Cam Valley forum

River Cam at Great Chesterford, June 2022; the bed is in very poor state covered with algal mats. Richard Pavitt is engaged in orthophosphate monitoring for CURAT (Cam Upper Reaches Action Team) **Credit: EssexLive**

Essex Cam Report

Water quality testing by Cam Valley Forum on The Essex Cam and its tributaries

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23 February 2024

Report ref 21634

1 CONTENTS

2 MAIN FINDINGS

This report presents the results of Cam Valley Forum monitoring of nitrate concentrations and more importantly Soluble Reactive Phosphorus (orthophosphate) concentrations in water samples from the Essex Cam, some of its tributaries, and final treated effluent discharging from several sewage treatment works ultimately discharging into the Cam. On 16 August 2022 the Essex Cam was not flowing above Newport STW, most tributaries were dry, and augmentation of the Cam by Affinity Water using borehole supply was in progress. High levels of orthophosphate in the Cam from Newport STW downstream to Stapleford were confirmed, with strong evidence that the source was largely the sewage treatment works (STWs). Sampling in November showed reductions in levels probably due to a combination of dilutive, increased flows and ingress from sources other than STWs. EA data from their site at the end of the Audley End to Stapleford reach showed that levels of orthophosphate were high enough during most of 2022 and especially during the summer to be detrimental to biodiversity.

3 SUMMARY

In 2021 Cam Valley Forum (CVF) started a Citizen Science programme of water quality monitoring on the Rhee, Granta and Cam. CVF's aim was to gather data on the concentrations of the important nutrients orthophosphate and nitrate, better to understand how concentrations of these known river pollutants vary over the catchment. The Essex Cam was included but only later in the nutrient programme. Although much is already known about levels of these nutrients, a deeper understanding was deemed to be achievable by sampling at sites in sequence on the same dates to try to control factors such changes in river flow, rainfall and soil runoff.

CVF recognises that monitoring of the Essex Cam in 2022 was not fully site-systematic, and that more frequent sampling at a larger number of sites and on all tributaries (when flowing) would have been preferred in order to provide more robust patterns of nutrient levels over seasons and stretches. However, the results obtained are compelling. They showed that nitrate, being a pollutant of landscape origin from agriculture, from the aquifers that support flow of our Chalk streams, from human wastewater, and from other sources, was at high levels downstream of Newport to the end reach at Stapleford. However, levels through the seasons (EA data) in the reach upstream of Newport vary and depend greatly on the proportion of flow into the river from each the various potential water sources. The presence of high levels of orthophosphate from Newport downstream to Stapleford was confirmed. The main sampling date was 16 August 2022, in a period of low rainfall and when the Cam was dry above Newport and most tributaries had ceased flowing. CVF then found overwhelming evidence that treated effluent from sewage treatment works (STWs) was making a major contribution to high orthophosphate levels in the river. Quendon, Newport and Saffron Walden STWs had become the 'heads of flow' of the Quendon discharge ditch, Essex Cam and Madgate Slade respectively, the start of the flows effectively 100% treated sewage.

Highlighted in this report were the influence on orthophosphate concentrations of the marked seasonal changes in river flow. Low summer flows do result in higher and deleterious levels of orthophosphate. Outlined is the necessity for augmentation support for the Cam using precious supplies of groundwater pumped from the aquifer by Affinity Water.

Some stretches of the Essex Cam can appear attractive. However, a closer look at the river bed can reveal shockingly high amounts of slimy algal matting and reduced biodiversity. Algal growth affects dissolved oxygen levels in the water, and are detrimental to any sensitive Chalk stream plants struggling to grow there. It is well documented that strong growth of algae benefits from a eutrophic state and the high orthophosphate levels in the Essex Cam must be playing an integral part in creating the condition.

Some good news: future prospects are better. Anglian Water is adding infrastructure to several STWs on the Essex Cam to reduce phosphorus levels in the effluent. Quendon, Newport and Elmdon STWs should all have phosphorus strippers and the necessary consent limits put in place by the end of 2024. Phosphorus discharge from these STWs should reduce by around 80%. Of concern though, Great Chesterford STW discharges will continue with no imposed consent limit, which seems to the author to be illogical especially if orthophosphate levels are to be reduced further upstream. This issue needs urgent re-consideration by the EA, or least a reasoned explanation for its decision. Agricultural and rural management sources still require urgent address. The addition of at least one Integrated Constructed Wetland to help reduce nutrient levels has been put forward as an aspiration by Anglian Water (for Elmdon) – a laudable concept to follow up on as quickly as possible and where ever possible elsewhere also.

This report has not been written by a professional ecologist and the author has not approached any professional soils scientist, ecologist or the EA for guidance in the preparation of this report. A little knowledge of some issues can be a dangerous thing and if any comment or statement made by myself as a volunteer turns out to be erroneous it has resulted from misunderstandings, insufficient knowledge of specialist issues, or only partial access to official information.

4 BACKGROUND

Cam Valley Forum has been concerned for many years about the poor state of our Chalk streams. They are internationally important in the conservation of biodiversity, the UK having about three-quarters of the world total, which includes our Cam, Rhee and Granta and most of their tributaries. Our local Chalk streams have declined over recent decades for three principal reasons: loss of flow from the Chalk aquifer, channel modifications, and water quality pollution. This latter issue is the focus of this report. The Chalk streams have suffered due to groundwater abstraction resulting from increasing public water supply demand, water that could support much-needed summer flows.

Resultant low summer flows exacerbate the harm to biodiversity due in large part to our catchment's high river orthophosphate levels – several important reaches of our rivers for orthophosphate remain classified as 'Poor' by the Environment Agency (EA), and at least one is 'Bad'. Currently, levels are still far too high, though it should be said that the ongoing efforts to reduce phosphorus load in household cleaning products, by the agricultural sector, and by the wastewater treatment sector have contributed to some reduction in concentrations in river water. So far, however, this reduction is deemed insufficient on most reaches, leading to CVF and its allies continuing to demand that further substantial reductions are made. It is heartening to know that further significant plans by Anglian Water to reduce Phosphorus in discharge from three STWs should shortly be enacted.

5 ACKNOWLEDGEMENTS

Richard Pavitt Cam Upper Reaches Action Team (CURAT)
Keith Baker (CURAT-Newport)
Richard Bridgwood, Duxford
Derek Smith, Newport
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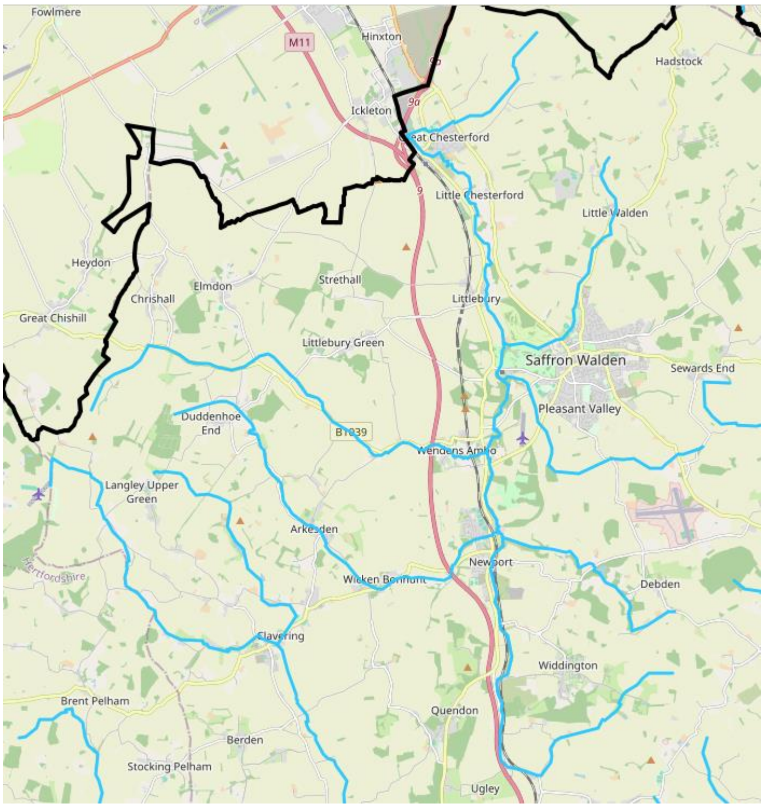
Andrew Murray, Huntsman Advance Materials UK Ltd
Affinity Water
Anglian Water
Audley End Estate
B A Hydro Solutions Ltd
Cambridge Water Company
Environment Agency (EA)
The Rivers Trust
South East Water Laboratories

6 ACCESS TO EA WATER BODY DATA

The three main water bodies making up the Essex Cam are listed below, with their overall ecological status defined by the EA. Debden Water is another named waterbody but this is not included as CVF did not take samples from it. For this report, the Essex Cam is deemed to end at Stapleford at its confluence with the River Granta. The nomenclature of the 'Cam'/Granta' is confusing with interchanging names for various parts of it, so the EA's definition of the various water bodies clarifies where CVF was monitoring.

Upstream of Newport Water body GB105033037480 - 'Moderate' ecological status
Newport to Audley End Water body GB105033037480 - 'Moderate' ecological status
Audley End to Stapleford Water body GB105033037590 - 'Poor' ecological status

Map produced by Affinity Water, showing the company's northern border, the Essex Cam and watercourses in their region linked to the Essex Cam



7 EA SAMPLING SITES

EA have several sampling sites across the area. Data from laboratory analyses of these samples are published online contemporaneously (EA 'WIMS') and are very important sources of information on analysable physical and chemical parameters. Some sites have data back to 2000, but others start much later and some have ceased taking measurements. The Essex Cam has EA sampling sites at:

- Station Road bridge Newport (upstream of Newport STW)
- Wendens Ambo road bridge B1052
- Littlebury bridge
- Great Chesterford road bridge (upstream of Gt. Chesterford STW)
- Hinxton road bridge (downstream of Gt Chesterford STW)
- Whittlesford, A505 road bridge
- Whittlesford village
- Stapleford, Dernford lock gauging station.

There are five other sites on tributaries, but not all are currently monitoring:

- Wicken Water road bridge, School Lane
- Wendon Brook B1383 road bridge
- Madgate Slade Home Farm, D/S Saffron Walden STW, limited data
- Ickleton Brook road bridge, Ickleton
- Sawston Stream gauging station No.1
- Sawston Spring Stream aka Dernford Chalk stream (downstream of Sawston STW).

Data that are accessible online include pH, water temperature, conductivity, total ammoniacal nitrogen, unionised ammonia-nitrogen, nitrate-nitrogen, alkalinity, orthophosphate reactive as P, and dissolved oxygen. Occasionally published are Total Phosphorus and results for heavy metals, industrial and agricultural chemicals, and survey-chemicals such as per-and polyfluoroalkyl substances (PFAS, 'forever chemicals').

There is so much information revealed in these archives. They form the backbone of information on water quality extensively used by the EA for regulatory decision-making, and by consultative bodies.

8 STW FINAL EFFLUENT DISCHARGE FLOWS AND RIVER FLOWS

One parameter absent from the EA WIMS datasets is the river flow at times of sampling. Only exceptionally is STW treated effluent flow reported, for example there are data for Bassingbourn STW 2000-2008.

Affinity Water considers there to be about 10 points of treated effluent discharge in the catchment, the largest being Saffron Walden. From their calculations they estimate that the minimum contribution to the baseflow is 'almost insignificant' (0.5 million litres per day (Ml/d), 5.8 litres per second (l/s) – source: Affinity Water (Alessandro Marsili), presentation to CURAT, 8 July 2022. However, one mapped STW does not connect to the Essex Cam and a private STW at Duxford is not included. I am unsure exactly where downstream their 'baseflow' measurements are no longer taken, however they do include Great Chesterford STW on their map of STWs.

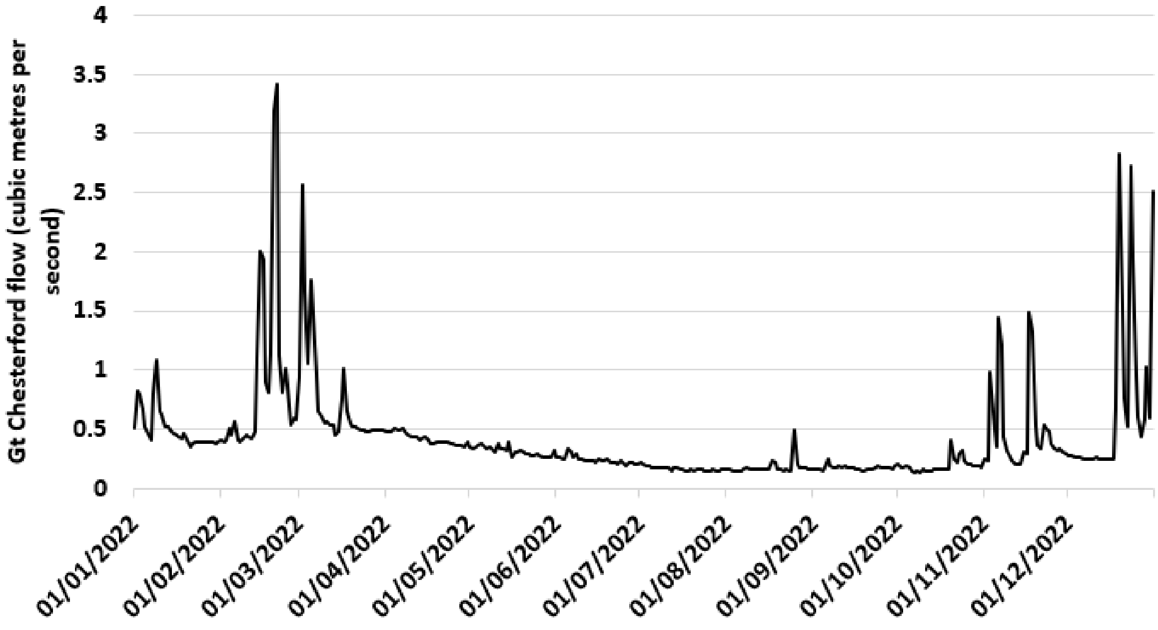
When average final effluent flows are applied the total flow from STWs are considerably greater, depending on which reach of the river is being considered. Including Stapleford, from Anglian Water (average of 2016-2020): Quendon: about 4 l/s, Newport: 9.0 l/s, Saffron Walden: 35.8 l/s, Great Chesterford: 12.1 l/s, Elmdon: 3.3 l/s, Hexel/Huntsman at Hinxton(private data source): 42 to 111 l/s, Sawston: 29.8, total: 136 l/s (11.8Ml/d).

