Water Quality in the Evenlode Catchment 2023

Principal Authors: Steven Loiselle, Izzy Bishop and Soraya Wooller.

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Acronyms and Abbreviations

ARMI	Anglers Riverfly monitoring initiative (“Riverfly”)
DO	Dissolved oxygen
CDOM	Coloured dissolved organic matter
CNL	Cotswold National Landscape
CSO	Combined Sewage Overflow
EA	Environment Agency
ECP	Evenlode Catchment Partnership
EDM	Event Duration Monitoring
FWW	FreshWater Watch
MuW	Milton-under-Wychwood
NA	No data available
NO_3	Concentration of nitrogen in the form of nitrate as (mg/L)
PO_4	Concentration of phosphorus in the form of orthophosphate (mg/L)
SAGIS	Source Apportionment Geographical Information System
STW	Sewage Treatment Work
SWC	Smarter Water Catchments

1. Executive summary

Overview

The River Evenlode is a 45-mile-long tributary of the River Thames, running through the Cotswolds. The Evenlode Catchment Partnership (ECP) is led by Wild Oxfordshire and brings together partners from across the catchment including members of the Evenlode community, Thames Water, the Environment Agency (EA) and Earthwatch Europe; all working towards improving the catchment for the benefit of wildlife and people. **The goal is to return the Evenlode catchment to 'good ecological status'.**

In 2023 Citizen scientists were regularly monitoring twice the number of locations as the EA. 32 sites were monitored by citizen scientists in at least three of the four seasons in 2023, compared with 15 sites by the EA. The catchment comprises 16 water bodies. Of these, only nine (56%) had some kind of regular monitoring. All nine were covered by the EA, with six of these also covered by regular citizen science monitoring. Intermittent monitoring by citizen scientists, e.g. WaterBlitzes, increased this coverage to 15 out of 16 water bodies (94%).

Waterbody phosphate status (i.e. phosphorus in the form of orthophosphate, PO_4) varied across the catchment. Phosphate status, as determined by combining citizen science and EA monitoring, was generally better in the east (Glyme/Dorn) than the west (Evenlode). Eight water bodies had good or high phosphate status. These were located on the Glyme and Dorn tributaries, as well as on some of the small tributaries to the main Evenlode in the west of the catchment. The Glyme/Dorn is characterised by fewer sewage treatment works (STWs) and a more restrictive permits, with STW output discharges limited to 1 mg/L. No water body had a bad phosphate status, although the water body that comprises the Evenlode between Compton Brook and Bledington Brook (including Four Shires) had poor phosphate status. Some water bodies had only intermittent citizen science measurements from uneven sampling throughout the year, which is associated with greater uncertainty in their assigned status.

There was considerable variation in the nutrient conditions of individual monitoring sites within some water bodies, which can be partially explained by differences in the results from sampling sites upstream vs downstream of STWs. This was for example particularly true for the Littlestock Brook, and for two stretches of the main River Evenlode: a) between Compton Brook and Bledington Brook, and b) between the Glyme confluence and the Thames. Greater variation was recorded where the number of sampling sites within a water body was higher, implying that increasing the monitoring effort can reveal additional information about nutrient variations within water bodies.

A distinct seasonal trend in phosphate was detected, with phosphate concentrations highest during summer months when flows were low. Low rainfall periods reduce the dilution of any pollutants that have a constant input throughout the year, e.g. treated sewage effluent. The increased concentrations of phosphate during warmer months, when algal photosynthesis is at a maximum, has a major impact on the ecological conditions of the receiving streams and rivers. This leads to algal blooms, periphyton (algae and diatoms) growth on aquatic macrophytes (large plants), and a reduction in dissolved oxygen (DO). This combination negatively impacts the macrophyte community and the capacity of aquatic ecosystems to support biodiversity.

Nitrate concentrations (i.e. nitrogen in the form of nitrate, NO_3) were elevated throughout the catchment, but were highest in upstream water bodies in the northeast of the catchment (though lack of data in these areas means higher levels of uncertainty). Elevated concentrations in many areas of the catchment clearly indicated nitrate sources, which can be both point sources (e.g. STWs) and diffuse sources (e.g. agricultural land, and septic systems). These observed elevated nitrate concentrations can negatively impact aquatic biodiversity, e.g. hampering the growth and survival of amphibians, fish and amphipods (shrimp-like invertebrates). Elevated nitrate can interact with other environmental stressors, such as increased sediment or pollution loads, and compound their negative effects. It should be noted, however, that the median nitrate concentration recorded in all water bodies was below the 50mg/L NO_3 limit (i.e. 11 mg/L N-NO_3) used in the EC Nitrates Directive.

In areas with low phosphate concentrations, the lack of phosphate should limit algal growth, but where phosphate is higher, it is likely that nitrate may be the limiting factor to algal growth. This suggests that the control of nitrate concentrations is important for reducing eutrophication in several areas of the catchment. The Evenlode between Compton and Bledington Brook, as well as Cornwell Brook, have elevated phosphates *and* nitrates and are at particularly high risk for impacts of eutrophication.

As with phosphate concentrations, there was considerable variation in nitrate concentrations within some water bodies. This was particularly true for the water bodies comprising the main River Evenlode. This could potentially be explained by the varying influence of different tributaries on the main channel; more data is needed from upstream and downstream of the confluences to confirm this. In contrast to phosphate concentrations, **there was no discernible seasonal trend for nitrates.**

Continuous monitoring using multiparameter sondes upstream and downstream of the Chipping Norton and Milton-under-Wychwood (MuW) STWs showed the clear influence of STWs on water quality. Coloured Dissolved Organic Matter (CDOM), DO, temperature, turbidity and tryptophan were recorded by sondes located downstream of Chipping Norton and MuW STWs. Daily maxima of these determinands were very consistent with daily STW discharge cycles, which, in turn, were closely linked to domestic water use.

MuW STW has a significantly greater impact on downstream water quality than Chipping Norton STW. This is exacerbated by the frequent operation of the storm overflow at MuW. Storm overflow discharge events at MuW STW were associated with elevated concentrations of most dissolved and particulate-related matter that was measured downstream, suggesting that rainfall was not sufficient to dilute the additional pollutant load on Littlestock Brook from MuW STW storm overflows.

Recommendations

Thames Water had previously agreed with ECP's assessment to include phosphorous stripping upgrades in their draft business plan (PR24). Upgrades to 13 sewage treatment works were included in the draft plan as recently as summer 2023, but these were absent from the business plan formally submitted to Ofwat for scrutiny. Thames Water's current business plan (PR24) therefore contains no STW upgrades related to phosphorus stripping for the Evenlode catchment, or to meet their legal commitments under the Water Framework Directive. Thames Water has also postponed 105 previously-funded improvement schemes across its network, including those for Moreton-in-Marsh, until the 2025 – 2029 period with a sum of £1.13 billion allocated to the costs of completing these essential works. The ECP will continue to build the case and campaign for change with a focus on tertiary treatment at MuW STW and Chipping Norton STW.

The placement of sondes upstream and downstream of the MuW STW and Chipping Norton STW has provided important information on the timing and the degree of impact from these STWs. The ECP is evaluating the potential benefits of moving the sondes to record data that will allow an assessment of the conditions in the receiving waters downstream of other STWs, as well as using the sondes to evaluate the benefits of in-stream mitigation efforts.

Given the exemplary efforts of citizen scientists to fill the monitoring gaps related to potential pollution sources, there is a clear opportunity to establish regular monitoring at sites where intermittent monitoring has revealed potential issues (namely Hanborough, Church Enstone, Bledington, and around Charlbury).

Sars Brook has not been monitored by either the EA or by citizen scientists. It is therefore recommended to establish regular monitoring points, preferably using the same approach of establishing regular monitoring around potential pollution sources.

Biological monitoring of benthic invertebrates using the Anglers Riverfly Monitoring Initiative (ARMI, or "Riverfly") protocols should be expanded, to determine the links between poor water quality and ecological impact.

Walking safaris should be conducted along stretches of the Evenlode, particularly where water quality impacts have been highlighted from current monitoring; using YSI meters (handheld probes as deployed by the EA) in addition to FreshWater Watch (FWW) monitoring.

2. The Evenlode catchment

The River Evenlode is a 45-mile-long tributary of the River Thames, running through the Cotswolds. Volunteers have been routinely contributing to river health monitoring since 2019, because poor water quality is a particular concern.

