About the catchment

Background site information

Drift Reservoir is located in far west Cornwall, within the Penwith Peninsula (EA) Operational Catchment which falls within the Cornwall West and the Fal (EA) Management Catchment.

Catchment Challenges

Drift Reservoir (Figure 1) is challenged by pesticides (specifically linuron, mecoprop, metaldehyde and pendimethalin) and blue-green algal blooms driven by nutrient enrichment. Interventions in the catchments were led by **Cornwall Wildlife Trust** (CWT).

- Water quality challenges in the reservoir are pesticides and blue-green algal blooms driven by nutrient enrichment;
- Detrending analysis of turbidity data between 2012 and 2018 shows that most of the high peaks were driven by climatic conditions (particularly high rainfall): differences in sediment pollution were due to inter annual variability rather than catchment management interventions; no statistically significant change in water quality can be observed throughout the duration of the project;
- In feeder streams, all Total Oxidised Nitrogen (TON) concentrations input to the reservoir during rainfall events are higher than the SWW target of 2 mg L^{-1} in the reservoir, highlighting high nutrient input from the catchment;
- Although high TON concentrations were observed during rainfall events in the Sancreed Brook, low river flow in the catchment resulted in lower loads from that site;
- Most Soluble Reactive Phosphorus samples fall within the "moderate" category; nutrient input during rainfall events do not yet meet the criteria set by the EA for reservoir water.
- Levels of individual pesticide detections in the reservoir were below 0.1 µg L^{-1} throughout the monitoring periods.

Figure 1 Drift reservoir (left) within the catchment (right), illustrating the prevalence of intensive arable farming above the reservoir; photos by Emilie Grand-Clement.

Catchment Activities

Catchment activities in the Drift catchment focussed on measures to decrease phosphate inputs and better manage land to improve its ability to intercept nutrients and pesticides. Figure 2 illustrates the level of farm engagement in Upstream Thinking 2 within the Drift reservoir catchment. 73% of the catchment area has been engaged in the programme, including farm visits by an advisor, the provision of a farm plan or physical interventions and behaviour changes.

Physical interventions completed via Upstream Thinking, which were quantifiable within the Farmscoper software, amounted to a cumulative total of 482 ha. The most commonly used interventions are shown in Figure 3. Slurry store improvements and dirty water management all impact on phosphorus losses, whilst establishing new hedges and better farm track management can also provide benefits by reducing sediment losses.