Fortunately for citizen scientists, river flows are easily accessed at the EA hydrology website.

Flow data are important information and were used by the EA in decision-making on the suitability of a watercourse to receive effluent from a new or expanding STW. Flows are also used for modelling e.g. SAGIS, to determine Phosphorus apportionment in reaches. Daily flows are used by the EA to regulate river support augmentation. Up to about twenty percent of all groundwater abstraction from our aquifers is estimated to be used to support flows. Without support, flows of some rivers in the Cam catchment in summer, when aquatic biological activity is high, would sometimes be very low, or even zero, and pollutant chemicals and nutrients would attain even higher concentrations.

An example of river flow is at Great Chesterford which can be found here:
https://environment.data.gov.uk/hydrology/station/30a48024-6672-49cd-9244-df510f46d422

Cam flow data for Great Chesterford, 2022 (Flows are reported in cubic metres per second = 1000 l/s = 86.4 Ml/day)



Experts at Affinity Water comment that:

> '*…there is a somewhat flashy nature to the catchment flow. Despite the Cam being groundwater fed, there is a large component of the flow that is from rainfall/runoff and/or shallow perched aquifer intermittent discharges.*
>
> *Monitoring data and previous investigations suggest the river has little or no baseflow from the source to Wendens Ambo. The Chalk groundwater table is fairly below river bed elevation and the superficial deposits to downstream of Newport are of low permeability. Run-offs are therefore*

predominant. There are some perched aquifers especially in the interfluve, disconnected from the Chalk Public Water Supply abstractions. Those small aquifers are linked to the presence of glacial till (sand and gravel) with embedded layers of boulder clay; springs from those perched aquifers are likely to be activated following wet periods and get dry quickly after prolonged dry periods. This is evident in hydrographs of data of the Wicken Water, Debden Brook and Wenden Brook.

This is further confirmed by the base flow index of the catchment being 0.50 –0.65 in both average and wet conditions, suggesting that groundwater contribution is overall just above half of the total river flow.

Changes in land use (urbanisation of areas near Newport for instance) are likely to produce more runoff, decrease the amount of aquifer recharge and contribute to increase the runoff component of the flow compared to the aquifer discharge.'

9 HOW PHOSPHATE AND NITRATE RESULTS ARE REPORTED

CVF reports nitrate as NO_3, whereas the EA reports it as NO_3-nitrogen. For a given NO_3-N value the nitrate equivalent is 4.429 times higher.

CVF focuses mainly on the analysable entity Soluble Reactive Phosphorus (SRP) and also on Total Phosphorus (TP).

The nomenclature for Soluble Reactive Phosphorus (SRP) is very challenging. Inorganic, Soluble Reactive Phosphorus forms a substantial part of Total Phosphorus in flowing, clear river water. Orthophosphate is the simplest molecular form of Phosphorus – the anion is one atom of phosphorus plus four of oxygen, PO_4^{3-}. It is sometimes called OP, or 'soluble reactive phosphate' but is more accurately described by analytical scientists as 'soluble reactive phosphorus'. The EA reports it as 'orthophosphate, reactive as P' in its publications (in all EA archive data used in this report) and is equivalent to Soluble Reactive Phosphate-P / SRP-Phosphorus / SRP-P / 'PO_4-P' / orthophosphate-P. The South East Water laboratories report their results as 'Phosphorus-SRP' which is another way of saying SRP-Phosphorus.

I gleaned some of the above from a clarifying email from Virginie Chotard, the EA Senior Environmental Planning Officer (Water Quality) sent out to EA staff on 29 September 2010.

She says, "I recently had a query about the relationship between orthophosphate and Soluble Reactive Phosphorus (SRP) in terms of converting factors. I can confirm that ***orthophosphate and SRP are the same*** *and no converting factor should apply.*

Please see attached confirmation from the national Lab Service".

The confirmation that Ms Chotard refers to

"*Det 180 is described as "OrthoP, reactive as P" commonly referred to as Orthophosphate PO_4^{3-}.*

In the literature it is also known as SRP (Soluble Reactive Phosphate). ***For our methodology this would be accurately described as Soluble Reactive Phosphorus****,*
as the chemistry will oxidise some easily oxidised Phosphorus compounds.
For many samples the analysis of Soluble Reactive Phosphate and Soluble Reactive Phosphorus will be same as the vast majority of the P will be in the form of PO_4 (Phosphate)"

The important point is that the EA and CVF values as reported to show the concentration of Phosphorus. From some reports in the literature, I suspect that the name "Soluble Reactive Phosphorus" has been used erroneously to show the value of the Phosphorus in the SRP.
We do not want confusion between workers and those who read publications and I hope the comments above clarify the nomenclature.

Note that for Citizen Science monitoring hand-held checkers such as made by Hach or Hanna display results as orthophosphate, akin to SRP. These latter values are roughly three times higher than values of the Phosphorus when the same concentrations are reported as orthophosphate-P / PO_4-P / reactive as P / 'soluble reactive phosphate-P / 'soluble reactive phosphorus'-P. I recommend that all values are converted to Phosphorus values for reporting.

Water companies with Phosphorus consent limits need to monitor their STWs at the inlet and final treated effluent stages to analyse for Total Phosphorus (among other parameters) to check that they are discharging within the agreed consent. Data on Total Phosphorus is important to the EA to understand sources of load entering watercourses from a range of sources, and to research the fate of Phosphorus within the river particularly in the bed sediment. In land soils and river sediments, Phosphorus is largely locked up in insoluble compounds often firmly bound to soil particles. It seems that only a small proportion of this in river bed sediments is converted to SRP at any one time. If orthophosphate concentrations are greatly reduced in the water while high concentrations of legacy Phosphorus remain in the sediment this equilibrium may change over time and more orthophosphate is released from the sediment – research is ongoing.

10 NUTRIENT ENRICHMENT /OVERLOAD – EUTROPHICATION

Phosphorus (P) and nitrogen (N) are the main nutrients involved in eutrophication, with phosphorus the main cause of eutrophication in freshwaters. Resultant excessive growth of algae can smother the river bed and deprive other plants of living space. Their growth can cause large diurnal changes in dissolved oxygen, amplified by bacterial activity during plant decomposition which is a further drain on oxygen levels. Diversification suffers.

Mainstone et. Al. wrote this in "Phosphorus and river ecology Tackling sewage inputs" published 2000[1]

[1] Phosphorus and river ecology *Tackling sewage inputs Mainstone, C. P., Parr, W. and Day, M.* March 2000

Natural phosphorus concentrations in river water are likely to lie below 30 μg l-1 (0.03 mg/l)in most cases, with background concentrations (admitting a small amount of human influence) somewhat higher than this.

Increasing soluble phosphorus concentrations from background levels to 200 - 300 μg l-1 (0.2-0.3 mg/l)and above therefore constitutes an important mechanism for the decline of submerged higher plants. Phosphorus concentrations in both the water column and the sediment can be important.

To promote healthy riverine plant communities and the wide range of animal species dependent on them, Phosphorus concentrations should be reduced to as near background levels as possible. The risk of adverse effects declines as phosphorus concentrations approach background levels, such that any incremental reduction should be seen as a positive step towards trophic restoration.

10.1 Water quality parameters for near-pristine Chalk streams

Based on French work and some historic English references, C. P. Mainstone (1999) [2] constructed a list of Key water quality parameters including phosphorus and nitrogen, with values expected in near-pristine conditions. Note that nitrate-nitrogen for lower reaches was set at 1.0 mg/l. This is 4.429 mg/l nitrate.

Indicative values (annual means) of key water quality parameters in Chalk rivers under near-pristine conditions

Parameter	Upper reaches	Middle reaches	Lower reaches
Suspended solids (mg l^{-1})	<2	4	6
SRP (mg P mg l^{-1})	<0.01	0.02	0.03
Total Phosphorus (mg P l^{-1})	0.02	0.04	0.06
Nitrate (mg NO_3-N l^{-1})	0.2	0.5	1.0
Total Ammonia (mg NH_3-N l^{-1})	0.01	0.03	0.05
pH	7.8-8.0	7.8	7.4

In this current third cycle of the EA's River Basin Management Plans, the EA recognises that, overall, agriculture and rural land management has now overtaken waste water treatment works as the most common cause of water bodies not achieving good status for nutrients.[3] This is a significant change from the second cycle when water industry sewage works were the most common cause. Of course, this does not apply to all river systems equally.

10.2 Reasons for Not Achieving Good Status (RNAG)

RNAG is a formal statement by the EA on rivers, providing information on management issues that prevent rivers reaching good status, attributable to identifiable sectors. Water bodies will have some negative issues common to all, but occasionally some reasons will be omitted for a specific element. For instance, for the reach Audley End to Stapleford, 'agriculture and rural land management' is not mentioned as a reason for Not Achieving phosphate. Sewage discharge (a point source) is an issue not only for phosphate but also affecting higher-order plants and river-bed plants.

RNAG for Water body GB105033037590, Audley End to Stapleford

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[2] Mainstone C. P. 1999, Chalk Rivers Nature and Conservation, part 1, page 18. http://publications.naturalengland.org.uk/publication/5981928

[3] Phosphorus and Freshwater Eutrophication Pressure Narrative (October 2019) https://consult.environmentagency.gov.uk/environment-and-business/challenges-and-choices/user_uploads/phosphorus-pressure-rbmp-2021.pdf

SWMI (Significant Water Management Issues)	Activity	Category	Classification Element
Point source	Sewage discharge (continuous)	Water Industry	**Phosphate**
Point source	Sewage discharge (continuous)	Water Industry	Macrophytes and Phytobenthos Combined
Point source	Trade/Industry discharge	Industry	Macrophytes and Phytobenthos Combined
Point source	Trade/Industry discharge	Industry	**Phosphate**
Unknown (pending investigation)	Unknown (pending investigation)	Sector under investigation	Perfluorooctane sulphonate (PFOS)
Physical modification	Other (not in list, must add details in comments)	Local and Central Government	Mitigation Measures Assessment
Physical modification	Other (not in list, must add details in comments)	Agriculture and rural land management	Mitigation Measures Assessment
Measures delivered to address reason, awaiting recovery	Not applicable	No sector responsible	Polybrominated diphenyl ethers (PBDE)
Flow	Groundwater abstraction	Agriculture and rural land management	Hydrological Regime
Flow	Groundwater abstraction	Water Industry	Hydrological Regime
Flow	Groundwater abstraction	Industry	Hydrological Regime
Flow	Surface water abstraction	Agriculture and rural land management	Hydrological Regime

CVF has, or course, concern about all classification elements in the table above, but for this report the focus is orthophosphate.

10.3 SAGIS MODELLING

SAGIS (Source Apportionment Graphical Information System) apportions contributions of Phosphorus load to potential sources. It has been updated in 2022 using data from 2014-2021. The model helps to estimate the 'Fair Share' of Phosphorus reductions required by various sectors to achieve a good status. Fair Share as a concept is a significant issue as it allows the EA to judge critically where effort is needed most, particularly for wastewater investment planning. Estimates from diffuse sources in general have a greater degree of uncertainty that estimates for STWs.

SAGIS output for the Essex Cam and its tributaries (accessed 29/11/23)

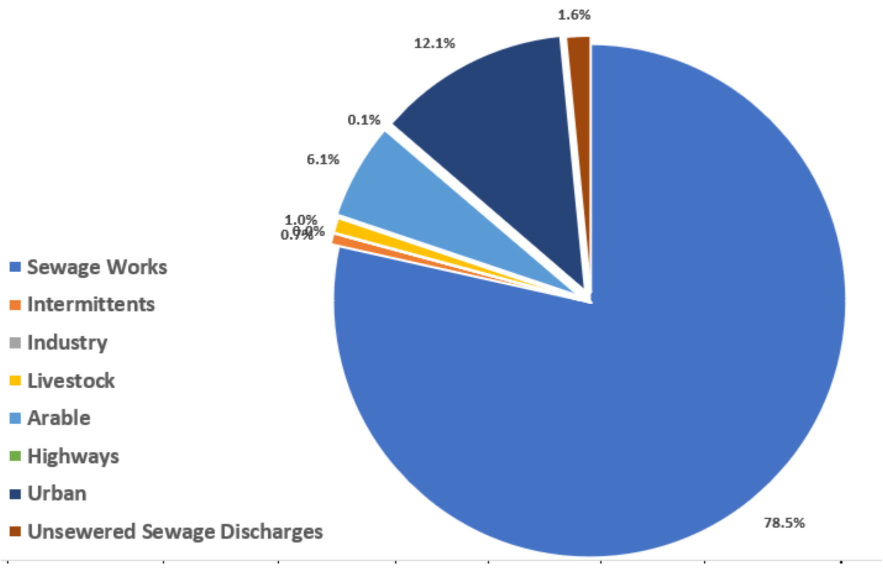
Water Body ID	Water Body Name and Reaches	Sector percent load contribution							
		Sewage Works	Intermittents	Industry	Livestock	Arable	Highways	Urban	Unsewered Sewage Discharges
Essex Cam, main river									
GB105033037	Cam (US Newport)	29.25%	1.75%	0.00%	0.10%	20.67%	1.04%	25.39%	21.80%
GB105033037	Cam (Newport to Audley end)	33.44%	0.37%	0.00%	5.28%	34.29%	0.16%	17.33%	9.12%
GB105033037	Cam (Audley end to Stapleford)	78.50%	0.70%	0.00%	0.96%	6.07%	0.07%	12.14%	1.55%
Essex Cam tributaries									
GB105033037	Wicken Water	0.00%	4.43%	0.00%	7.03%	63.36%	0.52%	9.60%	15.06%
GB105033037	Wendon brook	0.00%	0.00%	0.00%	23.50%	66.09%	0.41%	0.10%	9.90%
GB105033037	Debden water	41.02%	0.04%	0.00%	4.62%	39.40%	0.00%	8.99%	5.92%
GB105033037	Slade	90.84%	0.71%	0.00%	0.19%	1.66%	0.00%	5.94%	0.67%
GB105033037	Tributary of Cam (Ickleton Brook)	96.61%	0.28%	0.00%	0.20%	1.16%	0.16%	1.04%	0.55%

The data used is the average Phosphorus load accumulated at the end of each reach. It is said that load data are converted to in-river concentration data but it is more complicated than that. The load does not directly relate to concentrations of orthophosphate in the water. For instance, winter runoff into the river during high rainfall may pollute the river with soil-adhering phosphorus and allow a build-up of phosphorus in the sediment but at the same time the concentration of orthophosphate in the river water would likely to be low, diluted by higher flows. Conversely, the additional load from the arable sector in a dry summer period might be low or zero, yet orthophosphate levels might be high, because discharge from STWs is constant and becomes more concentrated in the river water in low summer flow. The mechanics that produce the outcomes for each contributing sector are complex.

