvium of the Test valley is a Secondary Aquifer of limited extent and depth.

4.7.2 Groundwater Catchment

Figure 33 in Appendix C shows the boundaries of the Upper Test groundwater body superimposed on the surface water catchments. Figure 15 shows the same information but over a more limited area. Note that the in the vicinity of Wooton St Lawrence and south west Basingstoke the groundwater catchment boundary is inside and south west of the surface water catchment boundary, and as a consequence the groundwater catchment of the Upper Test is smaller than the surface water catchment. This is due to the effects of groundwater abstractions in the south west area of Basingstoke, see Figure 16, and also Figure 34 and Figure 35 in Appendix C.

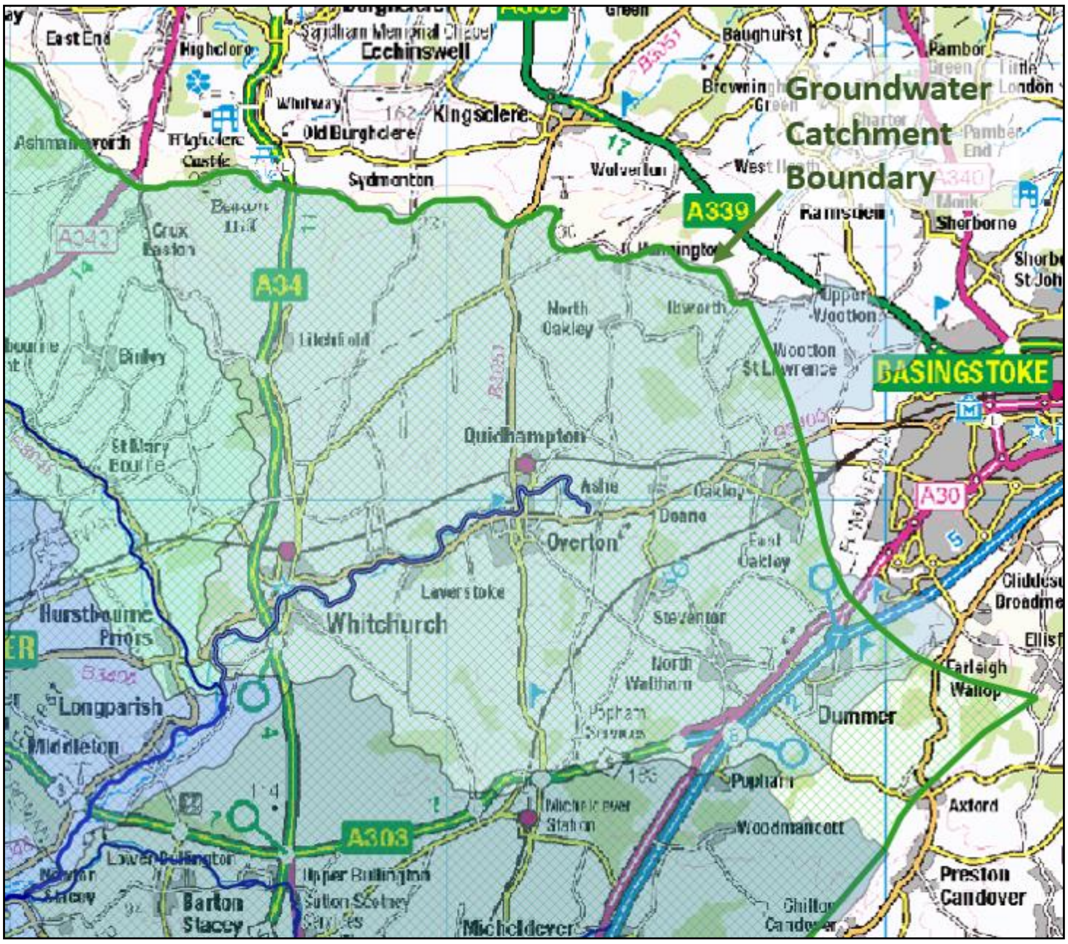


Figure 15 Groundwater Catchment of the Upper Test

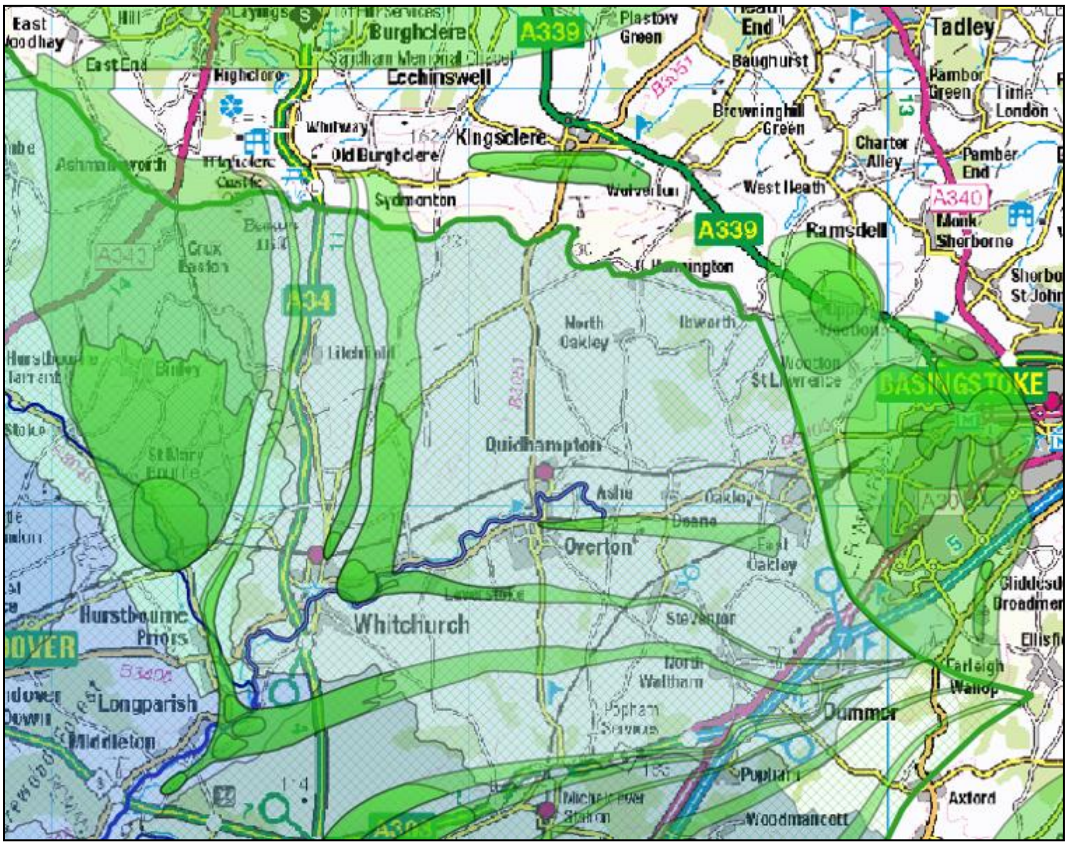


Figure 16 Groundwater Source Protection Zones superimposed on Catchment Boundaries

4.7.3 Groundwater Levels and Flow

Appendix F presents long term groundwater elevations trends for five monitor wells in the Upper Test catchment, located in and up to 4 km north of Whitchurch. This information was supplied by the Environment Agency. The period of record ranges from >30 to >60 years.

Based on linear interpolation the long term groundwater elevation records show slow downward trends. The long-term decline in groundwater levels based on 60 years of data at the Clapgate Cottage monitor well, 4 km north of Whitchurch, is approximately 0.04 m/y.

The long term decline on groundwater elevations is most likely the result of increased groundwater abstraction, although climate change may also be a contributory factor. A proportionate long-term decline in baseflow to the River Test would inevitably be associated with the decline in measured groundwater elevations.

The groundwater flow direction is generally to the south and south west. The groundwater divide that forms the northern and north eastern boundaries of the catchment runs west-east through Hannington, and then turns south east through Oakley, see Figure 17. The groundwater elevations are based on data from 1973, more recent catchment-scale data were not available.

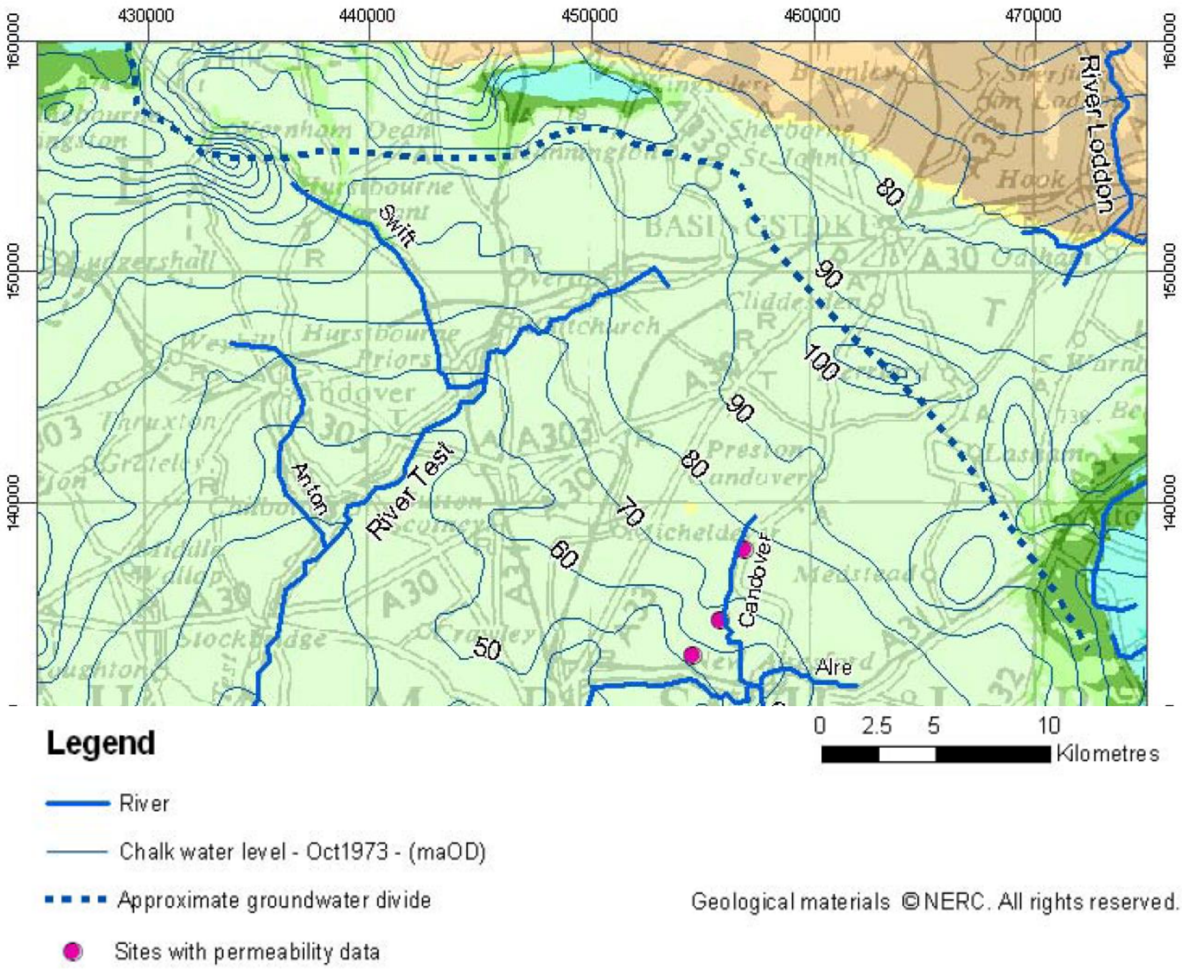


Figure 17 Groundwater Elevations in the Chalk Aquifer

Reproduced from Stuart and Smedley 2009 © British Geological Survey 2009

4.7.4 Groundwater Abstractions and Source Protection Zones

There are public water supply (PWS) abstractions from the Chalk Aquifer at Whitchurch and Overton in the Upper Test Catchment, and at Kingsclere PWS and Upper Wootton (Woodgarston PWS).

Figure 16 shows the groundwater source protection zones for the Upper Test. Figure 34 and Figure 35 in Appendix C show the groundwater source protection zones over a larger area.

Drinking water safeguard zones (SGZs) have been established for Whitchurch PWS, Overton PWS and Woodgarston PWS, see Figure 35 in Appendix C.

4.7.5 Available Groundwater Resources

According to the Catchment Abstraction Management Plan for the River Test, Environment Agency 2019a, the River Test Chalk groundwater body, GB40701G501200, has restricted water resources available for licensing. There is very little scope for any additional groundwater abstraction that would not cause additional impacts on sensitive water features.

Consequently, there is a presumption against new consumptive groundwater abstractions from the Test Chalk.

4.7.6 Stream - Aquifer Interaction

The Chalk Aquifer is in hydraulic continuity with the River Test and provides 97% of flows in the Upper River Test.

4.7.7 Effect of Groundwater Abstraction on Surface Water Quality and Ecology

It has been reported[nn] that depleted surface water flows in the River Test have had an adverse impact on water quality and ecology. The groundwater evidence, including the long-term decline in groundwater levels and apparent curtailment of the groundwater catchment by abstractions, support these concerns.

4.8 Effect of Climate Change on Groundwater and Surface Water

The effect of climate change on the Upper Test was accessed at a preliminary level using Environment Agency, Environment Agency 2021b, and Met Office information[oo], see Table 13 and Table 14.

Table 13 Climate Change Observed and Predicted - England

Parameter	Observed	Predicted			
	Mid-1970s to mid-2010s	2050s		2080s	
		+2 °C	+4 °C	+2 °C	+4 °C
Annual temperature	+0.9 °C	+1.3 °C	+1.2 °C	+1.4 °C	+2.4 °C
Sunshine	+9%				
Summer rainfall	Annual mean rainfall +4.5%	-15%	-14%	-15%	-22%
Winter rainfall		+6%	+6%	+8%	+13%
Monthly low river flows	ND	Up to 82% reduction[a]		Up to 87% reduction[a]	

Source: Environment Agency 2021b

a applies to flashy rivers - lesser depletion where BFI is high such as the River Test

Table 14 Effects of Climate Change on Temperature and Rainfall – Upper Test Area

Warming	Temperature: Number of Summer Days above 25 °C	Hottest Summer day	Warmest Winter day	Rainfall: rainy days per month in Summer	Rainfall: rainy days per month in Winter	Rainfall: Wettest Summer day	Rainfall: Wettest Winter day
1991-2019 Baseline	4	34.7 °C	18.1 °C	9	11	46 mm	48 mm
+2 °C	8	36.6 °C	18.4 °C	7	11	50 mm	50 mm
+4 °C	17	41.6 °C	19.7 °C	6	11	49 mm	50 mm

nn 2021-Riverfly-Census_200722.pdf (wildfish.org)
oo What will climate change look like in your area? - BBC News

The data indicate that temperatures will increase and that rainfall patterns will change with increased flood risk due to higher intensity winter and summer rainfall events. Rainfall will be lower in summer with higher temperatures increasing actual evapotranspiration. River flows may reduce overall but both high and low flows will become more extreme.

Mansour and Hughes 2017 ran a groundwater recharge model using 11 different future climate scenarios, based on the UKCP09 climate data set, each of which produced estimates of future rainfall and potential evaporation on a 1 km grid. The findings were that the recharge period was shortened and that monthly groundwater recharge variably increased or decreased by the 2050s and 2080s, depending on the climate scenario. It was predicted that it was more probable that groundwater recharge would increase. From the very high BFI of the River Test it is probable that climate change will cause average river flows on the Test to increase. However, the increased rainfall variability, shorter recharge periods and increased potential evaporation is likely to result in more extreme low flows as indicated in Table 13.

The potential reduction of low flows is of particular relevance because there will be less river flow available to dilute WWTW discharges, especially in summer. This will result in increased contaminant concentrations in the River Test under load standstill conditions; concentration standstill will only be achieved by reducing contaminant loads to the River Test at least during low flow periods.

4.9 Water Quality

4.9.1 Baseline Quality

No baseline (pre-development) surface water quality data were available for the Upper Test.

A groundwater sample from Overton PWS in the centre of Overton is reported on the BGS borehole records website, reference SU54/51, located at NGR SU 51600 48600. The analysis, dated 1934, reports chloride and nitrate concentrations respectively of 11 ppm as Cl_2 and 6.6 ppm as N_2 (approximately 11 and 6.6 mg/l). The 1934 nitrate concentration is higher than would be expected for background concentrations at that time, which pre-dates the start of modern agricultural practices with high fertiliser application rates. Overton PWS is in the centre of the town and the nitrate concentration may have been affected by local discharges from small private sanitation systems.

Limbrick 2003 reports a series of nitrate measurements for the Sutton Poyntz spring in South Dorset. This is a Chalk-spring which has been used for public water supply since 1858.

The 1894-1946 average nitrate concentration at the spring was 1.04 mg-N/l with no statistically significant trend. The nitrate concentration increased to an average of 6.37 mg-N/l over the period 1976-2001.

It is inferred that the baseline nitrate concentration in the River Test catchment would be of the order of 1 mg-N/l.

4.9.2 Groundwater

4.9.2.1 Monitor Wells

Groundwater quality monitoring data were obtained from the Environment Agency Water Quality Archive. Data were available for one monitor well in the Upper Test catchment, located at North Oakley Farm. Groundwater quality data for an additional three monitor wells located on or close to the catchment boundary were also selected. The monitor well locations are shown in Figure 18. None of these monitor wells are close to or downgradient of WWTWs.

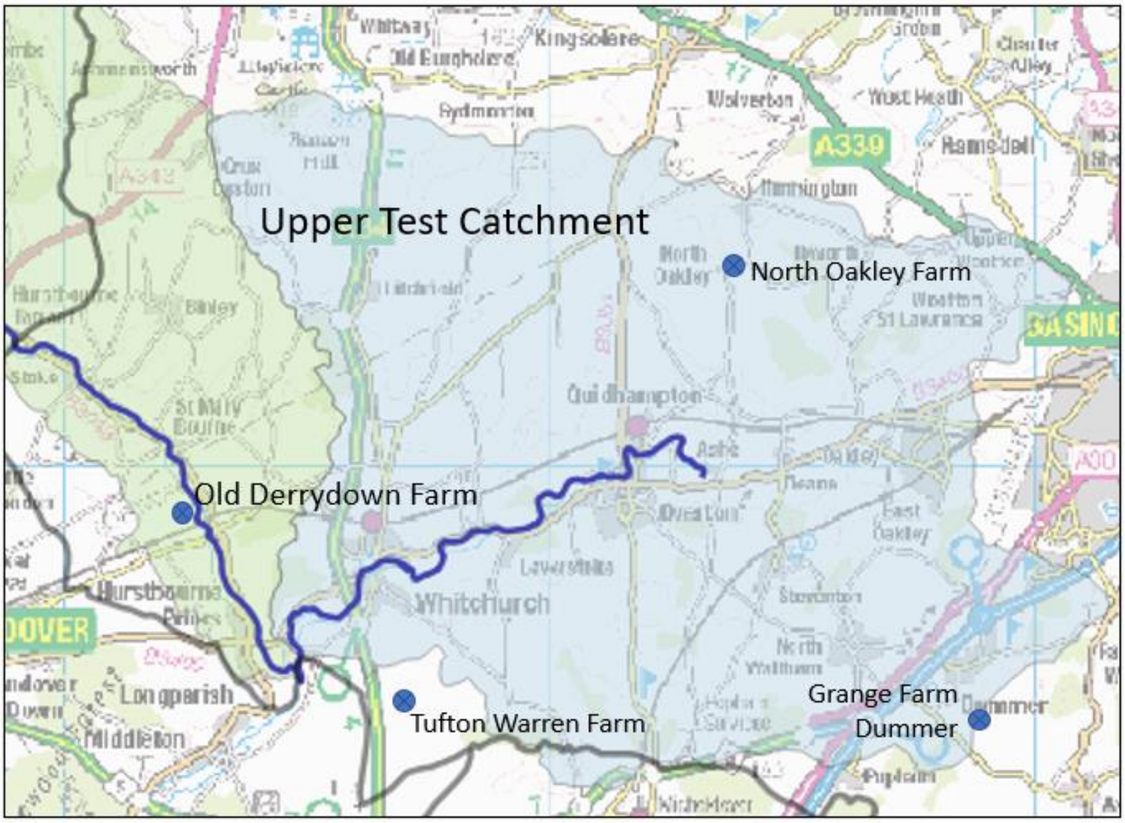


Figure 18 Monitor Well Locations

Table 15 provides the drilled depth, ground level elevation and approximate range of unsaturated zone thickness for each monitor well. The unsaturated zone thicknesses were derived from the available groundwater level data, and are based on limited data.

4.9.2.2 Inorganic Substances

Table 15 also lists the 2010-22 average major ion concentrations for each monitor well.

Table 15 Monitor Well Details and Major Ion Concentrations

Parameter	North Oakley Farm	Tufton Warren Farm	Grange Farm Dummer	Old Derrydown Farm
General				
Depth (m)	68.3	43.3	78.0	30.5
Ground Level (m OD)	160.0	81.5	149.5	82.8
Measured unsaturated Zone thickness (m)	60 - 68	circa 17	50 to 53	6.8 to 7.8
Groundwater Quality - 20010-22 Averages (mg/l)				
Calcium	106	97	117	102
Magnesium	3.17	1.56	2.29	1.48
Sodium	7.22	6.57	7.29	6.26
Potassium	5.97	0.72	2.28	0.91
Alkalinity as $CaCO_3$	260	210	266	222
Bicarbonate as HCO_3	316	256	324	270
Chloride	13.6	15.1	15.8	14.0
Sulphate as SO_4	10.2	10.4	10.5	10.2
Nitrate as N	6.05	6.93	6.95	6.74
Orthophosphate as P	0.0215	0.0166	0.0245	0.0229

Figure 19 shows the concentration trends for chloride, nitrate, ammoniacal nitrogen and orthophosphate at the North Oakley Farm monitor well for the period 2008-22. The following was noted:

- Chloride and nitrate concentrations appear to be on shallow increasing trends. The unsaturated zone is approximately 60m thick at this location, and therefore the water currently draining from the unsaturated zone matrix into groundwater would have entered the system as infiltration some 60 or more years ago. The pore water profile currently at or close to the water table probably contains high nitrate concentrations representative of historically higher fertiliser application rates. The peak nitrate concentration in the unsaturated zone porewater may not have reached the water table.
- Ammoniacal nitrogen was below the detection limit.
- Orthophosphate is at very low concentrations, and below the surface water EQS for High chemical classification.

Figure 20 shows the concentration trends for chloride, nitrate, ammoniacal nitrogen and orthophosphate at the Grange Farm monitor well at Dummer for the period 2010-22. This monitor well is located close to the surface water catchment boundary and south east of Whitchurch. The following was noted:

- Chloride and nitrate concentrations appear to be on shallow increasing trends. The unsaturated zone is approximately 50m thick at this location, and therefore the water currently draining from the unsaturated zone matrix into groundwater would have entered the system as infiltration some 50 or more years ago. The pore water profile currently at or close to the water table probably contains high nitrate concentrations representative of historically higher fertiliser application rates. The peak nitrate concentration in the unsaturated zone porewater may not have reached the water table.

- Ammoniacal nitrogen was below the detection limit.
- Orthophosphate is at very low concentrations, below the surface water EQS for High chemical classification but may be on an increasing trend.

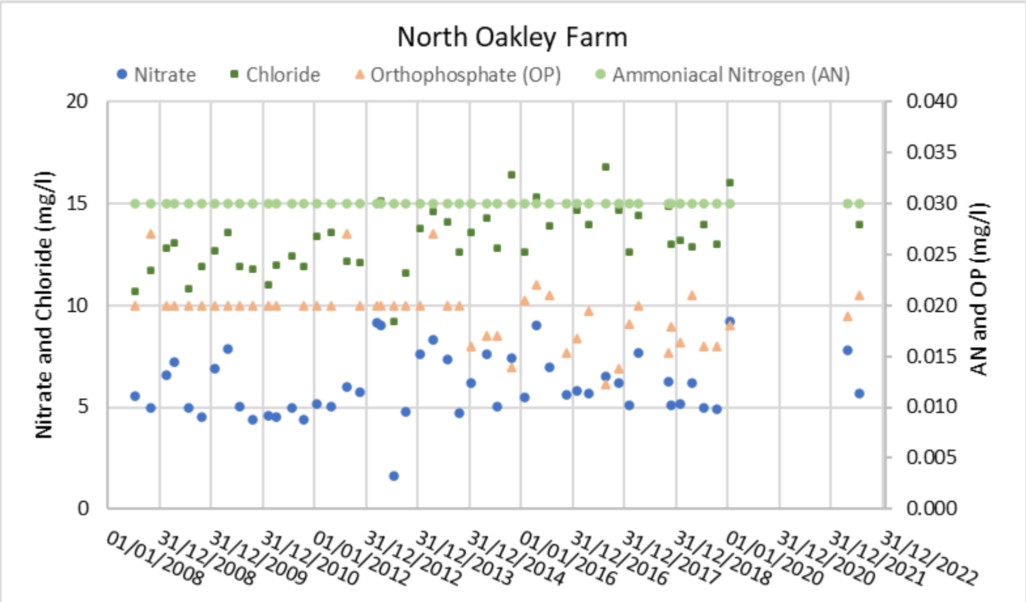


Figure 19 **Groundwater Quality at North Oakley Farm**

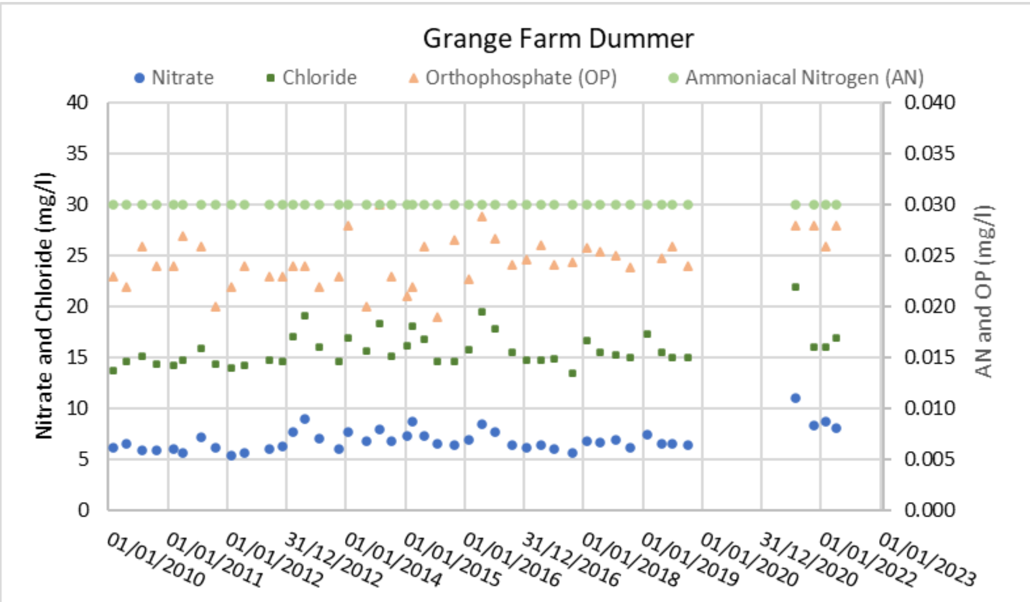


Figure 20 **Groundwater Quality at Grange Farm Dummer**

Figure 21 shows the concentration trends for chloride, nitrate, ammoniacal nitrogen and orthophosphate at the Tufton Warren Farm monitor well for the period 2010-22. This monitor well is located due south of Whitchurch and just outside the surface water catchment boundary. The following was noted:

- Chloride and nitrate concentrations appear to be on shallow increasing trends; these trends are on a somewhat steeper gradient and are more discernible than those at North Oakley Farm and Grange Farm. The unsaturated zone is approximately 17m thick at this location. The nitrate load entering groundwater from the unsaturated zone may be decreasing due to the beneficial effects of fertiliser controls introduced over the las 30 years. The increasing trend is probably the result of migration from upgradient sources.
- Ammoniacal nitrogen was below the detection limit.
- Orthophosphate is at very low concentrations and below the surface water EQS for High chemical classification. The method detection limit (MDL) was reduced in 2014 from 20 to 10 µg/l.

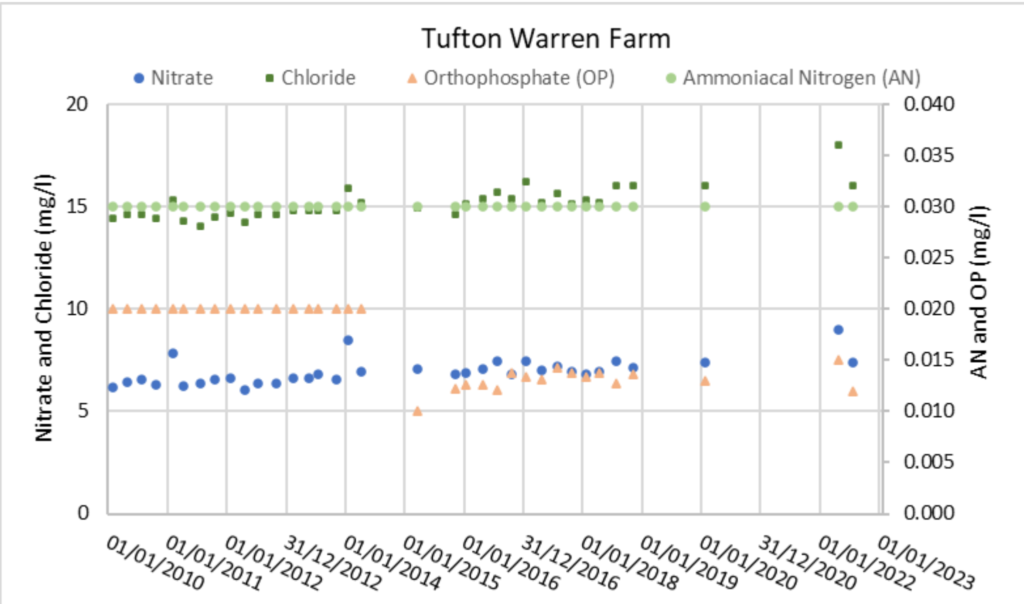


Figure 21 Groundwater Quality at Tufton Warren Farm

Figure 22 shows the concentration trends for chloride, nitrate, ammoniacal nitrogen and orthophosphate at the Old Derrydown Farm monitor well for the period 2010-22. This monitor well is located west of Whitchurch and in the surface water catchment of the Bourne Rivulet. This monitor well is close to the Bourne Rivulet and therefore the water table is shallow with an unsaturated zone approximately 7m thick.

At the Old Derrydown Farm monitor well chloride, nitrate and orthophosphate appear to be on increasing trends. Orthophosphate is below the surface water EQS for High chemical classification. Ammoniacal nitrogen is below detection limit.