The Evenlode Catchment Partnership (ECP) is led by Wild Oxfordshire and brings together partners from across the catchment including members of the Evenlode community, Thames Water, the Environment Agency (EA) and Earthwatch Europe; all working towards improving the catchment for the benefit of wildlife and people. **The goal is to return the catchment to 'good ecological status'.**

In 2023, the ECP's water quality monitoring in the Evenlode combined a number of information sources:

- **EA surface water monitoring**. The EA collected data from 17 sites, 15 of which were monitored in at least three of the four seasons.
- **Regular citizen science water quality monitoring**. Volunteers collected 266 water quality datapoints from 46 pre-agreed monitoring sites using the FWW toolkit. Of these sites, 32 were monitored in at least three of the four seasons.
- **Intermittent citizen science water quality monitoring**. FWW data was collected from an additional 258 locations on an ad-hoc basis, many during the Evenlode Blitz.
- **Near-continuous water quality monitoring (sondes).** Four Proteus water quality monitoring sondes collected near-continuous data including conductivity, temperature, pH, turbidity, CDOM, tryptophan, and DO. Measurements of ammonium ($NH4+$) by an ion selective electrode were shown to have several problems (short term baseline drift, rapid loss of calibration) in a focused study on sonde data quality control. Ammonium measurements are not currently being included in long term monitoring.
- **Biological monitoring**. Riverfly monitoring protocols guide citizen scientists to record data about benthic invertebrate numbers and assemblages. The results indicate the impact of water

quality on aquatic biodiversity. Riverfly monitoring was initiated in 12 locations across the catchment, more than doubling the coverage from the previous year.

Water quality in the Evenlode

The River Evenlode rises out of the limestone that underlies the Cotswolds, flowing south-east towards the clay vales of the River Thames. The Evenlode catchment contains 16 river water bodies including the Evenlode. The major tributaries are the Glyme and the Dorn. These river water bodies and sub-catchments are described by the EA (see EA, 2023) and will henceforth be referred to as EA operational sub-catchments. Additionally, there are lake water bodies in the catchment that are of high cultural value at Blenheim, Cornbury Park, Kidlington Park, and Glympton Park.

The landscape has important national and international significance, and includes the Cotswolds National Landscape (CNL), Sites of Special Scientific Interest, Conservation Target Areas, and the World Heritage Site of Blenheim Palace. The catchment includes important habitats including beechwoods, limestone grasslands, lowland meadows and fens. These habitats all support a wide range of wildlife, including remaining populations of nationally endangered water voles and tree sparrows. There is an important angling community on the Evenlode, where bullheads, chub, roach, and trout are present. However, the river habitat in the Evenlode catchment has been compromised by a combination of historical channel modification and pollution (e.g. sediment, nitrate, and phosphate).

In many places in the catchment, channels have been over-deepened, widened and straightened, resulting in uniform channel morphology, and separating the rivers from their floodplains. This has reduced the rivers' natural capacity to mitigate pollution and flood events. There are numerous weirs (35 on the Glyme alone) that modify river flow and create barriers to fish movement. The combined modifications leave the catchment vulnerable to flooding, reduced water quality, and consequent declines in biodiversity.

Nutrient pollution (i.e. excess phosphorus and nitrogen concentrations) can lead to overgrowth of algae and other micro-organisms in rivers, depleting available DO. This impedes the functioning of river and lake ecosystems, and has major impacts on biodiversity of both fauna and flora, as well as increasing the emission of greenhouse gases. Annual costs of phosphorus and nitrogen pollution have been estimated in the billions of pounds in European waters (Pretty *et al*., 2003, Withers *et al*., 2014). An international effort has been underway to reduce these concentrations, most often focusing on reducing loads of phosphate and nitrate from both point and diffuse sources. While phosphate is typically the main driver of eutrophication in freshwater ecosystems, elevated nitrate concentrations can have complementary and separate impacts. In fact, the concentrations of both nutrients need to be controlled to reduce the overall impact (Wurtsbaugh *et al*., 2019).

Phosphorus is typically a limiting nutrient in unimpacted freshwater ecosystems; low concentrations of available phosphorus (as phosphate) control plant growth. When present in high concentrations, which is common throughout much of the Evenlode catchment, phosphorus supports the formation of harmful algal blooms as well as epiphytic and benthic algae (Jarvie *et al*., 2006). This can lead to hypoxic "dead zones" that reduce fish populations and generate compounds that negatively impact the safety of water supplies and the recreational use of the water body. High phosphate concentrations can negatively impact in-stream vegetation communities, because the resulting growth of epiphytes on macrophytes and increase in phytoplankton can change the composition of original aquatic vegetation biodiversity.

Dissolved nitrogen-based nutrients, (i.e. ammonium, nitrate, or nitrite) have related impacts, both direct and indirect. In rivers with elevated phosphate concentrations, nitrate can act as the limiting nutrient, controlling algal growth. Elevated nitrate concentrations impact the growth and survival of amphibians, fish and amphipods. The EC Nitrates Directive was created thirty years ago for the protection of waters against pollution caused by nitrates from agricultural sources, and is complementary to the Urban Waste Water Treatment Directive, with respect to reducing the impacts caused by nutrient pollution. Nitrate concentrations are influenced by both hydrogeological factors as well as the presence of multiple sources (including agricultural activities, STWs, and septic tanks) in the catchment.

Worldwide, nutrient pollution in water bodies has increased, associated with increased urbanisation and the development of more intensive agricultural production. Anthropogenic sources can have multiple pathways, which can change throughout the year in response to climatic variables (e.g. precipitation and temperature) and human activities. Monthly, daily and even hourly changes in phosphorus and nitrogen loads can occur. Nutrient concentrations measured in rivers depend on hydrological variability (river discharge), ecological conditions, (e.g. macrophyte community) and natural background concentrations. There are multiple nutrient sources in most catchments, with the most important being:

- continuous treated wastewater
- event-driven untreated sewage effluent
- agricultural sources (including housed livestock, pasture and forestry)
- uncontrolled or poorly controlled domestic sources (septic tanks) and
- industrial effluents, and runoff from impervious surfaces (roads and carparks).

The EA's Source Apportionment Geographical Information System (SAGIS, 2022) calculated that 65% of the average phosphorus contribution across the Evenlode catchment came from sewage treatment works (STWs). However, for some sub-catchments, this value is much higher, such as 82.9% in Little Compton Brook and tributaries. Phosphate stripping is currently installed in only three of the 19 STWs in the catchment. These are in the Dorn and Glyme tributaries, at Enstone, Middle Barton and Woodstock STWs.

Water quality monitoring by the ECP is a vital step in prioritising STW asset improvements, mitigation actions, and monitoring gaps. In addition, the ECP is working with local landowners to support land management practices that will reduce nutrient runoff and increase biodiversity, such as minimum tillage and improved soil fertility management in agricultural areas (ECP, 2023). The ECP is also involved in improving the natural capacity of the catchment to mitigate pollution loads by interventions including creation of “leaky” dams, wetlands, and the reconnection of the river to its floodplain (ECP, 2023).

Why is water quality being monitored?

The ECP continue to have concerns about the water quality in the Evenlode catchment, particularly regarding point source pollution from STWs, as well as diffuse sources such as septic tanks and agricultural runoff. These latter remain more difficult to pinpoint, though evidence of their impact is apparent, with the EA's SAGIS model determining their variable contribution to the phosphate load of each sub-catchment. In addition, the 2022-23 Water Industry National Environment Programme (WINEP) has forced water companies to submit proposals for where they plan to invest in improvements in order to meet legally binding targets determined by the Environment Act, 2021.

Water quality monitoring therefore becomes vital in evidencing where targets are not being met and advising where improvements should be made. The summary of findings from the previous ECP water quality reports for the past 2 years can be found online (ECP Report 2022)

Working with RS Hydro, Earthwatch Europe installed 4 Proteus sondes in the Evenlode catchment in 2022, upstream and downstream of two STWs; Chipping Norton and MuW (Figures 1 and 2). These sondes measure water quality parameters at 15-minute intervals to reveal daily cycles and seasonal fluctuations, as well as changes caused by pollution and precipitation events. This data improves insight into the ecosystem's health and functions, by revealing patterns that cannot be detected by routine monthly samples. It supports and adds to the Citizen Science and EA monitoring that is being conducted at a much wider scale across the catchment.