It is noteworthy that some campaigners for reduction of orthophosphate levels in the Essex Cam may not agree with the model (partly because there seem to be two issues to debate, and partly because of poor comprehension of the model' outcomes). On the Newport to Audley End reach, the model suggests that STWs contribute only 33.44%. Yet in summers when the Debden Water, Wicken Water, and the main river can be dry above Newport STW, the sewage works and its treated effluent from it becomes the 'head of the river'. Despite some freshwater entering the Cam before Audley End and augmentation by Affinity Water the figure of 33.44% still seems too low. To iterate, the model uses data on average load entering the reach, over the year, and this explains why sewage works is deemed to 33.44%, even less than agriculture at 34.29%.

The SAGIS model's outcomes do not always sit well with the view of campaigners who believe they have evidence to attach blame to STWs, and when they find high levels of orthophosphate in their rivers in the summer and see tragic deterioration in the quality of plant-life and a proliferation of slimy algal matting, largely it seems as a result of the orthophosphate. However, Phosphorus inputs into rivers in runoff must be acknowledged too.

An example when the model estimates that a sewage works does contribute a far higher proportion (78.5%) of the total load is the reach Audley End to Stapleford, as shown below.



10.4 Water Framework Directive standards

Standards for phosphorus in UK rivers and lakes were introduced under the Water Framework Directive (WFD) in 2009 and the river standards were updated in 2015. These aimed to prevent/limit eutrophication

CVF uses the thresholds for orthophosphate in the following Table to describe the status of a reach from High to Poor. Data ought to be collected over a three-year period to do this formally so results are only indicative. The equations to calculate the threshold bands are in Appendix 2.

Water Framework Directive Soluble Reactive Phosphorus Standards for the typical alkalinity and altitudes of the Cam Catchment

	Status				
	High	Good	Moderate	Poor	Bad
Bands, P (mg/l)	0.00 - 0.05	0.051- 0.089	0.090 - 0.211	0.212- 1.089	> 1.089

Thus, a local Chalk stream with 'good' status has roughly just less than 0.1 mg/l orthophosphate-P.

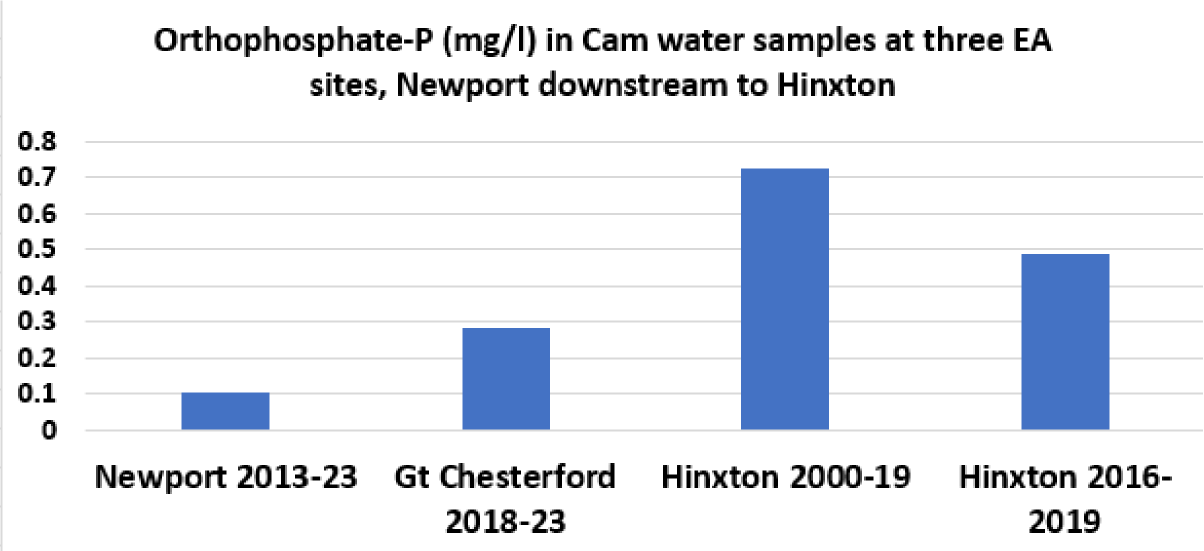
For comparative purposes, the River Wye and River Lugg are areas of special importance for nature conservation, both being SSSIs. The lower stretches of the Lugg, along with the Wye, are also a part of the River Wye Special Area of Conservation (SAC). Natural England's phosphate targets are set at 0.03 mg/l orthophosphate-P in the upper River Wye sub-catchment, and 0.05 mg/l in both the River Lugg and lower River Wye sub-catchments.[4]

The Cam catchment can boast that the small Hoffer's Brook has very low orthophosphate-P levels (<0.01 to 0.03 mg/l, 2013-2022), near its confluence with the Rhee; and Wicken Water has <0.02 to 0.07 mg/l at Newport. Several other Chalk streams also have exceptionally low levels near the spring head, e.g. Hobson's Conduit, but this is to be expected as very little orthophosphate is present in the aquifer.

11 EA ORTHOPHOSPHATE DATA, NEWPORT TO HINXTON

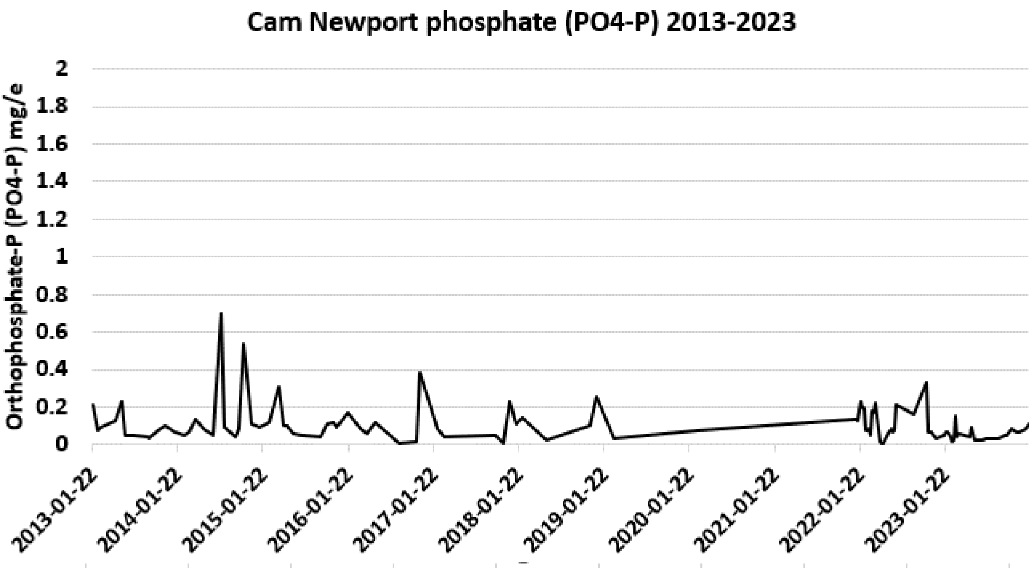
The following charts show data extracted from EA WIMS. In sequence the charts are for the sampling sites at Newport (Station Road), Great Chesterford road bridge, then Hinxton road bridge. They are not the same range of years, and often they are not sampled on the same dates thus factors such as flow cannot be discounted. Periods such as COVID-19 lockdown produced gaps in sampling, which shows up in the charts.

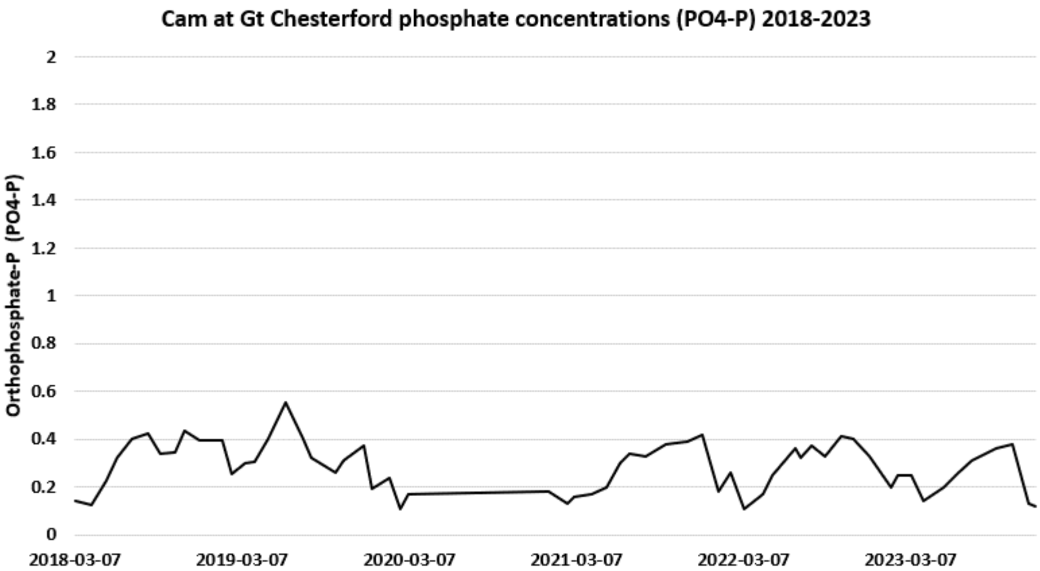
Nevertheless, the mean figures of orthophosphate-P at each site show a marked increases in levels of orthophosphate downstream, particularly at Hinxton. The increase is not so marked if Hinxton data earlier than 2016 is omitted.

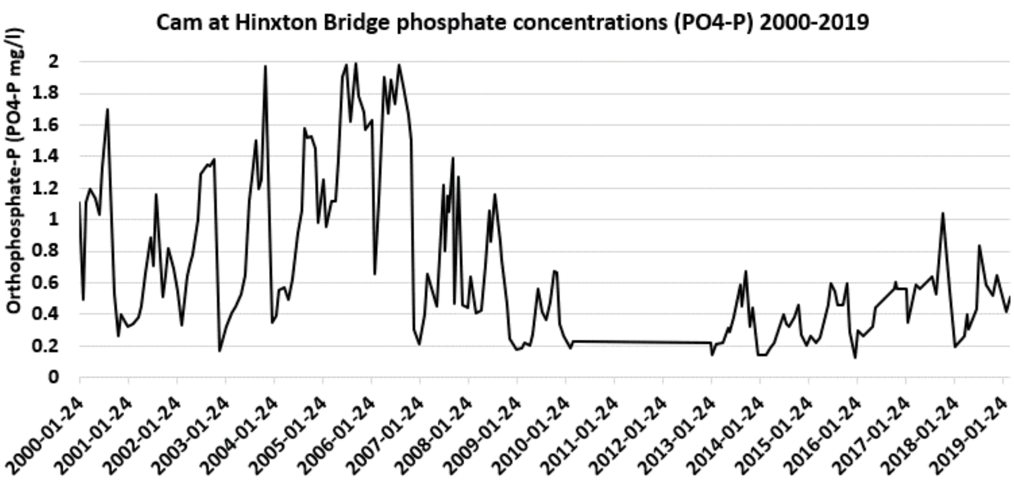


The full data for the individual sites are shown below . The sampling period and sample numbers vary between sites.