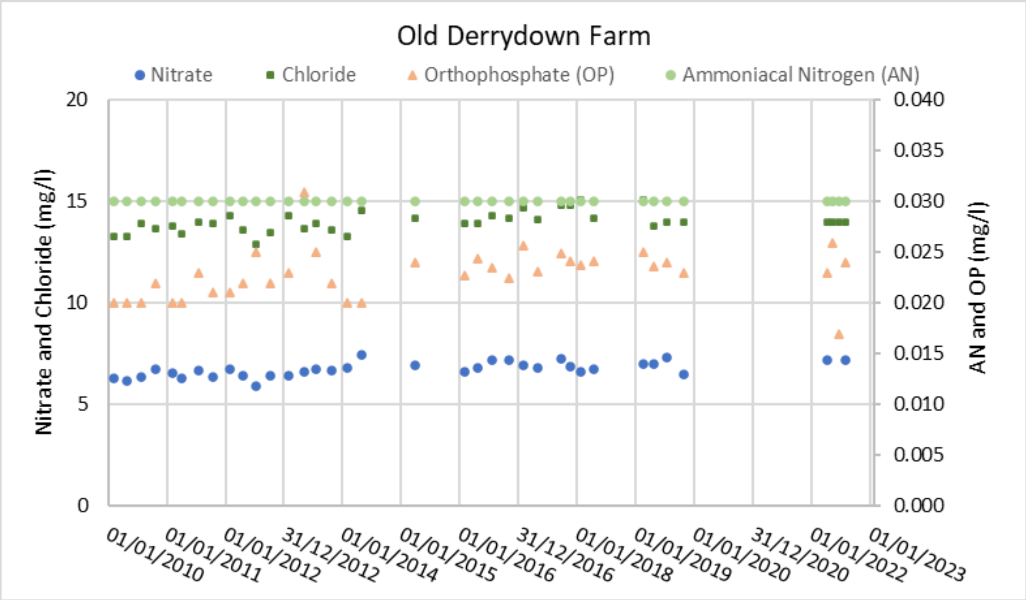


Figure 22 Groundwater Quality at Old Derrydown Farm

4.9.2.3 Organic Substances

A number of organic substances were reported at low concentrations in the monitor wells, see Table 16.

Atrazine and/or simazine were reported in all four monitor wells, and atrazine degradation products in three monitor wells. These are ubiquitous herbicides that are commonly detected in groundwater. They were widely used historically for weed control on railway lines and other built development. In all cases the concentrations were below the EQSs.

Chloroform and other trihalomethanes were detected in a few instances, but were not listed in Table 16. Trihalomethanes are usually chlorination by-products.

PFOS was detected above the EQS at Old Derrydown Farm in 2022. Two other PFAS substances were detected but there are no EQSs for these.

The other substances were detected at very low concentrations and are not likely to be of potential concern at this stage.

Table 16 Organic Substances in Groundwater

Substance	Chemical Use/Type	EQS[a] µg/l	North Oakley Farm	Tufton Warren Farm	Grange Farm Dummer	Old Derrydown Farm
Atrazine	Organochlorine herbicide	AA: 0.6 MAC: 2	0.005 to 0.014 µg/l 5 detections 2016-19, 2022	0.025 to 0.032 µg/l 3 detections 2010 2014, 2022	0.0001 to 0.033 µg/l 10 detections 2010-22	
Atrazine de-isopropyl	Atrazine degradation products			0.0316 µg/l 1 detection 2014	0.033 µg/l 1 detection 2022	
Atrazine-de-ethyl			0.032 µg/l 1 detection 2022			
Simazine	Organochlorine herbicide	AA: 1 MAC: 4			0.004 to 0.183 µg/l 6 detections 2010-22	0.003 to 0.004 µg/l 6 detections 2011-22
Bentazone	Organonitrogen herbicide			0.021 µg/l 1 detection 2010		
Metazochlor	Organo-nitrogen-chlorine herbicide			0.017 to 0.023 µg/l 3 detection 2010-13		
Flutriafol					0.01 µg/l 1 detection 2017	
Perfluorotridecane sulfonic acid (PFTrDS)	PFAS				0.002 µg/l 1 detection 2021	
Perfluorooctanesulfonic acid (branched) (PFOS)	PFAS	AA:0.00065 MAC: 36				0.0012 µg/l 1 detection 2022
Perfluorohexanesulfonic acid	PFAS					0.0027 µg/l 1 detection 2022
4,8-Dioxa-3H-perfluorononanoic acid (ADONA) (PFAS)					0.0009 µg/l 1 detection 2021	
Benzene	Aromatic hydrocarbons	AA:10 MAC: 50	0.48 µg/l 1 detection 2019			
Toluene					0.11 µg/l 1 detection 2018	
Ethylbenzene				0.12 µg/l 1 detection 2010		
m&p xylene				0.3 µg/l 1 detection 2010		
o-xylene				0.22 µg/l 1 detection 2010		

a freshwater Environmental Quality Standard

AA annual average MAC maximum acceptable concentration

PFAS Perfluorinated alkyl substance

4.9.3 Surface Water

4.9.3.1 Sampling Locations

Surface water quality monitoring data were also obtained from the Environment Agency Water Quality Archive. The surface water sampling locations discussed below are shown in Figure 23. These are all in the Upper Test apart from East Aston at Longparish which is in the Middle Test catchment.

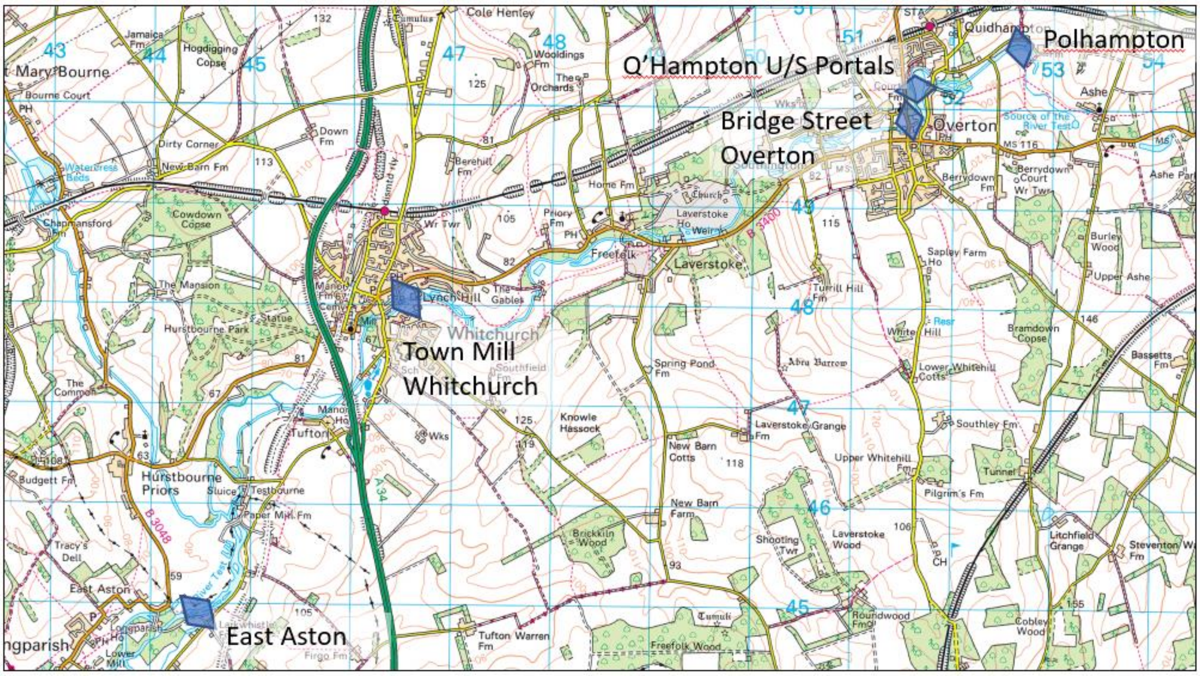


Figure 23 Surface Water Sampling Locations

4.9.3.2 Inorganic Substances

Figure 24 to Figure 28 show, from upstream to downstream, the trends in nitrate and orthophosphate, and also phosphorus at East Aston, in the Upper Test over the period 2010-22. East Aston is actually in the Middle Test catchment, approximately 1 km downstream of the downstream extent of the Upper Test. Additional historical data are available back to 2000. There are several gaps in the data records.

Nitrate is reported at concentrations between approximately 5.5 and 9.5 mg/l and on a uniform upward trend with closely similar trend gradients. There is little change in nitrate concentration from upstream to downstream. The nitrate concentration has increased to or slightly exceeded the concentration typically recorded in monitor wells in the Upper Test Catchment.

Figure 29 shows the orthophosphate concentration time series for all five surface water monitoring locations. Orthophosphate is on an upward trend at the upstream locations at Polhampton and Quidhampton, and on downward trends at the downstream locations. Based on 2022 data, orthophosphate concentrations decrease from upstream, 45 µg/l, to downstream reaching a minimum of 20 µg/l at Whitchurch and East Aston. Historically, orthophosphate concentrations increased from upstream, above the Portals outfall at Quidhampton, to downstream sampling locations.

Polhampton and Quidhampton sampling points are both above the Portals outfall location. Portals was a significant source of phosphorus historically, see Section 2.5.2.

At Polhampton and Quidhampton the orthophosphate concentrations are now (2020-22) generally below the WFD threshold for High chemical standard of 42 µg-P/l, although if the current trend continues the WFD classification will reduce to Good at the upstream locations, see Figure 24 and Figure 25.

At the downstream sampling locations the orthophosphate and phosphate concentrations are variable and on a long-term downward trend. Phosphorus concentrations are generally below the WFD High chemical standard threshold of 42 µg-P/l.

Historically the maximum phosphorus concentration was measured at Overton (Bridge Street), Figure 29. Phosphorus has been on downward trends at Overton, Whitchurch and East Aston. With the reduction in phosphorus emissions from Portals (which will now reduce to nothing due to closure of this facility) the maximum phosphorus concentrations now occurs at the upstream extent of the Test at Polhampton and Quidhampton, and at these two locations phosphorus is on an upward trend. The opposing trend lines crossed in about 2016.

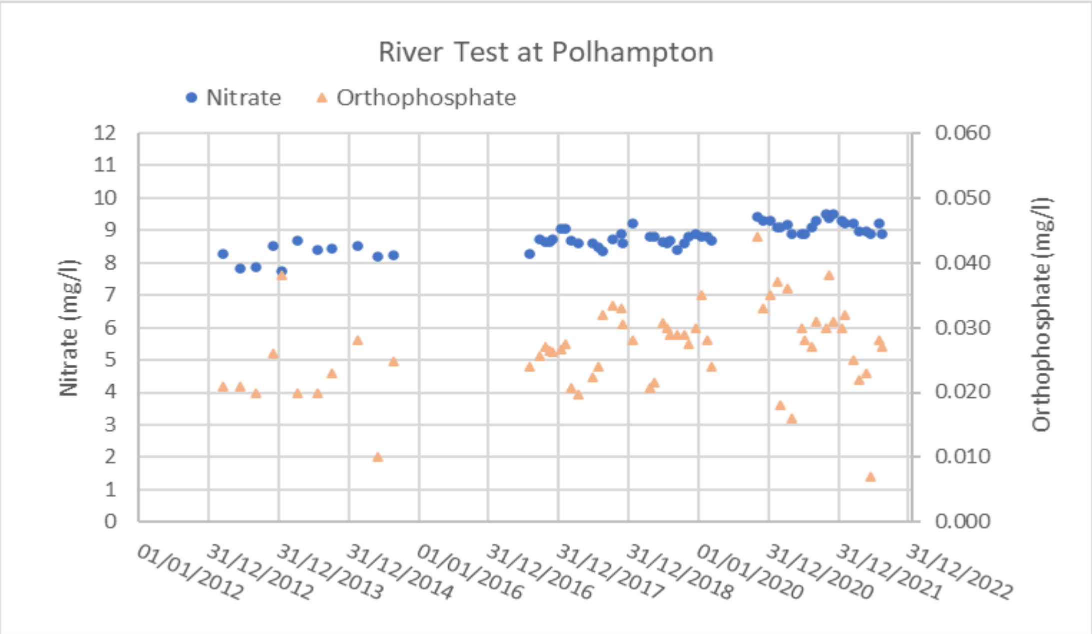


Figure 24 Concentrations in the River Test at Polhampton

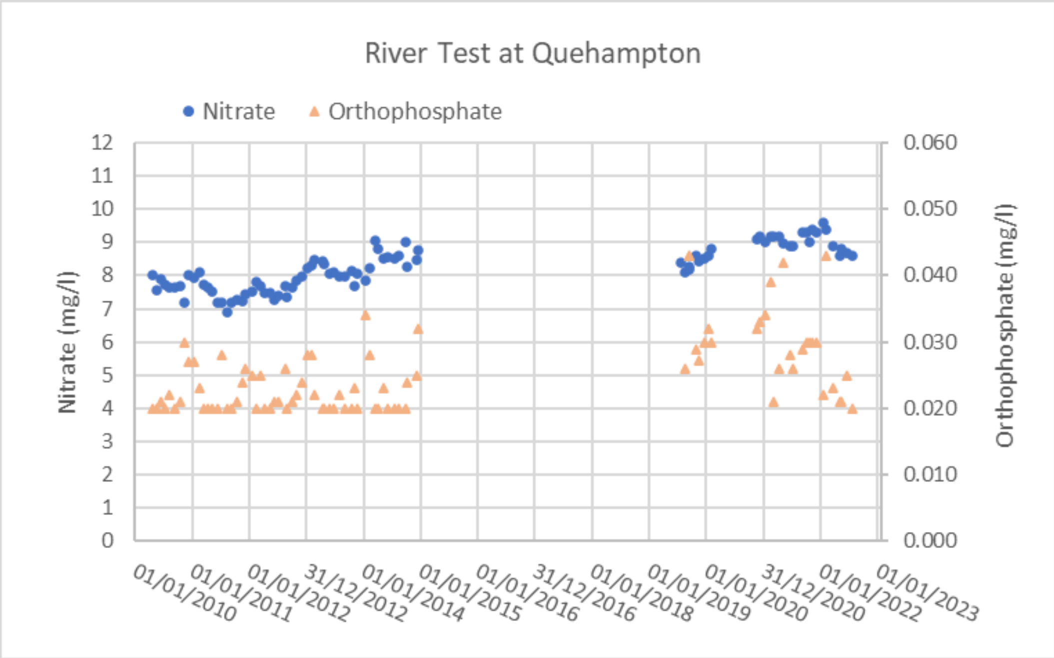


Figure 25 Concentrations in the River Test at Quidhampton

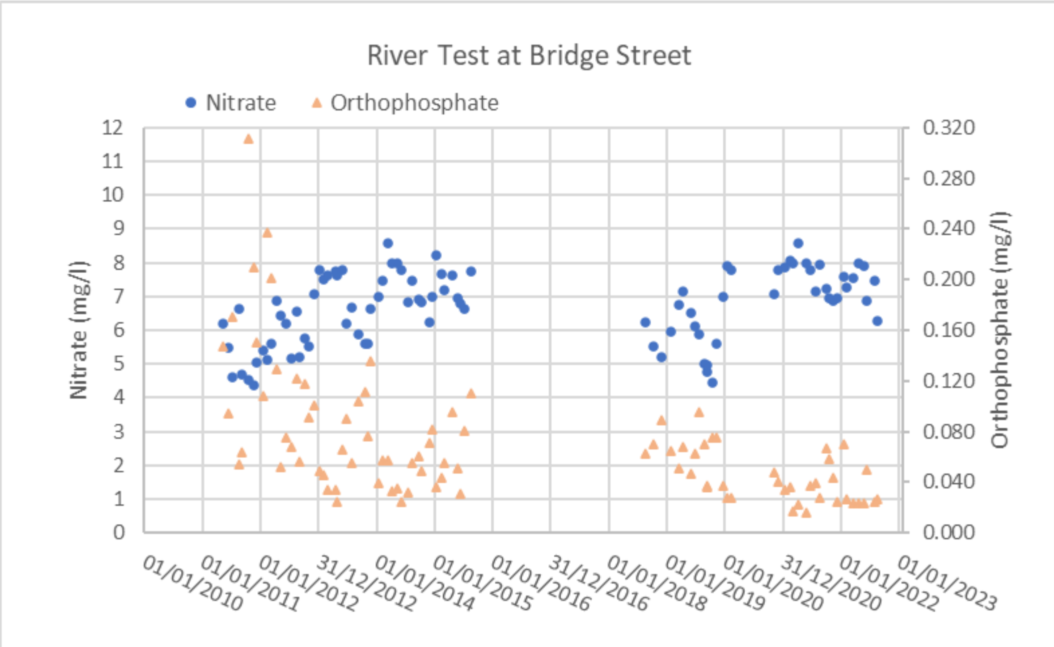


Figure 26 Concentrations in the River Test at Bridge Steet Overton

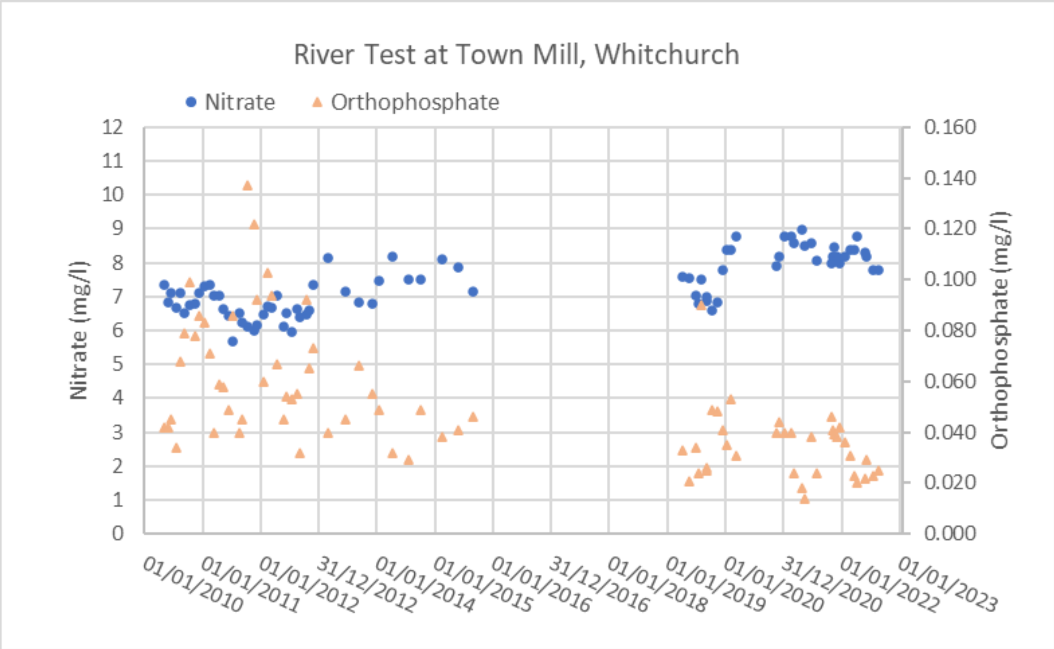


Figure 27 Concentrations in the River Test at Town Mill Whitchurch

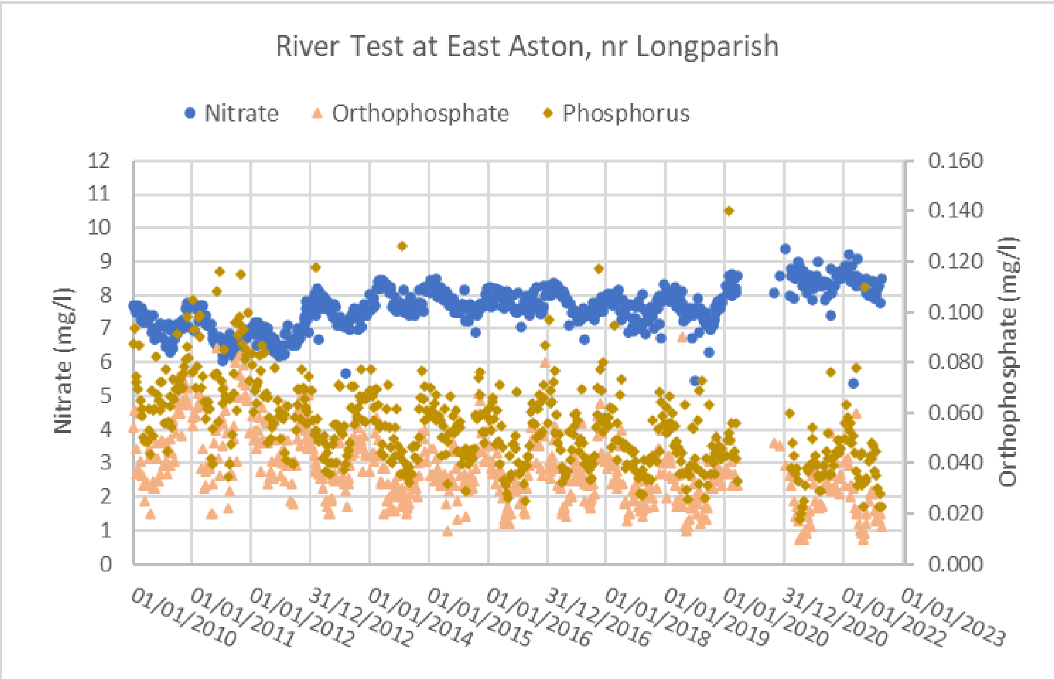


Figure 28 Concentrations in the River Test at East Aston
(Middle Test Catchment)

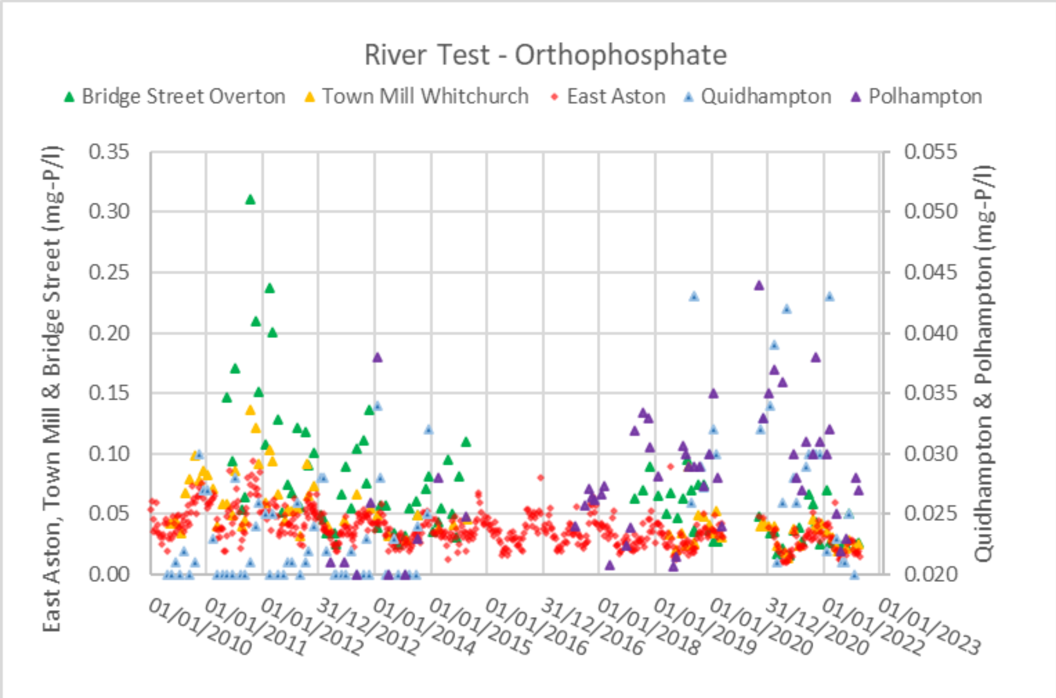


Figure 29 Orthophosphate - Upper Test

Figure 30 shows the ammoniacal nitrogen concentrations along the River Test from Polhampton to Whitchurch. Figure 31shows the ammoniacal nitrogen concentrations at East Aston. Ammoniacal nitrogen is generally below detection limits, except at Overton and Polhampton.

At Overton concentrations appear to be increasing, and exceeded the EQS for High ecological status (0.2 mg-N/l) in September 2021. The source is unknown; Overton WWTW, which discharges treated effluent to infiltration systems only 150m from the River Test, is downstream of the sampling location at Bridge Street, Overton, and therefore not a plausible source. Possible sources include Oakley WWTW, private sewage systems and/or the discharge from Portals WWTW.

At Polhampton the ammoniacal nitrogen concentrations are lower and appear stable.

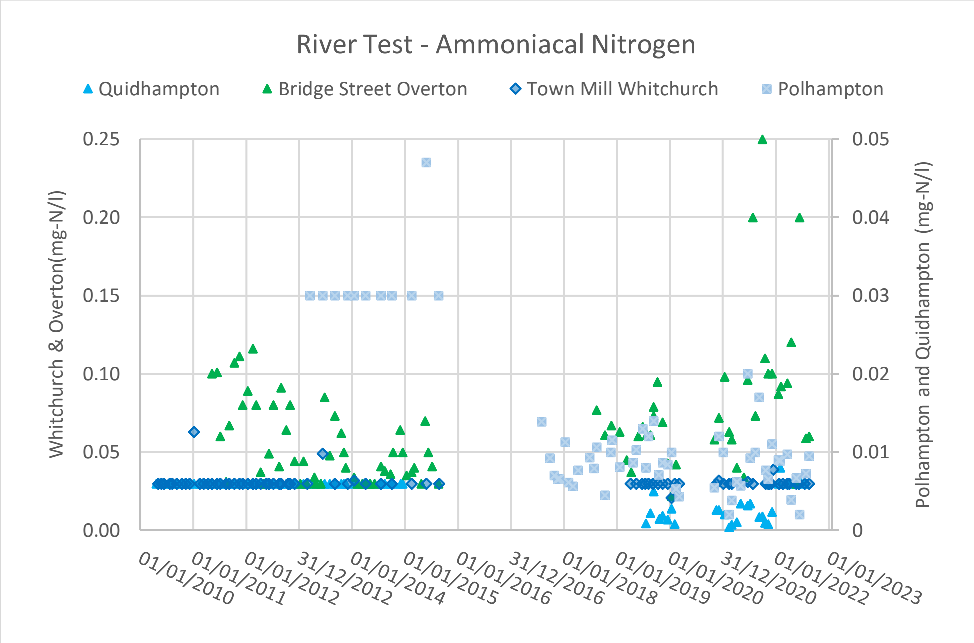


Figure 30 Ammoniacal Nitrogen - Upper Test

Organic nitrogen is only monitored at East Aston. Figure 31 shows the concentrations of organic nitrogen at East Aston in addition to the other nitrogen species, nitrate and ammoniacal nitrogen, and total nitrogen. Organic nitrogen is detected at low concentrations with occasional outliers and appears stable.

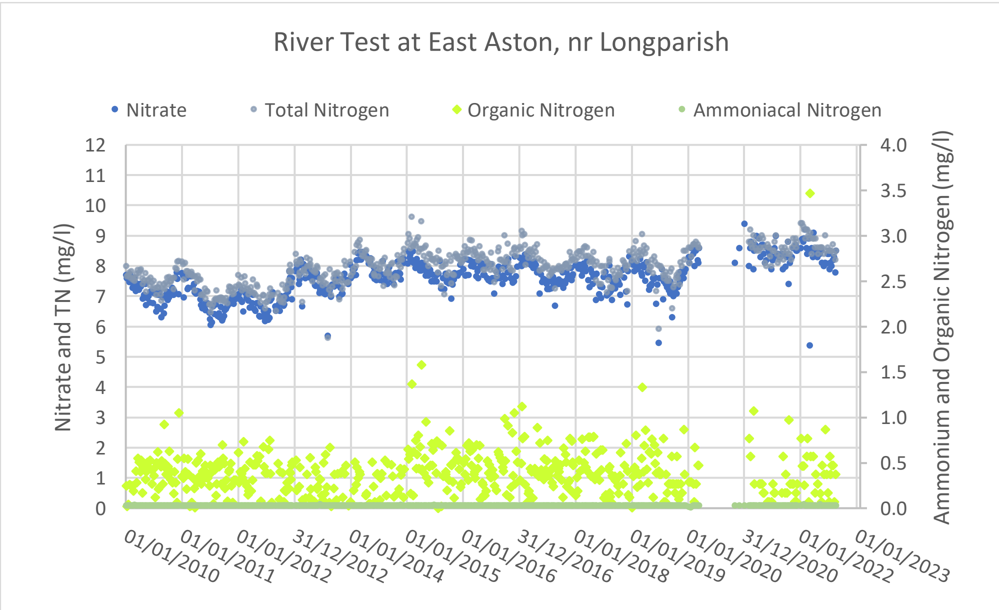


Figure 31 Nitrogen Species - River Test at East Aston

4.9.3.3 Organic Substances

No analytical results for organic substances were found for surface water sampling locations in the Upper Test, except the literature data described in Section 4.6.4. below. The only other exception is results for cypermethrin at Bridge Street Overton in 2019 and 2020.

The water quality sampling point at Wherwell 10 km downstream from Whitchurch is analysed for a wider range of parameters including a suite of organic substances. Atrazine was detected in the range 0.006 to 0.01 µg/l and simazine in the range 0.003 to 0.007 µg/l in 2010-11, and phenol in the range 0.07 to 0.4 µg/l in 2010-11. The EQSs (annual average) for atrazine, simazine and phenol are respectively 0.6, 1 and 7.7 µg/l, and therefore the EQS was not exceeded in any of these samples.

The herbicide 2,4D was detected on one occasion at Wherwell. Phenol was detected on 8 occasions in 2010-11, in the range 0.066 to 0.187 µg/l.

The target compound list (analytical suite) used for surface water samples at Wherwell is more limited than that used for groundwater and does not include a comprehensive pesticides suite and does not include any PFAS. In general, the analytical suite used by the Environment Agency for surface water samples is inadequate.

4.9.4 Water Quality Monitoring of the River Test for Organic Pollutants

A study reported by Robinson et al 2022, and supported by Southern Water Services Ltd, describes an investigation of the occurrence of organic pollutants in the River Test and River Itchen.

Samples were collected at ten locations on the River Test. The most upstream locations were on the Upper Test at Whitchurch and the Bourne Rivulet close to the confluence with the Test. The remaining locations were on the Middle and Lower Test.

In the majority of sampling investigations samples are analysed using quantitative methods where concentrations are measured by calibration against a pre-defined list of compounds on a “target compound list”. However, in the study reported by Robinson et al 2022 samples were analysed qualitatively by screening methods to identify the substances present in the sample without quantitative determinations. The objective of this approach was to identify the presence of multiple unknown organic substances at low concentrations without determination of concentration.

The organic substances in the samples were trapped on sorbent disks using a hydrophilic-lipophilic balanced sorbent (HLB-L) designed to sequester polar and semi-polar organic substances with a wide range of octanol-water partition coefficients (K_{ow}). Samples were then analysed by two methods, liquid chromatography with time-of-flight mass spectrometry (LC-Q-TOF) and by gas chromatography mass spectrometry (GC-MS). The sample treatment and analytical methods were selected to enable detection of a range of pharmaceuticals and personal care products (PPCPs), plant protection products (PPPs), and industrial chemicals (ICs).

The results were presented in summary tables and graphs separately for the Test and Itchen, but not by sampling location. The substances detected at sampling points on the River Test are summarised in Table 17.