It should be noted that measurements of ammonium (NH_4^+) by an ion selective electrode were also part of the original parameters being measured. In 2023, a focused study on the sonde output indicated that the ammonium probes on all four sondes could not maintain calibration, with a marked drift by 8 – 12 days after calibration. This was associated to the day-to-day conditions of both brooks. Measurements of ammonium using the sondes are currently not being considered for long term monitoring purposes until this can be rectified.

Figure 1: Earthwatch Europe installing a sonde to collect autonomous measurements of water quality. Sondes are placed in stilling wells and regularly monitored.

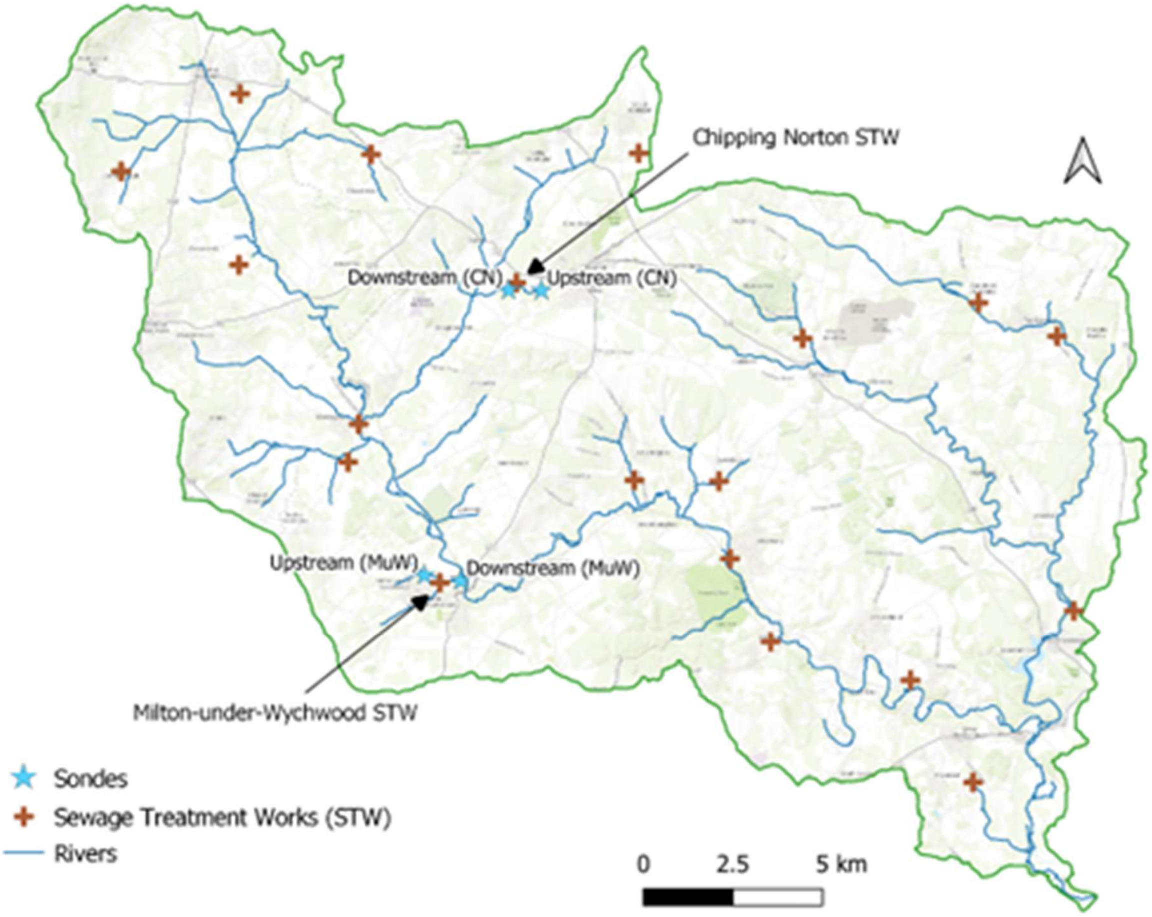

Figure 2. Map of the Evenlode catchment in Oxfordshire, UK, showing the locations of STWs, (indicated by a red cross) and water quality monitoring sondes (indicated by a blue star) near the towns of Chipping Norton (CN) and Milton-under-Wychwood (MuW).

3. 2023 Water quality overview

The Evenlode is split into 18 separate "water bodies" for the purposes of environmental management. 16 are river sub-catchments and two are lakes. These water bodies provide a helpful way of conceptualising spatial patterns in water quality. This section combines EA and citizen science data to calculate the 2023 water quality status of each river water body compared to Water Framework Directive standards.

Phosphate

Water body phosphate status varied across the catchment. Phosphate status was generally better in the east (Glyme/Dorn) than the west (Evenlode, Figure 3).

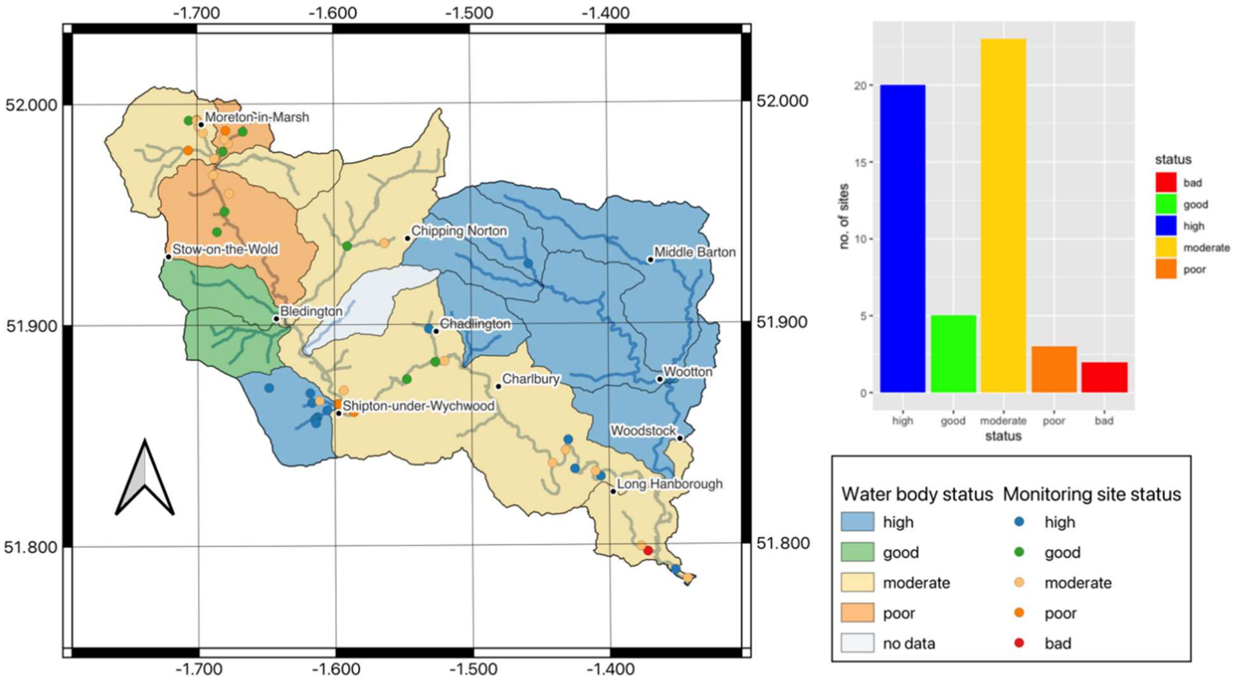

Figure 3: Phosphate status of water bodies across the catchment.

- Eight water bodies had good or high phosphate status. These were located on the Glyme and Dorn tributaries, as well as on some of the small tributaries to the main Evenlode in the west of the catchment.
- No water bodies had bad phosphate status.
- The water body that comprises the Evenlode between Compton Brook and Bledington Brook (including Four Shires) had poor phosphate status.
- Sars Brook was not evaluated because no data were available.
- Above its confluence with the Dorn (high), the Little Compton Brook (moderate) and Westcote Brook (good) showed higher concentrations. However, these classifications are based on intermittent citizen science measurements and may therefore be affected by the uneven sampling throughout the year. More consistent regular monitoring would indicate whether elevated concentrations were present during periods of low river flow.