[4] Compliance Assessment of the River Wye SAC Against Phosphorus Targets https://naturalresources.wales/evidence-and-data/research-and-reports/water-reports/river-wye-compliance-report/?lang=en


Cam Newport phosphate (PO4-P) 2013-2023
Orthophosphate-P (PO4-P) mg/e
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2013-01-22
2014-01-22
2015-01-22
2016-01-22
2017-01-22
2018-01-22
2019-01-22
2020-01-22
2021-01-22
2022-01-22
2023-01-22


Cam at Gt Chesterford phosphate concentrations (PO4-P) 2018-2023
Orthophosphate-P (PO4-P)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2018-03-07
2019-03-07
2020-03-07
2021-03-07
2022-03-07
2023-03-07


Cam at Hinxton Bridge phosphate concentrations (PO4-P) 2000-2019
Orthophosphate-P (PO4-P mg/l)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2000-01-24
2001-01-24
2002-01-24
2003-01-24
2004-01-24
2005-01-24
2006-01-24
2007-01-24
2008-01-24
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2017-01-24
2018-01-24
2019-01-24

11.1 EA IN-DEPTH STUDY OF DATA FROM CAM SAMPLES AT NEWPORT, STATION ROAD

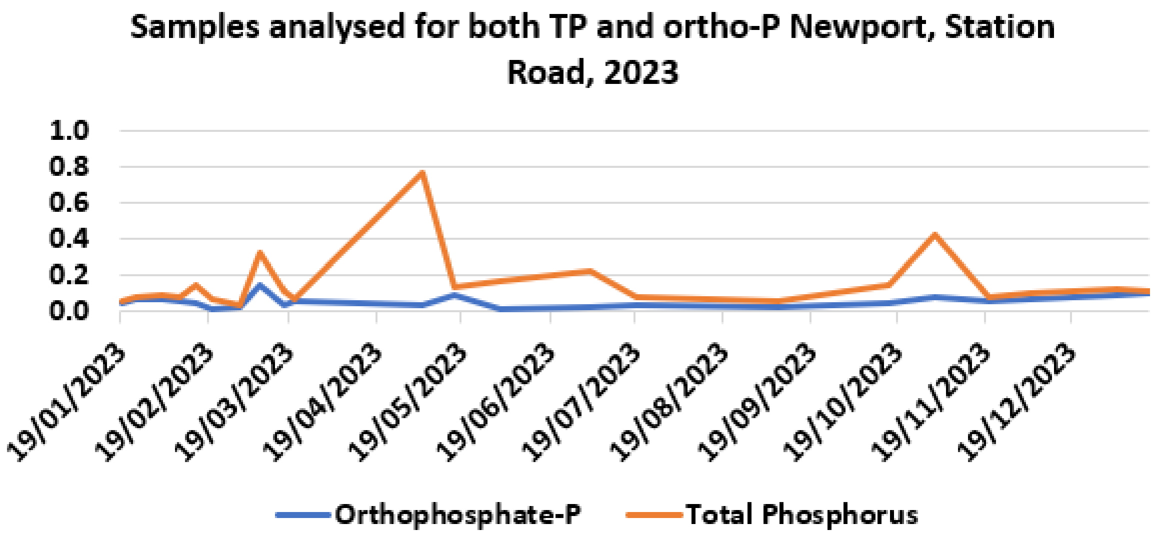
It is noteworthy that the EA has engaged in intensive sampling of the Cam at Newport, Station Road from 2022 to date - 90 sampling attempts over 25 months, which include 19 fails because of no-flow. This sampling frequency is unprecedented in my experience and, for a river, analyses of up to seven forms of nitrogen and three forms of phosphorus is uncommon.

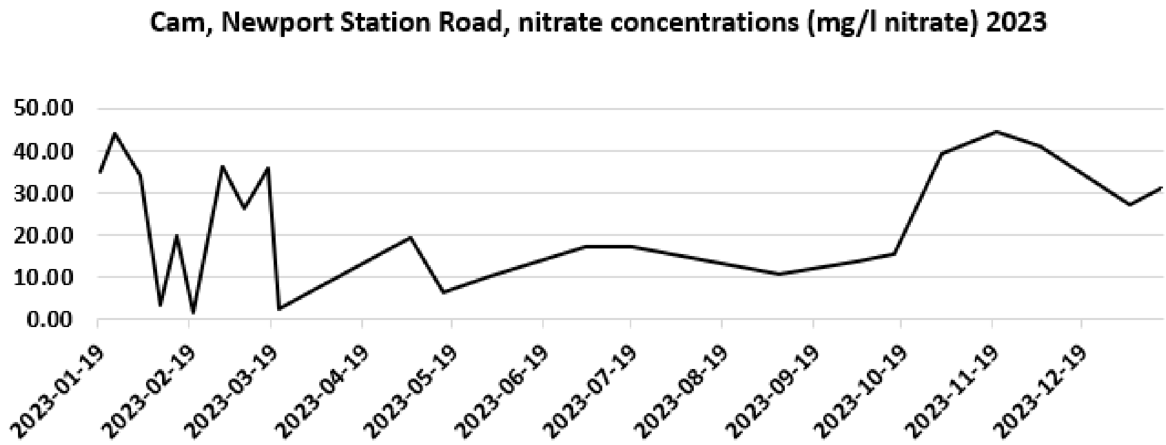
The intensive sampling started in 2022 but that year is not shown here as there were so many no-flow lack of samples.

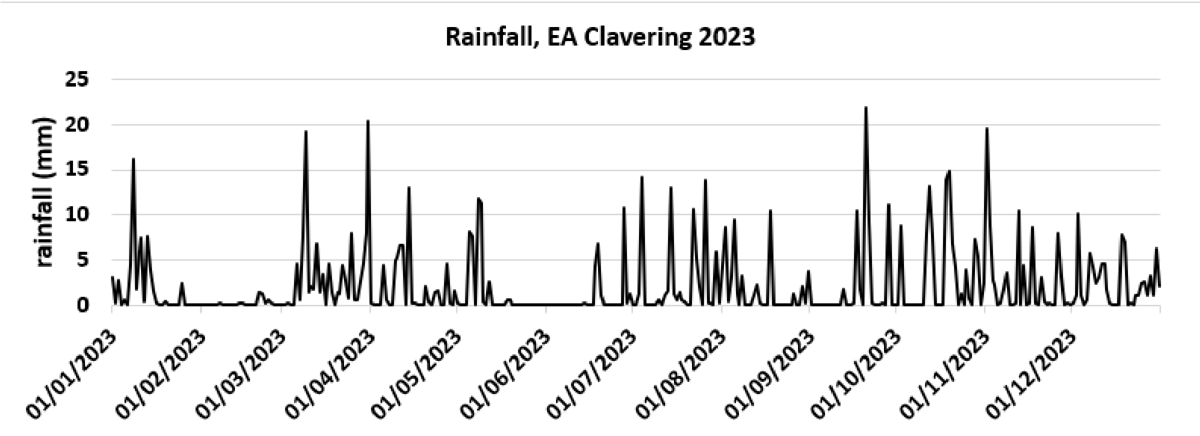
Clearly, there is some important underlying reason for this sampling, which could perhaps be modelling of flows in an intermittent-flow reach, or a re-assessment of the influence of the upper reach quality on water quality downstream . This is EA water quality sampling *par excellence*, and although citizen science volunteers would be capable of doing similar studies, the requirement for UKAS laboratory analyses creates one more level of organisation, effort, time and funding.

Having compared the Newport 2023 results of Total Phosphorus against orthophosphates-P, when both were analysed in the same samples (22 samples), and then comparing these with nitrate results and the rainfall in the same period, patterns start to emerge. There are indications that the changing ratios over time of the different phosphorus entities are linked to changing proportions from runoff and from the aquifer. Marked changes in nitrate concentration allow further interpretations.

Reporting of the entire dataset and interpretations of it by the EA will make interesting reading.







12 CVF WATER QUALITY MONITORING

One aim of the nutrient monitoring was to try to apportion river levels of orthophosphate and to a lesser extent nitrate to point or diffuse sources.

Monitoring started in 2021, with two separate aims: first a programme designed to measure the distribution and abundance of faecal indicator bacteria in the Rhee and Cam. The aim was to try to apportion levels to categories of origin – sewage treatments works, agriculture, urban, or 'wild'. These data would be used to inform Anglian Water regarding whether disinfection of a nearby STW (Haslingfield) would be justified, linked to an application by CVF to Defra for a Designated Bathing Water at Sheep's Green, on the Cam at Cambridge. In 2022, some faecal bacteria sampling was done at Dernford on the Essex Cam and at Sawston STW but mainly for local reasons. This faecal contamination project is reported elsewhere.

The second aim was to determine the concentrations of two major nutrients phosphorus (as orthophosphate and Total Phosphorus) and nitrogen (as nitrate). With additional funding in place, monitoring was expanded to reach out further upstream on the Rhee, to the Granta and the Essex Cam. The latter reach of the river was not sampled until later in the project, from May to November 2022. With adequate funding now in place for laboratory analyses of samples, sadly and frustratingly restrictions on volunteer input time prevented a full survey of the river, Mike Foley being the only sampler for this reach. Some STWs and smaller reaches were not visited, and more frequent sampling would have been more useful.

Unless reported otherwise, samples were sent to and analysed at the UKAS laboratories of South-East Water, via a dedicated refrigerated collection van.

Reports No. 1 and 2 covering the 2021 summer results can be accessed from the CVF website at

- https://camvalleyforum.uk/wp-content/uploads/2021/11/Report-No.-1-CVF-Water-Quality-Testing-of-the-Cam-21-08-24.pdf

- https://camvalleyforum.uk/wp-content/uploads/2021/11/Report-No.-2-Cam-Valley-Forum-Water-Quality-Monitoring-of-the-Cam.pdf

However, these reports do not cover the late monitoring on the Essex Cam.

12.1 August Monitoring at Sewage Treatment Works for nutrients

EA does not publish Phosphorus levels in treated final effluent if the STW does not have phosphorus reduction treatment, and orthophosphate levels are also not reported. It was decided therefore that collection of data on orthophosphate was a good reason for sampling at STWs. With this information, sampling the watercourses both upstream and downstream of the STWs' outfalls would be more meaningful.

At any sampling time, levels of Total Phosphorus should be the same or higher than those of orthophosphate-P. Occasionally when TP levels was found to be slightly lower, this probably resulted from some samples taken for each analysis separately (about one minute apart). Alternatively, a direct comparison between a TP value and an orthophosphate-P value is lost when values are meaned.

Caution: a small number of samples will usually have a higher degree of uncertainty attached to them, in that variability is higher and individual data points are more scattered about the population mean.

An interactive map of the sampling sites can be found here. https://www.google.com/maps/d/edit?mid=1Y-abnA3WbzhWH09t0sSKHldEUIrK2F0&usp=sharing

Of the seventeen Anglian Water and two private sewage works that CVF monitored through the Cam catchment, six are associated with the Essex Cam.

12.2 Sources of orthophosphate and nitrate at STWs

Orthophosphate has many sources, with less in detergents in recent years since legislation was limited amounts supplied in products. An additional burden on STWs is the orthophosphate deliberately added to our water supply to control plumbosolvency, to protect the water from deposition of lead from lead pipes. Orthophosphate in water supplied to Zone 2 in Cambridge tends to mean around below 0.5 mg/l (CWC, unpublished). Levels vary and at times, some Anglian Water supply can contain over 1.0 mg/l. Affinity Water inputs are not known.

It can be assumed that nitrate levels are high where supply is the aquifer groundwater, and will therefore remain high in wastewater delivered from homes to STWs. It is present in the local water company's water supply in Zone 4 (Linton) at a mean of 34 mg/l (CWC published quality report). It is assumed that some nitrate arises from other additions prior to delivery to the SWTs. It is further increased by nitrification of ammonium in the sewage liquor into nitrite, then nitrate. Nitrification is a vital component of the treatment process to reduce the high levels of ammonium entering the STWs to levels below consent limits in the final treated effluent.

12.2.1 CVF Orthophosphate results at STWs

Orthophosphate levels were found to vary considerably between works, the defining factor being whether the STW had a Phosphorus discharge consent. Saffron Walden and Sawston STWs did not have high concentrations in their treated effluent because they have consent limits imposed and Phosphorus-stripping treatment (ferric sulphate) had been added to the works. They were discharging below their permitted limits. The private Huntsman/Hexel works had low phosphorus inputs hence there is a low level in the discharge.

Checking the EA data in EA WIMS shows that the last record of orthophosphate analysis at Great Chesterford STW was in 2008. In that year measurements ranged from 4.16-6.14 mg/l orthophosphate-P. CVF's two samples, averaged, were 4.68 mg/l and within that range. The Bassingbourn's level of 2.414 mg/l (mean of 1.145 and 3.682) appeared low, but also fits well with EA figures last published in 2008.

It is clear that orthophosphate concentrations in treated final effluent are high if no pro-active additional treatment such as P-stripping is added to the works.

CVF orthophosphate, nitrate and Total Phosphorus monitoring at sewage treatment works (16 May 2022 to 28 November 2022)

Discharge watercourse	Datset for sewage treatment works pure effluent	Number samples for Orthophosphate-P	Mean Orthophosphate-P (mg/l)	Number samples (Total Phosphorus)	Total Phosphorus (mg/l)	Number samples (Nitrate)	Nitrate (mg/l)
Bourn Brook	Bourn STW	1	7.838	1		1	35.7
Essex Cam	Quendon STW	2	6.194	1	5.24	2	173.4
Granta	Linton STW	6	5.664	1	5.01	3	123.9
Essex Cam	Newport STW	2	5.022	2	4.98	2	69.8
Essex Cam	Great Chesterford STW	2	4.682	1	4.09	1	99.4
Mill River>Rhee	Litlington STW	1	4.450	1	4.48	1	94.7
Mel>Rhee	Melbourn STW	4	4.190	1	4.57	1	50.3
Granta	Bartlow Barns private STW	1	3.930	-	-	1	64.8
Bourn>Granta	Ashdon STW	3	3.785	1	5.26	2	165.1
Rhee	Foxton STW	3	3.630	-	-	-	-
Granta	Shudy Camps STW	3	2.550	1	2.09	3	81.9
Mill river>Rhee	Bassingbourn STW	2	2.414	1	1.38	2	70.2
Rhee	Haslingfield STW	7	0.803	1	1.78	3	62.7
Essex Cam	Saffron Walden STW	1	0.684	1	0.95	-	-
Essex Cam	Sawston STW	4	0.660	1		1	108.0
Cam	Cambridge STW	5	0.396	1	0.26	1	77.9
Rhee	Ashwell STW	2	0.338	1	0.43	2	95.8
Essex Cam	Huntsman/Hexcel private STW	2	0.103			2	41.0
Hoffer Brook	Duxford Water recycling centre *Hanna HI-713 test	1	5.57*				