Table 17 Organic Substances Detected in Water samples from the River Test at Whitchurch

Substance Group	**Number of Compounds Detected: River Test at Whitchurch**		**Most Frequently Detected Compounds at River Test Sampling Points** *(not necessarily at Whitchurch)*
	March 2019	**June 2019**	
Pharmaceuticals and personal care products (PPCPs)	9	9	Frequently detected (>50%): Carbamazepine, Lamotrigine, Fexofenadine, Cetirizine, O-Desmethylvenlafaxine, Flecainide, Caffeine, Citalopram, Sulfapyridine, Diclofenac, Carbamazepine-10.11-epoxide
Plant protection products (PPPs)	21	17	Detected at all sampling points: Atrazine, simazine, Atrazine-desethyl, Frequently detected (>30%): Atrazine-desisopropyl, DEET, Imidacloprid, Diuron, Boscalid, Dichlorobenzamide, Azoxystrobin, Melamine, Methoprene, Griseofulvin
Industrial chemicals (ICs)	4	7	Frequently detected (>25%): Benzenesulfonamide, N-butyl, 2-Ethylhexanoic acid, Fluoranthene, 2-Methylnaphthalene, 2,4,7,9-Tetramethyl-5-decyne-4,7-diol, Pyrene, Naphthalene, 3,5-Dimethylphenol

These results show that the River Test is contaminated throughout its length by chemicals likely to be derived from the following sources:

- WWTW discharges: The PPCPs detected are likely to be wholly or mainly derived from WWTW discharges. The frequency of occurrence of PPCPs increased downstream of discharges from larger WWTW. For example, the maximum number of detections of PPCPs (62 substances) was at site T4 on the River Test. T4 is located where effluent directly discharges from Andover WWTP (population equivalent ~ 63,000) to the River Test.

- Agriculture: At least some of the PPPs are likely derived from diffuse and point source agricultural pollution.

- Industrial: PPPs may be partly derived from wastewater treatment plant serving food and drink production facilities and from other locations where pesticides are and/or have been used historically.

The source(s) of industrial chemicals is uncertain but could include road runoff, atmospheric deposition, WWTWs, and industrial discharges.

The study by Robinson et al 2022 identifies the presence of a large number of organic substances in the River Test and therefore a possibility of harm to the aquatic ecology of the River Test. However, the study does identify a need to follow up the qualitative investigation with quantitative investigation to allow the risk associated with the detected substances to be quantified.

4.10 WFD Classification

The full Water Framework Directive classification (2019) is included in Appendix E.

In summary, the WFD Cycle 3 surface water classifications are:

Aspect	2019	Reason for failure
Ecological	High	
Physico-chemical	High	
Chemical	Fail	Mercury Polybrominated Diphenyl Ethers (PDEs)

The WFD Cycle 3 groundwater classifications are:

Aspect	2019	Reason for failure
Overall	Poor	
Quantitative	Good	
Chemical	Poor	Diffuse source – poor nutrient management
Supporting elements – trend assessment	Upward trend	

4.11 Protected Habitat Sites

The entire River Test, from the source at Ashe in the Upper Test to Upper Estuary near Totton a distance of approximately 40 km, is designated as a Site of Special Scientific Interest (SSSI) under the Wildlife and Countryside Act 1981[pp]. This provides a relatively lower level of protection compared to other designations.

The River Itchen is designated as an SSSI[qq] and as Special Area of Conservation (SAC)[rr] under the Habitats Directive (92/43/EEC) and the Conservation of Habitats and Species Regulations 2017 (as amended). The SAC designation area is limited to the watercourse and covers a smaller area than the SSSI designation which includes marginal areas.

There are ten terrestrial units and one riverine of the Test SSSI in the Upper Test:

pp SSSI detail (naturalengland.org.uk)
qq SSSI detail (naturalengland.org.uk)
rr Designated Sites View (naturalengland.org.uk)

Unit Numbers	Habitat	Condition
84	Riverine	unfavourable no change
1	Lowland mixed broadleaved and yew woodland	unfavourable no change
4, 5, 6, 9, 10		favourable
2, 3, 8	neutral grassland	unfavourable recovering
7	Fen, marsh and swamp	unfavourable recovering

The riverine units of the Test and Itchen SSSIs are assessed by Natural England as follows (September 2022 data):

- River Test: 8 No. riverine units, all unfavourable - no change.
  (only one riverine unit, No. 84, from source to Bourne, is in the Upper Test)
- River Itchen: 6 No. riverine units, all unfavourable - no change.

The SAC status of the Itchen provides a higher level of protection for the Itchen compared to the Test. The Test and the Itchen are hydrologically and ecologically similar and the reason for the different designations is not clear. Atkins 2013 reports that the Itchen is exceptionally rich in plant species "*throughout the system on the Itchen*" whereas there is "*greater transition on the Test with the most diverse communities being found in the lower reaches where the substrate is more varied*", which may explain the different designations.

The Test and Itchen drain to the Solent where there are further relevant designations:

- Solent Maritime SAC: designated for a variety of habitats, including estuaries, sandbanks, mudflats, coastal lagoons and shifting dunes. The SAC supports Spartina swards (*Spartinion maritimae*) and Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*).
- Solent and Southampton Water Special Protection Area (SPA) / RAMSAR: The area supports extensive intertidal sandflats and mudflats, large invertebrate populations, and breeding tern populations.
- Solent and Dorset Coast Potential SPA:

The impact of nitrogen, which is the primary growth-limiting nutrient in the marine environment, on the above designated sites in the Solent must be assessed under the Conservation of Habitats and Species Regulations (2017, as amended). The Habitats Regulations Assessment (HRA) process will apply, which is designed to ensure that there are no adverse effects on the integrity of SAC, SPA and RAMSAR sites.

4.12 Ecological Monitoring Data

Wildfish report the results of river fly sampling on 12 English rivers, including the Test and Itchen, for the years 2015-17 with a follow-up in 2021[ss, tt].

Based on the river fly sampling the River Test was ranked in ninth position out of twelve for cumulative water stress, based on sediment, phosphorus and chemical scores, in both surveys, and therefore close to the bottom of the list. The Itchen was ranked fifth and sixth in 2015-17 and 2021 respectively.

The Wildfish results are somewhat contradictory to the WFD classifications, although they are more consistent with Natural England's assessments, see Section 4.8. In 2019, the WFD classifications were assessed for the Upper Test as High for invertebrates, Good for macrophytes and phytobenthos, and High for ammonia, phosphorus, dissolved oxygen, pH and temperature, see Appendix E. The only Fail was for chemical – priority hazardous substances, as described in Section 4.5.

The underlying cause of the river fly classification is uncertain, but the presence of undetected substances including PHS may be a contributing factor.

It was also noted in Section 4.6.3 that orthophosphate is on an upward trend at the two upstream sampling locations on the River Test and that the measured concentrations over the period 2020-22 have been generally, but not always, below the threshold for High chemical classification under the WFD. If the current upward trend continues the classification will probably reduce to Good at the upstream locations.

It can be concluded that there is an evidence gap between the WFD and the river fly classifications that requires further investigation. In the interim, it should be assumed that the surface water quality and aquatic ecology of the Upper River Test requires further investigation and improvement.

ss Riverfly Census | The Decline Of Aquatic Invertebrates | Wildfish

tt 2021-Riverfly-Census_200722.pdf (wildfish.org)

5 CRITICAL EVALUATION OF THE BDBC WCS

5.1 Introduction

The WCS presents strategies for provision of water supplies and disposal of wastewater under the identified growth scenarios based on selected evidence and widely-accepted assessment processes.

However, as discussed in the following sub-sections the WCS:

- Did not follow relevant guidance.
- Included, in Section 3 *"Study Baseline"*, a relatively limited assessment of the existing surface water and groundwater conditions.
- Did not access all relevant data or identify evidence gaps.
- Includes multiple technical deficiencies.

The remainder of this Section includes the following assessments:

Section 5.2 compares the scope and content of the WCS to Environment Agency guidance on water cycle studies.

Section 5.3 describes the baseline condition of the Upper Test.

Section 5.4 identifies evidence gaps.

Section 5.5 is a critical assessment of the findings of the WCS.

Section 5.6 discusses nutrient neutrality in the context of the WCS.

5.2 Comparison of the Scope and Content of the BDBC WCS to Guidance

5.2.1 Evidence Gaps

The guidance, Environment Agency 2021a emphasises the importance of identifying evidence gaps which, if not addressed, would lead to uncertain outcomes and unreliable plans.

The WCS does not specifically consider evidence gaps and there are no recommendations to address evidence gaps.

5.2.2 Climate Change

The guidance, Environment Agency 2021a identifies climate change as a critical aspect of a WCS. The WCS does not consider the effects of climate change on the strategies proposed for water supply and wastewater. The flood risk assessment in the WCS does not appear to allow for climate change.

5.2.3 Flood Risk

The section on flood risk only considers the effect of additional wastewater flows on flood risk. The WCS does not consider whether the growth scenarios can be entirely accommodated in areas with low flood risk, which is an omission relative the Environment Agency WCS guidance.

The effect of increased wastewater flows to WWTWs discharging to watercourse has been assessed in the WCS. It was concluded that the wastewater flows were insignificant and would not increase flood risk. This was based on the 1% AEP wastewater flows but it appears that no allowance was made for climate change.

However the WCS did not assess the effects of increased wastewater discharges to the WWTWs that discharge to ground. This is an omission because discharges to groundwater could in principle cause peak river flows to increase as a result of rapid flow in the Chalk fissure system between the WWTW and the River Test. A rapid flow connection between the WWTWs at Oakley and North Waltham is not plausible due to the distances involved (see Table 5) but the infiltration systems that serve Whitchurch and Overton WWTWs are respectively 400 m and 150 m from the river. It is plausible that increased wastewater flows at Whitchurch and Overton could increase flood risk especially when the effects of climate change are taken into account.

5.3 Baseline Condition of the River Test and Contiguous Chalk Aquifer

5.3.1 Introduction

In the Baseline Section (WCS, Section 3), the WCS describes the WFD classifications but provides little or no quantitative information on water resources and water quality in the River Test catchment or elsewhere in the WCS study area.

5.3.2 River Flows and Groundwater Resources

River flow records for the Upper Test at Chilbolton are only available from 1989. The data record is generally too short to allow definitive trends to be identified.

Long-term groundwater level trends for monitor wells in a small area north of Whitchurch indicate that groundwater levels are declining. Approximately 97% of the flow in the River Test, and all of the low flows, are derived from groundwater discharge. Assuming that the area north of Whitchurch is representative of the entire groundwater catchment, it is likely that low flows on the Upper River Test are declining in proportion to the decline in groundwater levels.

There is a presumption against new consumptive abstractions from the Test Chalk, Environment Agency 2019a.

The WCS proposes that the load standstill approach should be used to accommodate increased wastewater discharges to the Upper Test. The available data indicates that groundwater levels and river flows are reducing, and it is also predicted that low flows are likely to decline further as a result of climate change. Under conditions of reducing river flows, especially low flows, maintaining constant contaminant loads will cause contaminant concentrations to increase because less dilution will be available in the River Test. The WCS proposes a very simplistic application of the load standstill principal which ignores the interaction of wastewater contaminant loads with river flows. The load standstill approach will not protect water quality and ecology unless wastewater loads are reduced to compensate for declining low river flows. It is also noted that any increase in abstraction in the Test Catchment required to support housing/population growth will also cause river flows to reduce.

5.3.3 Water Quality

The water quality of the River Test is adversely affected from multiple sources, but not adequately characterised:

Nitrate: nitrate concentrations are significantly higher than the historical baseline and increasing, principally due to contamination of groundwater by agricultural fertiliser application over several decades. The more recent introduction of nitrate vulnerable zones and other controls on fertiliser use has not yet, in general, reversed the upward concentration trends of nitrate in groundwater. In some areas the peak nitrate concentrations in the unsaturated zone have not yet reached the saturated zone. Trend diagrams in this report show that nitrate concentrations are increasing in groundwater and the River Test. It is likely that nitrate concentrations will continue to increase in the River Test for several decades because of the effect of groundwater quality on river water quality. Compared to agriculture, the contribution of nitrate from WWTW is relatively small. However no increase of WWTW-derived nitrogen is acceptable.

Phosphorus: Phosphorus concentrations are decreasing in the River Test downstream of Overton. Discharges from WWTWs, including Portals Paper Mill and Overton WWTW, appear to be the largest sources of phosphorus. The observed reduction at Overton Bridge Street, Figure 26, from approximately 120 µg/l in 2010 to approximately 40 µg/l in 2022 corresponds approximately to the estimated reduction in phosphorus load from Portals Paper Mill and Overton WWTW combined. Conversely, phosphorus concentrations are increasing upstream at Quidhampton and Polhampton; this could be the result of leaching of agricultural-fertiliser and/or discharges of sewage effluent to the Chalk from WWTWs upstream of Overton including Ivy Down Lane Oakley and Water Ridges Oakley. If the current trends continue the WFD classification for phosphorus upstream of Overton will reduce from High to Good in a few years or less.

Ammoniacal Nitrogen concentrations in the River Test appear to be on a long term upward trend at Overton. Ammoniacal nitrogen is stable at Polhampton and Quidhampton, where the detection limit is lower for post-2016 data. Ammoniacal nitrogen concentrations are generally below detection limits at Whitchurch and East Aston. The upward trend of ammoniacal nitrogen at Whitchurch WWTW does not appear to have impacted the River Test at discernible concentrations.

Priority Substances, Priority Hazardous Substances and other Trace Organic Contaminants: Trace concentrations of a small number of organic substances are reported in groundwater, none of which appear to be significant at present. However, additional groundwater quality monitor wells are needed to characterise the quality of groundwater in the catchment. Only very limited PS, PHS and TOrC data are available for the River Test. It is known that the River Test has been contaminated by mercury and polybrominated diphenyl ether based on the 2019 WFD classifications. Based on the information available for the preparation of this report, the degree and extent of contamination of the River Test by PS, PHS and other organic contaminants is inadequately quantified. Furthermore it is likely that the relatively simpler treatment technologies used at WWTWs in the Upper Test Catchment will be relatively ineffective for removal of PS, PHS and TOrC.

5.4 Identification of Evidence Gaps

A large number of evidence gaps have been identified, the more significant of which are as follows:

- The only groundwater level data available were for a small area north of Whitchurch. Groundwater level data, where available, should be collated for the entire Upper Test Catchment, and evaluated for evidence of catchment-wide trends. If necessary the groundwater level monitoring network should be extended to cover the entire catchment.
- Groundwater quality monitoring data were available for only one monitor well in the Upper Test Catchment. Additional data are needed to characterise contamination of groundwater within the catchment.
- The surface water quality monitoring data for the Upper River Test do not include regular or possibly any analysis for organic substances. It is noted that the River Test is monitored for a limited range of organic contaminants at Wherwell downstream of the Upper Test, but even at Wherwell the analytical suite only includes a limited number of TOrCs
- Phosphorus is not measured in treated wastewater discharged to ground at Whitchurch, Ivy Down Lane Oakley and North Waltham WWTWs, and nitrate/TIN/TN is not measured at Overton WWTW. The monitoring regimes at these WWTWs are inadequate and should be improved immediately by variations to the Environmental Permits for these sites.
- No evidence was found of any monitoring of treated wastewater discharged to ground for potentially harmful organic substances, including those classified as PS, PHS or otherwise classified as harmful or toxic to the environment.
- No evidence was found of recent investigations of soil and groundwater at and in the vicinity of the WWTW infiltration systems at Whitchurch, Overton, Oakley or North Waltham WWTWs, and no evidence of any follow-up of the investigations carried out at Whitchurch WWTW approximately 40 years ago. The condition of soil and groundwater beneath and in the vicinity of the infiltration systems at each WWTW has not been characterised either at all or to an appropriate level.

- Load standstill cannot be demonstrated for the WWTWs in the Upper Test Catchment based on the data presented in the WCS. An appropriate load standstill assessment can only be demonstrated if it is supported by data and quantitative assessments. For nitrate this will require an assessment of back-diffusion from the Chalk matrix based on site-specific data for each WWTW. It will also be essential to carry out detailed investigations of the unsaturated and saturated zones beneath and in the vicinity of each infiltration system to identify and where needed assess the risk associated with other unidentified contaminants that may be present.
- No post-2014 monitoring data were available from the Environment Agency Water Quality Archives for the Portals Paper Mill discharge.

5.5 Critical Assessment of the Water Supply and Wastewater Strategies in the WCS

5.5.1 Water Supply Strategy

The WCS identifies four Water Neutrality Scenarios (WNS) based on various total water demand growth projections combined with demand efficiency measures in existing and new homes.

The Medium WNS was considered to be "*technically and financially feasible*". However, the Medium WNS only delivers 31 to 46% of water neutrality leaving 54 to 69% of the increase in total water demand to be sourced from other measures.

The High WNS was based on maximum water efficiency measures, including water meters installed in 100% of residential properties, retrofitting of water efficiency systems in 50% of existing properties, and grey water recycling in all new homes. The High WNS delivered 100% neutrality, but was considered theoretical and not practically achievable.

The WCS stated that:

> " *Since development within the study area is not proposed to exceed that for which both South East Water and Southern Water are planning, it is not necessary to evaluate the impacts of water supply in the study area independently of the WRMPs and their assessments*.

This meant that the WCS did not include any critical review or verification of the water company WRMPs.

The WRMPs rely on leakage reduction (for Southern Water this is 15% by 2025 and 50% by 2050), consumer demand reduction, temporary and non-essential use bans, with limited resource development. It is estimated in this Review that leakage reduction of 50% by 2050 would deliver an additional 2.8 Ml/d, which is about 10% of the existing water demand.

There can be no certainty that leakage reduction, water efficiency and other measures will meet their respective WRMP targets. The WCS does not provide critical assessments of the water company WRMPs, and therefore significant uncertainty remains as to whether the objectives in the WRMPs can be delivered. Therefore the 54 to 69% shortfall on the water neutrality assessment may not be delivered, resulting in undersupply.

The water neutrality strategies developed in the WCS will inform local planning policy and practice, but the WCS does not demonstrate with any degree of confidence that adequate water supplies will be available for either growth scenario.

5.5.2 Wastewater Strategy

The WCS proposed that the additional volumes of treated effluent discharged from the WWTWs in the Upper Test Catchment can be accommodated without detrimental effects by adopting the principle of "*load standstill*". In this context the load is the rate of discharge of contaminant mass, for example in kilograms per day.

The load standstill approach requires that the concentrations of contaminants in the treated effluent are reduced in proportion to the additional treated wastewater volumes such that the contaminant load discharged to the environment does not increase.

There are two fundamental objections to the load standstill principle. Firstly, load standstill does not provide any betterment that may be needed to reverse water quality and ecological decline. Secondly, under conditions of reducing low flows, load standstill will result in concentration increases during low flow periods compared to the baseline, and in general it is the concentration rather than load that causes adverse effects.

Irrespective of whether load standstill is appropriate for the Upper Test, the load standstill approach described in the WCS is fundamentally flawed for several reasons as follows:

- The WWTW Environmental Permits set emission limit values for several parameters based on (i) annual averages and (ii) maximum allowable concentrations. The WCS proposes a proportional decrease in the annual average ELVs for each WWTW but only where existing ELVs have been set in the Environmental Permit. However the WCS does not propose that the MAC ELVs should also be proportionately reduced. Without a reduction in the MAC-based ELVs the contaminant loads will increase under the proposal in the WCS.

- The WCS should, but does not, also propose that the emission controls in the WWTW permits should be upgraded to a common standard, with each WWTW required to meet the same ELVs for the same suite of contaminants. At present all WWTWs have ELVs for BOD, TSS and ammoniacal nitrogen, but Whitchurch, Oakley and North Waltham WWTW have ELVs for TIN but not phosphorus/phosphate, and Overton WWTW has ELVs for phosphorus but not TIN.

- The WCS states that "*In the vast majority of freshwater environments phosphates are growth-limiting nutrients*." (page 54, paragraph 5) and that the River Test is "*particularly sensitive to phosphate* *pollution*" (page 58, paragraphs 1 and 6). However, the WCS only recommends that the effect of phosphate from Whitchurch WWTW on the River Test is investigated by the Water Company (page 58, paragraph 5). In view of the accepted sensitivity, the appropriate strategy to apply to phosphate emissions from WWTWs is to apply controls on emissions unless the Water Company can demonstrate that they are not required.

- The WCS does not consider the effects of the broad range of inorganic and organic substances in treated effluent from WWTW. As described in Section 2.3.2 it is known that pharmaceuticals, personal care products and other trace organic contaminants survive conventional wastewater treatment and persist in the environment to varying degrees The treated effluents discharged from WWTWs in the Upper Test Catchment will contain a large number of these substances for which ELVs are not set and for which there is very limited, if any, monitoring and in many cases only an emerging understanding of the harm that these substances may cause. These unregulated substances include a large number of Priority Substances (PS) and Priority Hazardous Substances (PHS). In 2019 the WFD status of the River Test and numerous other rivers in England was downgraded to "Fail" because in the case of the Test of the detection of mercury and polybrominated diphenyl ethers (PBDE), both of which are PHSs. PBDEs are a large group of brominated organic compounds used as flame retardants, Environment Agency 2019b. For any contaminant without an ELV the increase of the wastewater volumes could result in a proportional increase in the load discharged.

- The load standstill approach proposed in the WCS does not allow for reductions in low flows that it is predicted will be caused by climate change and may also be caused by any increased abstraction required to support housing/population growth. Wastewater loads will need to be reduced in proportion to declining low flows to avoid the increased contaminant concentrations during low flow periods.

- Treated effluents from the four WWTWs in the Upper Test Catchment are discharged to ground using various infiltration systems. These infiltration systems have been operating for decades, and in the case of Whitchurch WWTW for at least 90 years. The soil and groundwater beneath each infiltration system is inevitably contaminated, and as such should be considered as a form of contaminated land. In effect the WCS proposes an increase of the volume of discharge, and changes to the chemical character, of treated effluent to contaminated land without any proposals to assess the consequences. In a presentation to BDBC on 1 September 2022 Mr David George explained the likelihood that discharging higher volumes of treated effluent with lower nitrate concentrations would result in back-diffusion of nitrate from storage in the Chalk Aquifer beneath the infiltration system. The consequence of this back-diffusion is that additional mass of nitrate would be released from storage in the Chalk over a prolonged period and therefore the nitrate loads reaching the River Test would not reduce in accordance with the design under the load standstill approach. Consequently, nitrate load standstill would not be achieved at the River Test.

- It is likely that other, currently unknown, contaminants have accumulated beneath and downgradient of the infiltration systems and that these contaminants may also be mobilised by the changed operational regimes proposed in the WCS. Some of these contaminants could be mobilised by back-diffusion in the same way as nitrate, while other contaminants may be mobilised by other mechanisms.

At a regulatory level the obligations placed on the water companies, such as Southern Water, and industry are not on a level playing field. For example, in 2018 Portals Paper Mill near Overton was required to meet the BATC AEL (equivalent to an ELV) for phosphorus, derived from the EU Industrial Emissions Directive (IED), of 0.25 mg-P/l by 2020. In contrast, Whitchurch WWTW does not have an ELV for phosphorus and the WCS does not propose that one should be set. A recent letter to LPAs from the Chief Planner sets out a proposal to require that wastewater discharges from all water company WWTWs in catchments with European Sites should meet the technically achievable phosphate ELV of 0.25 mg-P/l by 2030, but this is not yet transcribed in law. In another example, Southern Water have constructed various upgrades at their WWTWs under Permitted Development Rights whereas proposed improvements at the Vitacress Salads Ltd (VSL) site at St Mary Bourne has required a planning application which has been supported by a detailed Environmental Statement and other information.

5.6 Nutrient Neutrality

The nutrient neutrality proposals in the Levelling-up and Regeneration Bill 2022 (LURB), if implemented as described in Section 1.6, will require all WWTWs to be upgraded to meet a total inorganic nitrogen[uu] technically achievable limit (TAL) of 10 mg-N/l by 2030.

This will override the proposed amendments to total inorganic nitrogen ELVs in the WCS:

Whitchurch WWTW: The proposed ELV of 17.2 mg-N/l will reduce to 10 mg-N/l.

Oakley WWTW: The proposed ELV of 21.4 mg-N/l will reduce to 10 mg-N/l.

Overton WWTW: There is no existing nitrogen ELV in the Permit and the WCS did not propose introducing an ELV for nitrogen. The LURB will require the 10 mg-N/l ELV to be included in the Overton WWTW permit.

North Waltham: In principle, the proposed total inorganic nitrogen ELV of 8.1 mg-N/l at North Waltham would be unaffected. However, the 8.1

uu The letter from the Chief Planner dated 21 July 2022 refers to a TAL of 10 mg/l for nitrate; it is assumed that when implemented in Permit variations that the ELVs will be expressed as 10 m-N/l of total inorganic nitrogen mg-N/l ELV is lower than the TAL and therefore there is a likelihood that at North Waltham an ELV of 10 mg-N/l will adopted.

If the total inorganic nitrogen TAL is enforced for WWTWs those deficiencies in the load standstill method proposed in the WCS that relate to nitrogen will be removed. However, the deficiencies related to all other contaminants will remain.

Table 18 compares the nitrogen emissions from WWTWs under the current baseline (actual and permitted DWF), the WCS proposals and the LURB. Comparison of the loads in Table 18 provides the following findings:

- At the current actual DWFs and assuming emissions are at the permitted ELVs, the total nitrogen loading from the WWTWs to the River Test is 100.5 kg-N/d.
- If the WWTWs were operated at their permitted DWFs the nitrogen load would increase by 32.2 kg/d (30%). The corresponding concentration increase in the River Test is estimated at 0.24 mg-N/l based on the mean daily flow at Whitchurch.
- The total nitrogen load based on the proposals in the WCS increases to 106.8 kg-N/d, including an allowance for nitrogen emissions from Overton WWTW. The WCS does not deliver full neutrality for nitrogen because of the absence of a proposed ELV at Overton WWTW.
- The LURB would reduce the total nitrogen inorganic emissions from WWTWs by 45.7 kg-N/d compared to the current baseline. The corresponding concentration decrease in the River Test is estimated at 0.34 mg-N/l based on the mean daily flow at Whitchurch.
- There are no WFD limits for TIN and therefore the estimated changes in river concentrations provided above would not change the WFD classifications of the River Test.

Table 18 Total Inorganic Nitrogen Emissions from WWTWs

WWTW	Baseline – Actual DWF			Baseline – Permit DWF			WCS Proposal			LURB		
	Actual DWF (m3/d)	TIN-ELV (mg-N/l)	TIN Load (kg/d)	Permit DWF m3/d)	TIN-ELV (mg-N/l)	TIN Load (kg/d)	Actual DWF 2039 (m3/d)	TIN-ELV (mg-N/l)	TIN Load (kg/d)	Actual DWF 2039 (m3/d)	TIN-LV (mg-N/l)	TIN Load (kg/d)
Whitchurch	1753	32	56.1	2336	32	74.8	3268	17.2	56.2	3268	10	32.7
Overton[a]	1001	None (25)	25.0	1160	None (25)	29.0	1246	None (25)	31.2	1246	10	12.5
Oakley	534	35	18.7	722	35	25.3	875	21.4	18.7	875	10	8.75
North Waltham	36	20	0.72	167	20	3.3	88	8.1	0.71	88	10	0.88
Totals			**100.5**			**132.4**			**106.8**			**54.8**

a For calculation purposes the current and WCS ELV at Overton WWRW was set at the current average emission value.

6 CONCLUSIONS AND RECOMENDATIONS

6.1 Conclusions

6.1.1 Condition of the River Test and Test Chalk

River flows and groundwater levels in the Upper Test Catchment are declining and it is predicted that climate change will cause further reductions of low flows in the River Test.

The water quality of the River Test is adversely affected from multiple sources, but is not adequately characterised due to an inadequate number of groundwater quality monitor wells and the limited analytical suite at surface water sampling points on the Upper Test.

Nitrate concentrations are increasing in the River Test and in groundwater in the Test Chalk. In some areas the peak nitrate concentrations in the unsaturated zone have not yet reached the saturated zone. Agriculture appears to be the major cause of increasing nitrate concentrations, but WWTWs are a secondary cause. Back-diffusion of nitrate from storage in the Chalk matrix is a particular concern. Back-diffusion from matrix storage takes effect when concentrations decrease in mobile fissure groundwater and will affect all nitrate in storage irrespective of the original source.

Phosphorus concentrations are decreasing in the River Test downstream of Overton but apparently increasing upstream. Reductions in phosphorus loads from Overton WWTW and Portals paper mill have contributed to improving phosphorus conditions downstream of Overton, and the closure of Portals may generate further improvement. If the current trends continue the WFD classification for phosphorus upstream of Overton may reduce from High to Good in a matter of few years. The main source of phosphorus appears to be WWTWs. Historical phosphorus discharges to the River Test have probably caused phosphorus to accumulate in river sediments, which will slow the decline of dissolved phosphorus concentrations. The cause(s) of increasing phosphorus concentrations upstream of Overton requires investigation; phosphorus loads from the infiltration systems at Oakley WWTWs are likely to be at least partly responsible.

Ammoniacal Nitrogen concentrations appear to be on a long term upward trend at Overton, with higher concentration outliers occurring more frequently since 2018. At other sampling locations ammoniacal nitrogen is detected at low concentrations and is stable or below detection limits.

Only very limited TOrC data are available for the River Test due to a limited analytical suite. Groundwater samples are analysed for a wider range of TOrCs but there is only one groundwater quality in the Upper Test Catchment. It is known that the River Test has been contaminated by mercury and polybrominated diphenyl ether based on the 2019 WFD classifications, but a recent study indicates that many more TOrCs are also detectable. It is likely that the relatively simpler treatment technologies used at WWTWs in the Upper Test Catchment will be relatively ineffective for removal of TOrCs. Further investigation of TOrCs is needed.

The ecology of the River Test is under stress, as shown by independent lines of evidence including the historical physical modifications of channels and banks, chemical water quality, river fly census data and the condition of the River Test SSSI.

6.1.2 Evidence Gaps

A large number of evidence gaps have been identified, as detailed in Section 5.4. In some cases the data may exist but was not available for the preparation of this report. In other cases, for example TOrC data for the River Test, it is believed that the data are not being collected under the current monitoring programmes

6.1.3 Water Cycle Study

There are a number of serious deficiencies in the BDBC WCS as described throughout this report. It is concluded that the WCS is not fit for purpose and needs significant review and rewriting.

The water supply assessment in the WCS does not demonstrated with an acceptable level of confidence that sufficient supplies of water will be available to support the growth in water demand from new housing under either growth scenario.

The load standstill strategy proposed to accommodate the increase in wastewater flows does not allow for any betterment which may be needed to reverse water quality and ecological deterioration.

The load standstill methodology for future wastewater discharges proposed in the WCS contains a number of serious flaws and will not deliver load standstill either in the Chalk Aquifer or in the River Test. The methodology proposed in the WCS will result in an increase in contaminant loads discharged to the River Test from WWTWs. Furthermore, even with absolute load standstill contaminant concentrations will increase under future low flow conditions because of reducing low flows caused by the existing downward trend and future climate change effects.

Increasing wastewater volumes discharged at the WWTWs, as proposed in the WCS, is highly likely to result in mobilisation of a large number of inorganic and organic contaminants from storage in the unsaturated and saturated zones beneath and downgradient of the infiltration systems. Any release from storage has the potential to increase contaminant loads discharged to the River Test and violate the load standstill objectives. For nitrate it is likely that load and concentration standstill will only be achieved at the River Test if ELVs are set at significantly lower concentrations than those calculated in the WCS. No increase in wastewater loading is acceptable until detailed assessments have been carried out at each WWTW to develop permit conditions that will be protective of the River Test, taking into account the condition of the River Test as described above.

The WCS should include appropriate consideration of flood risk assessment including the effect of increased wastewater discharges on flood risk in the Upper Test Catchment.

The WCS does not include an adequate assessment of the effects of climate change on water supply, wastewater discharges and flood risk.