There were clear seasonal variations in phosphate concentrations within some water bodies.

- This was particularly true for the Littlestock Brook, and two stretches of the main River Evenlode: a) between Compton Brook and Bledington Brook, and b) between the Glyme confluence and the Thames.
- Variation between the phosphorus concentrations at individual sites can be partially explained by differences in the results from sampling sites upstream vs downstream of STWs, for example MuW STW on the Littlestock Brook.
- Greater variation was recorded where the number of sampling sites within a water body was highest. This implies that increasing the monitoring effort can reveal additional information about within-water body variation.

A distinct seasonal trend in phosphate was detected, with phosphate concentrations highest during summer months when flows were low (Figure 4).

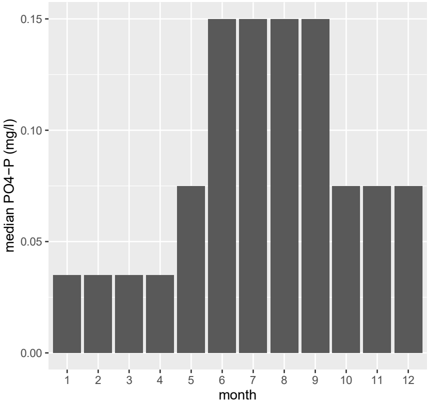

Figure 4: 2023 Phosphate concentrations by month.

- This seasonal trend was most pronounced in Littlestock Brook, Cornwell Brook, and in the water bodies that included the main River Evenlode. Low rainfall periods reduced the dilution of pollutants with a constant input throughout the year (e.g. treated sewage effluent), causing concentrations to increase far above recommended limits.
- The Glyme and Dorn water bodies tended to experience maximum phosphate concentration in early-mid autumn during periods of increased rain and agricultural activities, suggesting potential nutrient runoff. However, monitoring in these areas was limited, and these results should be interpreted with caution.

Intermittent monitoring by citizen scientists revealed new locations that warrant further investigation with regular monitoring (Figure. 5).

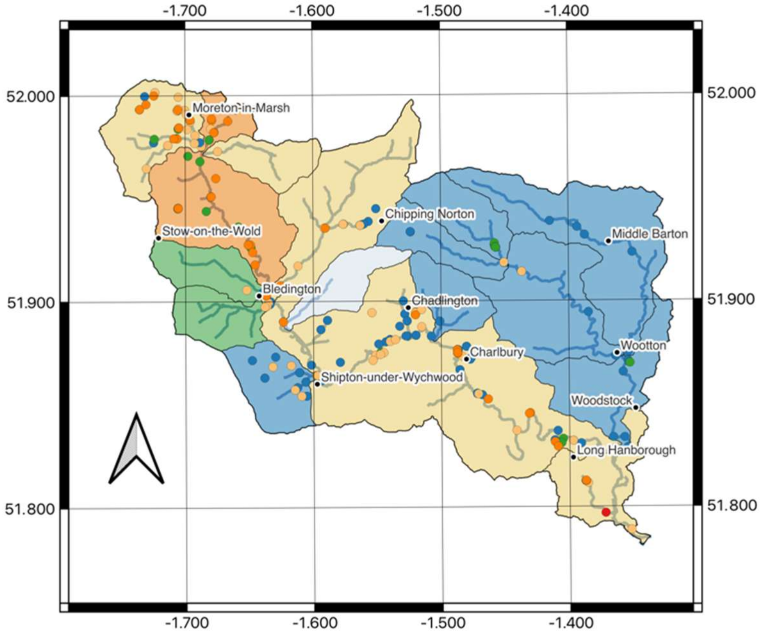

Figure 5:. Locations that recorded unusual phosphate levels.

- Moderate phosphate concentrations were recorded at two sites below Enstone STW on the River Glyme. Water body conditions indicate relatively low concentrations, but this is based on limited data.

- There is a cluster of sites with moderate or poor conditions on the Bledington Brook, again below the STW. This water body is otherwise estimated to be good quality.
- There are several sites with good conditions clustered around Chadlington, in a water body which showed moderate status overall.
- There are some sites rated 'poor' near Charlbury, where the overall water body condition was estimated to be moderate.

Nitrate

Nitrate concentrations were elevated throughout the catchment and were highest in water bodies in the northeast of the catchment, although limited data in these areas implies greater uncertainty in these results (Figure 6).

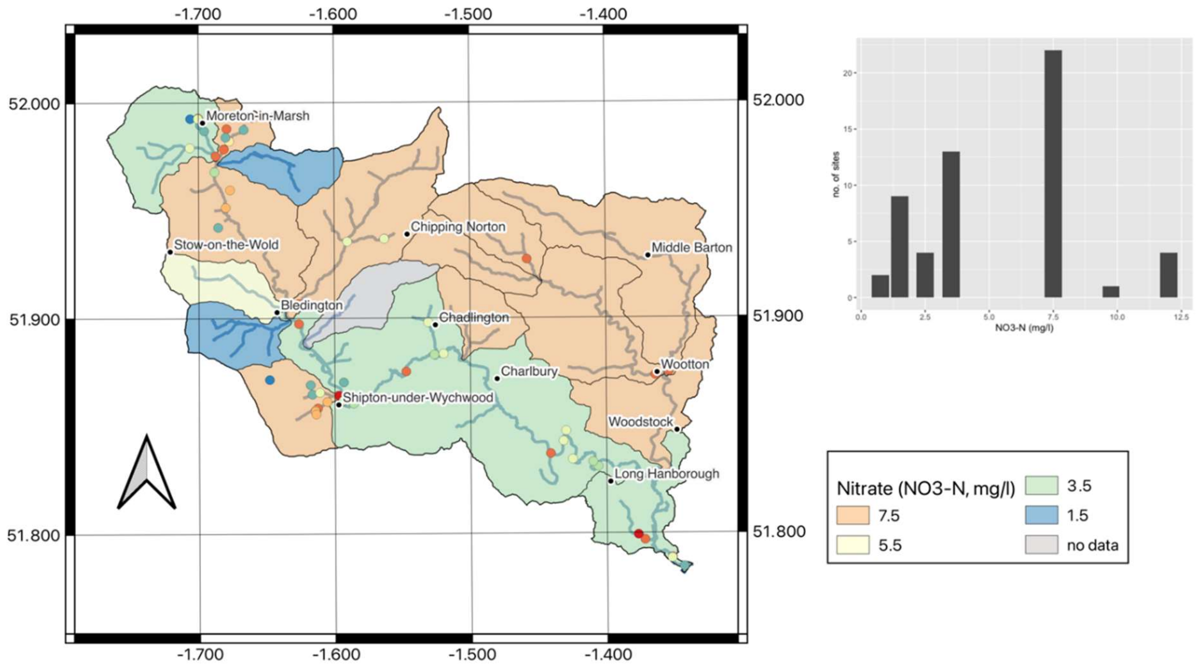

Figure 6: Variable median nitrate concentrations in the Evenlode catchment.

- The observed elevated nitrate concentrations can drive negative impacts on river biodiversity, for example, hampering the growth and survival of amphibians, fish and amphipods. Elevated nitrate can interact with other environmental stressors, such as increased sediment or pollution loads to compound their negative effects. It should be noted that the median nitrate concentration recorded in all water bodies was below the 50mg/L NO_3 limit (11 mg/L N-NO_3) used in the EC Nitrates Directive.
- In areas with low phosphate concentration, phosphate is likely to limit algal growth. Where phosphate concentrations are higher, nitrate concentration is more likely to be the limiting factor. The Evenlode between Compton and Bledington Brook, as well as Cornwell Brook, have elevated phosphates and nitrates, and are at elevated risk of eutrophication-related impacts (e.g. algal blooms).
- Median nitrate concentrations were highest in the upper catchment of the Evenlode and decreased in the lower courses of the main river.
- There is considerable uncertainty in results reported for Bledington Brook, Coldron and Taston Brooks, all water bodies on the River Glyme above its confluence with the Dorn, Little Compton

Brook, and Westcote brook. These water bodies were monitored only intermittently by citizen scientists, therefore these results may be affected by uneven sampling throughout the year.

- In general, seasonality of nitrate concentrations was less clear, compared with phosphate concentrations.