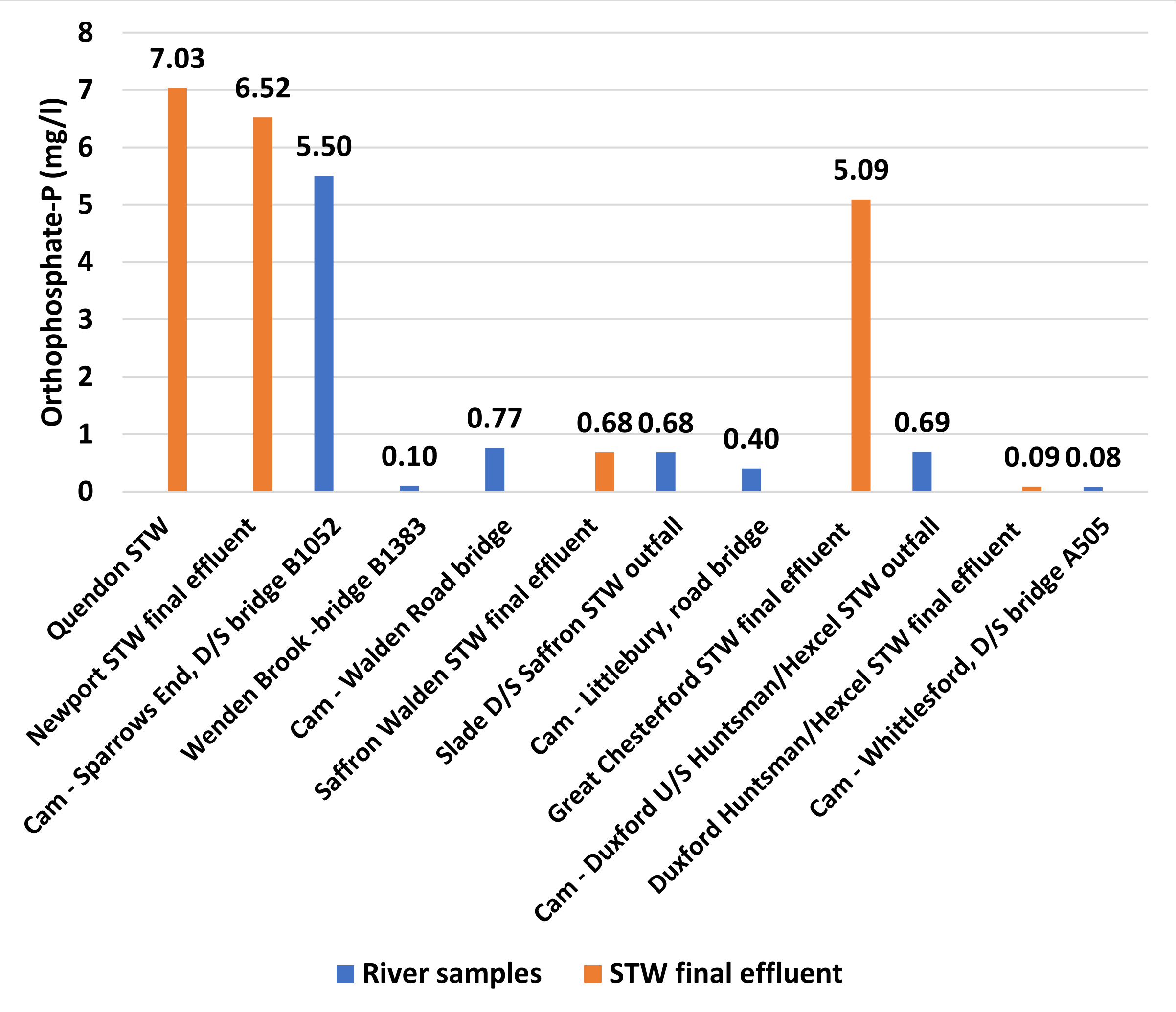
12.2.2 CVF Nitrate results at STWs

Nitrate levels in spot samples ranged from 41 to 173 mg/l nitrate.

12.3 Monitoring rivers for nutrients

The aim of sampling on 16th August 2022 was to measure orthophosphate at strategic sites from Quendon STW downstream to Whittlesford. Some river sites were in-between STWs, and some were just above or just below them. Several were also EA sampling sites.

CVF orthophosphate-P concentrations in sequenced samples taken on 16 August 2022



12.3.1 Orthophosphate results for river samples

1) Quendon STW

With an average discharge of about 4 l/s, it had the highest orthophosphate concentration. The ditch was dry above the STW outfall and effluent started the flow in the discharge ditch which drains various arable land and some dwellings upstream. The flow was unlikely to reach the Cam, probably sinking into the bed. Phosphorus settling into the ditch bed from soil runoff when it occurs (see photo, 23 November) would be redistributed along the ditch during higher drainage flows from upstream of the STW. The outfall is only 340m from the Rhee.

2) Cam - Newport

The Cam at Station Road bridge, Newport was damp at most, with no flow. EA sampling reports for the same site confirm that no-flow situations occurred on 15 visits between 17 June to 18 Oct with just three samplings achieved in that period.

Cam Station Road bridge, Newport, 16 August 2022

3) The Cam above Newport STW (Water Lane)

The Cam consisted only of pools of stagnant water. Further upstream, Wicken Water and Debden Water were not flowing into the Cam, similar to the situation during dry periods in 2019.

Archive photograph 29 August 2019, dry bed at confluence of Debden Water and Cam

The ‘head of the river’ on this date was effectively the treated effluent from Newport STW, with its very high concentration of orthophosphate-P (6.52 mg/l). With a very high concentration of nitrate also in the effluent, the Cam immediately became eutrophic. Average flow was 9 l/s (no doubt increased since 2020).

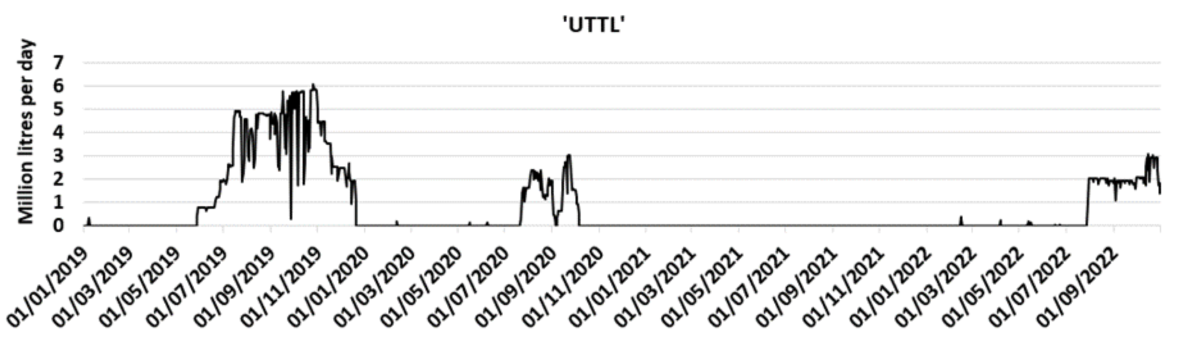
4) Cam - Sparrow’s End, downstream of the bridge on B1052

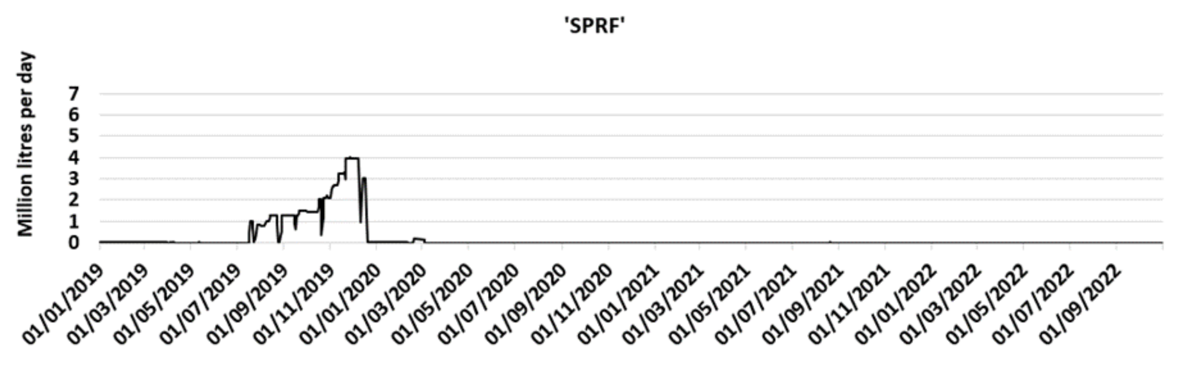
1.5km downstream of Newport STW, orthophosphate-P was still at a very high level (5.50 mg/l).

5) Wendon Brook, B1383

This Chalk stream was sampled shortly before it discharges into the Cam.   The stream itself was flowing, ‘more than a trickle’, and had a pleasingly low level of orthophosphate-P (0.10 mg/l). It would be influencing the nutrient content of the Cam by diluting it.   At a point upstream of Walden Road, the UTTL augmentation was providing support at about 23 l/s at the time of CVF’s 16 August sampling and again would be dilutive. The borehole water could have probable orthophosphate-P content of less than 0.01 mg/l. Wendon Brook flow could not be measured but was probably greater than 15 l/s.

When river flows at a monitoring station at Great Chesterford reduce to 147 l/s, it triggers a requirement by Affinity Water to start discharging bore-hole groundwater into the River Cam to maintain flows at or above this flow (Compliance & Ethics, Affinity Water, accessed 9 November 2022). Data for 2019 to 2021, and 2022 to 11 October were requested by CVF. Data for all years for comparison are charted below, for the two augmentation points UTTL and SPRF. In this period, 2019 was shown to require most support, less in 2020, none in 2021, and a resumed need in 2022.





6) Cam – Walden Road bridge

Only 840m downstream from the confluence of Wendon Brook and the Cam, there was a dramatic reduction in orthophosphate-P to 0.77 mg/l.   This was due to dilutive effects of incoming higher-quality waters. This level was however still an intolerably high level especially for that time in the year, when biological activity was still high.

7) Saffron Walden STW

With a measurement of 0.68 mg/l in the final treated effluent, this works was working comfortably within its consent limit. The average discharge flow of 35.8 l/s swells the Madgate Slade and in summer when the Slade is dry upstream it becomes the ‘head of the Slade’. Ultimately it discharges into the Cam.

Madgate Slade 16 August 2022, from upstream of the STW discharge outfall. The discharge can be seen in the distance; the discharge flow is sufficient to move the discharge backwards upstream about 30m.

Saffron Walden STW discharge outfall point into the Madgate Slade, 16 August 2022. We hope that the Moorhens bred successfully, with minimal human disturbance.

Archive photograph, Cam in eutrophic state - Audley End Hall Gardens, 24 June 2019

<u>8) Cam – Littlebury bridge</u>

The orthophosphate-P was now lower still, at 0.40 mg/l (but still too high a level). With few prospects of additional, natural flows into the river at this dry time of year to reduce the level to this, the reduction to this compared to Walden Road could have had several reasons:

- the slightly dilutive Slade flow entering the Cam

- all the while, direct evaporation away from the Cam surface will reduce flow and increase orthophosphate concentrations. Trans-evaporation losses will be marked where riverside and aquatic higher-order plants take up water via their roots. The counter-balance will be the rapid biological use of orthophosphate by these plants and the prolific algal masses.

- we should not mislead by analytical results from just a few samples. Some differences in orthophosphate values from samples will vary if taken just a few minutes apart and more frequent sampling is preferable.

Cam - just downstream of Little Chesterford, 26 March 2022, Algal mats over the river mat, strong growth enabled by high levels of orthophosphate

Credit: Richard Pavitt

Cam – Great Chesterford, June 2022, Very poor-looking river bed with algal mats. Richard Pavitt engaged in CURAT citizen science monitoring

Credit: EssexLive

Location of the EA hydrology measurement station on the Cam (blue pin)

On 16 August, the Cam flow measured by the EA was a mean of 158 l/s. Specifically at the time of sampling (1237h) it was 151 l/s. Without Affinity Support the flow would be around 125 l/s, or less taking into account trans-evaporation and some loss through the bed.

<u>9) Great Chesterford STW</u>

The very high orthophosphate-P level of 5.09 mg/l was immediately indicative that there is no Phosphorus-stripping at the works. The average effluent flow is 12 l/s. Uses these figures, this amount of orthophosphate would be diluted 13.58 times ((151+12)/12)) when effluent mixed with river water resulting in an estimated concentration mixed with river water of 0.37 mg/l. At Littlebury the concentration was 0.40 mg/l. Added together the estimate of total concentration is 0.77mg/l.

In my estimation, the contribution from the Great Chesterford STW effluent is significant, in the summer, in low flows.

Discharge outfall, west of M11 and downstream of Great Chesterford

10) Cam – Duxford Mill, main river and post-mill section

It is in this stretch that the Huntsman/Excel STW treated effluent discharges into the Cam. Immediately upstream of the outfall the orthophosphate-P level was 0.69 mg/l, fairly close to the figure of 0.77 mg/l estimated by adding together the Littlebury (0.40 mg/l) and Great Chesterford STW (0.37 mg/l) figures.

At the Huntsman/Excel site groundwater is sourced from on-site boreholes and is used as a coolant for their adhesives industry. After use it is discharged into the Cam via the treatment works which also receives surface water from the site, and sewage from just 190 residential homes in Duxford. The treated final effluent flow is mostly 153 to 200 cu metres per hour, peaking at 400 cu m /hr [42.5 l/s to 55.5 l/s, peaking at 111 l/s], source: Andrew Murray, Huntsman.

This is a substantial flow especially at the high end that will have considerable beneficial impact on the river flow and river water quality. On 16 August the river flow at Great Chesterford gauging station was 158 l/s. In a dry period it could be assumed the Huntsman effluent flow was 42.5 l/s. This flow would increase the Cam flow by 25%, and should substantially reduce levels of orthophosphate-P as the level in the effluent was only 0.09 mg/l (to be expected based on the source of water and its uses, even with some sewage from homes with an estimated usage of [140 x 3.5 persons] litres of supply per day becoming just 1.1 l/s of the total final effluent).

12) Cam – A505 road bridge

The lab report of only 0.08 mg/l orthophosphate-P is puzzling. A sample tested by myself using the hand-held checker Hanna HI-713 gave a reading of 0.40 on 10 August 2022. EA sampling on 1 August 2022 gave a result of 0.49 mg/l. It must be assumed that the 0.08 mg/l value is anomalous.