6.1.4 Nutrient Neutrality

The nutrient neutrality proposals in the Levelling-up and Regeneration Bill 2022, if implemented as described in Section 1.6, will require WWTWs to be upgraded to meet a total inorganic nitrogen ELV of 10 mg-N/l by 2030. This will override the proposed amendments to nitrogen ELVs at Whitchurch WWTW (proposed ELV of 17.2 mg-N/l) and Oakley WWTW (proposed ELV of 21.4 mg-N/l). It will require the 10 mg-N/l ELV to be set for Overton WWTW. The WCS proposed a total inorganic nitrogen ELV of 8.1 mg-N/l at North Waltham which will be unaffected, although it appears to be an ambitious target which in practice may be increased to the 10 mg-N/l TAL.

6.2 Recommendations

- The WCS should be reviewed and re-written taking into account the comments above. At the very least the WCS should identify and assess the implications of evidence gaps, include climate change assessments for all aspects (i.e. water supply, wastewater and flood risk), in accordance with Environment Agency guidance, and deliver absolute wastewater load and concentration standstill, or better, for all contaminants of concern.

- No further development of housing, beyond that currently approved for development, should be permitted in the BDBC area until it can be demonstrated with an acceptable level of confidence that sufficient supplies of water will be available to support the associated growth in water demand. This requires more than a set of options for demand and leakage reduction, and resource expansion, it also requires assessment of the uncertainties and confidence associated with each measure.

- The rate of discharge of wastewater at the WWTWs in the Upper Test Catchment should not be increased until detailed assessments have been made of the potential effects of these changes on groundwater in the Chalk Aquifer and on the River Test. This should be supported by appropriate investigation programmes at each WWTW.

- The load standstill methodology proposed in the WCS should be amended to ensure that absolute load standstill will be delivered for all relevant contaminants including any currently unknown contaminants present beneath and in the vicinity of each infiltration system. The load standstill methodology should also consider the effects of future climate change on low flows to deliver concentration standstill or better under low flow conditions.

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Appendix A

Effects of Growth Scenarios on Wastewater Treatment

Appendix A Effects of Growth Scenarios on Wastewater Treatment

Table 19 Effects of Housing/Employment Growth on Wastewater Treatment Capacity, River Test Catchment

WWTW	Current Permitted DWF (m^3/d)	Current Measured DWF (m^3/d)	Calculated Headroom (m^3/d)	Statistics after Growth Scenario 1 and Scenario 2				
				Number of Proposed Housing Units	Number of New Jobs Created	Future 2039 DWF (m^3/d)	Headroom Capacity (m^3/d)	Approximate residual housing capacity
Whitchurch	2,336	1,753	584	2,881 3,871	845 845	2,884 3,268	*-548* *-932*	*-1,765* *-3,002*
Overton	1,160	1,001	159	390 630	0	1,153 1,246	7 *-86*	23 *-277*
Oakley	722	534	188	590 880	0	763 875	*-41* *-153*	*-132* *-494*
North Waltham	167	36	131	134 134	0	88 88	79 79	256 256
Ashmansworth	5	ND	ND	0	0	-	Current DWF data not provided for this WWTW but no growth identified	
Hannington	10	3	7	0	0	3	No growth identified for this WWTW.	

From: AECOM 2022 Table 4-3

DWF dry weather flow

Appendix B

Descriptions of Waste Water Treatment Works:
Whitchurch WWTW
Overton WWTW
Ivy Down Oakley WWTW
North Waltham WWTW
Water Ridges Oakley WWTW
Hannington and WWTW

Appendix B Descriptions of Wastewater Treatment Works

Appendix B1 Whitchurch Wastewater Treatment Works

B1.1 General

The layout and engineering of Whitchurch WWTW was assessed from various documents, historical OS maps, and Google Earth imagery, and additional information was obtained from Southern Water's Drainage and Wastewater Management Plan (DWMP) for the Test and Itchen, Southern Water 2022. The effects of Whitchurch WWTW on groundwater were assessed from limited documentary information available from public domain records, reports, and scientific literature.

B1.2 Description, Layout and Operations

Whitchurch WWTW is located on the northern side a dry valley which is oriented south east to north west. The River Test is located approximately 600 m from the north west boundary of the WWTW site.

The 1942 OS map, see *Figure B2* below, shows an early layout of the Whitchurch WWTW with what appear to be a number of infiltration ditches within the boundaries of the present day sewage works. The 1942 map also shows a meter house but no other details. At that time the sewage works was operated by Kingsclere and Whitchurch Rural District Council. No treatment works appears to have been present in 1942.

The 1908 OS map extract, see *Figure B1* below, does not show Whitchurch WWTW indicating that the WWTW was constructed between 1908 and 1942. Baxter et al 1981 recorded that the Whitchurch WWTW "*has been operated for over 50 years",* i.e. from before 1930.

Baxter et al 1981 reported that screened domestic sewage was discharged to 33 linear lagoons (i.e. ditches), each ditch being 1 to 2m deep and having an area of approximately 190 m^2 i.e. 6,270 m^2 in total. They also reported that the ditches were operated on a fortnightly rotation, with half in use and half being mechanically de-sludged. The daily dry weather throughput was 600 m^3/d with a mean infiltration rate of 40 mm/d. The only treatment provided prior to discharge to land was screening, which is assumed to mean the removal of over-size material in simple screens.

Figure B3a also shows the layout of the infiltration ditches in use at the time and the groundwater elevation contours interpolated from groundwater levels measured at the time of the investigation. It is notable that the layout of infiltration ditches shown on *Figure B3a* is very similar to that shown on *Figure B2*, the 1942 OS map, with just the addition of a small number of ditches to the north west. It appears likely that there was very little change in operations at Whitchurch WWTW between 1942 and 1981.

The waste water treatment plant which can now be seen on the aerial images and OS mapping was built in 1982, Beard and Giles, 1989. The waste water treatment plant appears to comprise a number of smaller holding and/or treatment tanks, 2

No. trickling filters each approximately 30 m diameter, and 2 No. smaller cylindrical tanks approximately 10m diameter which appear to be humus tanks. The treatment technology installed appears to be conventional primary and secondary treatment.

Beard and Giles record that the dry weather sewage throughput in 1982 was 700 m^3/d, and that from 1982 onwards, after the sewage treatment plant was built, the dry weather flow had increased to 900 m^3/d. From 1982 treated sewage effluent was discharged to a system of underground french drains in place of the open ditches.

Google Earth images dated December 1999 to April 2008, *Figures B4 to B6*, show the WWTW with the treatment works built in 1982 and the outlines of the french drains in the field area north west of the treatment works.

The subsequent Google Earth image dated April 2017 shows (i) infiltration ditches north west of the treatment plant presumably replacing the french drain system installed in 1982, and (ii) an additional area of infiltration ditches to the south east of the treatment works, see *Figures 7 to 9* below. The additional infiltration ditches to the south east approximately double the area where treated sewage is discharged to land, and also extends the area of disposal to the south east away from the River Test.

A proposal was developed in 2010 to reduce the nitrate concentrations in the treated effluent at Whitchurch WWTW by installation of a methanol denitrification plant and associated sand filters. However, this was abandoned and instead additional infiltration trenches were constructed in 2013. The purpose of the new infiltration trenches was to promote additional denitrification in the ground beneath the site.

The new infiltration trenches were built on adjacent farmland which required a change of use planning application. The statement in the planning application supporting document was:

> "*This allows increase natural treatment by the earth, making the nitrate concentration within the groundwater at the nearby monitoring wells within acceptable limits.*"

It is not clear whether the revised proposals were supported by technical design studies and/or post-completion verification monitoring.

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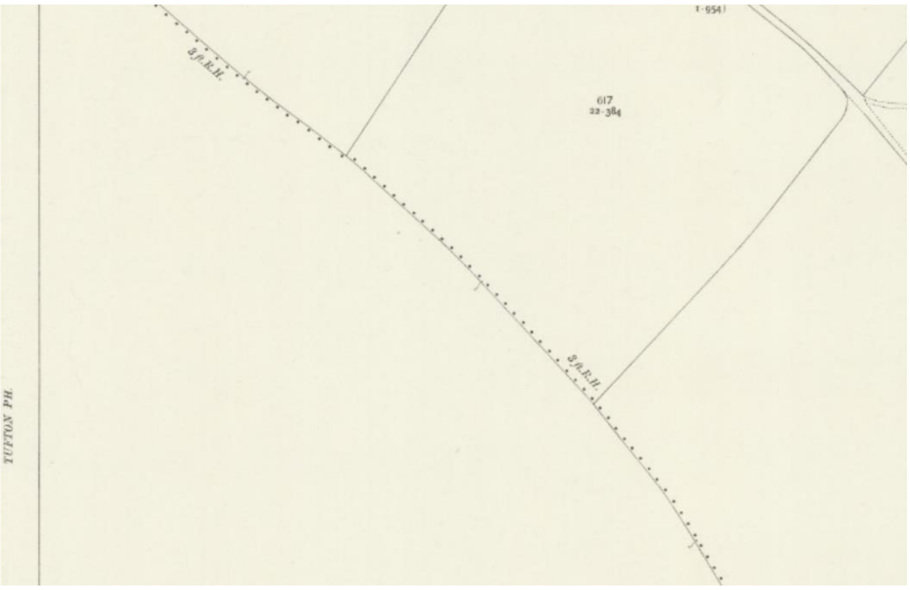


Figure B1 Extract from 1908 Ordnance Survey Map, 25 Inch Series, Hampshire and Isle of Wight, sheet XXV.1, nominally 1:2500 scale

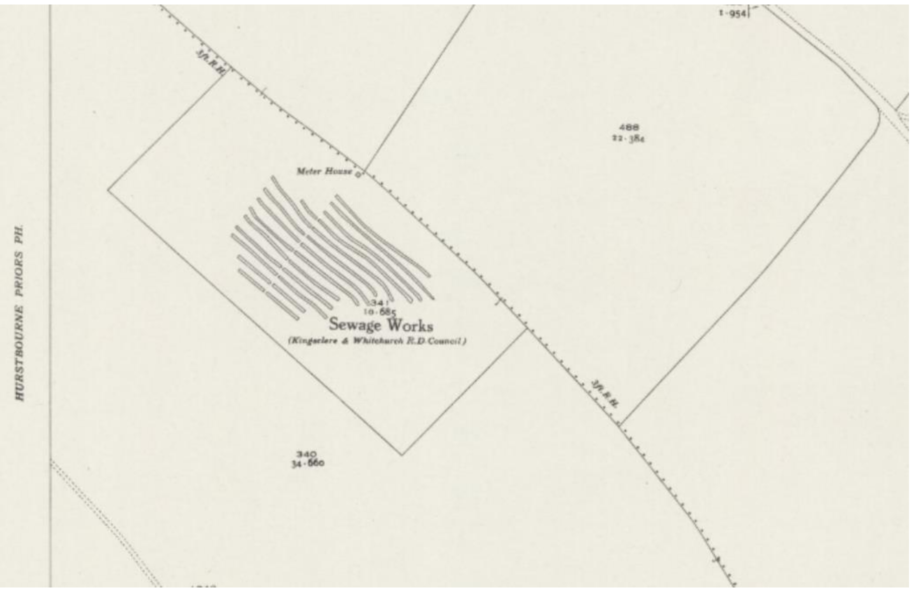


Figure B2 Extract from 1942 Ordnance Survey Map, 25 Inch Series, Hampshire and Isle of Wight, sheet XXV.1, nominally 1:2500 scale

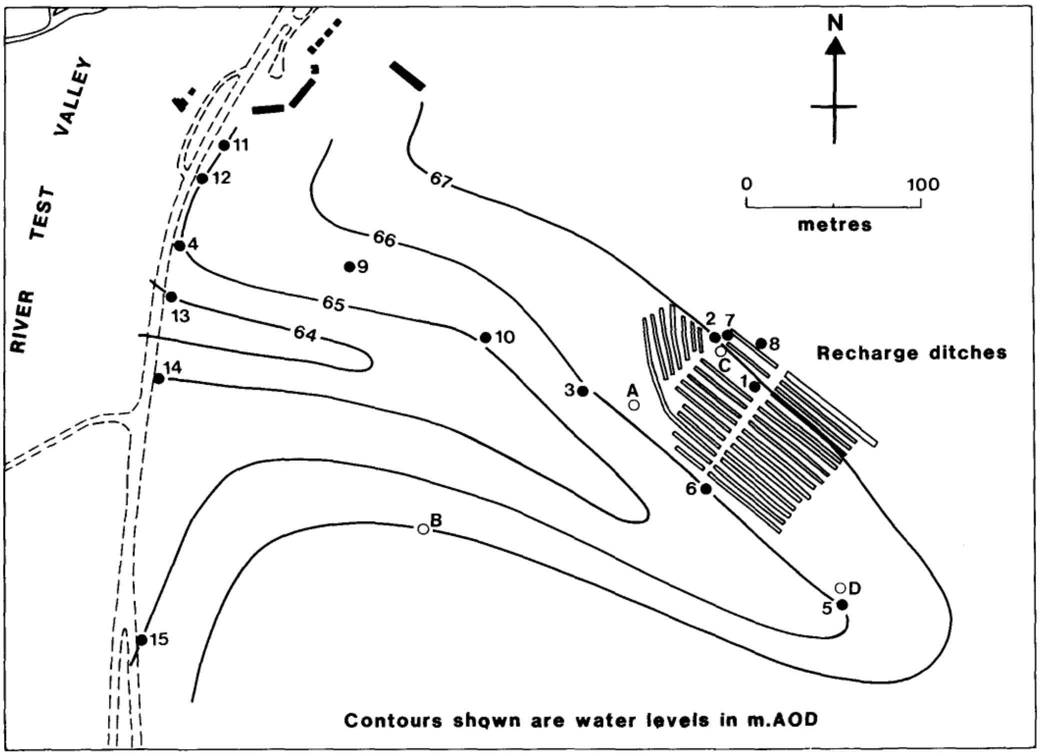


Figure B3a Monitor Well Locations at Whitchurch WWTW
Reproduced from Baxter et al 1981

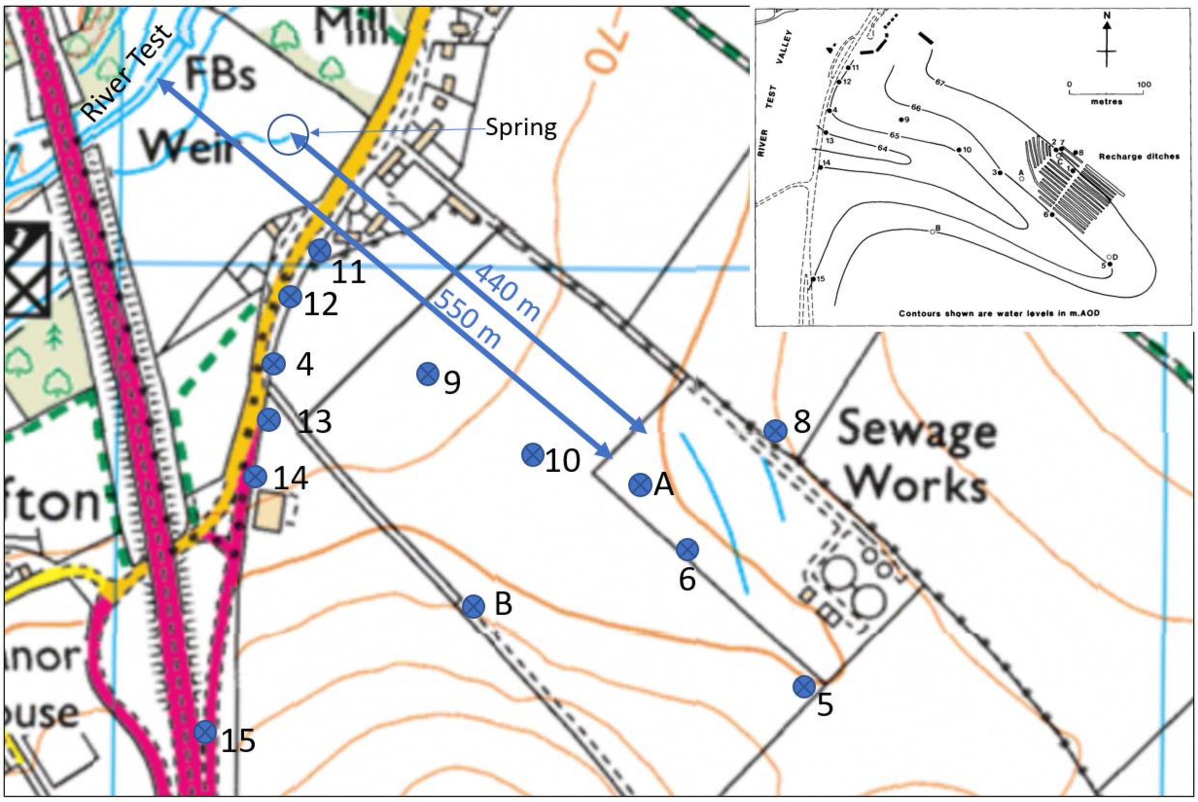


Figure B3b Monitor Wells at Whitchurch WWTW – approximate locations on OS map extract

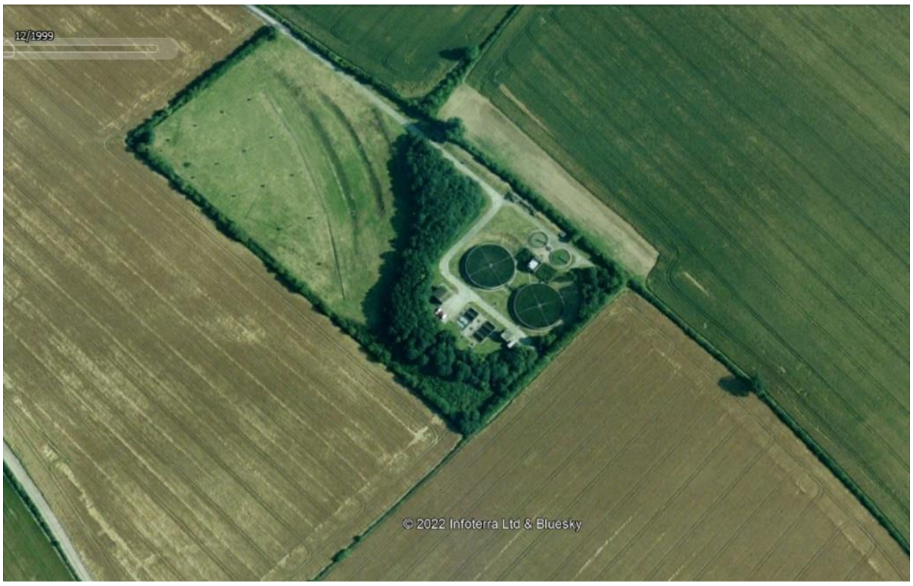


Figure B4 Aerial image dated January 1999

Figure B5 Aerial image dated January 2005

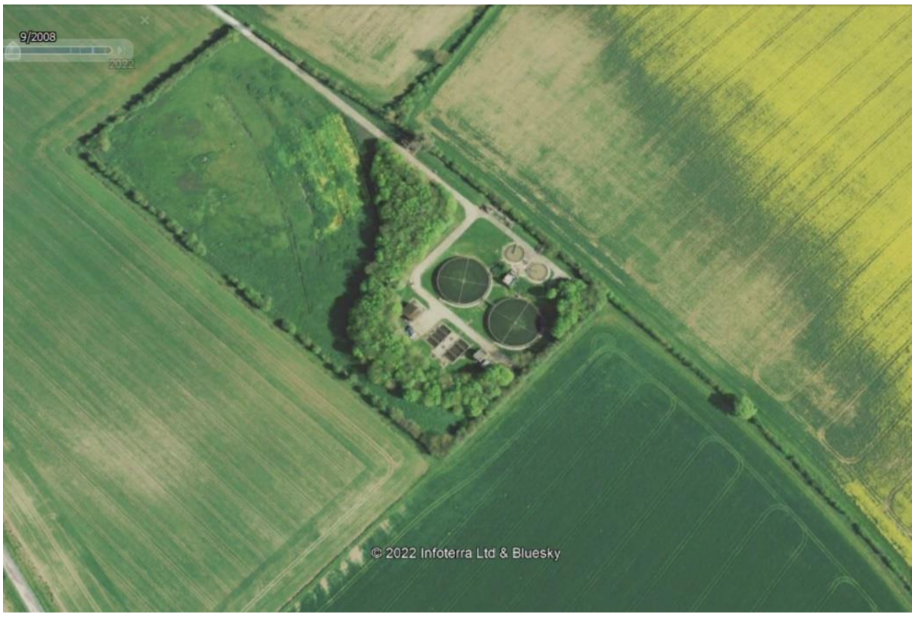


Figure B6 Aerial image dated April 2008

Figure B7 Aerial image dated April 2017

Figure B8 Aerial image dated July 2020

Figure B9 Aerial image dated April 2022

B1.3 Effects on Groundwater

Baxter et al 1981 describe an investigation at WWTW where 19 No. monitor wells were installed at locations within the WWTW and between the WWTW and the River Test, see *Figures B3a and B3b*. At two locations, labelled A and B on *Figure B3a*, multi-level monitor wells were installed, where groundwater samples can be obtained from 2 or more discrete depths.

Groundwater elevation contours followed the topographic contours of the dry valley feature with groundwater flow in a north westerly direction towards the River Test. One upgradient monitor well was installed, labelled no. 5, and monitor well no. 15, and multilevel monitor wells at B were on the opposite side of the dry valley from the WWTW. Monitor wells 5, 15 and the multilevel monitor wells at B would be expected to be relatively unaffected by sewage effluent discharge from the WWTW.

The unsaturated zone was 10m thick beneath the sewage effluent discharge (infiltration) area.

Baxter et al 1981 report the results of sampling sewage effluent (one sample) and groundwater from monitor wells. Water samples were analysed for ammonia, total organic nitrogen, nitrite, nitrate, chloride and boron, BOD, DOC, and VOCs. It is assumed that ammonia was measured as total ammoniacal nitrogen (TAN) and therefore measured the aggregate concentrations of ammonia, NH_3, and ammonium, NH_4^+. The analytical results reported by Baxter et al 1981 are reproduced in *Table B1* below.

Beard and Giles 1989, report the results of the 1981 investigation described by Baxter et al 1981, together with ongoing sampling of the monitor wells following the introduction of secondary treatment in 1982.

The results in Table 1 from Baxter et al 1981and *Table 2*, below, show the following:

- Monitor wells in the sewage effluent discharge area, No. 1, 2, 3, 6, 7, 8 and A_{top}, were obviously impacted by sewage effluent with increased concentrations of ammonia, total oxidised nitrogen (TON), nitrite, phosphate and chloride, boron, BOD, DOC and VOCs. A_{top} is believed to be approximately 19m deep with 9m of saturated zone.
- Monitor wells immediately downgradient of the discharge area, No. 3 and 6, were contaminated by sewage effluent to a similar degree to those in the discharge area.
- Monitor well in the plume, No.14, appeared to be somewhat contaminated by sewage effluent. The relatively high concentrations of sewage-derived contaminants, especially chloride and ammonium, in 14 suggests a centre-plume alignment in an East - West direction through this location close to the centre of the dry valley but not fully aligned with it. This interpretation is tentative given the relatively low contaminant concentrations in 14 and the possibility that 14 was contaminated from other sources such as the adjacent road.
- Monitor wells in the downgradient plume area, No. 4, 11, 12, 13, & 15, together with the lower monitor wells at A (A_{mid} and A_{base}) in the discharge area, were largely uncontaminated by sewage effluent with similar concentrations to the upgradient monitor well 5 and monitor wells B_{base} and B_{top}.
- Downgradient monitor well 5, together with monitor wells 15, B_{base} and B_{top} which are on the opposite side of the dry valley, were effectively uncontaminated as would be expected based on their locations.

These results show that there was significant attenuation of sewage-derived contamination in the expected area of the plume along the dry valley. Monitor well 14 is approximately 300m downgradient and close to the centre of the dry valley and was obviously impacted by sewage-derived contamination as indicated by slightly elevated concentrations of ammonia, nitrite, phosphate and chloride, and also the high concentration of TON in 14 compared to the background concentrations in 5, 15, B_{top} and B_{base}.

Baxter et al 1981 also reported the results of a tracer test carried out at the site. The travel time through the unsaturated zone was measured at 18 hours.

TABLE 1

Mean values for chemical analysis of groundwater (all as mg/l)

BORE	NH_3 (N)	TON	NO_2 (N)	PO_4 (P)	Cl	B	BOD (ATU)	DOC+	VOC≠
1	15.8	3.33	0.27	6.39	46.0	0.58	30.8	7.2	0.4
2	11.5	3.86	0.088	3.69	44.3	0.53	18.8	16.8	0.8
3	17.8	1.43	0.064	3.46	45.6	0.79	5.4	24.9	2.3
6	6.4	4.76	0.053	4.26	45.6	0.93	6.8	28.0	0.9
*7	13.2	3.01	0.14	4.20	41.9	0.45	9.3	4.4	0.6
*8	22.6	0.15	0.03	1.29	51.4	0.75	15.0		
*A(bottom)	0.012	6.31	0.005	0.058	13.7	0.035	1.1	3.4	0.04
*A(middle)	0.012	6.30	0.004	0.037	12.3	0.047	1.3	2.7	0.09
*A(top)	14.8	0.18	0.005	0.980	46.8	0.74	5.6	4.7	9.7
*10	0.044	6.54	0.018	0.037	15.7	0.11	2.9	6.2	0.02
11	0.018	7.29	0.003	0.030	14.2	0.04	1.8	1.7	0.007
12	0.015	7.01	0.004	0.048	13.3	0.04	1.3	1.5	0.004
4	0.031	6.30	0.007	0.046	12.3	0.04	1.1	2.6	0.009
13	0.021	8.55	0.004	0.033	15.0	0.04	1.5	1.7	0.004
14	0.349	9.60	0.031	0.054	27.7	0.24	1.1	1.9	0.005
15	0.017	7.45	0.003	0.029	16.6	0.04	1.3	1.4	0.004
16	0.011	7.87	0.005	0.017	12.4	0.04	1.1	2.2	0.15
5	0.018	7.42	0.006	0.038	13.4	0.03	2.3		
*B(bottom)	0.009	6.89	0.004	0.033	14.7	0.03	1.3	2.2	0.8
*B(top)	0.009	8.29	0.004	0.020	19.2	0.04	1.8	1.7	0.02
SEWAGE	22.2	0.65	0.31	7.38	57.2	2.10	221	66.8	

*using in situ samplers

+Dissolved carbon after stripping of VOC

≠ Volatile organic carbon removed by N_2 stripping

Reproduced from Baxter et al 1981

Baxter et al also report the findings from an investigation of the nitrogen balance between the infiltration ditches and monitor well 2, see Table 2 from their paper below. The results in the following table are mean values from multiple measurements made over a period of up to 9 hours on four separate occasions. They concluded that there was evidence of considerable loss of nitrogen, of up to 43%, in the unsaturated zone caused by microbiological denitrification. Baxter et al 1981 reported the presence of up to 1% methane in soil gas of the unsaturated zone which is indicative of anaerobic conditions required for denitrification.

TABLE 2

Results of nitrogen balance experiments

No.	LAGOON TDN* (mg/l)	LAGOON TOC (mg/l)	LAGOON t°C	BORE 2 TDN* (mg/l)	BORE 2 TOC (mg/l)	BORE 2 t°C	Dilution %Effluent	N Predicted mg/l	N Lost %
1	32.9	37.4	15	19.9	16.0	12.5	85	29.0	31
2	36.4		16	19.7		12.5	95	34.8	43
3	29.1	49.8	14.5	19.7	19.7	14.0	88	26.4	26
4	70.7	39.0	9.5	35.0	22.0	13.0	80	57.9	39

* total dissolved nitrogen = TON (total oxidised N) + Kjeldahl N

Beard and Giles 1989, compared concentrations of sewage-derived contaminants in monitor wells at Whitchurch WWTW from the earlier pre-1982 operations, when untreated sewage effluent was discharged to infiltration ditches, to the post-1982 operations when treated sewage effluent was discharged to the french drain system. These comparative results are shown in Tables 3 and 4 from the paper by Beard and Giles:

Table 3 Chemical quality of Groundwater Whitchurch Site. Crude sewage - open ditch regime
average values in milligrammes per litre

Borehole Location	NH_3 N	NO_2 N	NO_3 P	PO_4	Cl	B C	DOC
R Area middle 1	20.3	0.03	0.47	6.9	48	0.87	12.5
R Area boundary 2 19m depth	13.9	0.01	0.15	1.0	43	0.64	5.0
R Area boundary 2 34m depth	0.07	0.05	6.0	0.03	13	0.02	1.4
Effluent Crude	16.5	0.57	1.6	4.6	47	1.7	47.0

Table 4 Chemical quality of Groundwater Whitchurch Site. Treated Sewage - french drain regime
average values in milligrammes per litre

Borehole Location	NH_3 N	NO_2 N	NO_3 P	PO_4	Cl	B C	DOC
R Area Middle 1	0.02	0.03	20.0	5.3	54.6	1.1	5.2
R Area boundary 2 19m depth	0.19	0.02	18.0	0.8	47.2	0.9	2.4
Effluent nitrified	0.27	0.09	18.8	6.6	53.7	1.0	6.7

The monitor well numbering used by Beard and Giles is believed to correlate to *Figure B3* from Baxter et al as follows:

Beard & Giles 1989	**Figure B3**
R Area Middle 1	monitor well 6
R Area boundary 2 19m depth	monitor well A_{top}
R Area boundary 2 34m depth	monitor well A_{mid} or A_{base}

It is inferred from the discussion in Beard and Giles 1989, that the sampling for results reported in their Table 3 was carried out in 1981 and sampling for the results reported in their Table 4 approximately five years later i.e. in 1986.

It can be seen from the comparitive results that before the secondary sewage treatment plant was built the sewage effluent was characterised by high concentrations of ammonia and nitrite, and correspondingly low concentrations of nitrate. Concentrations in the monitor wells reflected that of raw sewage, except for nitrite which was attenuated rapidly, and phosphate and DOC which were attenuated in the boundary monitor wells A_{top} and A_{base}.

Following installation of the secondary treatment plant in 1982 the character of the effluent changed to that high in nitrate with lower concentrations of ammonia, nitrite and DOC, but with similar concentrations of total nitrogen (TN) of approximately 20 mg/l. The concentrations of nitrate increased significantly. Denitrification appears to have ceased in the groundwater system due to the discharge of oxidised/nitrified effluent with lower DOC. There was little change in the distribution and attenuation of phosphate. Chloride and boron were effectively unchanged between the pre- and post- 1982 operational systems.