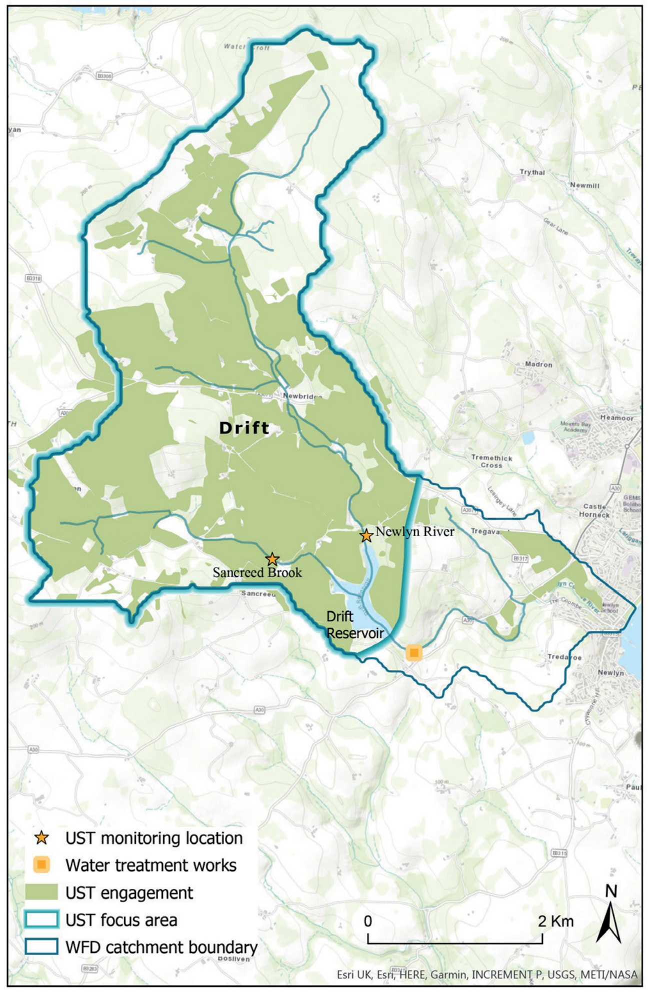

Figure 2 Map of engagement by the CWT as part of UsT in the Drift catchment.

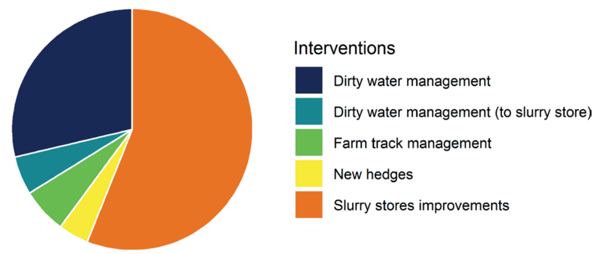

Figure 3 Top 5 interventions (quantified in Farmscoper) used in the Drift catchment.

Figure 4 Monthly turbidity variations in Drift reservoir between 2012 and 2018 (A) and detrended monthly averages for the same time period (B), with full line indicating the monthly mean and the ribbon area the associated range of data.

Water quality in the Drift catchment

Turbidity in Drift reservoir

Continuous measurements of turbidity in Drift reservoir enable an understanding of rapid variations in the suspended sediment signal, and is also an invaluable resource to study long-term, seasonal and inter-annual variations of sediment input to the reservoir. Measured turbidity variations at Drift reservoir (Figure 4A) show a cyclic pattern with an annual peak generally occurring in spring to summer, with high turbidity values measured in the summers of 2014 and 2016 (with maximum values reaching ca. 30 NTU). The occurrence of these high peaks is linked to a combination of catchment management, climatic and environmental factors. For instance, low vegetation cover following tillage leaves soils vulnerable to erosion (as well as to losing carbon to the atmosphere); combined with high rainfall and steep slopes, this could have had detrimental impact on water quality in the reservoir.

Figure 4B shows the detrended turbidity signal: in this signal, the influence of climate has been removed from the dataset. This resulting dataset clearly shows the disappearance of the high peaks of summers 2017 and 2016, which can therefore be linked to seasonal conditions, including high energy summer rain storms. Other peaks, however, remain (e.g. January 2013 and October 2015). These events are likely to be driven by environmental conditions in the catchment. While no clear impact of catchment management to improve water quality can be seen since 2015, there is also no deterioration in the water quality over this period. Further interventions would be required to reduce the loss of soil from agricultural fields into the reservoir.

Figure 5 The Sancreed Brook; Photo by Emilie Grand-Clement (UoE).

Nutrient content in feeder streams

Nutrient inputs to the reservoir from the two feeder streams, the Sancreed Brook (Figure 5) and the Newlyn River (Figure 6), were measured during a number of rainfall events. Results (Figure 7) show significantly higher TON concentrations in the Sancreed Brook (e.g. mean concentrations between 3.7 mg L^{-1} and 4.7 mg L^{-1}) than in the Newlyn River (e.g. mean concentrations between 2.5 mg L^{-1} and 3.05 mg L^{-1}) for each hydrological year; for both sites these values are consistently above the target of 2 mg L^{-1} set by SWW in the reservoir as an indicator of improvement.