There was considerable temporal variation in nitrate concentrations in some water bodies.

- This was particularly true for the water bodies along the main River Evenlode.
- This could be related to multiple sources and sinks of nitrate in the different tributaries on the main river.
- More data is needed from upstream and downstream of potential sources (e.g. STWs, agricultural land, and livestock runoff areas) as well as the confluences of major tributaries to confirm the presence and timing of nitrate sources.

Intermittent monitoring by citizen scientists revealed new nitrate pollution sources that warrant further investigation with regular monitoring (Figure 7).

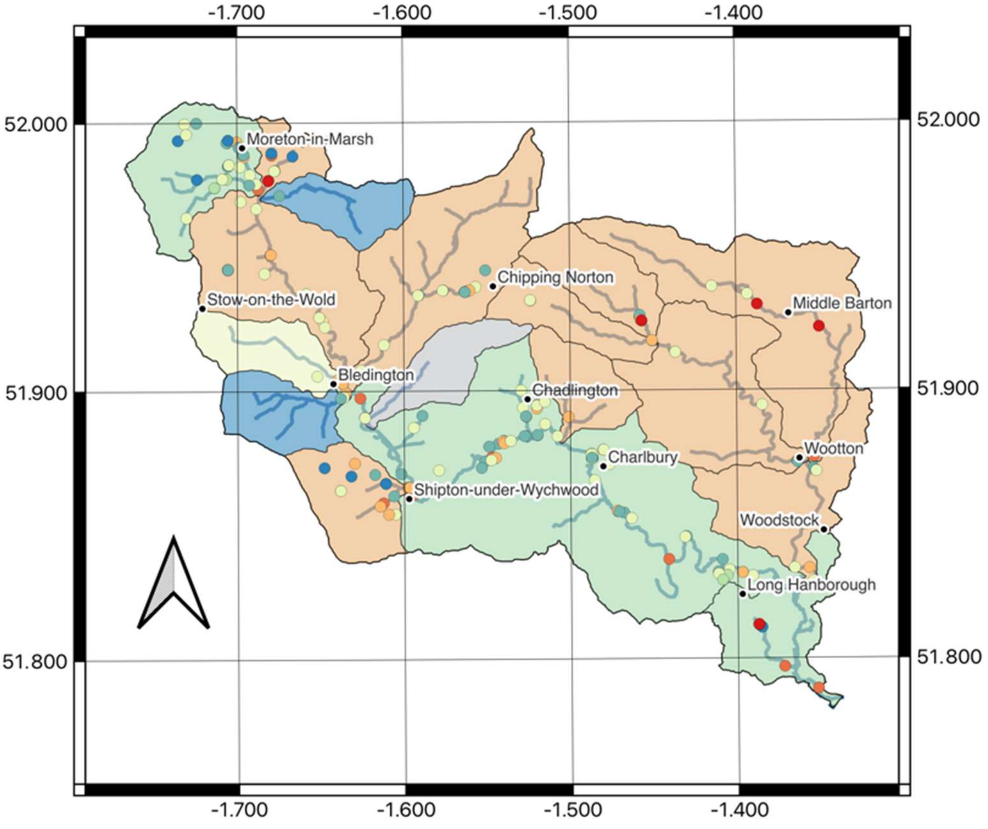

Figure 7: Locations in the catchment that recorded unusual nitrate levels.

- High nitrates were recorded below Enstone STW on the River Glyme. Phosphates were also high here (see above).
- Two locations on the River Dorn near Middle Barton had unexpectedly high nitrate results.
- The small tributary of the Evenlode at Ashford Mill had unexpectedly high nitrate results. This is the only site on this tributary to date.

4. Causes of poor water quality

Investigations into the impacts of various STWs around the catchment are ongoing using sonde data, as well as focused studies using hand-held probes, and citizen science data. This section provides results from those investigations, as well as insights on the impacts of land use from analysis of citizen science data.

Sewage treatment works

CDOM, DO, temperature, turbidity and tryptophan

Near-continuous data from sonde monitoring reveals the clear influence of STWS on water quality at Chipping Norton and MuW. Diurnal cycles with two daily maxima for CDOM, DO, temperature, turbidity and tryptophan are consistently recorded by the sondes that are located downstream of the Chipping Norton and MuW STWs. The timing of these contaminant peak values is consistent with recorded daily cycles in STW discharge, which in turn are coincident with patterns of domestic water use (Table 1).

Table 1: Annual average impacts of Milton-Under-Wychwood and Chipping Norton STWs

MuW	**Upstream**	**Downstream**	**% Change**
CDOM	43.6	59.3	**30.6%**
DO %sat	86.8	73.6	**-15.2%**
Temperature	10.8	11.5	**6.6%**
Tryptophan	9.8	21.3	**118.2%**
Turbidity	53.8	27.2	**-49.5%**
Specific Conductivity	436.6	548.7	**18.4%**
ORP	386.1	430.2	**11.43%**
pH	8.1	7.87	**-2.6%**
Chipping Norton	**Upstream**	**Downstream**	**% Change**
CDOM	31.3	79.0	**150.7%**
DO %sat	80.6	75.1	**-6.9%**
Temperature	11.8	12.0	**9.0%**
Tryptophan	12.2	28.9	**137.0%**
Turbidity	10.6	10.7	**-0.5%**
Specific Conductivity	589.1	598.4	**1.61%**
ORP	429.6	338.7	**-21.3%**
pH	7.9	8.81	**11.82%**

Significantly, combining sonde data (i.e. increases in the upstream to downstream concentrations of CDOM, and tryptophan, and decreases in DO) with the available MuW STW 15-minute discharge data showed that the Little Stock Brook experienced the highest negative impacts in the summer and autumn, during periods of lowest river flow and lowest STW discharge.

By contrast, the Chipping Norton Brook showed a less-well defined period of greatest impact (i.e. increases in the upstream to downstream concentrations of CDOM, tryptophan, and decreases in DO), with maxima coinciding in periods of both high and low STW discharge. Additionally, the data from the Chipping Norton Brook showed evidence of upstream impacts from secondary pollution sources. Increases in CDOM and tryptophan, and decreases in DO were recorded by the sonde located upstream of the Chipping Norton STW.

Phosphate

Monitoring by citizen scientists confirms the role of STWs as major sources of phosphate-related pollution (Figure 8).

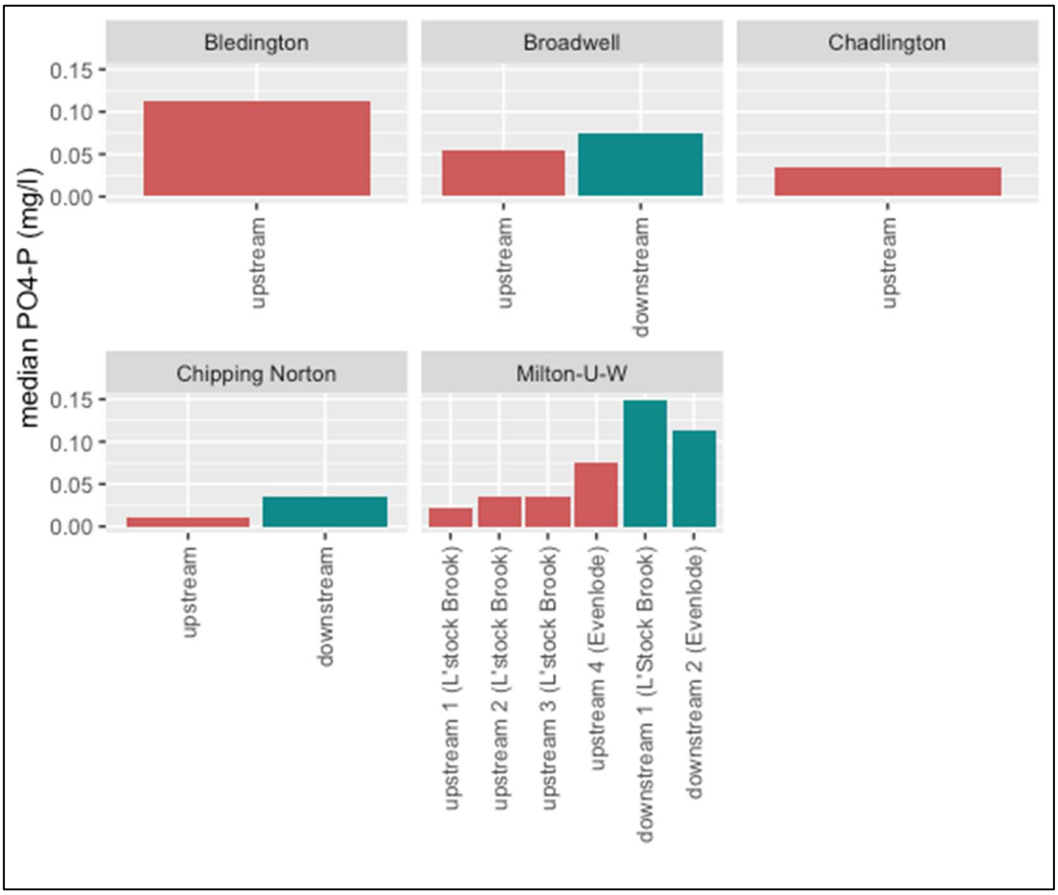

Figure 8: Graphs showing upstream and downstream phosphate levels associated with five STWs