Table 20 Analytical Results from Groundwater Sampling at Whitchurch WWTW in 1981

	Sewage	BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH8	BH10	BH11	BH12	BH13	BH14	BH15	BH16	A			B	
																	A_b, (base)	A_m (mid)	A_t (top)	B_b, (base)	B_t (top)
		DA	DA	UG Plume	DG Plume	UG	IDG	DA	DA	Plume	DG Plume	DG Plume	DG Plume	DG Plume	OP	?	DA			OP	
NH_3-N	22.2	15.80	11.50	17.80	0.03	0.018	6.40	13.20	22.60	0.044	0.018	0.015	0.021	0.349	0.017	0.011	0.012	0.012	14.80	0.009	0.009
TON-N	0.65	3.33	3.86	1.43	6.30	7.42	4.76	3.01	0.15	6.54	7.29	7.01	8.55	9.60	7.45	7.87	6.31	6.30	0.18	6.89	8.29
NO_2-N	0.31	0.270	0.088	0.064	0.007	0.006	0.053	0.140	0.030	0.018	0.003	0.004	0.004	0.031	0.003	0.005	0.005	0.004	0.005	0.004	0.004
PO_4-P	7.38	6.39	3.69	3.46	0.046	0.038	4.26	4.20	1.29	0.037	0.030	0.048	0.033	0.054	0.029	0.017	0.058	0.037	0.980	0.033	0.020
Cl	57.2	46.0	44.3	45.6	12.3	13.4	45.6	41.9	51.4	15.7	14.2	13.3	15.0	27.7	16.6	12.4	13.7	12.3	46.8	14.7	19.2
B	2.1	0.58	0.53	0.93	0.04	0.03	0.93	0.45	0.75	0.11	0.04	0.04	0.04	0.24	0.04	0.04	0.035	0.047	0.740	0.03	0.04
BOD	221	30.80	18.80	6.80	1.10	2.30	6.80	9.30	15.00	2.90	1.80	1.30	1.50	1.10	1.30	1.10	1.10	1.30	5.60	1.30	1.80
DOC	66.8	7.20	16.80	28.00	2.60		28.0	4.40		6.20	1.70	1.50	1.70	1.90	1.40	2.20	3.40	2.70	4.70	2.20	1.70
VOC		0.40	0.80	0.90	0.009		0.90	0.60		0.020	0.007	0.004	0.004	0.005	0.004	0.150	0.040	0.090	9.70	0.80	0.02

DA sewage effluent discharge area
DG Plume downgradient plume
OP opposite side of dry valley
UG upgradient
UG Plumeupgradient plume adjacent to the discharge area

Note: the location of monitor well 16 was not provided by Baxter et al 1981

Appendix B2 Overton WWTW

B2.1 General

Relatively limited information was available for Overton WWTW. The layout and engineering of Overton WWTW was assessed from historical OS maps and Google Earth imagery, and also from a paper by Beard and Giles 1989. Additional information was obtained from Southern Water's DWMP for the Test and Itchen, Southern Water 2022, and a planning application in 2011.

Overton WWTW is located at NGR SU 5036 4972 in Lynch, approximately 1.2 km north west of Overton. It serves Overton and Laverstoke. It is believed that sewage effluent is subjected to secondary treatment and then the treated effluent is discharged to the Chalk in elongated infiltration lagoons.

The WWTW dates from before 1941 and therefore has been in operation discharging to the Chalk Aquifer for at least 81 years. Infiltration lagoons have been in operation at Overton WWTW since before 1983, Beard and Giles 1989.

B2.2 Layout and Operations

Historical Ordnance Survey maps show that the WWTW was built pre-1941, see Figure B10. The WWTW was not shown on the Ordnance Survey map dated 1909 (map extract not included in this report), and therefore was built between 1909 and 1941.

The 1941 layout, Figure B10, shows 3 No. circular "filter beds", and 8 No. "sludge beds". No infiltration systems are shown on the map. It is assumed that treated effluent was discharged to the Chalk in an infiltration system which is not shown on the map, either by seepage from the "sludge beds", or possibly by surface spreading on the adjacent field to the south; surface spreading was employed by Southern Water Authority and predecessors, Beard and Giles 1989.

A Google Earth image dated 1999 shows Overton WWTW much expanded with the original 3 No. rotary filter beds to the north and infiltration lagoons to the south, see Figure B11. The sludge beds have been removed.

The layout remains largely unchanged until 2008, except for an additional infiltration lagoon installed before 2005.

In 2011 the site was extended to the north, the original rotary filter beds were decommissioned and replaced by a new 350 m^3 storm tank, 2 No. new trickling filters, and 2 No. new humus tanks, see Figure B12. No further significant changes appear to have occurred. Planning documents, 4Delivery 2011, indicate that:

- Before 2011 there were no numerical emission limit values.
- ELVs were introduced by a permit variation, with numerical ELVs introduced for TSS, BOD, COD, ammoniacal nitrogen, phosphorus and iron.
- Ferric dosing plant was installed at this time to meet the new ELV of 1 mg-P/l. It is assumed that this involves dosing with ferric trichloride or other iron salt to precipitate phosphorus.

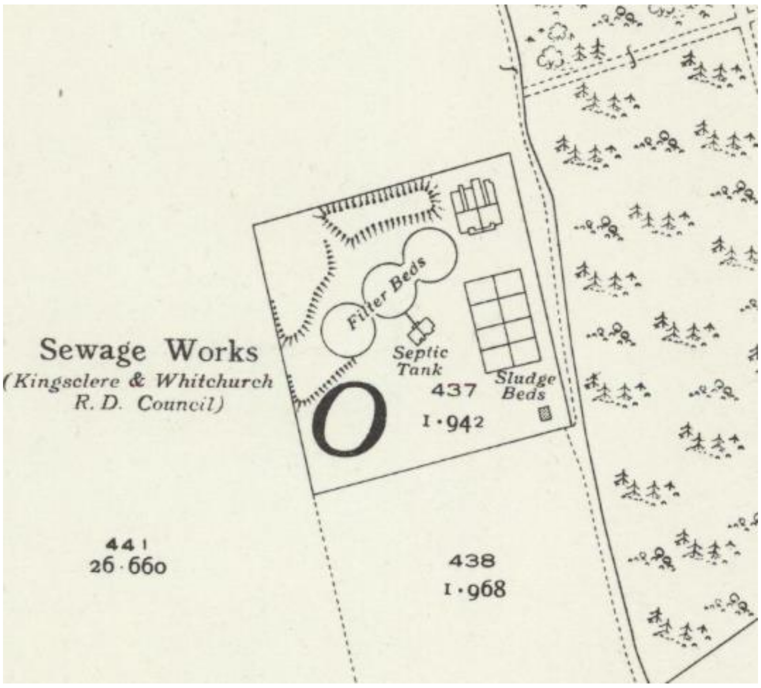


Figure B10 Extract from 1941 Ordnance Survey Map, 25 Inch Series, Hampshire and Isle of Wight, sheet XVI.10, nominally 1:2500 scale

Figure B11 Overton WWTW in 1999

Figure B12 Overton WWTW in 2017

Appendix B3 Ivy Down Lane Oakley WWTW

B3.1 General

Relatively limited information was available for Oakley WWTW. The layout and engineering of Oakley WWTW was assessed from historical OS maps and Google Earth imagery, and additional information was obtained from Southern Water's Drainage and Wastewater Management Plan (DWMP) for the Test and Itchen, Southern Water 2022. Historical information was available from Beard and Giles 1989.

Oakley WWTW is located at NGR SU 564 511 approximately 1 km north east and east of East Oakley and 1 km NNE of Oakley. It serves East Oakley and Oakley only.

It is believed that sewage effluent is subjected to primary and secondary treatment, Southern Water 2022, and then the treated effluent was discharged to the Chalk in French drains, Beard and Giles 1989, and more recently in infiltration trenches and lagoons.

French drains were in operation at Oakley WWTW for some time prior to 1989, Beard and Giles 1989. The original date of construction could not be determined during the preparation of this report. However, according to the Environment Agency Public Register a permit for the site was originally issued in 1979. Therefore Oakley WWTW is believed to have been in operation for some 43 years or more.

B3.2 Layout and Operations

Figure B13 shows the layout of Oakley WWTW in 2008. Google Earth imagery shows no change in layout between 1999 and 2008. There appear to be four rotary trickling filters to the west of the site and several infiltration trenches to the east of the site. There are also a number of other tanks.

Oakley WWTW was upgraded in 2011 by the installation of two N-SAF (Nitrifying Submerged Aerated Filters) to meet the 95%ile ammoniacal nitrogen discharge limit of 5 mg-N/l[vv] and 2 No. new humus tanks.

Figure B14 shows the layout in 2017 with the two new humus tanks and the N-SAF plant. A group of rectangular tanks close to the eastern site boundary has been removed.

Figure B13 Aerial image of Oakley WWTW dated April 2008

vv Nitrifying and Denitrifying processes in a single package plant - WCSEE (wplinternational.com)

Figure B14 Aerial image of Oakley WWTW dated April 2017

Appendix B4 Water Ridges WWTW Oakley (closed)

Water Ridges WWTW Oakley was a small WWTW which was located at NGR SU 5640 5106. It is located immediately south of East Oakley and not in the vicinity of a watercourse.

It is believed, from Environment Agency Public Register information to have operated approximately from 1966 to 2009.

From Google Earth images dates it appears to have comprised eight contiguous tanks in a row (possibly sedimentation tanks), two trickling filters and an unknown infiltration system.

Google Earth images from 2017 show vegetation gradually spreading over the trickling filters and the assumed sedimentation tanks.

Appendix B5 North Waltham WWTW

North Waltham WWTW is a small sewage treatment works which serves the village of North Waltham. It is located at NGR SU 5610 4693, 400m north of the centre of North Waltham village at an elevation of approximately 110m OD.

Environment Agency Public Register information indicates that the WWTW has been in operation since at least 1979, if not earlier.

From Google Earth imagery it is believed to comprise a treatment plant and a French drain infiltration system. Until 2008 the treatment plant appeared to comprise reception/sedimentation tanks, 2 No,. rotary trickling filters and other tanks and plant, together with an assumed French drain infiltration system to the west of the site. Between 2008 and 2017 additional treatment plant were added, which based on the two rectangular tanks to the north of the original rotary filter beds may have included nitration plant to control ammoniacal nitrogen. It also appears that the original trickling filters were decommissioned at the same time.

Figure B15 shows the site layout in 2020.

Figure B 15 North Waltham WWTW in July 2020

Appendix B6 Hannington WWTW and Ashmansworth WWTW

Hannington WWTW is a very small sewage treatment works which serves the village of Hannington. It is located at NGR SU 5397 5487, 400m south of the centre of Hannington village.

Environment Agency Public Register information indicates that the WWTW has been in operation since at least 1985, if not earlier. It appears to have been rebuilt between 1999 and 2005. It is understood to comprise a treatment plant and infiltration system, but no details were available.

Ashmansworth WWTW is a very small sewage treatment works which serves the village of Ashmansworth. It is located at in the centre of Ashmansworth village. It is understood that treated effluent is discharged to the Chalk Aquifer.

Environment Agency Public Register information indicates that a WWTW has been in operation at a location east of Ashmansworth since at least 1979, if not earlier, but the permit was revoked in 2001. It appears that this may have been an earlier WWTW which has been closed.

Appendix B7 Portals WWTW (Industrial)

B7.1 General

Portals WWTW is an industrial WWTW which serves Portals paper mill. Portals WWTW dates from before 1930.

Portals WWTW is located at NGR SU 519 507 in Quidhampton, approximately 1.5 km north east of Overton, and immediately south of Portal's paper mill.

It is believed that industrial effluent is subjected to secondary treatment and then the treated effluent is discharged to the River Test. It is not known whether treated effluent was discharged to the Chalk Aquifer at any time in the operational history of the site.

Portals WWTW is regulated as part of the Portals Paper Mill which is an Installation for the purposes of the Environmental Permitting Regulations 2016. In 2019 a revised EPR Permit was issued which included a derogation in respect of compliance with emission limit values (BAT-AELs) from the WWTW[ww]. At that time the paper mill was regulated under the EU Industrial Emissions Directive (IED). Post-Brexit the IED BAT-AELs will continue to be enforced by the Environment Agency until new legislation is developed.

According to the Decision Document[xx] the effluent discharge from the paper mill has a significant effect on water quality in the River Test, especially on phosphorus and phosphate concentrations. The operator applied for a derogation that would permit the plant to discharge total phosphorus (TP), total nitrogen (TN), and COD (chemical oxygen demand) at loadings, and therefore concentrations, which exceed the BAT-AELs in the BAT Conclusions[yy] for their industry sector (Pulp and Paper). A time-limited derogation was granted until September 2020. After this date the operator was required to discharge TP, TN and COD at the BATC loading rates respectively of 5, 0.4 and 0.04 kg/tonne of finished product.

The emission limit value for TP post-2020 is 0.25 mg-P/l as an annual average; the limit during the derogation period was 0.5 mg-P/l as an annual average, and 2 mg-P/l prior to 2016.

ww RG25 3JG, Portals De La Rue Limited: environmental permit issued - GOV.UK (www.gov.uk)
xx Decision_document.pdf (publishing.service.gov.uk)
yy BAT conclusions for Pulp and Paper Sector, 2014/687/EU, COMMISSION IMPLEMENTING DECISION - of 26 September 2014 - establishing the best available techniques (BAT) conclusions, under Directive 2010/•75/•EU of the European Parliament and of the Council, for the production of pulp, paper and board - (notified under document C(2014) 6750) - (2014/687/EU) (europa.eu)

B7.2 Layout and Operations

Google Earth images indicate that the layout of the WWTW did not change over the period 1999 to 2022, see Figures B16 and B17. The images show what appear to be reception tanks, secondary treatment systems (rotary filter beds), and other infrastructure.

Historical Ordnance Survey maps show that the WWTW was built pre-1930, see Figures B18 and B19. The WWTW was not shown on the Ordnance Survey map dated 1909 (map extract not included in this report), and therefore was built between 1909 and 1930.

The 1930 layout, Figure B18, shows a number of square "filter beds" with a narrow linear feature immediately to the south. There are six larger square features in a block which are marked as filter beds, and six smaller square features in a line which may have the same function or may have been infiltration lagoons.

The 1940 layout, Figure B19, shows the same features as the 1930 map with the addition of two trickling filters.

Figure B16 Aerial image of Portals WWTW dated January 1999

Figure B17 Aerial image of Portals WWTW dated April 2022

Figure B18 Portals WWTW in 1930

Extract from 1942 Ordnance Survey Map, 25 Inch Series, Hampshire & Isle of Wight, sheet XVII.11, nominally 1:2500 scale

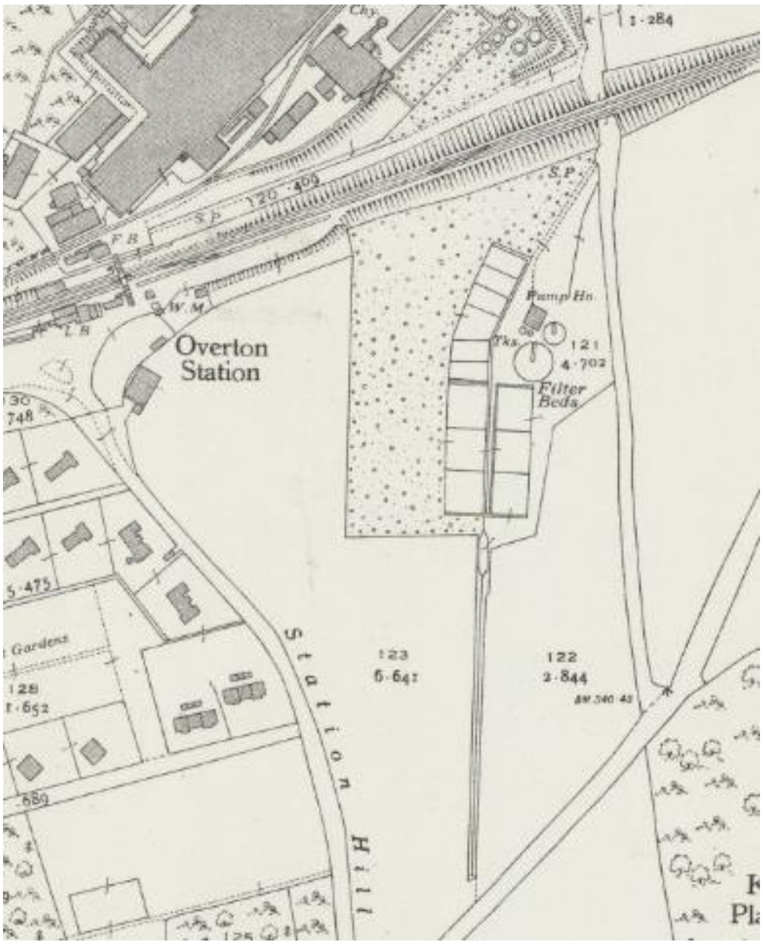


Figure B19 Overton WWTW in 1942
Extract from 1942 Ordnance Survey Map, 25 Inch Series, Hampshire & Isle of Wight, sheet XVII.11, nominally 1:2500 scale

Appendix C

Catchment Boundaries and Groundwater Source Protection Zones

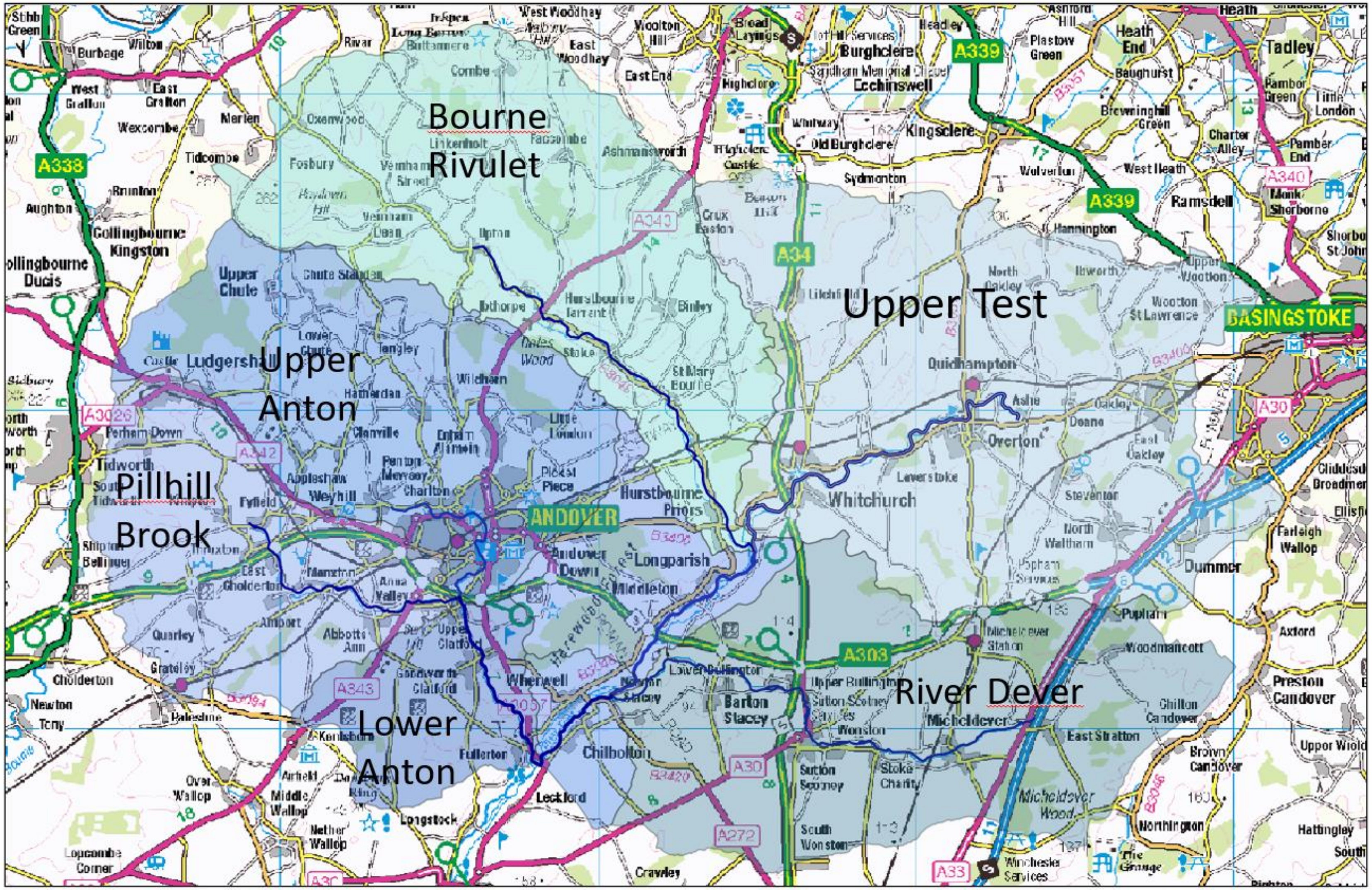


Figure 32 **Surface Water Catchments - Upper and Middle Test**

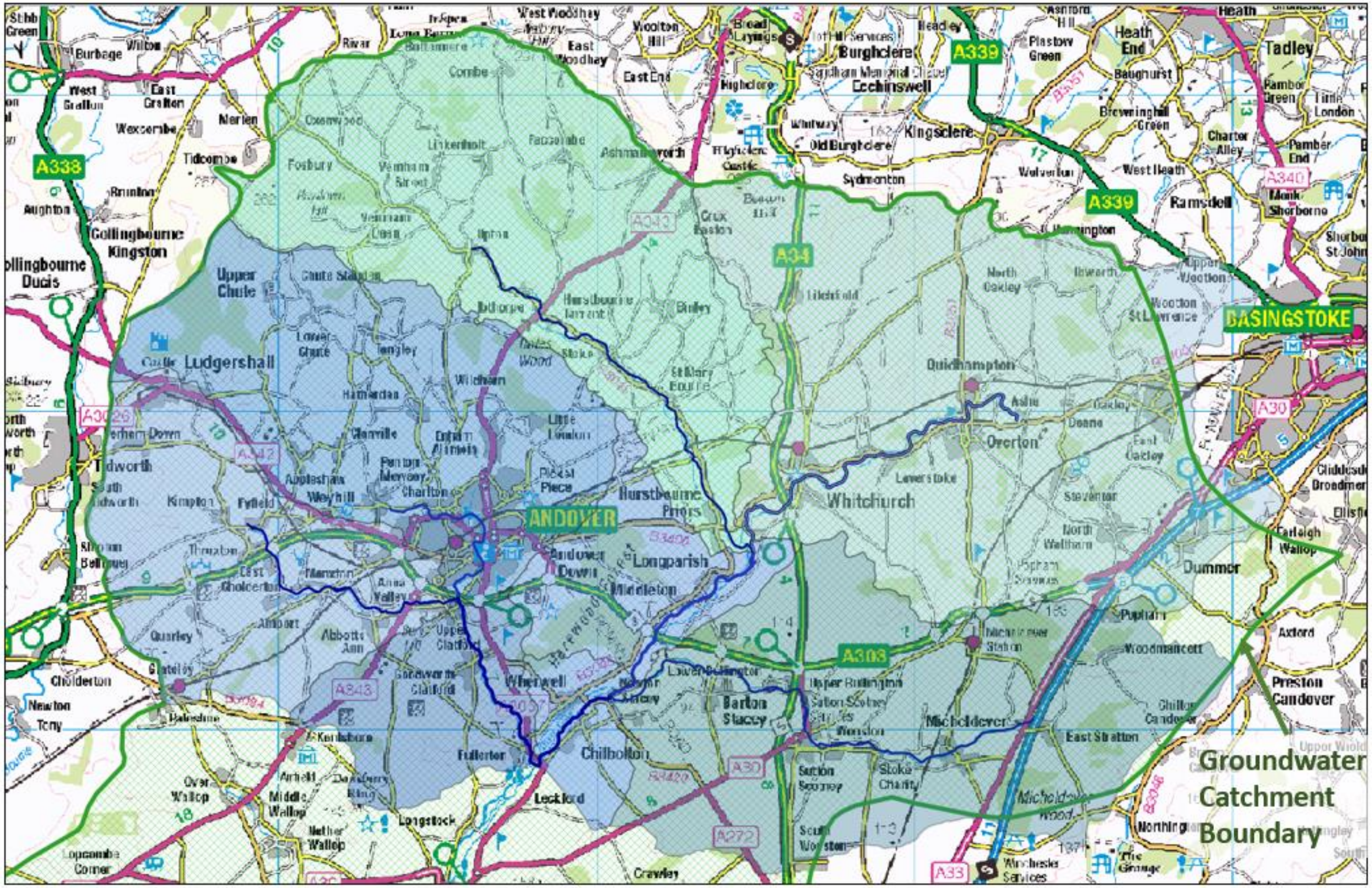


Figure 33 **Groundwater Catchment superimposed on Surface water Catchments**

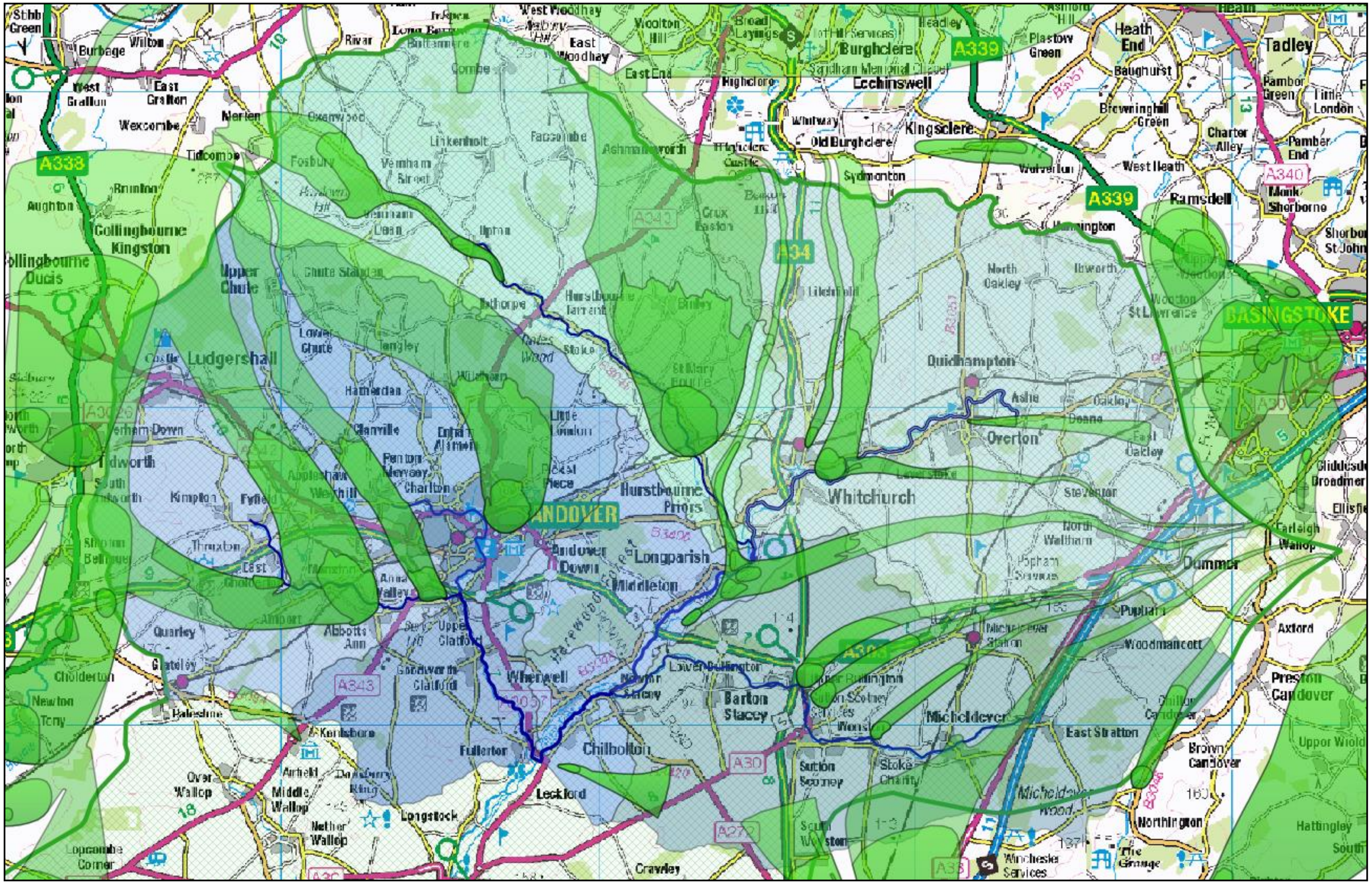


Figure 34 **Catchment Boundaries with Groundwater Source Protection Zones Overlaid**

Figure 35 **Groundwater Source Protection Zone Map**

Drinking Water Safeguard Zones (Groundwater) (England)

Source Protection Zones merged (England)
- Zone I - Inner Protection Zone
- Zone I - Subsurface Activity
- Zone II - Outer Protection Zone
- Zone II - Subsurface Activity
- Zone III - Total Catchment
- Zone III - Subsurface Activity

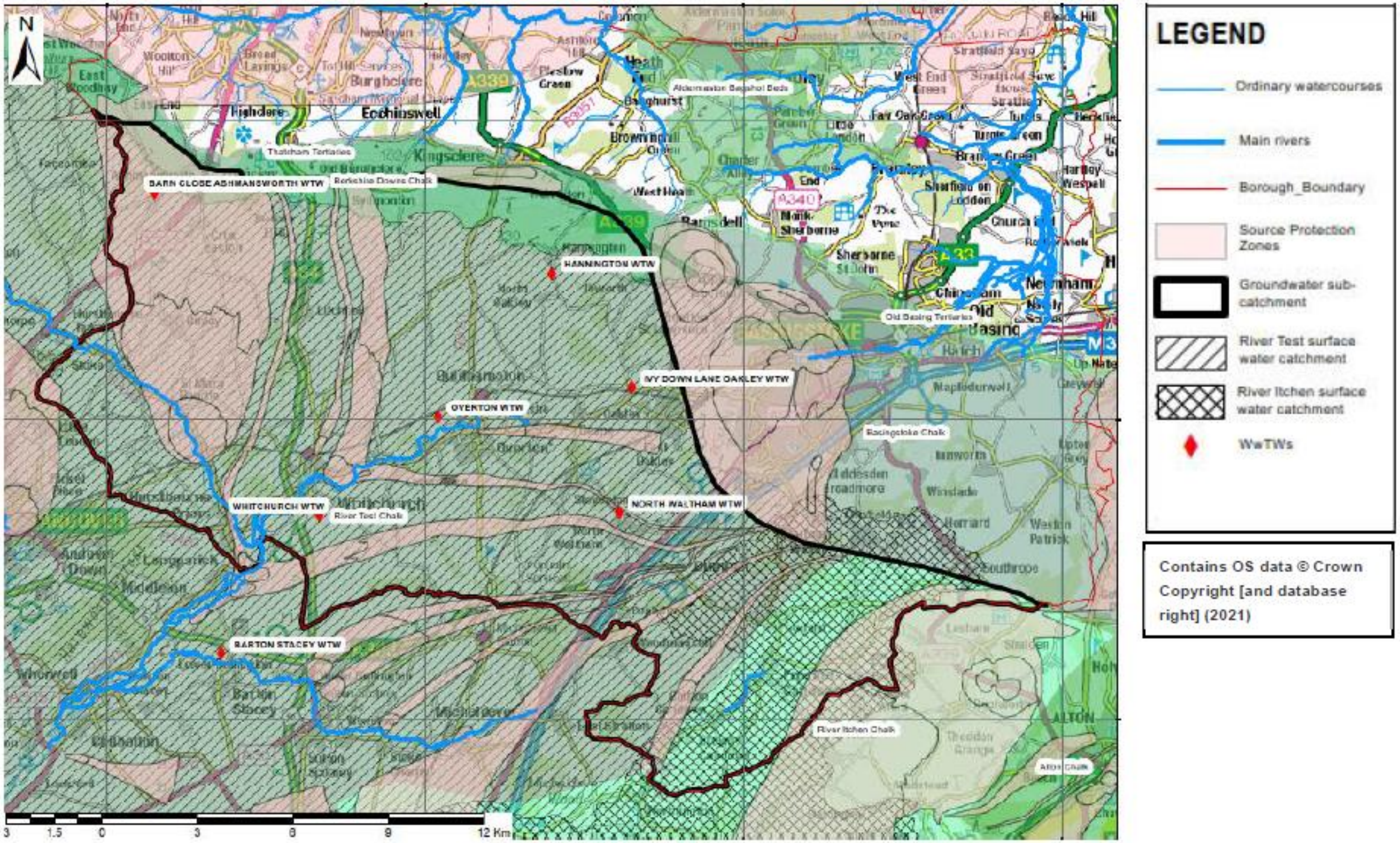


Figure 36 **Surface and Groundwater Catchment Definition**
Reproduced from AECOM 2022

Appendix D

Water Quality Data

Appendix D Water Quality Data

Table 21 Phosphorus EQS for the Upper Test

EQS Standard	Upper River Test				units
WFD Class	**High**	**Good**	**Moderate**	**Poor**	
EQR	0.702	0.532	0.356	0.166	
Term, a	0.905	0.778	0.595	0.247	
RPref=	26.4	26.4	26.4	26.4	µg/l
Term b	-2.122	-2.122	-2.122	-2.122	
Term c	3.544	3.544	3.544	3.544	
Power	1.62	1.89	2.28	3.02	
EQS_P	**42**	**78**	**191**	**1045**	µg/l

Derived using the equations from the 2015 Regulations[zz] and the altitude and alkalinity data for the East Aston sampling point.