For phosphate losses during rainfall events, there are little differences between sites. Overall, phosphate values in the catchments place both streams in the "moderate" category, whilst some samples occasionally fall in both "good" and "poor" categories". Overall, the nutrient input during rainfall events do not yet meet the criteria set by the EA for in reservoir water.

Figure 6 The Newlyn River; Photo by Emilie Grand-Clement (UoE).

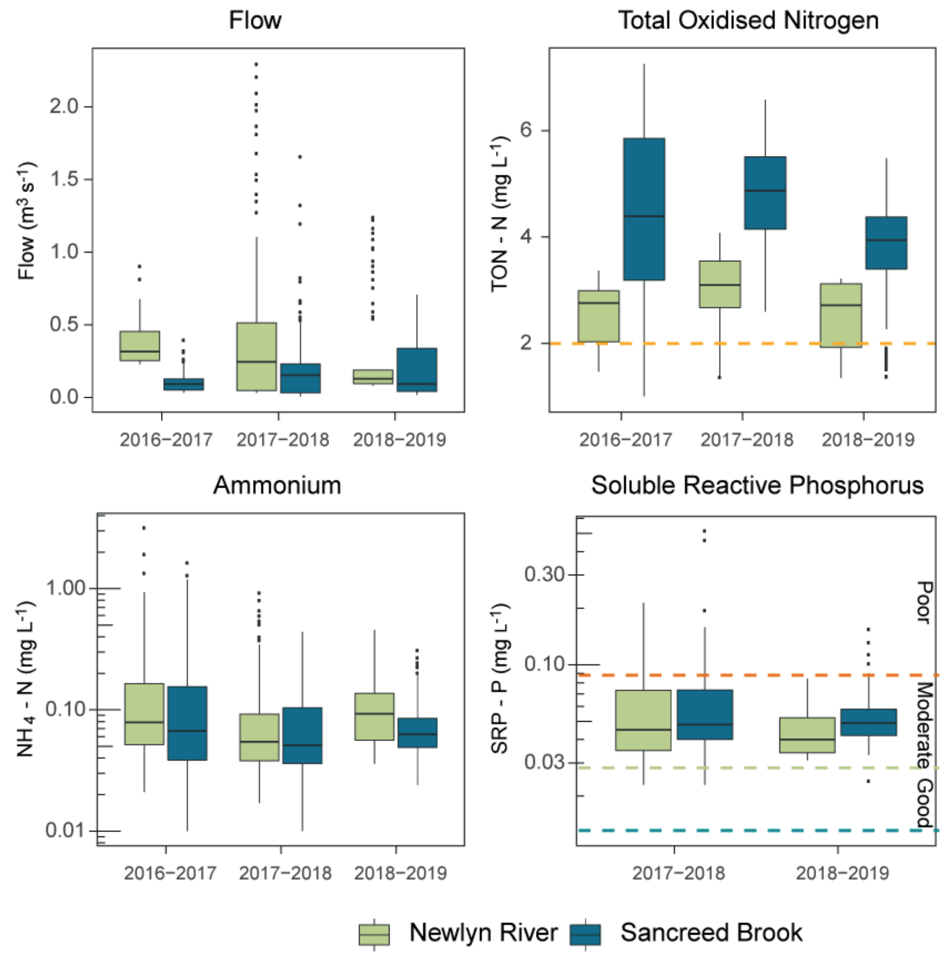

Figure 7 Flow Total Oxidised Nitrogen, ammonium and Soluble Reactive Phosphorus concentrations in the feeder streams to Drift reservoir, with dashed lines representing the regulatory limits for Total Oxidised Nitrogen and total phosphorus respectively.

Figure 7 also shows that the Newlyn River tends to have higher stream flow during monitored events than the Sancreed Brook for 2016-2017 and 2017-2018 monitoring years. This results in slightly higher nutrient loads (i.e. the actual mass of nutrient carried by the stream to the reservoir) compared to Sancreed Brook, despite experiencing lower concentrations (Figure 8). This has implications for catchment management, as interventions in the Newlyn River sub-catchment will have a slightly higher impact on the delivery of nutrients during high flows, thus future catchment interventions could be more valuable in this sub-catchment.