- Data from citizen science monitoring upstream and downstream of three STWs (at MuW, Chipping Norton, and Broadwell) consistently showed significantly higher phosphate concentrations downstream of STW discharge points. This trend persisted across all seasons, with particularly high concentrations in the summer and autumn. The results from 2023 further confirmed findings from previous years.
- Elevated phosphates downstream of MuW STW were detected both in Littlestock Brook as well as in the main River Evenlode, suggesting that the Littlestock Brook was a phosphate source to the main river.
- Regular monitoring upstream of Bledington STW at Kingham-Bledington footbridge recorded elevated phosphates during summer months from an unknown source.
- Regular up and downstream monitoring at Bledington STW began in May 2023. Initial results suggest that phosphate concentrations were even higher downstream, but more data is required to confirm this trend.
- Regular monitoring upstream of Chadlington STW at Mill End Brook showed that phosphates here are low. There is currently no downstream monitoring for comparison.

Other Consented Discharges

Citizen science and sonde data indicated that consented discharges from private sewerage systems could be impacting water quality in some locations (Figure 9).

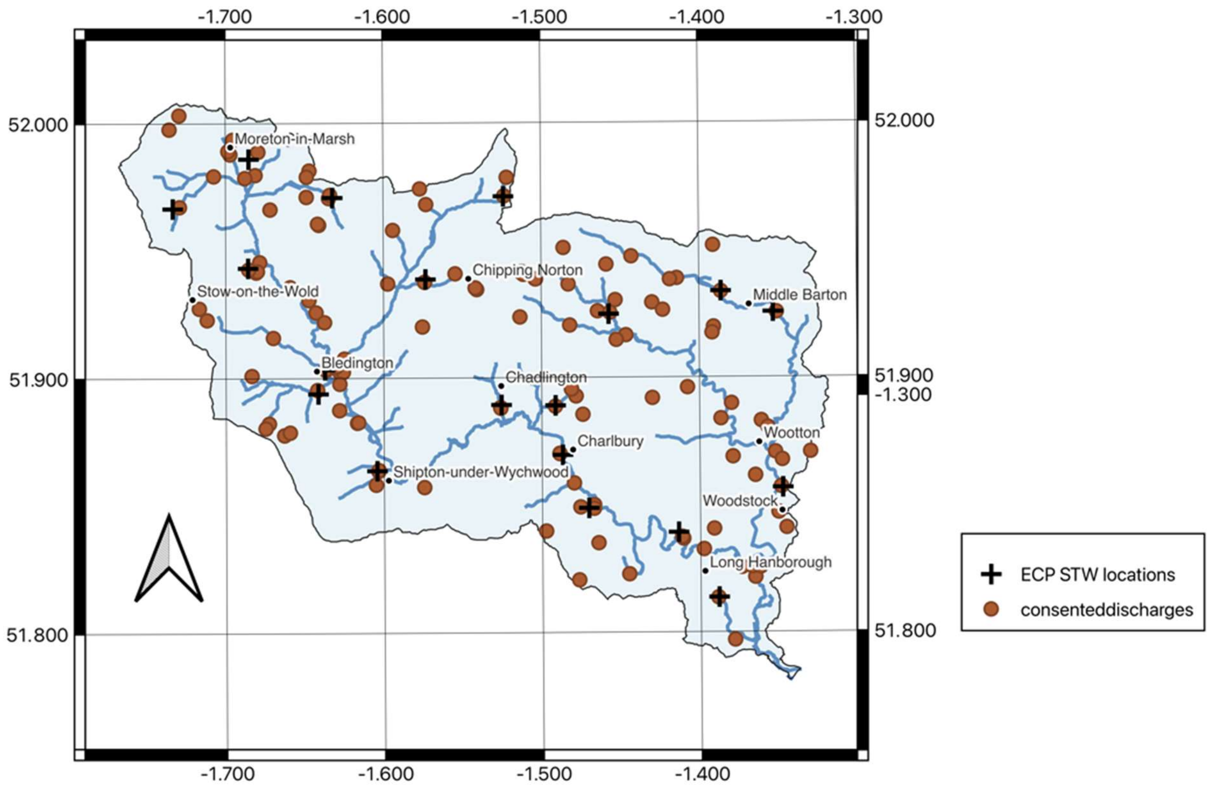

Figure 9: Points where other consented discharges have been identified and monitored by citizen scientists.

- Citizen scientists identified sewage outfalls across the catchment, as part of their regular monitoring activities and in specific outfall walk throughs (Chipping Norton Brook). Of these potential pollution sources, 40 were actively discharging. Both phosphates and nitrates were significantly higher at sites with an active outfall than at sites without ($P < 0.01$).
- There were 157 active consented discharge permits issued for the Evenlode catchment, covering a variety of discharge types including private sewerage, agricultural discharges, and effluents from transport and industry (Figure 9). More focused attention should be given to these discharges by citizen scientists in 2024.
- Of the sondes placed upstream of the STWs, the data recorded by the sonde upstream of the Chipping Norton STW showed markedly different dynamics and conditions compared with that placed upstream of the MuW STW. The data suggest the presence of a sewage discharge which has yet to be identified, but is likely to be linked to the consented discharge (private sewerage) located here. An initial investigation showed a consistent discharge with elevated nitrate concentrations. Further investigation will be made in 2024.

Agriculture

Elevated levels of total suspended solids were recorded by the sonde upstream of MuW STW during rainfall events. This is consistent with diffuse pollution, potentially from agricultural runoff. These findings need to be explored further to understand the influences of farming practices.

5. Impacts of poor water quality

Riverfly monitoring was conducted at 12 sites across the catchment, building on the five sites that were previously being monitored. Riverfly monitors calculate an ARMI score based on the relative abundance of the invertebrates they observe, with any scores lower than a site-specific ‘trigger level’ potentially indicative of a pollution event. Typically, Riverfly monitors must collect a year’s worth of data before a site-specific ‘trigger level’ can be reliably set by the EA.

Although we do not yet have enough data at the new sites to determine a reliable trigger level, we do know that our established sites have trigger levels ranging between 3 and 5. None of our established sites had any trigger level breaches in 2023, and our new sites did not record any ARMI scores lower than 3. There are some early indications from the Riverfly data that high ARMI scores (all between 8-10) were recorded more frequently at Ascott Mill than at other sites, but more data is required to confirm this.

The establishment of the new Riverfly monitoring sites was an exciting development for catchment-wide monitoring. Over time we will be able to compare results from all sites, as well as relating the abundance of different groups of invertebrates to water quality data. One hypothesis is that some groups of invertebrates (particularly *Ephemerillidae*) are sensitive to high phosphate levels, so it will be interesting to see if spatial variations in phosphates are impacting this group.

6. Citizen science contributions

Citizen science has been a core part of integrated water quality monitoring in the Evenlode since 2018. This section highlights how volunteers continued to contribute to our understanding of water quality in 2023.

Citizen scientists are now regularly monitoring twice the number of locations as the EA (Figure 11).