Table 22 Nitrate and Orthophosphate Concentrations at River Test Sampling Points

Nutrient	**Averaging Period**	**Sampling Point**				
		Polhampton	**Quidhampton**	**Overton**	**Whitchurch**	**East Aston**
Nitrate (mg-N/l)	2010-22	8.79	8.24	6.71	7.37	7.59
Orthophosphate (mg-P/l)	2010-22	0.027	0.025	0.069	0.050	0.038
	2022	0.024	0.025	0.034	0.026	0.025
	2021	0.030	0.030	0.035	0.034	0.027
	2020	0.033	0.032	0.036	0.041	0.039

WFD Classification	
High	
Good	
Moderate	
Poor	

zz The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015

Environment Agency Water Quality Data

R Test at Polhampton – Headwater sampling point

Samples from 9 Nov 2021 to 29 Jul 2022

Notation	Determinand	Units	9 Nov 2021 10:16	6 Dec 2021 11:35	19 Jan 2022 13:03	4 Feb 2022 12:46	23 Mar 2022 10:16	19 Apr 2022 11:03	17 May 2022 14:14	24 May 2022 10:27	14 Jun 2022 10:59	29 Jul 2022 09:28
0061	pH		7.54	7.41	7.35	7.43	7.41	7.34		7.25	7.49	7.53
0076	Temperature of Water	°C	10.7	8.2	9.6	9.4	10.7	11.5		12	13.3	12.2
0077	Conductivity at 25 C	μs/cm	620	621	622	611	610	713		614	619	625
0085	BOD : 5 Day ATU	mg/l	< 1	< 1	1.2	1.1	< 1		1.2	1.4	1.6	< 1
0111	Ammoniacal Nitrogen as N	mg/l	0.0065	0.011	0.009	0.0089	0.0097	0.0039		0.0067	< 0.002	0.0073
0116	Nitrogen, Total Oxidised as N	mg/l	9.4	9.5	9.3	9.2	9.2	9		9	8.9	9.2
0117	Nitrate as N	mg/l	9.39	9.5	9.3	9.2	9.2	8.99		8.99	8.89	9.2
0118	Nitrite as N	mg/l	0.0061	0.0035	0.0024	0.0029	0.0038	0.0052		0.0073	0.01	0.0045
0119	Ammonia un-ionised as N	mg/l	4.0e-05	5.0e-05	4.0e-05	4.0e-05	5.0e-05	2.0e-05		3.0e-05	< 1.0e-05	5.0e-05
0135	Solids, Suspended at 105 C	mg/l	5.4	< 3	5.8	< 3	3.6			4.4	4.1	< 3
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	250	250	250	250	250		240	240	250	240
0180	Orthophosphate, reactive as P	mg/l	0.038	0.031	0.03	0.032	0.025	0.022		0.023	0.0071	0.028
0301	Carbon, Organic, Dissolved as C :- {DOC}	mg/l	0.59	0.66	0.51	0.63	0.61		0.72	0.67	1.1	0.68
9901	Oxygen, Dissolved, % Saturation	%	81.8	91.1	97.6	98.4	96.4	107.6		103.6	106.9	95.7
9924	Oxygen, Dissolved as O2	mg/l	9.06	10.7	11.1	11.2	10.7	11.7		11.1	11.2	10.2

Samples from 7 Jan 2021 to 26 Oct 2021

Notation	Determinand	Units	7 Jan 2021 10:46	16 Feb 2021 11:02	3 Mar 2021 10:36	8 Apr 2021 10:04	4 May 2021 09:15	21 Jun 2021 11:07	9 Jul 2021 11:07	16 Aug 2021 09:48	9 Sep 2021 10:54	26 Oct 2021 09:57
0061	pH		7.77	7.34	7.36	7.36	7.43	7.64	7.09	7.44	7.51	7.28
0076	Temperature of Water	°C	8.2	9.6	9.4	9.8	9.3	11.7	14	11.8	12.1	10.6
0077	Conductivity at 25 C	μs/cm	607	600	608	611	526	614	615	622	614	623
0085	BOD : 5 Day ATU	mg/l	< 1		1.1	1	1.4	< 1	1.1	1	< 1	< 1
0111	Ammoniacal Nitrogen as N	mg/l	0.01	< 0.002	0.0038	0.0062	0.0057	0.02	0.0092	0.01	0.017	0.0077
0116	Nitrogen, Total Oxidised as N	mg/l	9.3	9.1	9.1	9.2	8.9	8.9	8.9	9.1	9.3	9.5
0117	Nitrate as N	mg/l	9.3	9.1	9.1	9.19	8.89	8.88	8.89	9.09	9.29	9.49
0118	Nitrite as N	mg/l	0.0036	0.0031	0.0039	0.0064	0.009	0.018	0.014	0.011	0.0086	0.0052
0119	Ammonia un-ionised as N	mg/l	9.0e-05	< 1.0e-05	2.0e-05	3.0e-05	3.0e-05	0.00018	3.0e-05	6.0e-05	0.00012	3.0e-05
0135	Solids, Suspended at 105 C	mg/l	3	3.5	3.7	11	4.7	4.3	< 3	< 3	< 3	< 3
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	250	250	250	250	240	250	240	250	250	250
0180	Orthophosphate, reactive as P	mg/l	0.035	0.037	0.018	0.036	0.016	0.03	0.028	0.027	0.031	0.03
0301	Carbon, Organic, Dissolved as C :- {DOC}	mg/l	0.57	0.74	0.6	0.72	0.88	0.81	0.8	0.87	1	0.7
9901	Oxygen, Dissolved, % Saturation	%	82.5	94.6	97.7	101.9	97.6	85	100.6	95.7	87.6	84.2
9924	Oxygen, Dissolved as O2	mg/l	9.71	10.8	11.2	11.5	11.2	9.2	10.3	10.3	9.4	9.35

River test at Overton above Portals

Samples from 21 Oct 2021 to 21 Jul 2022

Notation	Determinand	Units	21 Oct 2021 12:52	9 Nov 2021 10:26	6 Dec 2021 11:46	19 Jan 2022 12:44	4 Feb 2022 10:41	23 Mar 2022 10:31	29 Apr 2022 13:40	13 May 2022 12:19	14 Jun 2022 11:12	21 Jul 2022 09:43
0061	pH		7.69	7.68	7.62	7.56	7.52	7.59	7.61	7.8	7.55	7.69
0076	Temperature of Water	°C	10.7	10.4	8	9	9.1	11.1	11.6	11.9	13	12.9
0077	Conductivity at 25 C	µs/cm	605	606	618	608	613	604	605	616	612	604
0085	BOD : 5 Day ATU	mg/l	1.1	< 1	< 1	1.5	1.2	< 1	1.2	1.8	1.8	< 1
0111	Ammoniacal Nitrogen as N	mg/l	0.0047	0.0039	0.012	< 0.03	0.04	< 0.03	< 0.03	< 0.03	0.032	< 0.03
0116	Nitrogen, Total Oxidised as N	mg/l	9	9.4	9.3	9.6	9.4	8.9	8.6	8.8	8.7	8.6
0117	Nitrate as N	mg/l	9	9.4	9.3	9.6	9.4	8.9	8.6	8.79	8.69	8.6
0118	Nitrite as N	mg/l	0.0047	0.0049	0.0036	< 0.004	< 0.004	< 0.004	0.0048	0.0057	0.0059	0.0044
0119	Ammonia un-ionised as N	mg/l	4.0e-05	4.0e-05	8.0e-05	< 0.00019	0.00023	< 0.00023	< 0.00025	< 0.0004	0.00026	< 0.00034
0135	Solids, Suspended at 105 C	mg/l	3.2	3.6	< 3	4.3	3.8	3.6	4.4	3.8	15	9.5
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	250	250	250	250	240	250	250	240	240	240
0180	Orthophosphate, reactive as P	mg/l	0.03	0.03	0.03	0.022	0.043	0.023	0.021	0.021	0.025	0.02
0301	Carbon, Organic, Dissolved as C :- {DOC}	mg/l	0.91	0.64	0.7	0.62	0.8	0.62	0.64	0.8	1.1	0.62
9901	Oxygen, Dissolved, % Saturation	%	93.3	87.4	94.1	98.3	96.4	102.2	113.2	117.2	105.6	94.2
9924	Oxygen, Dissolved as O2	mg/l	10.3	9.75	11.1	11.3	11.1	11.2	12.3	12.6	11.1	9.92

Samples from 4 Dec 2020 to 30 Sep 2021

Notation	Determinand	Units	4 Dec 2020 11:40	13 Jan 2021 11:40	16 Feb 2021 11:15	3 Mar 2021 10:29	8 Apr 2021 10:20	4 May 2021 09:07	21 Jun 2021 11:16	9 Jul 2021 11:29	9 Sep 2021 11:04	30 Sep 2021 11:59
0061	pH		7.64	7.59	7.5	7.49	7.61	7.64	7.64	7.5	7.66	7.93
0076	Temperature of Water	°C	9.2	9.4	9.5	9.2	9.6	9.7	11.9	13.6	12.2	11.2
0077	Conductivity at 25 C	µs/cm	610	611	596	603	606	590	603	605	599	605
0085	BOD : 5 Day ATU	mg/l	1.1	< 1		1.3	1.4	1.8	< 1	1.3	1.5	< 1
0111	Ammoniacal Nitrogen as N	mg/l	0.013	0.01	< 0.002	0.0035	0.0051	0.017	0.016	0.017	0.0085	0.009
0116	Nitrogen, Total Oxidised as N	mg/l	9.2	9	9.2	9.2	9.2	9	8.9	8.9	9.3	9.3
0117	Nitrate as N	mg/l	9.2	9	9.2	9.2	9.19	8.99	8.89	8.89	9.29	9.3
0118	Nitrite as N	mg/l	0.0043	0.0037	0.003	0.0035	0.0062	0.0083	0.014	0.01	0.0066	0.0041
0119	Ammonia un-ionised as N	mg/l	0.0001	7.0e-05	< 1.0e-05	2.0e-05	4.0e-05	0.00013	0.00015	0.00013	8.0e-05	0.00015
0135	Solids, Suspended at 105 C	mg/l	< 3	4.2	9.1	< 3	3.1	5.3	3.4	< 3	< 3	3.3
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	250	240	250	250	250	240	240	240	240	240
0180	Orthophosphate, reactive as P	mg/l	0.033	0.034	0.039	0.021	0.026	0.042	0.028	0.026	0.029	0.03
0301	Carbon, Organic, Dissolved as C :- {DOC}	mg/l	0.62	0.72	0.65	0.64	1.3	1.4	0.87	0.72	0.85	0.65
9901	Oxygen, Dissolved, % Saturation	%	91.1	91.2	96.1	99	105.9	98.5	91.6	105.1	95.3	93.9
9924	Oxygen, Dissolved as O2	mg/l	10.5	10.4	11	11.4	12	11.2	9.87	10.9	10.2	10.3

R Test Bridge Street Overton u/s Whitchurch

Samples from 21 Oct 2021 to 29 Jul 2022

Notation	Determinand	Units	21 Oct 2021 12:38	9 Nov 2021 10:36	6 Dec 2021 11:56	19 Jan 2022 12:35	7 Feb 2022 11:18	22 Mar 2022 10:36	19 Apr 2022 10:47	24 May 2022 10:42	14 Jun 2022 11:24	29 Jul 2022 10:26
0061	pH		7.73	7.81	7.78	7.74	7.78	7.77	7.68	7.67	7.79	7.8
0076	Temperature of Water	°C	11.4	11.1	8.5	9.3	8.6	11.8	11.9	12.1	13.6	13.6
0077	Conductivity at 25 C	µs/cm	632	662	701	646	650	654	636	593	668	638
0085	BOD : 5 Day ATU	mg/l	1.2	1.1	< 1	1.5	< 1	1.6	1	1.3	1.6	1.1
0111	Ammoniacal Nitrogen as N	mg/l	0.11	0.1	0.1	0.087	0.092	0.094	0.12	< 0.03	0.2	0.059
0116	Nitrogen, Total Oxidised as N	mg/l	7	6.9	7	7.6	7.3	7.6	8	7.9	6.9	7.5
0117	Nitrate as N	mg/l	6.97	6.87	6.97	7.59	7.29	7.56	7.98	7.89	6.88	7.48
0118	Nitrite as N	mg/l	0.029	0.028	0.035	0.013	0.011	0.04	0.023	0.01	0.024	0.02
0119	Ammonia un-ionised as N	mg/l	0.0012	0.00129	0.00099	0.00083	0.00092	0.00116	0.00122	< 0.0003	0.00295	0.00089
0135	Solids, Suspended at 105 C	mg/l	4.4	6.2	8.6	7.4	5.8	4.3	5	4.6	5.7	4.8
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	250	260	270	260	250	270	250	240	260	240
0180	Orthophosphate, reactive as P	mg/l	0.058	0.044	0.025	0.07	0.027	0.024	0.024	0.024	0.05	0.025
0301	Carbon, Organic, Dissolved as C :- {DOC}	mg/l	2	2	2.7	1.9	2	2.2	2.1	0.93	2.4	1.5
9901	Oxygen, Dissolved, % Saturation	%	88.2	83.9	92.4	96.9	99.2	102.1	105.1	106	107.3	98.2
9924	Oxygen, Dissolved as O2	mg/l	9.62	9.21	10.8	11.1	11.6	11	11.3	11.4	11.1	10.2

Samples from 4 Dec 2020 to 30 Sep 2021

Notation	Determinand	Units	4 Dec 2020 11:28	13 Jan 2021 11:52	16 Feb 2021 11:29	3 Mar 2021 10:20	8 Apr 2021 10:29	27 May 2021 10:56	21 Jun 2021 11:27	26 Jul 2021 10:09	16 Aug 2021 10:00	30 Sep 2021 12:10
0061	pH		7.79	7.64	7.64	7.62	7.76	7.85	7.79	8.35	7.79	7.92
0076	Temperature of Water	°C	9.3	9.5	9.9	9.4	9.6	12	12.2	14.9	13	12.1
0077	Conductivity at 25 C	µs/cm	643	626	622	636	623	631	633	678	639	658
0085	BOD : 5 Day ATU	mg/l	1.4	1.4		1.2	1.2	1.9	< 1	1.9	1.4	1.5
0111	Ammoniacal Nitrogen as N	mg/l	0.072	0.098	0.063	0.058	0.04	0.034	0.096	0.2	0.073	0.25
0116	Nitrogen, Total Oxidised as N	mg/l	7.8	7.9	8.1	8	8.6	8	7.8	7.2	8	7.3
0117	Nitrate as N	mg/l	7.79	7.88	8.08	7.99	8.59	7.99	7.78	7.14	7.96	7.24
0118	Nitrite as N	mg/l	0.0085	0.016	0.016	0.0091	0.011	0.01	0.019	0.059	0.036	0.065
0119	Ammonia un-ionised as N	mg/l	0.00077	0.00076	0.0005	0.00043	0.00041	0.00051	0.00128	0.00522	0.00103	0.00444
0135	Solids, Suspended at 105 C	mg/l	4	5.7	4.5	< 3	< 3	4	6.1	< 3	4.1	7.5
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	260	240	250	260	250	240	250	250	250	270
0180	Orthophosphate, reactive as P	mg/l	0.04	0.034	0.036	0.017	0.022	0.016	0.037	0.039	0.028	0.067
0301	Carbon, Organic, Dissolved as C :- {DOC}	mg/l	2	1.8	1.6	1.9	1.4	1.9	2	2.5	2	3.2
9901	Oxygen, Dissolved, % Saturation	%	86.5	92.6	95	96.7	105.2	100.3	86.8	98.7	100.5	82.7
9924	Oxygen, Dissolved as O2	mg/l	9.91	10.6	10.7	11.1	12	10.8	9.29	9.95	10.6	8.87

Town Mill Whitchurch u/s Whitchurch STW

Samples from 18 Nov 2021 to 21 Jul 2022

Notation	Determinand	Units	18 Nov 2021 12:06	1 Dec 2021 14:08	16 Dec 2021 10:21	24 Jan 2022 11:47	22 Feb 2022 10:44	22 Mar 2022 11:12	6 Apr 2022 11:00	24 May 2022 10:57	9 Jun 2022 14:08	21 Jul 2022 11:32
0061	pH		7.9	7.96	7.88	7.93	7.85	7.93	7.81	7.97	8.06	8.18
0076	Temperature of Water	°C	9.5	9.5	10.5	8.5	9.3	11.5	10.6	12.3	14.2	15.3
0077	Conductivity at 25 C	µs/cm	616	587	622	613	612	628	615	585	614	617
0085	BOD : 5 Day ATU	mg/l	1.4	1.5	1.2	< 3	1.4	1.7	1.6	1.6	1.2	< 1
0111	Ammoniacal Nitrogen as N	mg/l	< 0.03	< 0.03	0.039	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
0116	Nitrogen, Total Oxidised as N	mg/l	8.5	8.2	8	8.2	8.4	8.4	8.8	8.3	8.2	7.8
0117	Nitrate as N	mg/l	8.48	8.19	7.98	8.19	8.39	8.38	8.78	8.29	8.18	7.77
0118	Nitrite as N	mg/l	0.018	0.014	0.019	0.014	0.0073	0.02	0.02	0.011	0.016	0.027
0119	Ammonia un-ionised as N	mg/l	< 0.00042	< 0.00048	0.00056	< 0.00042	< 0.00037	< 0.00052	< 0.00037	< 0.00061	< 0.00074	< 0.00081
0135	Solids, Suspended at 105 C	mg/l	6.9	5.9	6.6	8.7	11	7.2	3.9	5.1	11	4.4
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	240	240	250	250	240	250	250	230	240	250
0180	Orthophosphate, reactive as P	mg/l	0.039	0.038	0.042	0.036	0.031	0.023	0.02	0.022	0.029	0.023
0301	Carbon, Organic, Dissolved as C :- {DOC}	mg/l	1.5	0.92	1.8	1.7	1.3	1.4	1.5	0.93	1.3	1.8
9901	Oxygen, Dissolved, % Saturation	%	113.9	91.2	92	88.6	98.1	114	111	118.9	119.2	117.2
9924	Oxygen, Dissolved as O2	mg/l	13	10.4	10.2	10.3	11.2	12.4	12.3	12.7	12.2	11.7

Samples from 4 Dec 2020 to 9 Nov 2021

Samples from 4 Dec 2020 to 9 Nov 2021

Notation	Determinand	Units	4 Dec 2020 11:13	7 Jan 2021 11:02	16 Feb 2021 11:46	3 Mar 2021 10:08	29 Apr 2021 12:48	11 May 2021 09:43	23 Jun 2021 10:25	29 Jul 2021 11:07	26 Oct 2021 09:40	9 Nov 2021 10:53
0061	pH		7.88	8.08	7.78	7.8	8.07	7.03	8.01	8.33	7.79	7.83
0076	Temperature of Water	°C	8.6	7.3	9.6	8.9	10.1	10.7	12.4	13.8	10.5	10.6
0077	Conductivity at 25 C	µs/cm	620	607	606	613	577	580	612	622	618	614
0085	BOD : 5 Day ATU	mg/l	1.4	< 1		1.4	< 1	1.4	1	1.6	1.1	1.2
0111	Ammoniacal Nitrogen as N	mg/l	0.032	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	0.031	< 0.03	< 0.03	< 0.03
0116	Nitrogen, Total Oxidised as N	mg/l	8.2	8.8	8.8	8.6	9	8.5	8.6	8.1	8	8.2
0117	Nitrate as N	mg/l	8.19	8.79	8.79	8.59	8.99	8.49	8.58	8.06	7.98	8.18
0118	Nitrite as N	mg/l	0.014	0.015	0.012	0.0079	0.013	0.011	0.019	0.037	0.02	0.017
0119	Ammonia un-ionised as N	mg/l	0.0004	< 0.00045	< 0.00032	< 0.00032	< 0.00055	< 6.0e-05	0.00067	< 0.00072	< 0.00035	< 0.00039
0135	Solids, Suspended at 105 C	mg/l	5.5	5.3	5.5	3.8	< 3	< 3	5.5	3.6	3.2	13
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	240	240	230	240	230	230	240	240	240	240
0180	Orthophosphate, reactive as P	mg/l	0.044	0.04	0.04	0.024	0.018	0.014	0.038	0.024	0.046	0.041
0301	Carbon, Organic, Dissolved as C :- {DOC}	mg/l	1.6	0.93	1.2	1.3	1.2	1.1	1.7	1.7	1.4	1.3
9901	Oxygen, Dissolved, % Saturation	%	90.4	92.9	100.3	102.5	110.9	107.1	107.9	113.1	93.5	92.4
9924	Oxygen, Dissolved as O2	mg/l	10.5	11.2	11.4	11.9	12.5	11.9	11.5	11.7	10.4	10.3

R Test at East Aston d/s Whitchurch STW and u/s of Longparish

ɔn mples from 18 May 2022 to 25 Jul 2022

Notation	Determinand	Units	18 May 2022 11:23	25 May 2022 09:12	6 Jun 2022 11:06	13 Jun 2022 11:15	22 Jun 2022 12:02	28 Jun 2022 12:39	8 Jul 2022 10:06	13 Jul 2022 10:37	18 Jul 2022 09:40	25 Jul 2022 09:35
0061	pH				8				8.04			
0076	Temperature of Water	°C	14	11.5	12.7	13	15	14.1	14.2	16.1	14.2	15.3
0077	Conductivity at 25 C	µs/cm			586				604			
0085	BOD : 5 Day ATU	mg/l			1.2				1.1			
0111	Ammoniacal Nitrogen as N	mg/l	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
0113	Nitrogen, Organic as N	mg/l	0.07	0.47	0.37	0.87	0.37	0.17	0.07	0.57	0.37	0.47
0114	Nitrogen, Kjeldahl as N	mg/l	0.1	0.5	0.4	0.9	0.4	0.2	0.1	0.6	0.4	0.5
0116	Nitrogen, Total Oxidised as N	mg/l	8.5	8.1	8	8.1	8.1	8.4	8.4	7.9	8.1	8
0117	Nitrate as N	mg/l	8.49	8.09	7.99	8.09	8.08	8.39	8.39	7.89	8.09	7.99
0118	Nitrite as N	mg/l	0.013	0.0099	0.011	0.014	0.016	0.012	0.014	0.013	0.013	0.015
0119	Ammonia un-ionised as N	mg/l			< 0.00067				< 0.00074			
0135	Solids, Suspended at 105 C	mg/l	4.8	6.4	6.1	6.2	6.6	4.2	10	6.4	5.4	4.7
0162	Alkalinity to pH 4.5 as CaCO3	mg/l			230				230			
0180	Orthophosphate, reactive as P	mg/l	0.02	0.016	0.025	0.028	0.028	0.029	0.028	0.021	0.017	0.018
0192	Phosphate :- {TIP}	mg/l	0.026	0.027	0.029	0.026	0.04	0.036	0.039	0.034	0.03	0.03
0301	Carbon, Organic, Dissolved as C :- {DOC}	mg/l			1.4				1.2			
0348	Phosphorus, Total as P	mg/l	0.033	0.034	0.041	0.043	0.048	0.042	0.047	0.037	0.035	0.045
9686	Nitrogen, Total as N	mg/l	8.6	8.6	8.4	9	8.5	8.6	8.5	8.5	8.5	8.5
9901	Oxygen, Dissolved, % Saturation	%			106.9				109.4			
9924	Oxygen, Dissolved as O2	mg/l			11.3				11.2			

Samples from 11 Mar 2022 to 10 May 2022

Notation	Determinand	Units	11 Mar 2022 10:55	18 Mar 2022 10:00	25 Mar 2022 09:31	1 Apr 2022 12:23	8 Apr 2022 11:03	13 Apr 2022 10:17	22 Apr 2022 10:01	29 Apr 2022 11:00	5 May 2022 12:54	10 May 2022 09:29
0061	pH		8.05				8.07					7.65
0076	Temperature of Water	°C	10.1	9.2	8.9	8.1	8.6	11	10.7	11.5	13.4	12.5
0077	Conductivity at 25 C	µs/cm	602				596					593
0085	BOD : 5 Day ATU	mg/l	1.2				1.3					1.1
0111	Ammoniacal Nitrogen as N	mg/l	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	0.039
0113	Nitrogen, Organic as N	mg/l	0.57		0.57		0.17	0.37	0.27			0.161
0114	Nitrogen, Kjeldahl as N	mg/l	0.6		0.6		0.2	0.4	0.3	< 1.0e-05		0.2
0116	Nitrogen, Total Oxidised as N	mg/l	8.5	8.6	8.3	9.1	8.4	8.5	8.3	8.4	8.4	8.4
0117	Nitrate as N	mg/l	8.49	8.59	8.29	9.09	8.39	8.49	8.29	8.39	8.39	8.39
0118	Nitrite as N	mg/l	0.011	0.009	0.0087	0.0094	0.01	0.013	0.013	0.01	0.012	0.015
0119	Ammonia un-ionised as N	mg/l	< 0.00055				< 0.00049					0.00039
0135	Solids, Suspended at 105 C	mg/l	8.1	7.7	6.2	4.9	4	12	7.2	5.2	5.6	7.5
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	240				240					230
0180	Orthophosphate, reactive as P	mg/l	0.022	0.06	0.02	0.021	0.016	0.013	0.013	0.012	< 0.01	0.012
0192	Phosphate :- {TIP}	mg/l	0.039	0.074	0.023	0.027	0.026	0.031	0.026	< 0.02	0.023	0.024
0301	Carbon, Organic, Dissolved as C :- {DOC}	mg/l	1.3				1.2					1.2
0348	Phosphorus, Total as P	mg/l	0.044	0.078	0.037	0.031	0.034	0.043	0.031	0.044	0.023	0.11
9686	Nitrogen, Total as N	mg/l	9.1	8.4	8.9	8.9	8.6	8.9	8.6	8.4		8.6
9901	Oxygen, Dissolved, % Saturation	%	100.5				104.1					94.2
9924	Oxygen, Dissolved as O2	mg/l	11.3				12.1					10

Bourne Rivulet at Iron Bridge

Sampling results

Displaying the twenty most recent samples. You can see all 219 sample results (note that in some cases this may take a considerable time, and use significant data bandwidth).