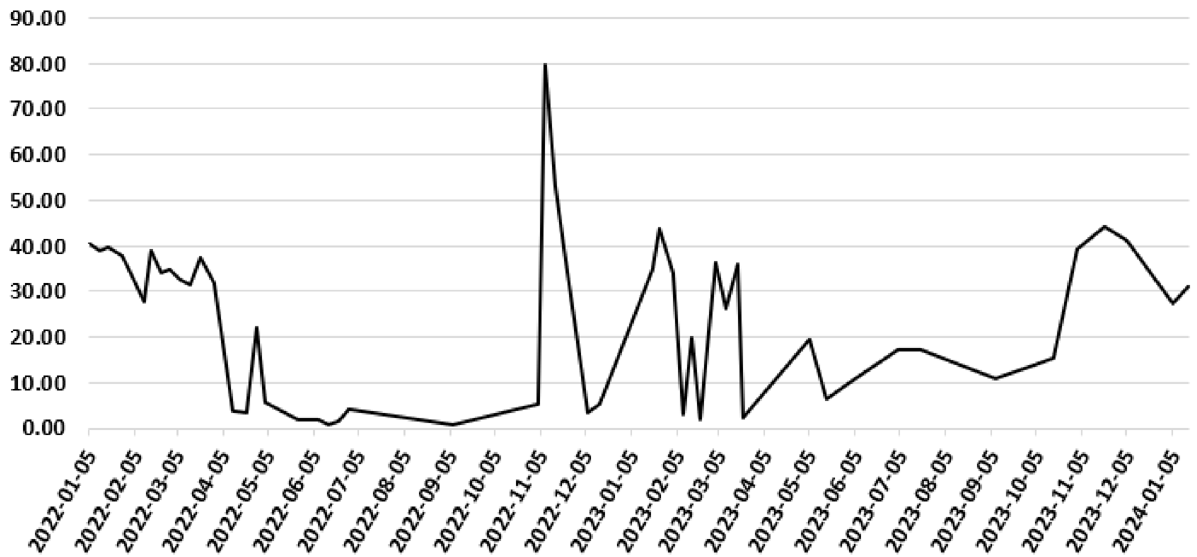
12.3.2 Nitrate results for river samples with EA data for comparison

Sources of nitrate will be mostly the aquifers (by way of agricultural contamination), sewage works or industry. Nitrate pollution of rivers is a broad-landscape problem, much of the high nitrate levels present in aquifers being associated with fertiliser usage in agriculture leaching into the aquifer from the soils above. Nitrate also leaches directly into ditches or directly into the river. STWs are at a disadvantage, having to accept wastewater from residential homes already contributing high levels of nitrate before the sewage arrives at the works. Few analyses were made for nitrate in the 16 August sampling, as so much data are available via EA WIMS. At Whittlesford A 505 bridge, the concentration was 43.1 mg/l nitrate, close to EA values around that time: EA samples measured 39.3mg/l on 1 August, and 43.7 on 8 September.

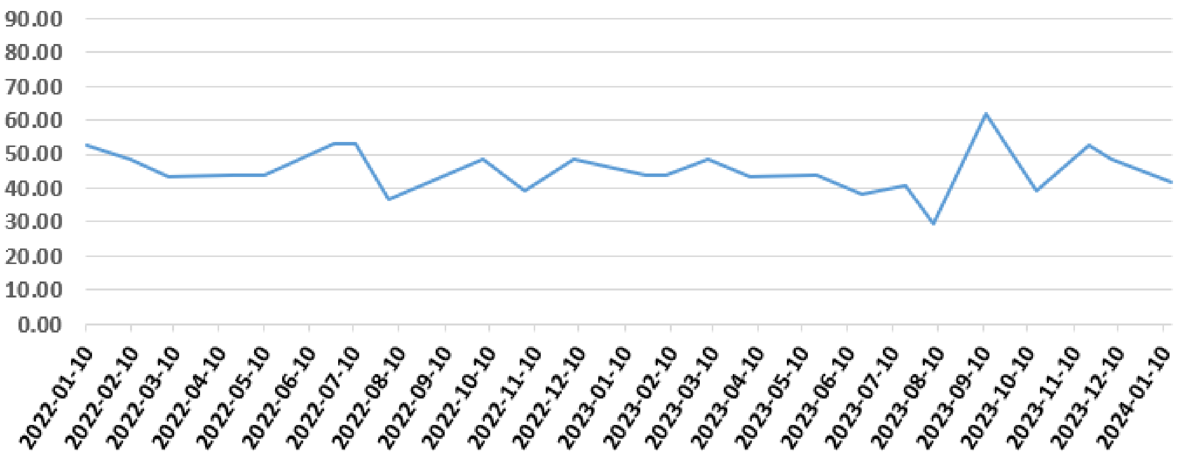
EA sampling has shown that nitrate concentrations varied hugely along the river. The data from Newport, Station Road bridge show a large range from 2022 to date - from just 0.84 mg/l nitrate to 79.71 mg/l. In contrast in the same period levels at Great Chesterford were higher and more stable, mostly 40 to 50 mg/l, minimum 29.18, maximum 61.99.

The differences in these EA data on nitrate levels - 52 samples analysed in a period of just 25 months at Newport (January 2022 to January 2024), show clearly in the following two charts.

Cam, Newport Station Road, nitrate concentrations (mg/l nitrate)



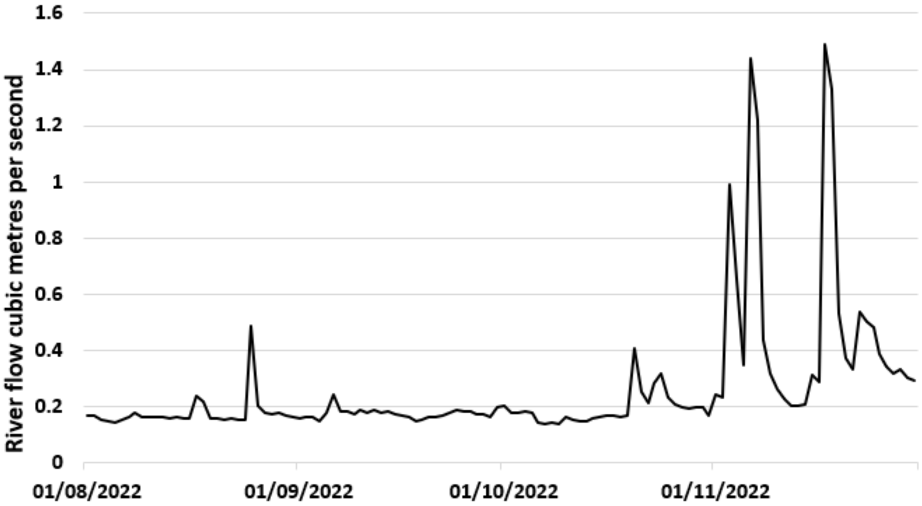
Cam, Great Chesterford, nitrate (mg/l nitrate)



12.4 Autumn sampling from the Essex Cam

Most autumn samples were taken on 23 November with a small number on 28 November. River flows and rainfall need to be taken into consideration when comparing results at different times of year. These data provide valuable information to help interpret the nutrient data collected.

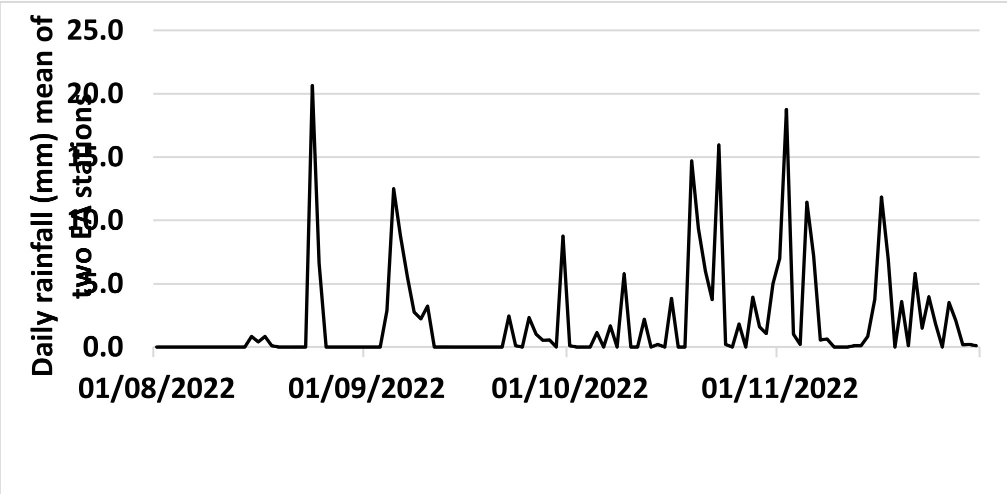
River flow recorded by the EA at Great Chesterford



Actual River flows at Great Chesterford on the upper Essex Cam sampling dates were:

16 August - 158 l/s
23 November - 501 l/s
28 November - 331 l/s

Rainfall data from two EA recording stations Ashdon and Elmdon



12.4.1 CVF STW samples taken on 23 November

Samples were taken from Quendon, Newport and Great Chesterford STWs final effluent on 23 November 2022, and from the Huntsman/Hexel private STW on 28 November. A sample was also taken on 28 November from Sawston STW, which discharges into the Cam at Dernford (samples also having been taken previously on 16 May, 29 June, and 1 August). All phosphorus results at the STWs are shown below

Dataset by STW	Mean Orthophosphate-P (mg/l)	Total Phosphorus (mg/l)
Quendon STW		
B9 16/08/22	7.034	
B10 23/11/2022	5.353	5.24
	6.194	
Newport STW		
B9 16/08/22	6.520	6.23
B10 23/11/2022	3.524	3.55
	5.022	
Great Chesterford		
B9 16/08/22	5.092	
B10 23/11/2022	4.271	4.09
	4.682	
Huntsman/Hexcel private STW		
B9 16/08/22	0.090	
B11 28/11/22	0.116	
	0.103	
Sawston STW		
B5 16/05/2022	0.603	
B6 29/06/2022	0.677	
B7 01/08/2022	0.911	
B11 28/11/22	0.450	
	0.660	

The results show reduced concentrations of orthophosphate-P in the effluent samples taken late November, compared to 16 August. One reason for this could be that the STWs were no longer receiving ‘dry weather flows’ of raw sewage whereas on 16 August they surely must have been. ‘Dry weather flow’ is the average daily flow to a waste water treatment works during a period without rain' (source: the EA). By 23 November, sewage exiting homes etc was then becoming mixed with greater amounts of surface water from various sources, which dilute the original sewage by the time is reaches the STW, and thus the final effluent is also diluted.

Quendon STW's discharge was low on 23 November. Most of the ditch flow in the outfall area was from upstream, a very different scenario from 16 August, and current was rapid, the water was brown due to soil runoff, and the water would certainly exit into the river, taking soil with adhered Phosphorus with it, and also soluble orthophosphate.

Quendon STW outfall and its discharge ditch, 23 November at 1407h. The effluent discharge is no more than a trickle at this time

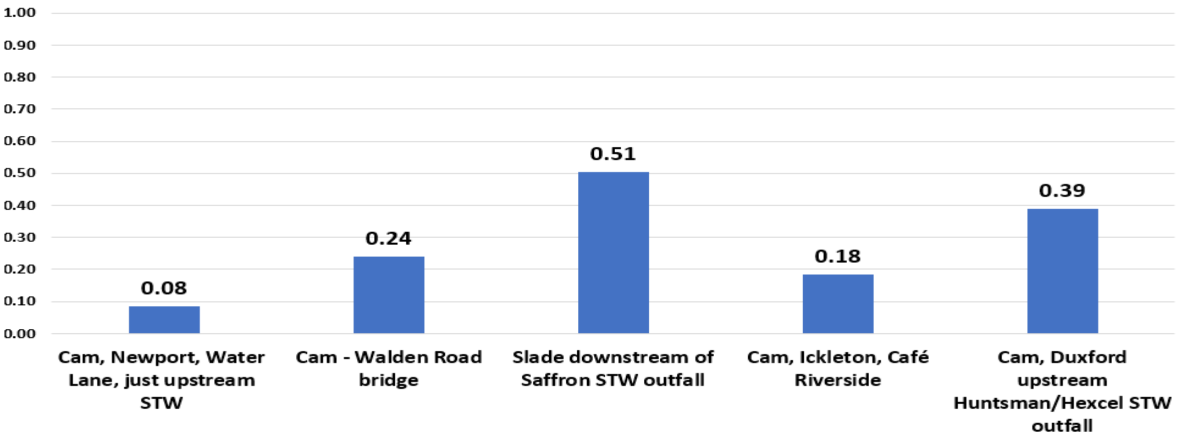
12.4.2 River water samples taken on 23 or 28 November

Samples were taken from a limited number of sites, including at Ickleton downstream of Great Chesterford STW:

- Cam, Newport, Water Lane, upstream Newport STW, downstream Wicken Brook confluence
- Cam - Walden Road bridge
- Madgate Slade downstream Saffron STW outfall
- Cam, Ickleton, Café Riverside
- Cam, Duxford upstream Huntsman/Hexcel STW outfall

The Ickleton Brook was not located and sampled on 23 November. Very likely it had no flow on 16 August and the low dry weather flow of effluent from Elmdon STW was likely to have sunk into the stream bed or evaporated before reaching the Cam.

Concentrations of orthophosphate (mg/l) in river samples 23 November 2022 at sites from Newport to Duxford



Additionally, samples were taken on 28 November from the outfall discharge of Huntsman/Hexel STW (0.12 mg/l orthophosphate-P) and from the Cam at Whittlesford A505 bridge (0.28 mg/l orthophosphate-P).