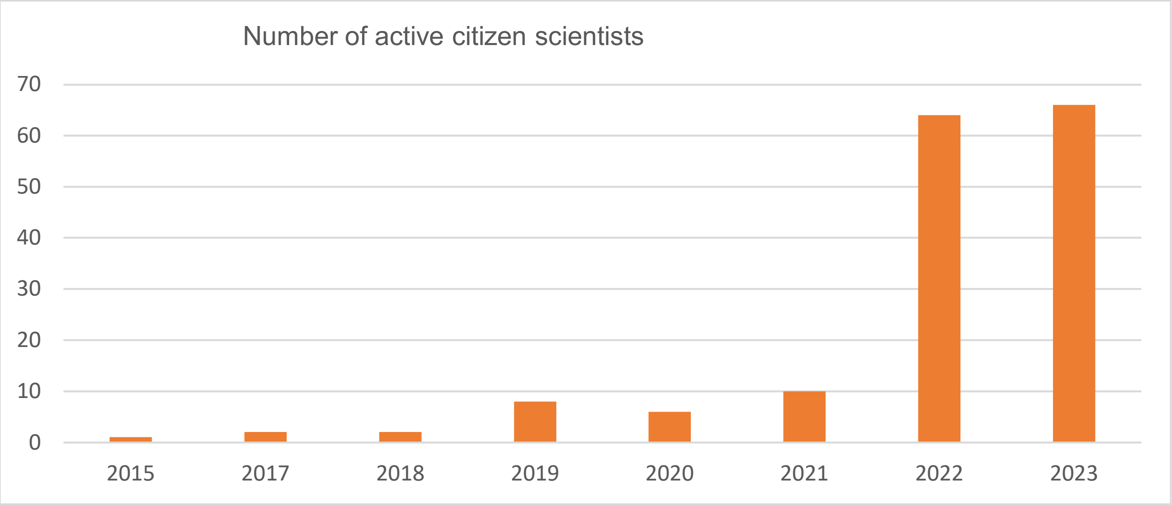

Figure 10: Growth of citizen science in the ECP

- 42 new citizen scientists registered and took part in regular monitoring in 2023, and there were 92 active ‘catchment champions’ committed to regular monitoring of at least one site in the catchment.
- 32 sites were monitored by citizen scientists in at least three of the four seasons in 2023, compared to 15 by the EA.

- Intermittent monitoring by citizen scientists (e.g. WaterBlitzes in the Spring and Autumn) increased the number of water bodies monitored from 9 to 15 out of a total 16 water bodies in the Evenlode catchment.
- Sampling effort (i.e. monitoring sites per km^2) was highest in water bodies in the west of the catchment, for all data sources (Figure 11).

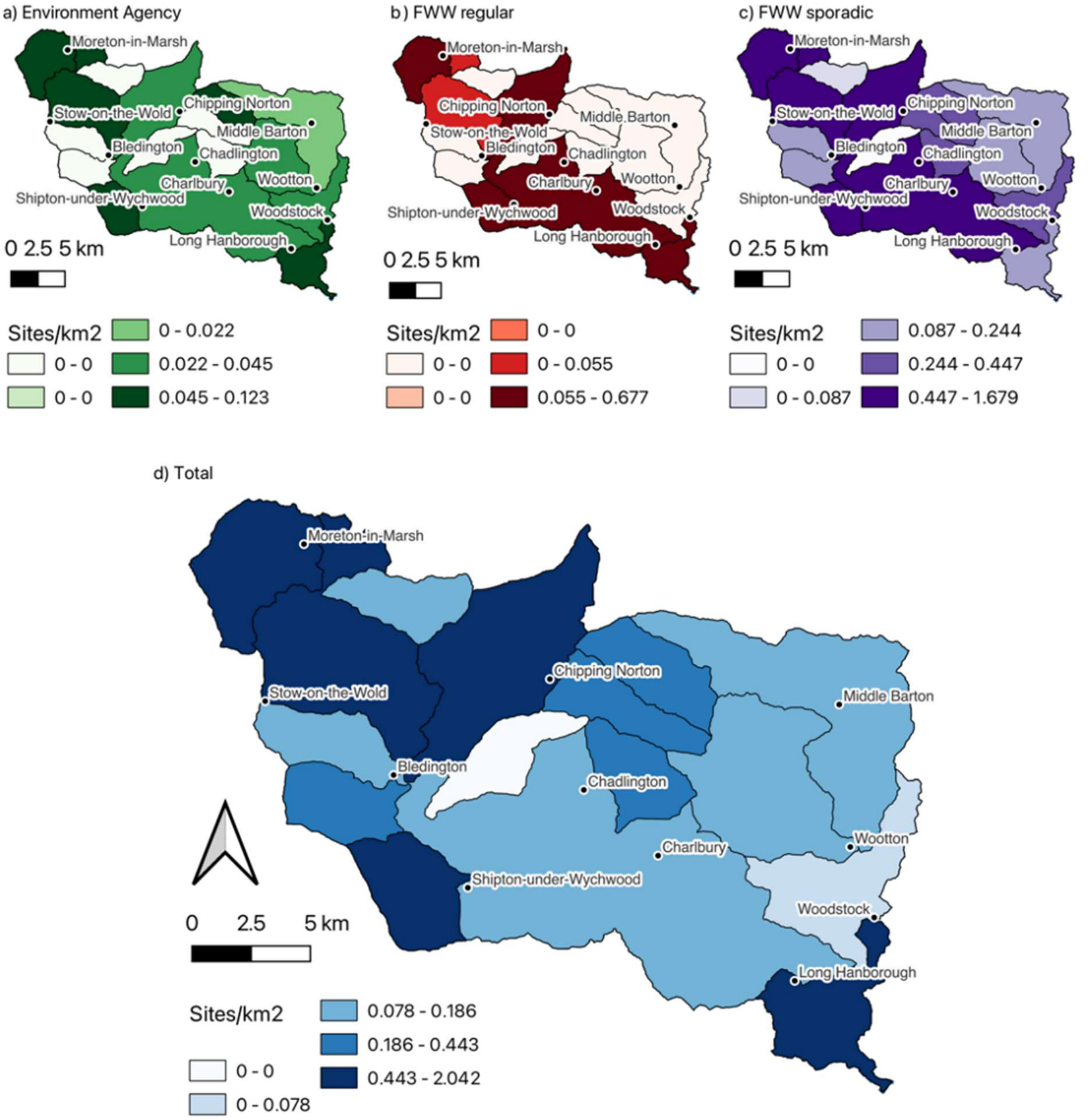

Figure 11: The Evenlode catchment divided into sub-sections, showing the areas where data was collected, and where there were gaps.

There were significant differences between EA data and citizen scientist data: phosphates (Figure 12)

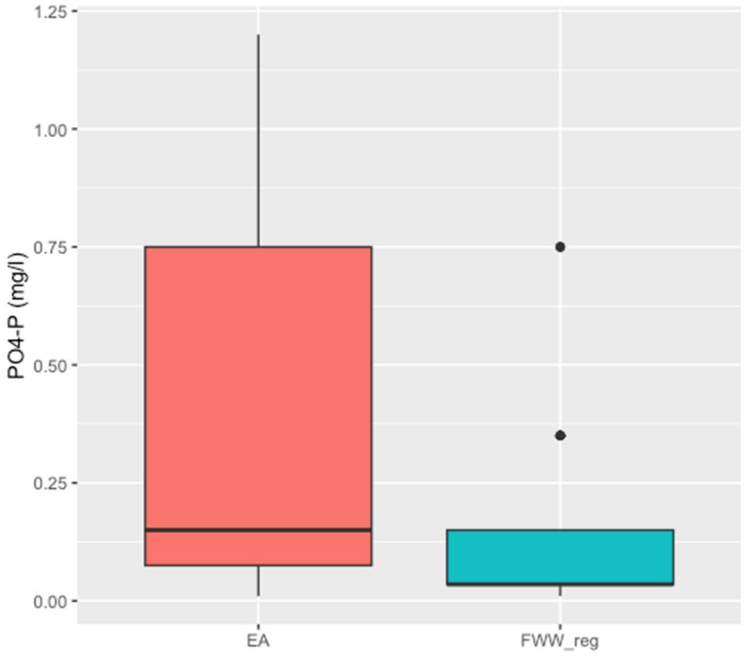

Figure 12: Differences between EA and citizen scientists' phosphate data

- The average phosphate concentration recorded by the EA was significantly higher ($P < 0.01$) than the average recorded by citizen scientists.
- This difference persisted after both methods were corrected to account for the detection limits of the FWW method, and for differences in the timing of monitoring.
- The EA typically monitored at the most downstream accessible location of any water body to include all impacts of pollution.
- Citizen science monitoring included upstream areas that were less affected by pollution, thereby showing the potential for good or even high phosphate status to be achieved, if pollution is addressed.