Samples from 13 Dec 2021 to 25 Jul 2022

Notation	Determinand	Units	13 Dec 2021 11:45	29 Dec 2021 12:43	12 Jan 2022 10:57	24 Feb 2022 09:49	24 Feb 2022 09:55	16 Mar 2022 09:59	19 Apr 2022 10:18	12 May 2022 09:24	9 Jun 2022 14:24	25 Jul 2022 09:18
0061	pH		7.97	8.21	7.95	7.75	7.77	7.89	7.94	8.04	8.05	7.93
0076	Temperature of Water	°C	10.1	10.3	7.3	8.2	8.3	9.6	10.1	10.3	14.1	13.9
0077	Conductivity at 25 C	µs/cm	545	654	531		538	545	549	545	530	541
0111	Ammoniacal Nitrogen as N	mg/l	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
0116	Nitrogen, Total Oxidised as N	mg/l	7.1	6.9	7.4		7.4	7.4	6.9	6.7	6.1	5.8
0117	Nitrate as N	mg/l	7.09	6.89	7.39		7.39	7.39	6.89	6.69	6.09	5.77
0118	Nitrite as N	mg/l	0.011	0.011	0.0061		0.0055	0.0067	0.0078	0.013	0.012	0.028
0119	Ammonia un-ionised as N	mg/l	< 0.00052	< 0.00056	< 0.0004	< 0.00027	< 0.00029	< 0.00041	< 0.00048	< 0.00056	< 0.00074	< 0.00062
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	230	220	230		220	240	230	230	220	230
0180	Orthophosphate, reactive as P	mg/l	0.045	0.052	0.044		0.043	0.025	0.018	0.034	0.036	0.036
9901	Oxygen, Dissolved, % Saturation	%	91.2	97.1	99.8		95.7	97.6	113.1	100.6	108.4	96.2
9924	Oxygen, Dissolved as O2	mg/l	10.3	10.9	12		11.2	11.1	12.7	11.3	11.1	9.91

Samples from 17 Dec 2019 to 25 Nov 2021

Notation	Determinand	Units	17 Dec 2019 12:57	13 Jan 2020 14:32	11 Feb 2020 10:45	17 Mar 2020 09:31	3 Jun 2021 11:16	21 Jun 2021 11:22	29 Jul 2021 10:53	30 Sep 2021 10:56	25 Oct 2021 13:40	25 Nov 2021 09:58
0061	pH		7.88	8	8.05	7.94	8.12	7.79	8.25	8.21	7.91	7.87
0076	Temperature of Water	°C	8.7	9.5	8.6	9	12.7	12	13.6	11.1	11.5	7.7
0077	Conductivity at 25 C	µs/cm	528	542	557	556	555	547	549	544	544	542
0111	Ammoniacal Nitrogen as N	mg/l	< 0.03	0.007	< 0.03	< 0.03	< 0.03	0.064	< 0.03	< 0.03	< 0.03	< 0.03
0116	Nitrogen, Total Oxidised as N	mg/l	6.7	7.1	7.1	7.2	6.8	7	6.4	6.5	6.8	7.3
0117	Nitrate as N	mg/l	6.69	7.1	7.1	7.2	6.78	6.98	6.38	6.49	6.78	7.29
0118	Nitrite as N	mg/l	0.0063	0.0033	< 0.004	0.004	0.017	0.018	0.023	0.013	0.016	0.011
0119	Ammonia un-ionised as N	mg/l	< 0.00038	0.00012	< 0.00049	< 0.00044	< 0.00067	0.00084	< 0.00071	< 0.00059	< 0.0005	< 0.00034
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	220	240	230	240	230	230	230	230	230	230
0180	Orthophosphate, reactive as P	mg/l	0.042	0.047	0.048	0.048	0.024	0.048	0.026	0.039	0.044	0.052
9901	Oxygen, Dissolved, % Saturation	%	95	98.5	100.9	97.3	101.2	94.8	103.8	94.6	99.1	93.9
9924	Oxygen, Dissolved as O2	mg/l	11	11.2	11.8	11.2	10.7	10.2	10.8	10.4	10.8	11.2

Groundwater
Oakley Farm Groundwater

Notation	Determinand	Units	12 Apr 2018 10:23	9 Nov 2018 09:46	28 Nov 2018 09:42	31 Jan 2019 12:39	24 Apr 2019 09:50	16 Jul 2019 09:29	15 Oct 2019 08:32	21 Jan 2020 12:28	27 Apr 2022 10:02	21 Jul 2022 09:28
0050	Lead	µg/l	< 2				< 2				< 2	
0052	Lead, Dissolved	µg/l	0.252				0.411				0.29	
0076	Temperature of Water	°C	11	11.8	11.2	9.9	11.5	12.7	11.5	10.8	10.5	19.6
0077	Conductivity at 25 C	µs/cm	583	618	590	622	549	592	594	592	577	578
0106	Cadmium, Dissolved	µg/l	< 0.01				< 0.01				< 0.01	
0108	Cadmium	µg/l	< 0.1				< 0.1				< 0.1	
0111	Ammoniacal Nitrogen as N	mg/l	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
0116	Nitrogen, Total Oxidised as N	mg/l	7.64	6.24	5.11	5.19	6.18	5	4.9	9.2	7.8	5.7
0117	Nitrate as N	mg/l	7.64	6.24	5.11	5.19	6.18	5	4.9	9.2	7.8	5.7
0118	Nitrite as N	mg/l	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
0158	Hardness, Total as CaCO3	mg/l	286				279				287	
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	241	279	251	260	255	260	260	260	250	240
0171	Bromide	mg/l	0.0353				0.033					
0172	Chloride	mg/l	14.4	14.9	13	13.2	12.9	14	13	16	15	14
0177	Fluoride	mg/l	0.124				0.108				0.17	
0179	Iodide	mg/l	< 0.003									
0180	Orthophosphate, reactive as P	mg/l	0.02	0.0154	0.0179	0.0164	0.021	0.016	0.016	0.018	0.019	0.021

Notation	Determinand	Units	27 Oct 2015 13:29	22 Jan 2016 12:49	19 Apr 2016 08:30	20 Jul 2016 11:26	16 Nov 2016 10:16	31 Jan 2017 08:57	28 Apr 2017 09:35	17 Aug 2017 12:41	24 Nov 2017 10:39	31 Jan 2018 10:03
0050	Lead	µg/l	< 2						< 2			
0052	Lead, Dissolved	µg/l	< 0.1	0.23	0.244	0.393	< 0.1	0.34	0.131			
0061	pH				7.63							
0076	Temperature of Water	°C	11.1	10.9	10.9	13	11.3	10.9	11.4	12.4	11.3	10.9
0077	Conductivity at 25 C	µs/cm	635	561	572	556	616	632	594	681	612	605
0106	Cadmium, Dissolved	µg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01			
0108	Cadmium	µg/l	< 0.1						< 0.1			
0111	Ammoniacal Nitrogen as N	mg/l	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
0116	Nitrogen, Total Oxidised as N	mg/l	7.39	5.49	9.01	6.95	5.63	5.82	5.69	6.52	6.21	5.12
0117	Nitrate as N	mg/l	7.39	5.49	9.01	6.95	5.63	5.82	5.69	6.52	6.21	5.12
0118	Nitrite as N	mg/l	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
0158	Hardness, Total as CaCO3	mg/l	290	286	279	299	280	287	271			
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	283	251	234	246	271	285	261	281	284	257
0171	Bromide	mg/l			0.0353				0.0285			
0172	Chloride	mg/l	16.4	12.6	15.3	13.9	15	14.7	14	16.8	14.7	12.6
0177	Fluoride	mg/l	0.251	0.135	0.098	0.16	0.254	0.236	0.221			
0179	Iodide	mg/l			< 0.003				< 0.003			
0180	Orthophosphate, reactive as P	mg/l	0.0139	0.0205	0.022	0.021	0.0154	0.0168	0.0194	0.0123	0.0138	0.0182
0182	Silica, reactive as SiO2	mg/l	14	12.1	10.7	12.4	14.2	14.1	13.5			

Tufton Warren Farm

Samples from 26 Jul 2018 to 25 Jul 2022

Notation	Determinand	Units	26 Jul 2018 09:44	9 Nov 2018 11:20	9 Jan 2019 13:14	3 Apr 2019 11:47	24 May 2019 11:35	18 Jul 2019 11:18	11 Oct 2019 11:55	21 Jan 2020 12:35	27 Apr 2022 11:40	25 Jul 2022 11:32
0050	Lead	µg/l				< 2					< 2	
0052	Lead, Dissolved	µg/l				0.141					0.49	
0076	Temperature of Water	°C	13.6	11.6	11.5	11.4		11.3	11.3	10.4	11.2	11.4
0077	Conductivity at 25 C	µs/cm	517	513	570	513		515	515	509	552	519
0106	Cadmium, Dissolved	µg/l				< 0.01					< 0.01	
0108	Cadmium	µg/l				< 0.1					< 0.1	
0111	Ammoniacal Nitrogen as N	mg/l	< 0.03	< 0.03	< 0.03	< 0.03		< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
0116	Nitrogen, Total Oxidised as N	mg/l	7.44	7.12	7.42	6.97		6.9	6.7	7.4	9	7.4
0117	Nitrate as N	mg/l	7.44	7.12	7.42	6.97		6.9	6.7	7.4	9	7.4
0118	Nitrite as N	mg/l	< 0.004	< 0.004	< 0.004	< 0.004		< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
0158	Hardness, Total as CaCO3	mg/l				244					282	
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	206	218	216	205		210	210	210	210	210
0171	Bromide	mg/l				0.0494						
0172	Chloride	mg/l	16	16	15.8	15.2		16	16	16	18	16
0177	Fluoride	mg/l				0.073					0.077	
0180	Orthophosphate, reactive as P	mg/l	0.0127	0.0136	0.0141	0.0145		0.013	0.015	0.013	0.015	0.012
0182	Silica, reactive as SiO2	mg/l				11.9					11	

Samples from 11 Jan 2016 to 11 Apr 2018

Notation	Determinand	Units	11 Jan 2016 10:11	25 Apr 2016 10:12	20 Jul 2016 13:14	17 Oct 2016 11:50	16 Jan 2017 10:44	26 Apr 2017 11:10	31 Jul 2017 10:32	24 Oct 2017 11:29	19 Jan 2018 10:16	11 Apr 2018 11:31
0050	Lead	µg/l		< 2		< 2				< 2		< 2
0052	Lead, Dissolved	µg/l	< 0.1	< 0.1	0.581	0.944	0.104	0.157				0.255
0061	pH			7.48								
0073	Cypermethrin	µg/l										< 1.0e-05
0076	Temperature of Water	°C	10.7	11.3	12.4	12	11	11.4	12.3	12.3	11.2	11.4
0077	Conductivity at 25 C	µs/cm	514	510	518	539	513	508	519	511	512	509
0103	Mercury, Dissolved	µg/l										< 0.01
0106	Cadmium, Dissolved	µg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01				< 0.01
0108	Cadmium	µg/l		< 0.1		< 0.1				< 0.1		< 0.1
0111	Ammoniacal Nitrogen as N	mg/l	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
0116	Nitrogen, Total Oxidised as N	mg/l	6.85	7.05	7.43	6.83	7.47	6.99	7.17	6.93	6.84	6.95
0117	Nitrate as N	mg/l	6.85	7.05	7.43	6.83	7.47	6.99	7.17	6.93	6.84	6.95
0118	Nitrite as N	mg/l	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
0158	Hardness, Total as CaCO3	mg/l	262	254	269	251	250	246				244
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	210	204	214	212	213	205	211	215	217	209
0171	Bromide	mg/l		0.0463				0.0477				0.0443
0172	Chloride	mg/l	15.1	15.4	15.7	15.4	16.2	15.2	15.6	15.1	15.3	15.2
0175	Cyanide as CN	mg/l										< 0.005
0177	Fluoride	mg/l	0.071	0.08	0.094	0.087	0.068	0.087				0.085
0179	Iodide	mg/l		< 0.003				< 0.003				< 0.003
0180	Orthophosphate, reactive as P	mg/l	0.0126	0.0126	0.0121	0.0137	0.0134	0.0131	0.0143	0.0138	0.0134	0.0137
0182	Silica, reactive as SiO2	mg/l	12.1	11.9	12.6	12.3	11.8	12.4				12
0183	Sulphate as SO4	mg/l		10.3		10.3				10.2		10.4
0205	Sodium, Dissolved	mg/l	7.2	6.56	6.95	6.86	6.44	6.46				6.8
0207	Sodium	mg/l		6.84		7.55				6.98		6.85
0209	Potassium, Dissolved	mg/l	0.631	0.605	0.594	0.704	0.647	0.682				0.659

Old Derrydown Farm

Samples from 15 Nov 2017 to 11 May 2022

Notation	Determinand	Units	15 Nov 2017 09:29	26 Jan 2018 11:28	11 Apr 2018 13:04	18 Feb 2019 13:01	26 Apr 2019 11:04	11 Jul 2019 10:15	23 Oct 2019 13:38	23 Jan 2020 12:18	8 Apr 2022 11:57	11 May 2022 09:46
0050	Lead	µg/l	2.92				< 2				< 2	
0052	Lead, Dissolved	µg/l			0.159		0.214				0.69	
0073	Cypermethrin	µg/l									< 1.0e-05	< 1.0e-05
0076	Temperature of Water	°C	11	10.8	10.7	10.9	10.7	11.9	12	10.4	10.3	
0077	Conductivity at 25 C	µs/cm	535	540	526	531	525	530	513	502	532	
0106	Cadmium, Dissolved	µg/l			< 0.01		< 0.01				0.011	
0108	Cadmium	µg/l	< 0.1				< 0.1				< 0.1	
0111	Ammoniacal Nitrogen as N	mg/l	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
0116	Nitrogen, Total Oxidised as N	mg/l	6.85	6.65	6.73	6.98	6.99	7.3	6.5	7	7.2	
0117	Nitrate as N	mg/l	6.85	6.65	6.73	6.98	6.99	7.3	6.5	7	7.2	
0118	Nitrite as N	mg/l	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
0158	Hardness, Total as CaCO3	mg/l			256		258				256	
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	226	231	214	225	201	230	220	230	230	
0171	Bromide	mg/l			0.0392		0.0444					
0172	Chloride	mg/l	14.8	15.1	14.2	15.1	13.8	14	14	14	14	14
0177	Fluoride	mg/l			0.072		0.064				0.08	
0179	Iodide	mg/l			< 0.003							
0180	Orthophosphate, reactive as P	mg/l	0.0241	0.0237	0.0242	0.0251	0.0236	0.024	0.023	0.027	0.023	0.026
0182	Silica, reactive as SiO2	mg/l			11.6		11.9				12	
0183	Sulphate as SO4	mg/l	11.7				10.9				11	
0205	Sodium, Dissolved	mg/l			6.69		6.71				6.7	
0207	Sodium	mg/l	6.85				6.77				6.7	
0209	Potassium, Dissolved	mg/l			0.887		0.928				0.89	
0211	Potassium	mg/l	0.899				0.913				0.88	

WWTW
Whitchurch STW
Inlet:

Samples from 2 Dec 2019 to 25 Jan 2022

Notation	Determinand	Units	2 Dec 2019 12:05	7 Jan 2020 09:04	18 May 2020 09:04	19 Aug 2020 09:25	23 Nov 2020 10:26	5 Mar 2021 13:37	5 May 2021 08:57	22 Jul 2021 08:43	13 Oct 2021 12:05	25 Jan 2022 08:40
0085	BOD : 5 Day ATU	mg/l	11.9	111	61.4	121	130	146	90.4	124	183	213
0092	Chemical Oxygen Demand :- {COD}	mg/l	288	267	192	326	378	467	643	344	476	487

Samples from 15 Mar 2017 to 14 Sep 2019

Notation	Determinand	Units	15 Mar 2017 07:55	28 Apr 2017 06:55	16 Aug 2017 12:45	23 Feb 2018 10:30	18 Apr 2018 08:20	7 Sep 2018 07:05	3 Oct 2018 10:40	25 Jan 2019 11:20	11 Jun 2019 12:23	14 Sep 2019 10:30
0085	BOD : 5 Day ATU	mg/l	81.9	113	184	201	102	123	92	167	123	233
0092	Chemical Oxygen Demand :- {COD}	mg/l	223	113	433	342	243	264	238	439	508	750

Treated:

Samples from 10 Dec 2021 to 15 Jun 2022

Notation	Determinand	Units	10 Dec 2021 09:50	1 Jan 2022 00:07	24 Jan 2022 09:00	25 Jan 2022 08:31	23 Feb 2022 12:19	1 Mar 2022 10:37	19 Apr 2022 09:01	17 May 2022 10:03	7 Jun 2022 09:26	15 Jun 2022 09:46
0085	BOD : 5 Day ATU	mg/l	4.24		4.78	3.28	4.75	5.62	6.37		13.1	3.44
0092	Chemical Oxygen Demand :- {COD}	mg/l				25.5						
0111	Ammoniacal Nitrogen as N	mg/l			0.47		0.203	0.187	0.564	0.277		0.243
0135	Solids, Suspended at 105 C	mg/l			10.6		8.45	11.6	9.8	8.9		5.4
3683	Nitrogen, Total Inorganic : (Calculated)	mg/l			22.8		23.9	22	25.6	21.9		21.9
4840	Sampling Frequency	no/ann		4								
4842	Population Equivalent - Calculated			4992								

Samples from 5 May 2021 to 19 Nov 2021

Notation	Determinand	Units	5 May 2021 08:54	1 Jun 2021 09:03	21 Jul 2021 09:00	22 Jul 2021 08:32	11 Aug 2021 09:00	27 Sep 2021 09:00	12 Oct 2021 09:04	13 Oct 2021 11:49	1 Nov 2021 09:01	19 Nov 2021 10:22
0085	BOD : 5 Day ATU	mg/l	2.88	5.55	4.49	10.2	3.41	3.66	3.98	6.19	4.06	
0092	Chemical Oxygen Demand :- {COD}	mg/l	37.1			42.5				29.2		
0111	Ammoniacal Nitrogen as N	mg/l		0.251	0.418		0.201	0.231	0.224		0.385	0.191
0135	Solids, Suspended at 105 C	mg/l		10.1	6.45		5.55	7.55	4.75		6.3	5.8
3683	Nitrogen, Total Inorganic : (Calculated)	mg/l		21.7	23.7		18.7	19.4	22.4		17.3	23.8

Overton STW
Inlet

Samples from 7 Jan 2020 to 18 May 2022

Notation	Determinand	Units	7 Jan 2020 09:38	18 May 2020 10:07	19 Aug 2020 09:58	23 Nov 2020 09:47	5 Mar 2021 09:59	5 May 2021 09:25	22 Jul 2021 09:24	13 Oct 2021 12:30	25 Jan 2022 09:30	18 May 2022 08:48
0085	BOD : 5 Day ATU	mg/l	123	> 141	175	151	139	100	193	159	252	195
0092	Chemical Oxygen Demand :- {COD}	mg/l	313	365	431	488	274	324	471	434	481	502

Samples from 28 Apr 2017 to 23 Oct 2019

Notation	Determinand	Units	28 Apr 2017 08:00	9 Aug 2017 07:44	13 Feb 2018 10:30	28 Apr 2018 07:10	1 Aug 2018 10:12	9 Nov 2018 11:10	26 Mar 2019 09:15	11 Jun 2019 11:45	23 Jul 2019 09:27	23 Oct 2019 10:57
0085	BOD : 5 Day ATU	mg/l	142	272	301	124	240	165	165	213	187	190
0092	Chemical Oxygen Demand :- {COD}	mg/l	258	752	708	323	522	262	461	620	337	499

Treated

Samples from 10 Dec 2021 to 15 Jun 2022

Notation	Determinand	Units	10 Dec 2021 09:27	1 Jan 2022 00:07	24 Jan 2022 09:21	25 Jan 2022 09:20	8 Feb 2022 09:01	1 Mar 2022 11:04	19 Apr 2022 09:23	17 May 2022 09:10	18 May 2022 08:46	15 Jun 2022 09:22
0085	BOD : 5 Day ATU	mg/l	3.5		< 1	25.7	3.44	2.96	4.74	3.29	3.93	3.5
0092	Chemical Oxygen Demand :- {COD}	mg/l				58.6					27.1	
0111	Ammoniacal Nitrogen as N	mg/l			0.275		0.137	0.141	0.25	0.315		0.0833
0135	Solids, Suspended at 105 C	mg/l			6.85		10.2	12	16.8	9.4		6
0348	Phosphorus, Total as P	mg/l			0.557		0.609	1.02	0.641	0.502		0.655
4840	Sampling Frequency	no/ann		4								
4842	Population Equivalent - Calculated			4759								
6051	Iron	µg/l			932		1580	1440	1800	1060		583

Samples from 5 May 2021 to 19 Nov 2021

Notation	Determinand	Units	5 May 2021 09:19	1 Jun 2021 09:26	21 Jul 2021 09:21	22 Jul 2021 09:11	11 Aug 2021 09:18	8 Oct 2021 09:05	12 Oct 2021 09:33	13 Oct 2021 12:23	1 Nov 2021 09:20	19 Nov 2021 09:58
0085	BOD : 5 Day ATU	mg/l	< 1	6.77	1.97	4.28	< 1	2.13	2.73	3.85	3.89	
0092	Chemical Oxygen Demand :- {COD}	mg/l	23.4			26.6				21.9		
0111	Ammoniacal Nitrogen as N	mg/l		2.39	0.111		0.044	0.048	0.022		0.047	0.112
0135	Solids, Suspended at 105 C	mg/l		14.9	4.55		4.1	5.8	5.05		5.85	6.65
0348	Phosphorus, Total as P	mg/l		0.542	0.866		1.4	0.423	0.645		0.497	0.602
6051	Iron	µg/l		1810	387		234	663	486		717	664

Oakley STW
Inlet

Samples from 23 Oct 2019 to 16 Jun 2022

Notation	Determinand	Units	23 Oct 2019 11:35	7 Jan 2020 10:15	18 May 2020 10:51	19 Aug 2020 10:37	23 Nov 2020 08:55	5 Mar 2021 09:17	5 May 2021 10:10	22 Jul 2021 09:59	13 Oct 2021 13:05	16 Jun 2022 10:00
0085	BOD : 5 Day ATU	mg/l	253	303	> 245	276	356	398	227	340	339	329
0092	Chemical Oxygen Demand :- {COD}	mg/l	635	889	718	796	1130	942	628	988	877	1240

Samples from 28 Apr 2017 to 23 Jul 2019

Notation	Determinand	Units	28 Apr 2017 08:40	9 Aug 2017 09:30	17 Oct 2017 15:25	25 Jan 2018 07:47	28 Apr 2018 07:40	6 Jul 2018 07:29	22 Nov 2018 10:54	19 Feb 2019 09:29	1 May 2019 08:53	23 Jul 2019 10:02
0085	BOD : 5 Day ATU	mg/l	298	229	391	258	223	434	333	327	298	335
0092	Chemical Oxygen Demand :- {COD}	mg/l	448	532	984	702	489	1780	903	790	645	876

Treated

Samples from 1 Jan 2022 to 16 Jun 2022

Notation	Determinand	Units	1 Jan 2022 00:07	24 Jan 2022 09:56	7 Feb 2022 09:02	8 Feb 2022 07:50	1 Mar 2022 11:40	19 Apr 2022 09:42	17 May 2022 09:36	7 Jun 2022 09:01	15 Jun 2022 09:01	16 Jun 2022 09:48
0085	BOD : 5 Day ATU	mg/l		8.68	9.62	10.8	6.95	5.04		5.67	4.37	7.39
0092	Chemical Oxygen Demand :- {COD}	mg/l				67.2						49.4
0111	Ammoniacal Nitrogen as N	mg/l		0.347	0.356		1.08	0.183	0.159		0.109	
0135	Solids, Suspended at 105 C	mg/l		11.7	11.8		13	6.25	7.45		5.75	
3683	Nitrogen, Total Inorganic : (Calculated)	mg/l		33.6	34		32.1	26.3	28.9		27.5	
4840	Sampling Frequency	no/ann	4									
4842	Population Equivalent - Calculated		5219									

Samples from 1 Jun 2021 to 10 Dec 2021

Notation	Determinand	Units	1 Jun 2021 09:47	21 Jul 2021 09:54	22 Jul 2021 09:48	11 Aug 2021 09:45	27 Sep 2021 09:37	12 Oct 2021 10:07	13 Oct 2021 12:51	1 Nov 2021 09:45	19 Nov 2021 09:16	10 Dec 2021 08:58
0085	BOD : 5 Day ATU	mg/l	6.27	4.64	7.16	4.19	5.85	10.5	17.9	6.41		8.87
0092	Chemical Oxygen Demand :- {COD}	mg/l			57.1				93.1			
0111	Ammoniacal Nitrogen as N	mg/l	0.103	1.01		0.266	0.26	0.844		0.922	0.513	
0135	Solids, Suspended at 105 C	mg/l	8.1	5.8		6.2	11.5	13.9		9.15	9.55	
3683	Nitrogen, Total Inorganic : (Calculated)	mg/l	28	26.3		23.4	23.4	23.7		25.8	32.6	

North Waltham STW
no inlet data
Treated

Samples from 27 Sep 2021 to 15 Jun 2022

Notation	Determinand	Units	27 Sep 2021 09:57	12 Oct 2021 10:38	1 Nov 2021 10:17	19 Nov 2021 08:49	24 Jan 2022 10:14	8 Feb 2022 07:23	1 Mar 2022 11:55	19 Apr 2022 10:01	17 May 2022 10:37	15 Jun 2022 07:12
7668	No flow /No sample		0	0	0	0	0	0	0	0	0	0

Samples from 23 Nov 2020 to 11 Aug 2021

Notation	Determinand	Units	23 Nov 2020 10:58	7 Dec 2020 10:39	7 Jan 2021 10:57	1 Feb 2021 10:07	4 Mar 2021 09:34	27 Apr 2021 07:29	4 May 2021 10:42	1 Jun 2021 10:09	21 Jul 2021 10:22	11 Aug 2021 10:06
0085	BOD : 5 Day ATU	mg/l	3.77	4.61	4.13	4.25	5.91					
0111	Ammoniacal Nitrogen as N	mg/l	0.072	0.17	0.846	0.276	0.15					
0135	Solids, Suspended at 105 C	mg/l	3.7	6	5.65	8.85	12.7					
3683	Nitrogen, Total Inorganic : (Calculated)	mg/l	13.9	16.7	21.8	17	19					
7668	No flow /No sample							0	0	0	0	0

Hannington STW
Incorrect treated data on website; no inlet data

Barton Stacey STW
Inlet

Samples from 22 Apr 2020 to 26 Jun 2022

Notation	Determinand	Units	22 Apr 2020 08:05	26 May 2020 08:55	4 Aug 2020 10:15	26 Nov 2020 13:50	21 Jan 2021 08:44	25 Jun 2021 10:33	13 Aug 2021 08:56	3 Nov 2021 09:24	31 Mar 2022 10:15	26 Jun 2022 10:18
0085	BOD : 5 Day ATU	mg/l	51.8	31.2	67.1	87.1	24.7	> 44	47.5	69.9	58.6	64.2
0092	Chemical Oxygen Demand :- {COD}	mg/l	197		193	201	112	186	145	167	98.6	178

Samples from 14 Dec 2017 to 3 Jan 2020

Notation	Determinand	Units	14 Dec 2017 10:20	22 Feb 2018 09:05	6 May 2018 08:10	24 Aug 2018 08:25	23 Oct 2018 08:59	6 Feb 2019 10:22	24 Apr 2019 09:42	13 Sep 2019 09:54	10 Dec 2019 08:41	3 Jan 2020 10:11
0085	BOD : 5 Day ATU	mg/l	98.8	70.1	49.7	43.2	62.7	70.9	96.3	90.8	68.6	45.9
0092	Chemical Oxygen Demand :- {COD}	mg/l	254	161	136	109	156	293	265	214	176	111

Treated

Samples from 11 Nov 2021 to 26 Jun 2022

Notation	Determinand	Units	11 Nov 2021 10:07	1 Jan 2022 00:07	6 Jan 2022 11:33	9 Feb 2022 11:00	30 Mar 2022 09:58	31 Mar 2022 10:05	22 Apr 2022 10:01	11 May 2022 10:50	25 Jun 2022 08:10	26 Jun 2022 10:10
0085	BOD : 5 Day ATU	mg/l	< 1		2.66	< 1	< 1	2.57	< 1	< 1	< 1	5.33
0092	Chemical Oxygen Demand :- {COD}	mg/l						10.7				15.5
0111	Ammoniacal Nitrogen as N	mg/l	0.027		0.065	1.11	0.0209		0.0556	0.0229	0.0579	
0135	Solids, Suspended at 105 C	mg/l	< 2		2.85	< 2	< 2		< 2	< 2	< 2	
0348	Phosphorus, Total as P	mg/l	0.143		0.315	0.21	0.107		0.111	0.127	0.147	
4840	Sampling Frequency	no/ann		4								
4842	Population Equivalent - Calculated			3956								
6051	Iron	µg/l	305		452	42.6	110		247	269	280	

Samples from 17 May 2021 to 3 Nov 2021

Notation	Determinand	Units	17 May 2021 09:23	24 Jun 2021 10:03	25 Jun 2021 10:17	3 Jul 2021 09:02	13 Aug 2021 08:42	13 Aug 2021 09:00	22 Sep 2021 09:29	6 Oct 2021 09:31	2 Nov 2021 09:32	3 Nov 2021 09:15
0085	BOD : 5 Day ATU	mg/l	2.53	< 1	1.98	2.11	3.83	< 1	< 1	2.08	2.24	2.82
0092	Chemical Oxygen Demand :- {COD}	mg/l			10.5		15.2					13.9
0111	Ammoniacal Nitrogen as N	mg/l	0.017	0.014		0.023		0.018	0.017	0.042	0.037	
0135	Solids, Suspended at 105 C	mg/l	2.5	< 2		< 2		< 2	< 2	2.8	< 2	
0348	Phosphorus, Total as P	mg/l	0.213	0.11		0.108		0.196	0.155	0.352	0.165	
6051	Iron	µg/l	356	363		241		773	1100	234	240	

Samples from 27 Jan 2014 to 26 Sep 2017

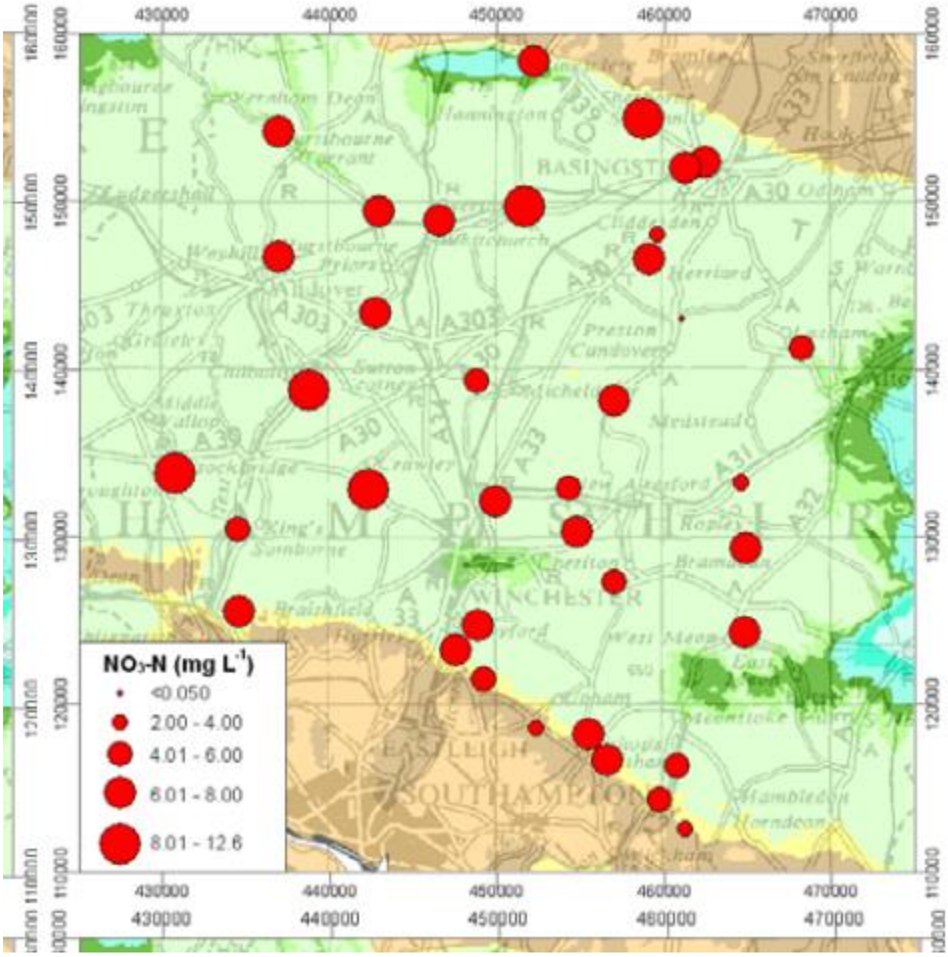
Notation	Determinand	Units	27 Jan 2014 12:26	25 Apr 2014 10:29	24 Mar 2015 11:10	29 Jan 2016 10:32	19 Apr 2016 10:30	20 Jul 2016 12:32	1 Nov 2016 14:39	31 Jan 2017 11:45	28 Apr 2017 10:49	26 Sep 2017 12:41
0050	Lead	µg/l	< 2	< 2					< 2			
0052	Lead, Dissolved	µg/l		< 2	0.18	0.209	0.146	0.131	0.192	0.104	0.136	
0061	pH			7.42			7.41					
0073	Cypermethrin	µg/l						< 1.0e-05			< 1.0e-05	
0076	Temperature of Water	°C	10.1	10.9	10.6	7.8	10.7	13.3	11	10.8	10.1	11.3
0077	Conductivity at 25 C	µs/cm	527	556	531	522	530	549	539	545	528	542
0106	Cadmium, Dissolved	µg/l		< 0.1	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
0108	Cadmium	µg/l	< 0.1	< 0.1					< 0.1			
0111	Ammoniacal Nitrogen as N	mg/l	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
0116	Nitrogen, Total Oxidised as N	mg/l	6.79	7.45	6.95	6.63	6.8	7.19	7.17	6.91	6.84	7.25
0117	Nitrate as N	mg/l	6.79	7.45	6.95	6.63	6.8	7.19	7.17	6.91	6.84	7.25
0118	Nitrite as N	mg/l	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
0158	Hardness, Total as CaCO3	mg/l	261	265	261	250	264	284	258	264	247	
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	222	225	223	221	219	225	220	236	212	230
0167	Sulphide as S	mg/l		< 0.01								
0171	Bromide	mg/l		0.0409			0.0425				0.041	
0172	Chloride	mg/l	13.3	14.6	14.2	13.9	13.9	14.3	14.2	14.7	14.1	14.8
0177	Fluoride	mg/l	0.088	0.067	0.075	0.071	0.074	0.086	0.067	0.073	0.078	
0179	Iodide	mg/l		< 0.003			< 0.003				< 0.003	
0180	Orthophosphate, reactive as P	mg/l	0.02	< 0.02	0.024	0.0227	0.0244	0.0235	0.0225	0.0257	0.0231	0.0249
0182	Silica, reactive as SiO2	mg/l	12.8	11.9	10.7	11.6	12.2	12.2	11.7	11.5	11.8	
0183	Sulphate as SO4	mg/l	< 10	11.1					10.1			
0205	Sodium, Dissolved	mg/l		8.98	6.18	6.06	6.38	6.94	5.82	6.27	6.09	
0207	Sodium	mg/l	6.51	9.01					6.17			
0209	Potassium, Dissolved	mg/l		1.06	0.824	0.973	0.858	0.814	0.891	0.974	0.993	
0211	Potassium	mg/l	0.886	0.964					0.957			

Stuart and Smedley 2009

Table 5.1 Statistical summary of field-determined parameters, major ions, nitrogen species and stable-isotopic compositions of groundwaters from the Hampshire Chalk aquifer

Parameter	Units	n	n (c)	Min	Mean	Max	P5	P25	P50	P75	P90	P95
Temp	^{o}C	31	0	10.1	11	15.5	10.1	10.3	10.7	11.1	11.5	12.8
pH		37	0	6.88	7.14	7.55	6.9	7.04	7.11	7.19	7.4	7.5
Eh	mV	23	0	340	407	440	343	400	415	426	433	435
DO	mg L^{-1}	30	0	4.5	7.68	10.6	4.68	6.62	7.75	8.74	9.6	10.4
SEC	µS cm^{-1}	37	0	466	563	715	467	532	565	581	638	690
δ^{2}H	‰	19	0	-46.1	-43.3	-40.4	-45.9	-44.7	-43.6	-41.9	-41.1	-40.8
δ^{18}O	‰	19	0	-7.32	-6.84	-6.18	-7.3	-7.14	-6.89	-6.7	-6.31	-6.28
δ^{13}C	‰	3	0	-15.5	-10.1	0.19	-15.4	-15.2	-15	-7.4	-2.84	-1.33
Ca	mg L^{-1}	36	0	94.4	109	144	97.2	102	105	113	121	123
Mg	mg L^{-1}	36	0	1.4	2.1	4.81	1.51	1.83	1.98	2.15	2.41	3.74
Na	mg L^{-1}	37	0	5.45	8.88	14.4	6.13	7.66	8.61	10.3	11.6	12.5
K	mg L^{-1}	37	1	<0.5	1.47	3.53	0.59	1.08	1.33	1.63	2.51	2.96
Cl	mg L^{-1}	37	0	11.8	17.7	26.3	12.9	15.6	17.7	19.3	21.9	23.5
SO_4	mg L^{-1}	36	0	4.73	12.9	22.8	7.56	10.7	11.8	14.7	18.4	19.2
HCO_3	mg L^{-1}	36	0	254	292	355	260	274	286	307	318	347
NO_3-N	mg L^{-1}	37	1	<0.05	6.58	12.6	2.68	5.72	6.53	7.33	8.99	10.7
NO_2-N	mg L^{-1}	36	24	<0.0006	0.0017	0.010	0.0001	0.0003	0.0005	0.0017	0.0048	0.0080
NH_4-N	mg L^{-1}	37	29	<0.005	0.00917	0.066	0.0001	0.0005	0.0012	0.0051	0.0336	0.0637
DOC	mg L^{-1}	27	0	0.46	0.813	1.24	0.58	0.7	0.8	0.91	1.0	1.1
Si	mg L^{-1}	35	0	4.57	5.73	9.37	4.79	5.21	5.57	6.03	6.71	7.34

DO: dissolved oxygen; P = percentile; n (c) = number censored; min and max are observed values


NO3-N (mg L-1)
<0.050
2.00 - 4.00
4.01 - 6.00
6.01 - 8.00
8.01 - 12.6

Appendix E

WFD Cycle 2 Classification

Appendix E Water Framework Regulations Classifications

The Water Framework Directive was implemented in England and Wales by the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003, as amended by the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017.