Cam, Newport Water Lane, bridge upstream of Newport STW, 23 November 2022

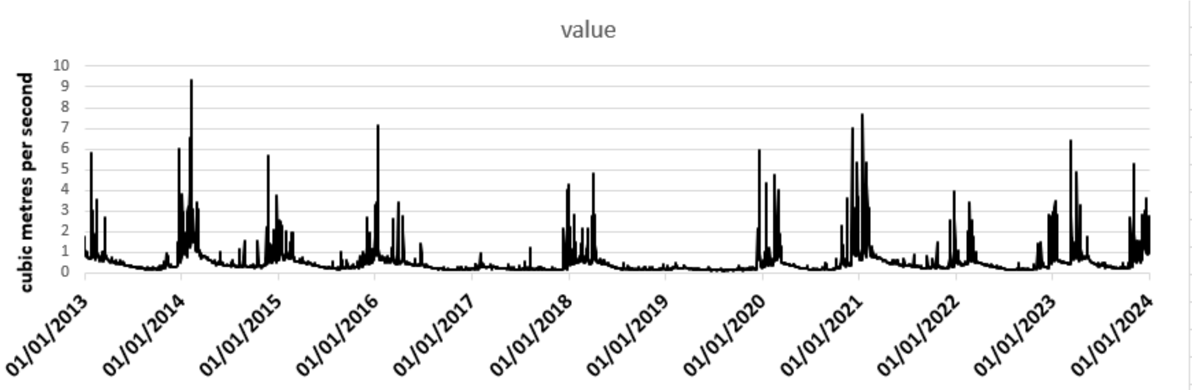
The result of just 0.08 mg/l orthophosphate-P just above Newport SWT is of interest. At Newport, Station Road on 21 November, the EA recorded orthophosphate-P at 0.071 mg/l. It might be said that over the 1.1km between the two sampling sites there had been no very little addition of orthophosphate into the river. Yet on one hand at least Wicken Brook and Debden Water were flowing into the Cam and increasing its flow, but also the river was passing through the edge of Newport and pollution from urban sources was likely to be entering the river, particularly after rainfall.

<u>A tentative conclusion from the limited data collected in late November is higher river flow has decreased orthophosphate concentrations.</u>

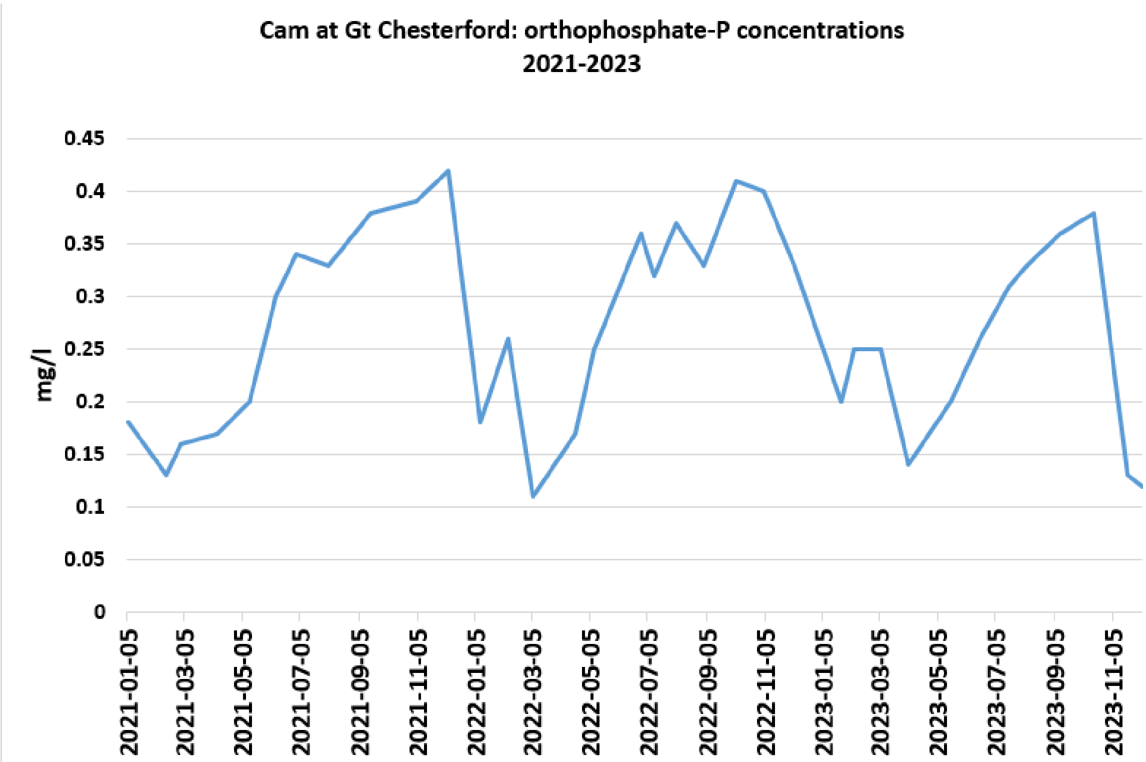
13 SEASONAL INFLUENCE ON NUTRIENT CONCENTRATIONS

Referring to EA WIMS data, there are pronounced seasonal effects on orthophosphate concentrations. If baseflow relied totally on aquifer sourcing, the trend would be for flows to be highest around in late winter. The chart shows more variability than this. With the baseflow index estimated at 0.50-0.65 the river is only part-sourced by groundwater, Nevertheless the period of lowest flows still tends to be during late summer/early autumn.

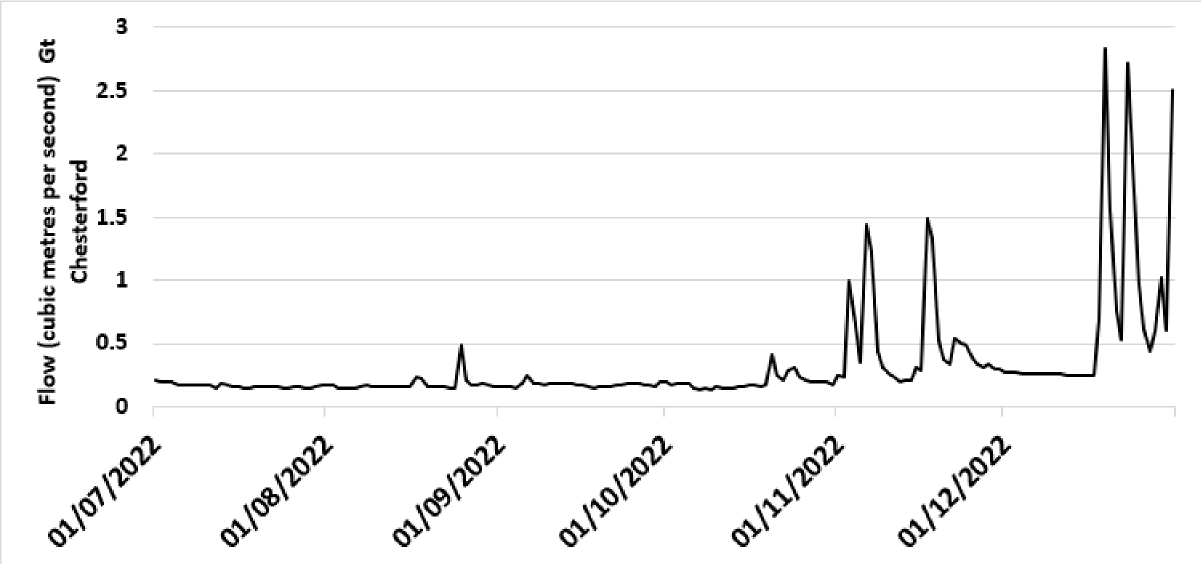
EA river flow data at Great Chesterford, 1 January 2013 to 1 January 2024



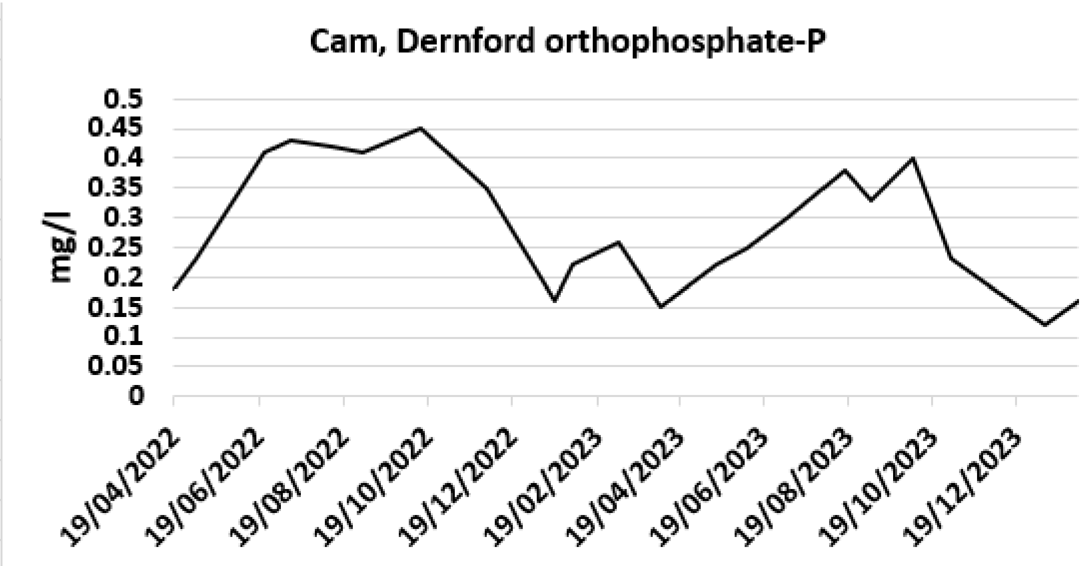
Over the three year period shown below in the chart of orthophosphate-P concentration in the Essex Cam at Great Chesterford, there are very clear fluctuations with dips in late winter and highest concentrations in summer/early autumn.



The drier summer period of 2022 is clearer in the chart below.



The trends in orthophosphate levels are also clear to see at Dernford Lock, at the end of the reach Audley End to Stapleford



Even during the highest dilutive river flows, orthophosphate concentrations are not reduced to less than about 0.1 mg/l. As the concentrations approach their peaks in summer, they become intolerably high.

14 INCIDENTAL OBSERVATIONS MADE DURING THE MONITORING PROJECT

14.1 OUTFALLS

No effort was made to search for outfalls discharging at the time. At one site, a substantial discharge was probably Affinity Water augmentation support directly into the Cam.

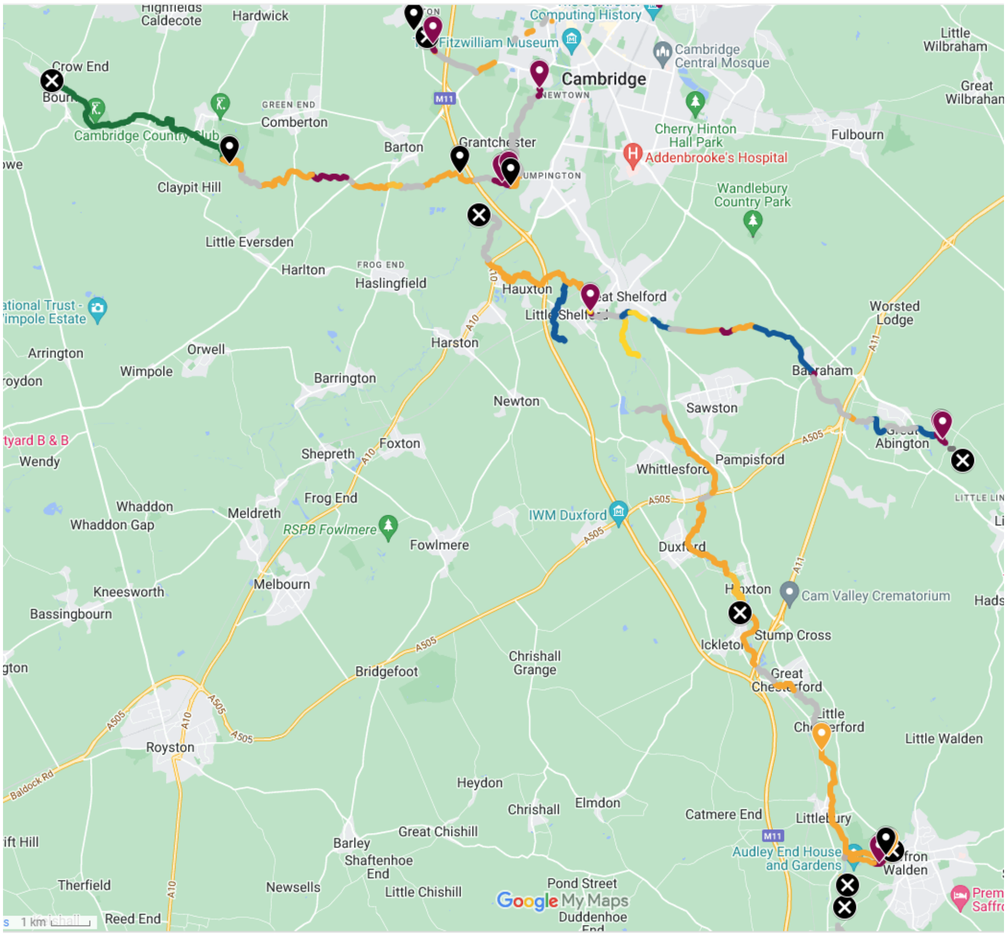
14.2 INVASIVE NON-NATIVE SPECIES

14.2.1 Himalayan Balsam

Himalayan Balsam was present at all the known sites where visited. Sites and abundance on the Essex Cam and tributaries were mapped in detail during a CVF survey of the Cam catchment in 2019.

An interactive Google Map of the Cam Catchment survey can be viewed via this link.