7. Methodological notes

This analysis brings together information from EA monitoring; citizen scientist monitoring made at regular (typically monthly) intervals; intermittent citizen scientist monitoring undertaken typically twice annually (i.e. Riverfly and water quality WaterBlitz data); and data from specific, focused studies.

- ‘Regular’ monitoring was considered to be data from either the EA or citizen scientists which occurred in at least three of the four seasons,
- The monthly distribution of citizen scientist recorded data was relatively uniform throughout the year, with the exception of the minimum number of measurements made in May 2023 (Figure 13).
- The monthly distribution of EA monitoring showed a reduction between Jan – April compared with the rest of the year (Figure 13).
- ‘Intermittent’ monitoring occurred in fewer than three seasons.
- ‘Intermittent’ datasets were used to provide supplementary information, for example calculating water body phosphate status where no regular monitoring data was available.

Figure 13: Dataset distribution by month from the EA and from citizen scientists.

Comparing EA and citizen science data

- The FWW monitoring methodology used by citizen scientists provided nitrate and phosphate data in discrete ranges from less than 0.02 mg/L, with an upper detection limit of 1 mg/L for phosphate and of 10 mg/L for nitrate (Figure 14, and “FWW_reg” in Figure 15).

Figure 14: Photograph showing FWW ranges for recording nitrate results

- The EA monitoring methodology provided continuous values for nitrate and phosphate in mg/L, with higher detection limits (“EAreal” in Figure 15).
- To compare data from the different monitoring methods, EA data was converted to the FWW range format. This means that EA measurements above FWW detection limits (1.0 mg/L for phosphate and 10 mg/L for nitrate) were converted to these values to facilitate direct comparison (“EA” in Figure. 15)

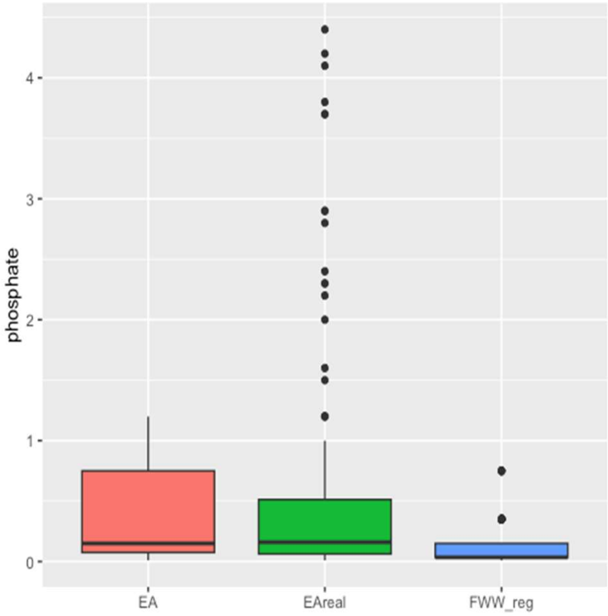

Figure 15: Ranges of EA and citizen scientists’ data with phosphate testing

Deriving phosphate status

- Boundaries for phosphate status were calculated based on the average alkalinity and altitude recorded by the EA at each monitoring location, using data from 2021- 2023, using the UK Technical Advisory Group method of assigning phosphorus standards for rivers.
- Measurements of phosphate concentration at each sampling site were assumed to be representative of the water body within which it lay. Where more than one monitoring station was present in a single water body, the lowest boundary values for that water body were used. Where there were no monitoring stations in a water body, the boundaries were based on the average of all other water bodies in the catchment.
- The phosphate boundaries for each water body were compared to the median phosphate measurement for a) each monitoring site (to derive phosphate status per site), and b) each water body (to derive phosphate status per water body). Citizen science and EA data were combined to derive water body status. Median values were used, as the distribution of concentrations in most water bodies was non-Gaussian (not normally distributed)

Table 2: Phosphate status boundaries per water body. Italics represent water bodies where no data was available.

wb_name	high	good	moderate	poor
Bledington Brook (Source to Evenlode)	*0.0359*	*0.0681*	*0.1719*	*0.9997*
Coldron and Taston Brooks	*0.0359*	*0.0681*	*0.1719*	*0.9997*
Cornwell Brook and tributaries (Source to Evenlode)	0.035	0.067	0.17	0.995
Dorn (Source to Glyme)	0.04	0.075	0.186	1.033
Evenlode (Bledington to Glyme confluence)	0.036	0.068	0.172	1
Evenlode (Compton Bk to Bledington Bk) and 4 Shires	0.029	0.057	0.149	0.944
Evenlode (Glyme to Thames)	0.039	0.073	0.181	1.022
Evenlode (Source to Four Shires S) and Longborough Stream	0.032	0.062	0.161	0.973
Glyme (Dorn confluence to Evenlode)	0.041	0.077	0.189	1.04
Glyme (Enstone to Dorn)	0.04	0.074	0.184	1.029
Glyme (Source to Enstone)	*0.0359*	*0.0681*	*0.1719*	*0.9997*
Heythorpe Stream and tributaries	0.031	0.06	0.156	0.962
Little Compton Brook and tributaries (Source to Evenlode)	*0.0359*	*0.0681*	*0.1719*	*0.9997*
Littlestock Stream to tributary of Evenlode at Shipton	0.036	0.068	0.171	0.999
Sars Brook (source to Evenlode downstream Bledington)	*0.0359*	*0.0681*	*0.1719*	*0.9997*
Westcote Brook (source to Evenlode at Bledington)	*0.0359*	*0.0681*	*0.1719*	*0.9997*

8. Recommendations for 2024

Thames Water had previously agreed with ECP's assessment to include upgraded phosphorous removal technologies to 13 sewage treatment works. These upgrades were (and are) included in the WINEP as recently as summer 2023, but were absent from their most recent business plan formally submitted to the Ofwat. Thames Water's business plan (PR24) now contains no SWT upgrades for phosphorus removal, or to meet their legal commitments for the Evenlode catchment under the Water Framework Directive and the Environment Act.

Thames Water has also postponed 108 previously funded improvement schemes across its network, including those for Moreton-in-Marsh, until the 2025 – 2030 period with a sum of £1.13 billion allocated to the costs of completing these essential works. The ECP will continue to build the case and campaign for change with a focus on tertiary treatment at MuW STW and Chipping Norton STW.

The placement of sondes upstream and downstream of the MuW STW and Chipping Norton STW has provided strong evidence of the daily, weekly and seasonal impacts of the STWs on the receiving rivers. The sondes allow the ECP to better understand the impacts of key events, precipitation, drought periods, and STW related spills on river quality. Given the two years of recorded data, and the clear decision to leave both STWs in their present state (without expected upgrades), moving the sondes to another secure location should be considered. The new location should either monitor the benefits of mitigation actions on daily and seasonal conditions of the river (upstream and downstream mitigation actions) or potential intermittent pollution sources to better identify, characterise and mitigate these sources.

Given the monitoring data gaps identified in the analysis, it is fundamental to establish regular monitoring at sites where intermittent monitoring has revealed potential issues (namely Hanborough, Church Enstone, Bledington, and around Charlbury) and in water bodies with no or limited monitoring (Sars Brook).

There are clear benefits and complementarity from combining water quality, biological, geomorphological and vegetational monitoring methods. Expanding biological monitoring to link poor water quality o ecological impacts using Riverfly monitoring should continue to be a priority. New methods to quantity riparian vegetation, in-stream macrophytes, and hydrological conditions should be explored and possibly integrated into opportunities for citizen scientists. These are presently being developed in UK and EU projects in which ECP partners are involved. Addition methods development for microbial conditions (e.g. e-coli concentrations), and ammonium concentrations should also continue to be pursued.

Walking safaris should be conducted along stretches of Evenlode particularly where potential pollution sources have been identified or highlighted from existing research. Hand held (calibrated) probes measuring additional parameters such as DO and temperature, along with standard FWW methods should be used, to better determine the impact of these sources on the receiving rivers and brooks.

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