Surface Water Classification

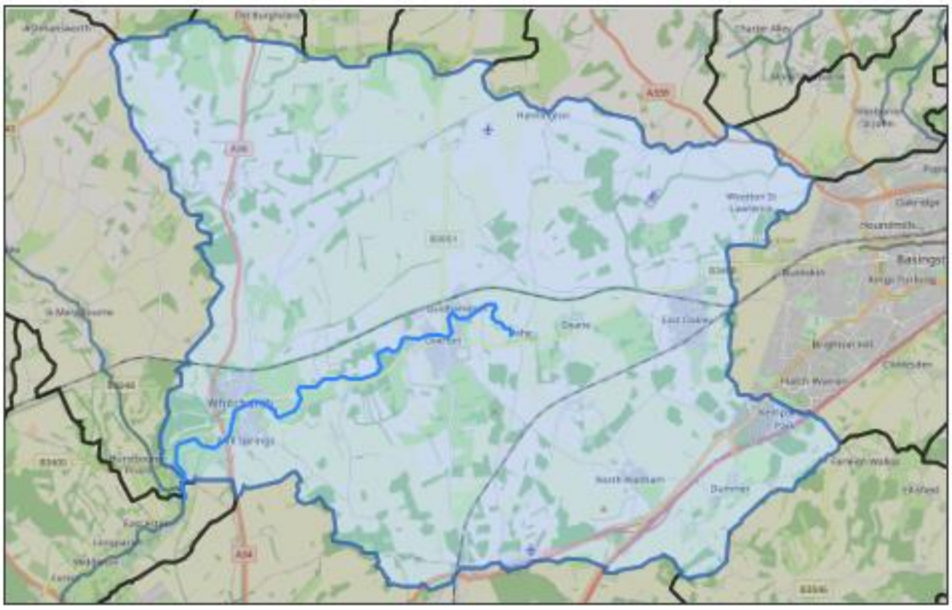


Figure 37 Upper Test Surface Water Catchment for WFD Purposes

Surface Water Classification – Cycle 2

Classification item	2013	2014	2015	2016	2019
Ecological	Good	Good	Good	Good	Good
Biological quality elements		Good	Good	Good	Good
Invertebrates		High	High	High	High
Macrophytes and Phytobenthos Combined		Good	Good	Good	Good
Macrophytes Sub Element		Good	Good	Good	Good
Physico-chemical quality elements	Good	Good	High	High	High
Ammonia (Phys-Chem)	High	High	High	High	High
Dissolved oxygen	High	High	High	High	High
Phosphate	Good	Good	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	Supports good	Supports good	Supports good	Supports good	High
Morphology	Supports good	Supports good	Supports good	Supports good	Supports good
Specific pollutants	High	High			
Copper	High	High			
Triclosan	High	High			
Zinc	High	High			
Chemical	Good	Good	Good	Good	Fail
Priority hazardous substances	Good	Good	Does not require assessment	Does not require assessment	Fail
Benzo(a)pyrene					Good
Cadmium and Its Compounds	Good	Good			
Di(2-ethylhexyl)phthalate (Priority hazardous)	Good	Good			
Dioxins and dioxin-like compounds					Good
Heptachlor and cis-Heptachlor epoxide					Good
Hexabromocyclododecane (HBCDD)					Good
Hexachlorobenzene					Good
Hexachlorobutadiene					Good
Mercury and Its Compounds					Fail
Nonylphenol	Good	Good			
Perfluorooctane sulphonate (PFOS)					Good
Polybrominated diphenyl ethers (PBDE)					Fail
Tributyltin Compounds	Good	Good			
Priority substances	Good	Good	Does not require assessment	Does not require assessment	Good
Cypermethrin (Priority)					Good
Fluoranthene					Good
Lead and Its Compounds	Good	Good			
Nickel and Its Compounds	Good	Good			
Other Pollutants	Does not require assessment	Does not require assessment	Does not require assessment	Does not require assessment	Does not require assessment

Surface Water Classification – Cycle 3

Classification Item	2019
Ecological	Good
Biological quality elements	Good
Invertebrates	High
Macrophytes and Phytobenthos Combined	Good
Macrophytes Sub Element	Good
Physico-chemical quality elements	High
Ammonia (Phys-Chem)	High
Dissolved oxygen	High
Phosphate	High
Temperature	High
pH	High
Hydromorphological Supporting Elements	Supports good
Hydrological Regime	High
Morphology	Supports good
Chemical	Fail
Priority hazardous substances	Fail
Benzo(a)pyrene	Good
Dioxins and dioxin-like compounds	Good
Heptachlor and cis-Heptachlor epoxide	Good
Hexabromocyclododecane (HBCDD)	Good
Hexachlorobenzene	Good
Hexachlorobutadiene	Good
Mercury and Its Compounds	Fail
Perfluorooctane sulphonate (PFOS)	Good
Polybrominated diphenyl ethers (PBDE)	Fail
Priority substances	Good
Cypermethrin (Priority)	Good
Fluoranthene	Good
Other Pollutants	Does not require assessment

Groundwater Classification

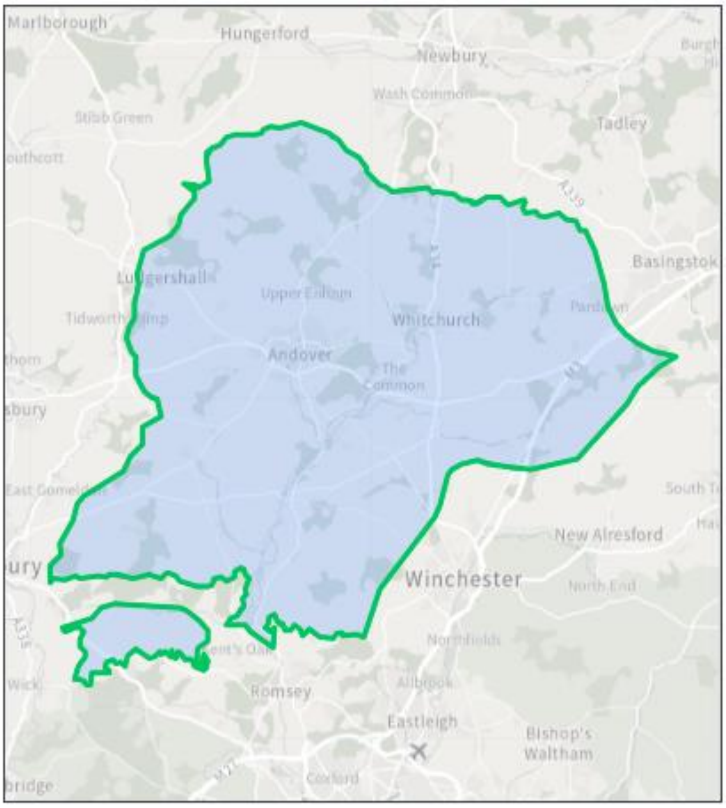


Figure 38 River Test Groundwater Catchment for WFD Purposes

Groundwater Classification – Cycle 2

Classification Item	2013	2014	2015	2016	2019
Overall Water Body	Poor	Poor	Poor	Poor	Poor
Quantitative	Good	Good	Good	Good	Good
Quantitative Status element	Good	Good	Good	Good	Good
Quantitative Dependent Surface Water Body Status	Good	Good	Good	Good	Good
Quantitative GWDTEs test	Good	Good	Good	Good	Good
Quantitative Saline Intrusion	Good	Good	Good	Good	Good
Quantitative Water Balance	Good	Good	Good	Good	Good
Chemical (GW)	Poor	Poor	Poor	Poor	Poor
Chemical Status element	Poor	Poor	Poor	Poor	Poor
Chemical Dependent Surface Water Body Status	Good	Good	Good	Good	Good
Chemical Drinking Water Protected Area	Poor	Poor	Poor	Poor	Poor
Chemical GWDTEs test	Good	Good	Good	Good	Good
Chemical Saline Intrusion	Good	Good	Good	Good	Good
General Chemical Test	Poor	Poor	Poor	Poor	Poor
Supporting elements (Groundwater)					
Prevent and Limit Objective	Active				Active
Trend Assessment	Upward trend	Upward trend	Upward trend	Upward trend	Upward trend

Groundwater Classification – Cycle 3

Classification Item	2019
Overall Water Body	Poor
Quantitative	Good
Quantitative Status element	Good
Quantitative Dependent Surface Water Body Status	Good
Quantitative GWDTEs test	Good
Quantitative Saline Intrusion	Good
Quantitative Water Balance	Good
Chemical (GW)	Poor
Chemical Status element	Poor
Chemical Dependent Surface Water Body Status	Good
Chemical Drinking Water Protected Area	Poor
Chemical GWDTEs test	Good
Chemical Saline Intrusion	Good
General Chemical Test	Poor
Supporting elements (Groundwater)	
Prevent and Limit Objective	Active
Trend Assessment	Upward trend

Reasons for not achieving good (RNAG) and reasons for deterioration (RFD)

All reasons (RFDs and RNAGs) attributed to the classification elements in this water body.

Reason Type	SWMI	Activity	Category	Classification Element	More information
RNAG	Diffuse source	Poor nutrient management	Agriculture and rural land management	General Chemical Test	Details
RNAG	Diffuse source	Poor nutrient management	Agriculture and rural land management	Trend Assessment	Details
RNAG	Diffuse source	Poor nutrient management	Agriculture and rural land management	Chemical Drinking Water Protected Area	Details

Appendix F

Groundwater Elevation Trends

Appendix F Groundwater Elevation Trends

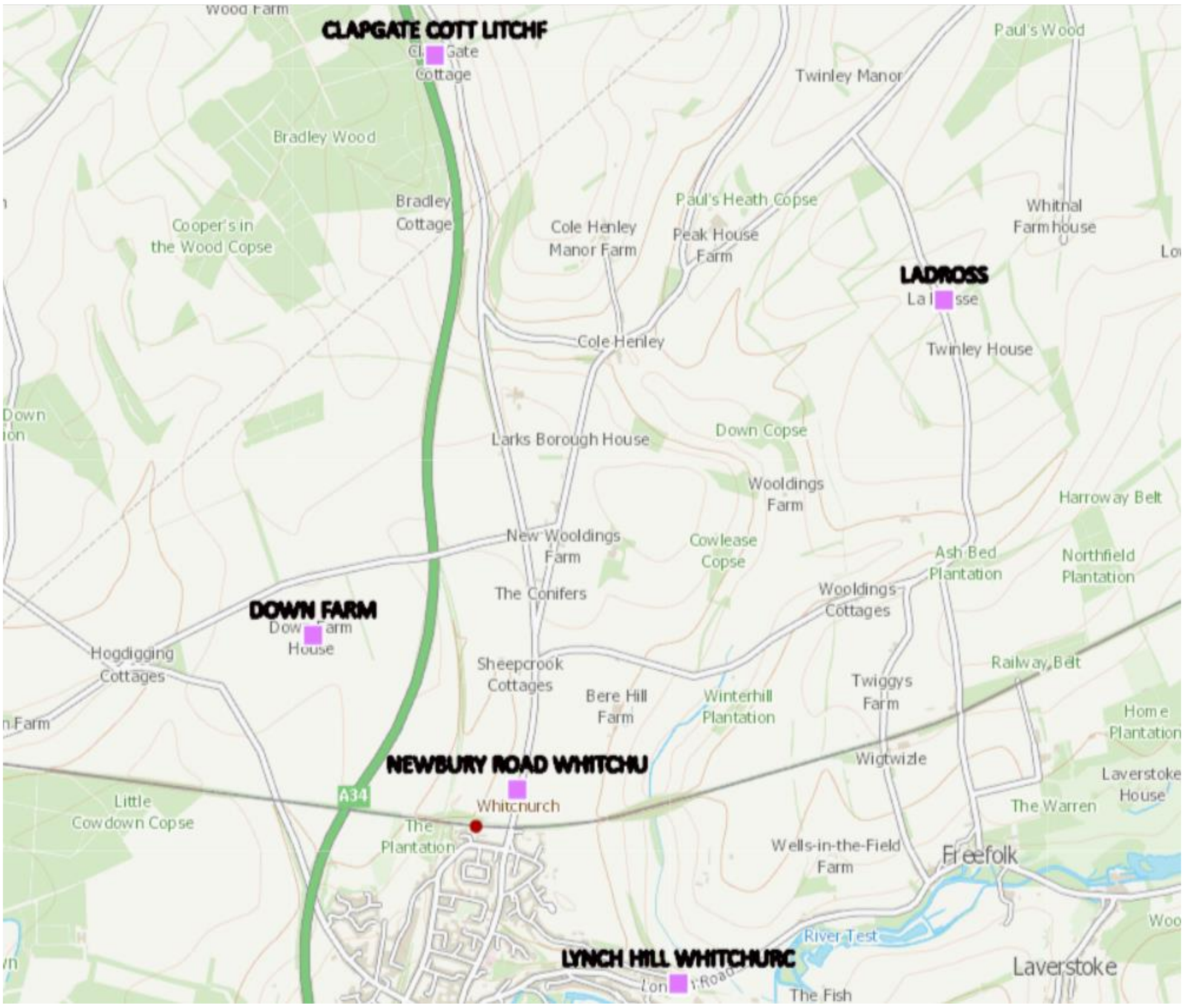
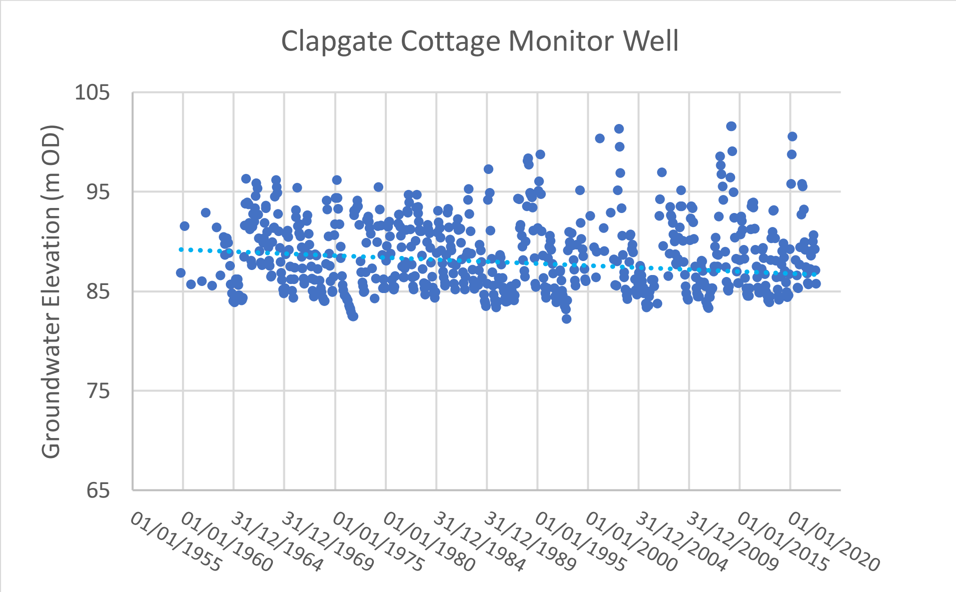


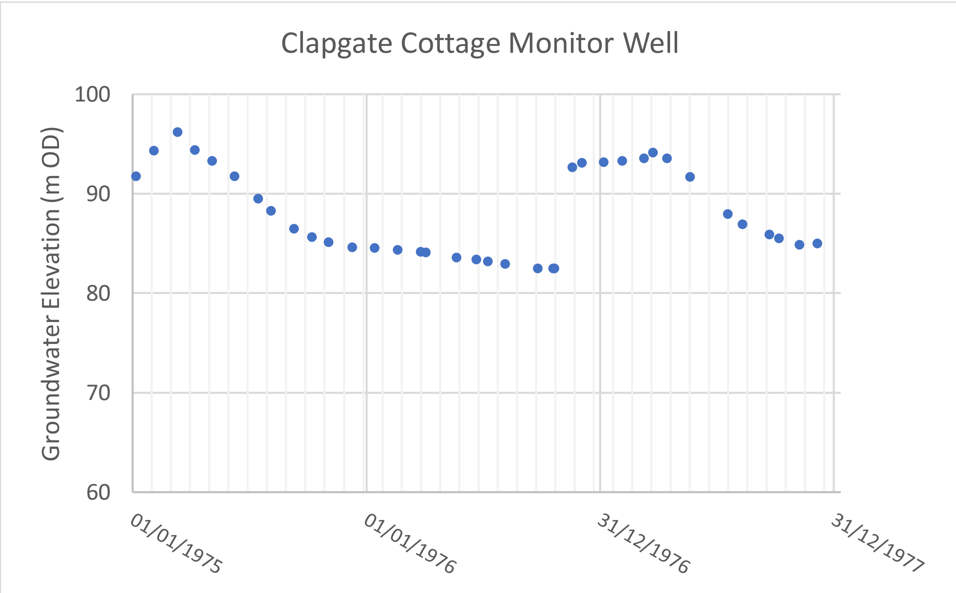
Figure 39 Groundwater Level Monitor Well Location Map

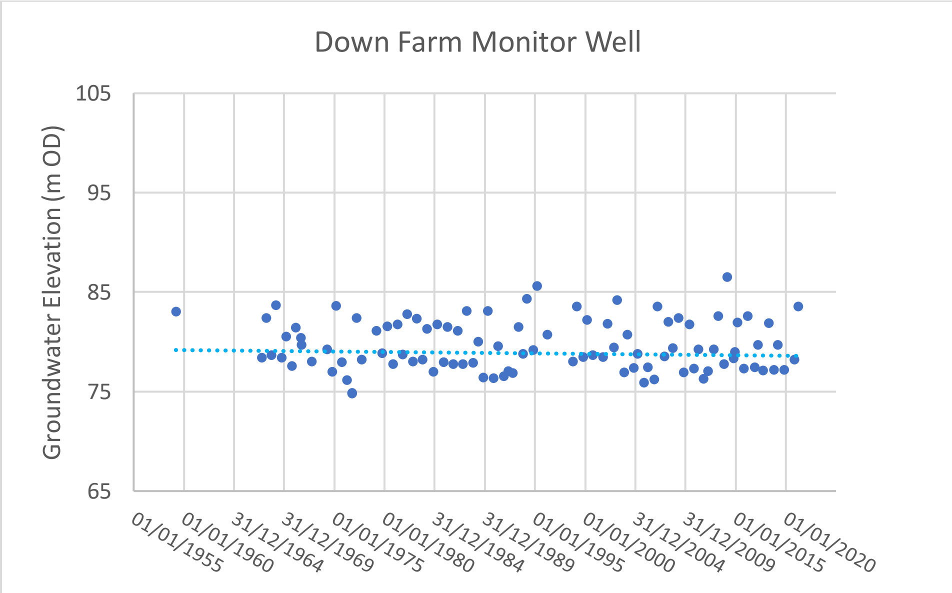
Table 23 Groundwater Level Monitor Well Locations

Monitor Well	**Location**	**NGR**	**Depth** (m)
Clapgate Cottage	Clapgate	SU 46150 52250	27.4
Down Farm	NW of Whitchurch	SU 45603 49739	ND
Ladross (Le Bresse)	NE of Whitchurch	SU 48435 51190	ND
Lynch Hill	Whitchurch	SU 47242 48230	ND
Newbury Road	Whitchurch	SU 46520 49070	55

Depths where available from BGS Borehole Archives, GeoIndex - British Geological Survey (bgs.ac.uk)


Clapgate Cottage Monitor Well
Groundwater Elevation (m OD)
105
95
85
75
65
01/01/1955
01/01/1960
31/12/1964
31/12/1969
01/01/1975
01/01/1980
31/12/1984
31/12/1989
01/01/1995
01/01/2000
31/12/2004
31/12/2009
01/01/2015
01/01/2020


Clapgate Cottage Monitor Well
Groundwater Elevation (m OD)
100
90
80
70
60
01/01/1975
01/01/1976
31/12/1976
31/12/1977


Down Farm Monitor Well
Groundwater Elevation (m OD)
105
95
85
75
65
01/01/1955
01/01/1960
31/12/1964
31/12/1969
01/01/1975
01/01/1980
31/12/1984
31/12/1989
01/01/1995
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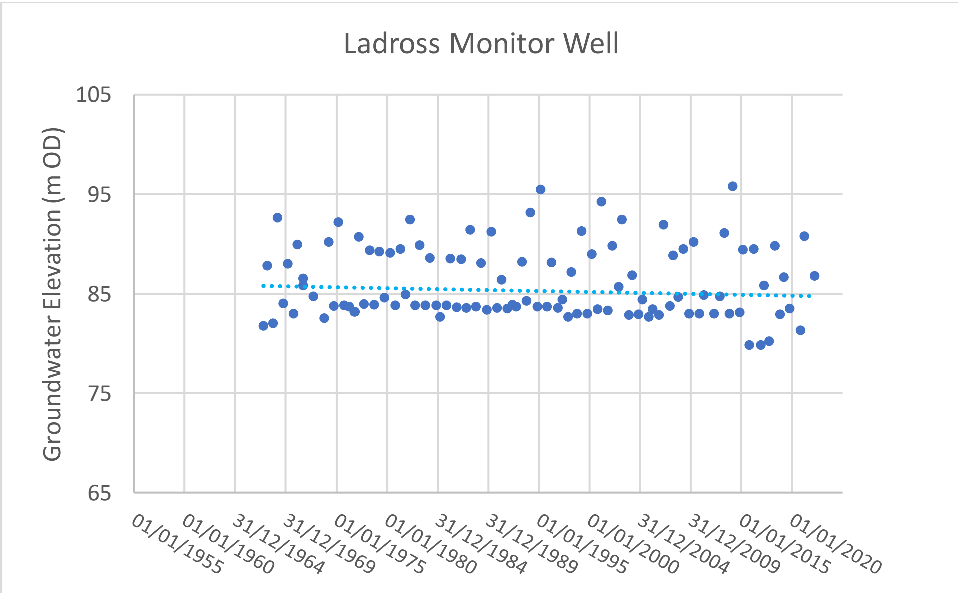
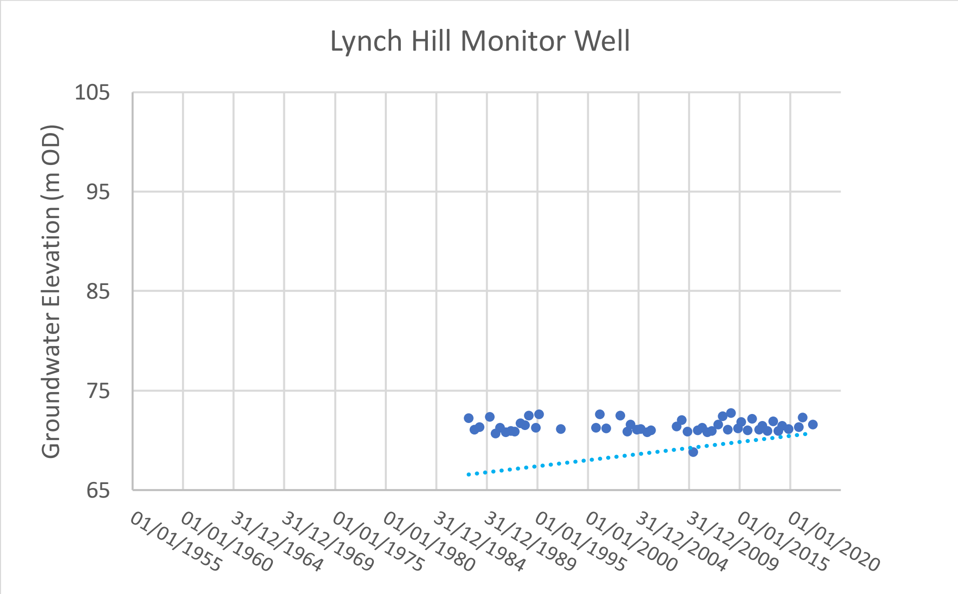
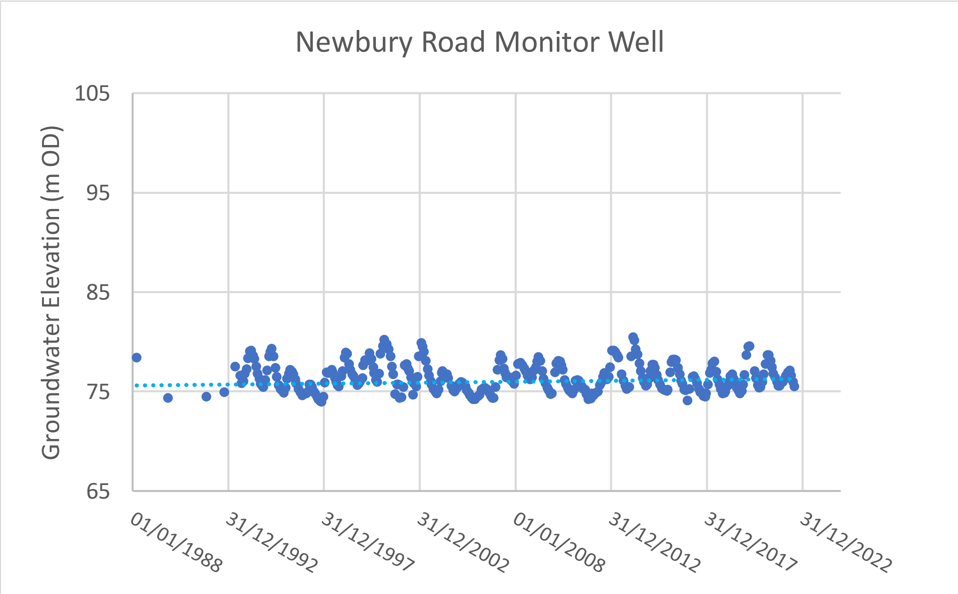
31/12/2009
01/01/2015
01/01/2020


Ladross Monitor Well
Groundwater Elevation (m OD)
105
95
85
75
65
01/01/1955
01/01/1960
31/12/1964
31/12/1969
01/01/1975
01/01/1980
31/12/1984
31/12/1989
01/01/1995
01/01/2000
31/12/2004
31/12/2009
01/01/2015
01/01/2020


Lynch Hill Monitor Well
Groundwater Elevation (m OD)
105
95
85
75
65
01/01/1955
01/01/1960
31/12/1964
31/12/1969
01/01/1975
01/01/1980
31/12/1984
31/12/1989
01/01/1995
01/01/2000
31/12/2004
31/12/2009
01/01/2015
01/01/2020


Newbury Road Monitor Well
Groundwater Elevation (m OD)
105
95
85
75
65
01/01/1988
31/12/1992
31/12/1997
31/12/2002
01/01/2008
31/12/2012
31/12/2017
31/12/2022

Appendix G

Nitrogen Loads Released from WWTW

Appendix G Nutrient Loads Released from WWTW

Table 24 provides the calculation of nitrogen loadings to the Chalk from WWTW in the Upper Test Catchment.

Table 24 Nutrient Loads from WWTW in the Upper Test Catchment

WWTW	DWF	Nitrogen			Phosphorus		
		Measured Mean Concentration in Treated Effluent	Load	Load	Measured Mean Concentration in Treated Effluent	Load	Load
units:	m^3/d	mg/l	kg/d	kg/a	mg/l	kg/d	kg/a
Whitchurch	2336	22	51.4	18771	6.5	15.2	5546
Overton	1160	25	29.0	10592	0.5	0.6	212
Oakley	722	30	21.7	7911	6.5	4.7	1714
North Waltham	167	12.5	2.1	763	8	1.3	488
Ashmansworth	10	20	0.2	73	6.5	0.1	24
Hannington	5	20	0.1	37	6.5	0.0	12
Sub-Totals	**4400**		**104**	**38,147**		**21.89**	**7996**
Unsewered	183		4.4	1589		0.91	333
Industrial - Portals	7000	3.1	21.7	7926	0.25	1.8	639.2
Totals	**11583**		**130**	**47662**		**24.6**	**8968**

Notes:

1. Nitrogen and phosphorus concentrations were estimated for Ashmansworth and Hannington WWTWs. Phosphorus concentrations were estimated for Oakley. The phosphorus concentrations for Whitchurch WWTW was based on historical data reported by Beard and Giles 1990.
2. Loads from unsewered systems was estimated by adding 4% to the total urban WWTW loads.
3. The loads assume continuous discharge at the dry weather flow (DWF) rate.
4. Portals will close in late 2022.