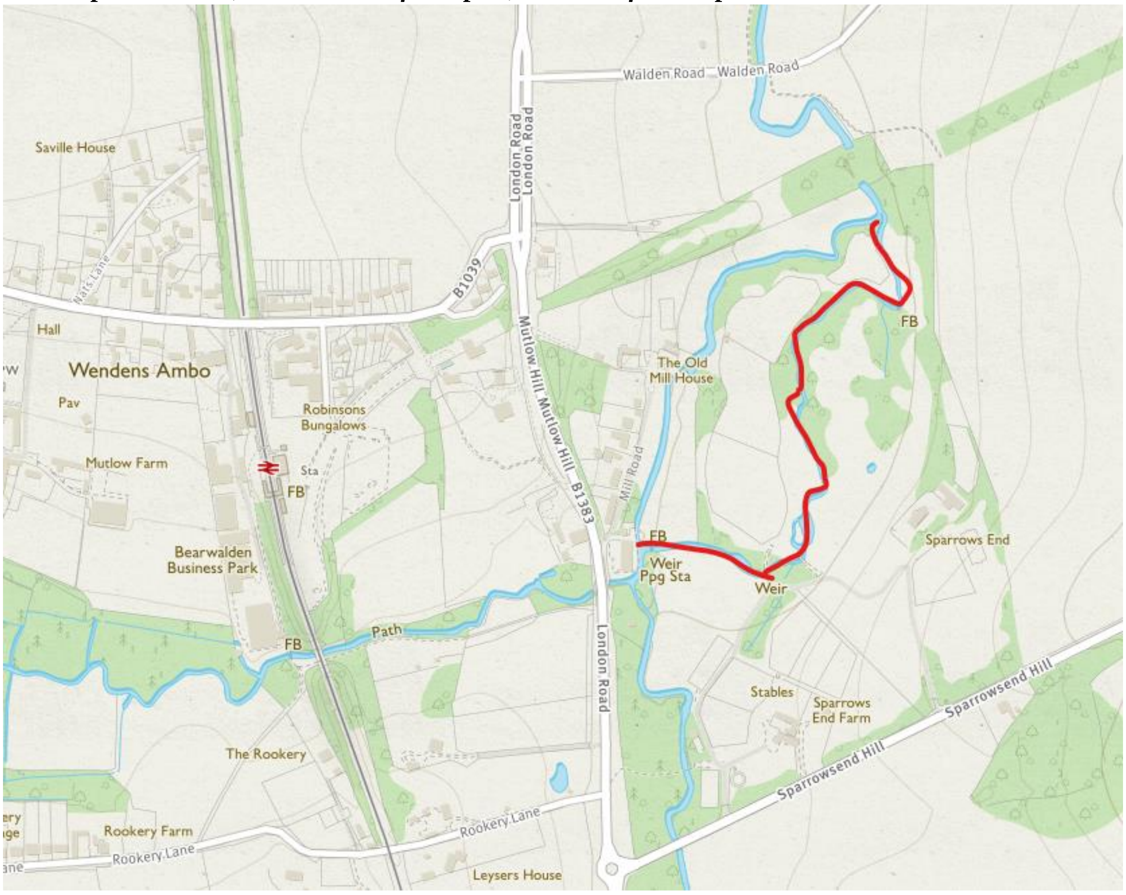
https://drive.google.com/open?id=1-0kJ0Ut2y62B0TZZo1ZCpGPnoOeOC5Mr&usp=sharing



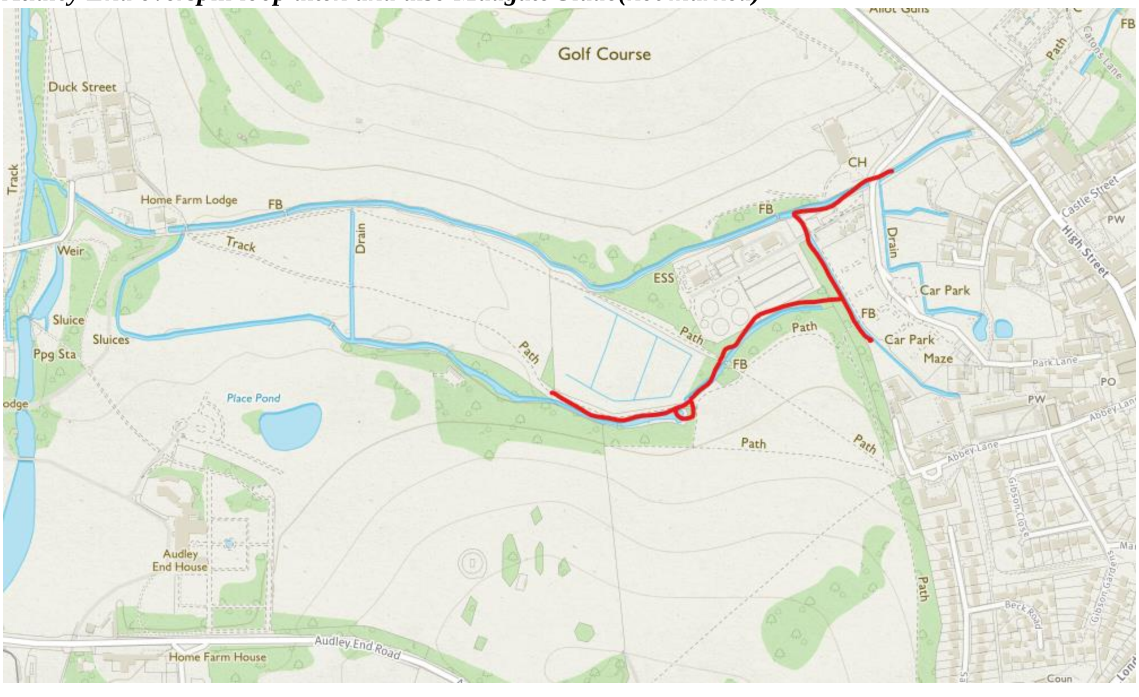
The abundance is colour coded. Only on green stretches was Balsam not found. Balsam was distributed along, and plant stands maintained by self-seeding, along many kilometres of the Essex Cam and other rivers.

The absolute uppermost incidences of Balsam in the various watercourses in the Essex Cam are shown below:

Cam: Sparrows End, downstream of Newport, Cam overflow loop



Audley End overspill loop ditch and also Madgate Slade(not marked)



Audley End overspill loop ditch, 24th June 2019

Audley End overspill loop ditch, more open section. Note lady of normal height in distance

Just two attempts at Balsam 'bashing' by a CURAT team in 2022 made significant inroads into this huge stand, with dramatically fewer plants growing there in 2023.

14.2.2 Signal Crayfish

The presence of signal crayfish (*Pacifastacus leniusculus*) can modify macroinvertebrate communities, which can subsequently lead to the impact on biotic scores such as artificially inflating LIFE (Lotic-invertebrate Index for Flow Evaluation), with scoring I believe undertaken in the river at Great Chesterford .

In 2022, Neil Patterson, a member of Audley Fly Fishers captured 450 crayfish from just one spot downstream of Littlebury over a 15-week period (Richard Pavitt, *pers. comm).* It must be distributed fare more widely on the Essex Cam than this. This invertebrate is becoming a force not to be underestimated in its ability to engineer the habitat.

15 Oil pollution

None was seen in 2022 but on 24 February 2021 a spill occurred at Newport in the Cam alongside 'The Common'. Local conservationist Derek Smith and I investigated the oil spill which in places covered the width of the water with iridescence but the source was nothing more than the rear wheel of a bike dumped into the river. It is said that one spoonful of this type of oil can cover an area equivalent to a football pitch.

Derek Smith, The Common Newport, bike wheel partly submerged

More serious pollution was our discovery of a source of viscous black oil exiting from a pipe in the bank, close to the bike wheel. Just a small amount polluted the water badly. The Parish Council and EA were informed (EA reference 1895948), and very quickly EA visited, laid down an oil-trapping boom, and after investigation confirmed that a nearby commercial oil tank was leaking into a surface water drain pipe.

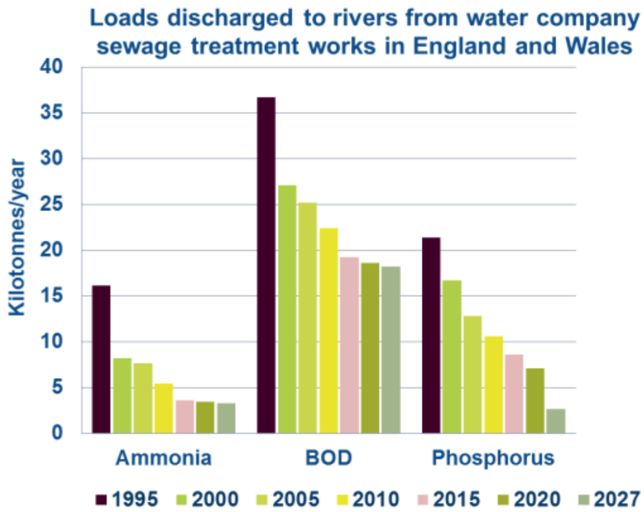
Light bike oil to left, viscous black oil, bottom right

16 Future Prospects

16.1 Phosphorus reductions from STWs since 1995. EA data England & Wales

Narrative from the EA[5] presents a somewhat gloomy overall picture of a declining rate in phosphorus reduction in rivers over the next few years. Huge strides have been made in the period 1995 to recent years, as shown by the chart below, predicts the discharge load of Phosphorus by 2027 from STWs.

Despite these reductions the EA has concerns that agriculture will continue to emit too much Phosphorus for too long.



'Despite this action to reduce this major source of P, we predict from our latest SAGIS-SIMCAT modelling that river P compliance will improve by only 2% nationally, on a river length or water body basis, as a result of the PR19 water industry investment to 2027. This is because although the water industry is 70% compliant with its 'fair share' of the P reductions needed to meet good status for river P, agriculture is 48% compliant and this constrains the extent of progress towards the good status objective'.

16.2 Plans at a local level for the Essex Cam.

Planned to be accomplished the end of 2024, Anglian Water will have new consent limits imposed on Phosphorus in the treated final effluent at discharge at Quendon, Newport and Elmdon STWs. The limits are 1.0 mg/l Phosphorus at each.

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[5] Phosphorus and Freshwater Eutrophication Pressure Narrative. Environment Agency. Published October 2019

By this action, levels of orthophosphate entering the Essex Cam in the effluent will be markedly reduced, even more so during the summer low flows. Great Chesterford STW will continue to have no limit, which seems to the author to need discussion.

Other plans by Anglian Water soon to be or very recently enacted include:

- Sewer network at Gasworks Crossroad – Event Duration Monitor to be added (December 2023)
- Saffron Walden STW – flow to full treatment to be enhanced (31 March 2025)
- Little Chesterford terminal pumping station – EDM to be added (December 2023)

17 APPENDIX 1

17.1 PHOSPHATE SOURCE APPORTIONMENT DATA FROM SAGIS

Information presented is apportionment of P concentration at WB boundary

This WB information consists of the cumulative totals for the upstream catchment for each waterbody

P concentrations have been converted into percentages and are shown in the 'percentage' tab

These percentage contributions for each sector can be used to generate pie charts

Please note:

• The SAGIS model was updated in 2022 using data from 2014-2021

• The model contains data on water quality, river flows, farming types, livestock, topography, rainfall etc

• The 'urban' component consists of runoff from non-agricultural land including local roads and paved surfaces, misconnections, contaminated surface water outfalls

• Columns for the following sectors have been removed (all cells were recorded as ""0%""): Mines, Atmospheric Deposition, Natural Background, and Lake Inputs.

Additional Information

Calibration effort has focused on model structure, time of travel and auto calibration techniques.

The SAGIS model has been calibrated but as yet not validated. As such the values provided should be treated as estimates at any given point.

Model based on a simplified river network, includes flow gauges, water quality sample points, discharges and abstraction features.

Flow units are in Ml/day, concentration in mg/l, load units are in Kg/day.

Data sources

Diffuse:

As per UKWIR 2015 build

Arable and livestock information is from the ADAS PSYCHIC model based on the 2010 agricultural census.

The other diffuse sectors are based on bespoke methodologies developed within the UKWIR SAGIS project. The methodologies are based on small studies and national assumptions, subsequently calculations for intermittents and urban loads, in particular, should be treated with caution and carefully scrutinised.

Point sources:

Data periods as the original model build. Dates itemised below:

STW flows 2010-12 observed; quality 2010 to 2012 observed where available. Older data has been used in preference to defaults if data is not available in this time period. Permit flows used using existing DWF and Mean/Q80. P permits up to and including AMP6 obligations.

River quality

Data periods as the original model build; predominantly 2010 to 2012 observed quality. Additional data has been used in to provide resolution in locations where no data is available in this time period.

Flows

National RBD SIMCAT model diffuse flows calibrated using 2010 to 2012 observed gauging data.

Caveat

Whilst the EA has done its best in performing the model calculations, they cannot be guaranteed free of error, and so the user takes responsibility for any use made of these calculations.

18 APPENDIX 2

The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017. Calculation of Phosphorus thresholds between EA classes Poor to High

Phosphorus Standards in Rivers(i)	
Annual mean reactive phosphorus concentration (in µg per litre) is calculated as follows:	
High	10 to the power of $((1.0497 \times \log_{10}(0.702)+1.066) \times (\log_{10}(RP_{ref}) - \log_{10}(3{,}500)) + \log_{10}(3{,}500))$
Good	10 to the power of $((1.0497 \times \log_{10}(0.532)+1.066) \times (\log_{10}(RP_{ref}) - \log_{10}(3{,}500)) + \log_{10}(3{,}500))$
Moderate	10 to the power of $((1.0497 \times \log_{10}(0.356)+1.066) \times (\log_{10}(RP_{ref}) - \log_{10}(3{,}500)) + \log_{10}(3{,}500))$
Poor	10 to the power of $((1.0497 \times \log_{10}(0.166)+1.066) \times (\log_{10}(RP_{ref}) - \log_{10}(3{,}500)) + \log_{10}(3{,}500))$

(i) In this table, "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. "RPref" represents the annual mean concentration of reactive phosphorus in µg/l estimated for the site under reference conditions using the equation: 10 to the power of (0.454 (log10Alkalinity) – 0.0018 (Altitude) + 0.476). If the value calculated for RPref using the equation above is less than 7 µg/l, it must be substituted for the purposes of calculating the standards for phosphorus by a value of 7 µg/l.

(ii) For the purposes of calculating RPref: 19 (i) "Alkalinity" is the concentration of CaCO3 in mg/l. If a site has an alkalinity greater than 250 mg/l CaCO3, a value for alkalinity of 250 must be used for the purposes of calculating RPref. If a site has an alkalinity of less than 2, a value for alkalinity of 2 must be used for the purposes of calculating RPref. (ii) "Altitude" means the site's altitude above mean sea level in metres. If a site has an altitude of greater than 355 metres, a value for altitude of 355 metres must be used for the purposes of calculating RPref