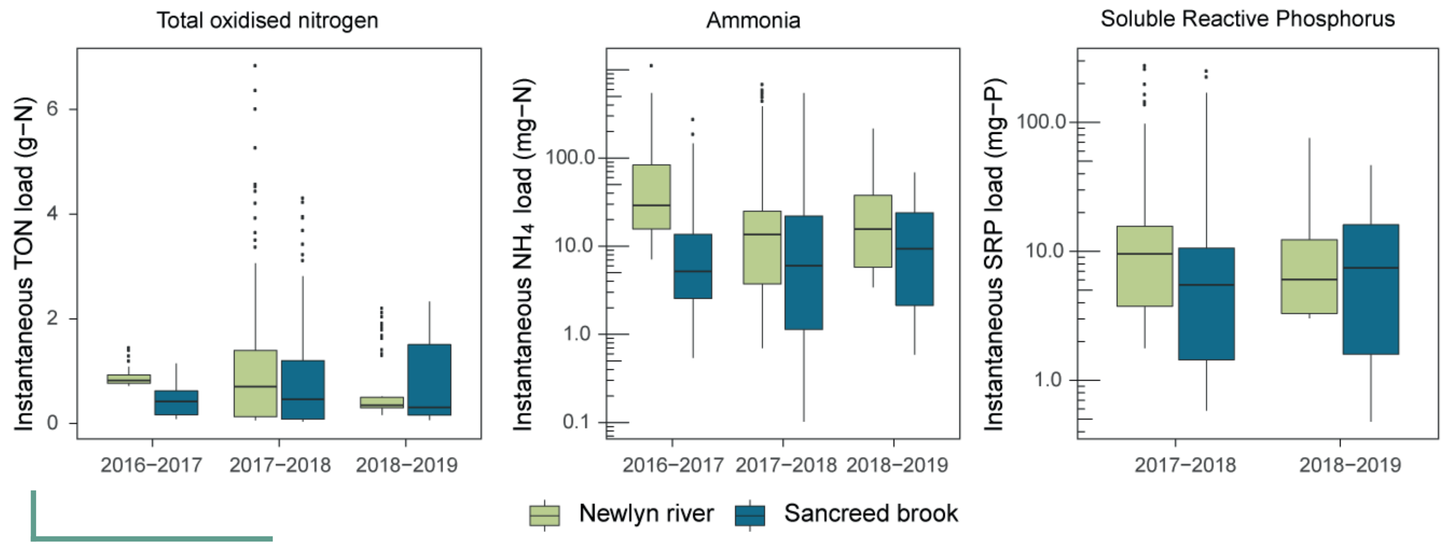

Figure 8 Total Oxidised Nitrogen, ammonia and Soluble Reactive Phosphorus loads (mg) for the rainfall events monitored between 2016-2017 and 2018-2019.

Pump sampler in the Sancreed Brook; Photo by Paul Henderson.

Water quality and diffuse pollution in rainfall events in feeder streams

In addition to nutrient content, the study of pollutant concentrations during specific rainfall events is useful to understand contaminant dynamics. The plots shown in Figure 9 highlight the different type of behaviour generally observed with TON and DOC, resulting in different hysteresis loop patterns in the catchment: TON generally present in the stream is being diluted by rain water during storms (i.e. concentrations decrease as flow increases), indicating that there is no immediate increase in concentration as an input of diffuse pollution; DOC, however is increasing in concentration during the event and peaks simultaneously to the peak in discharge, which indicates that it is flow and rainfall driven, with sources of DOC (such as manures or slurries on fields) being directly connected to the water course during times of high rainfall. These two different types of behaviour are reflected in two different hysteresis loops: clockwise for TON, and anticlockwise for DOC.

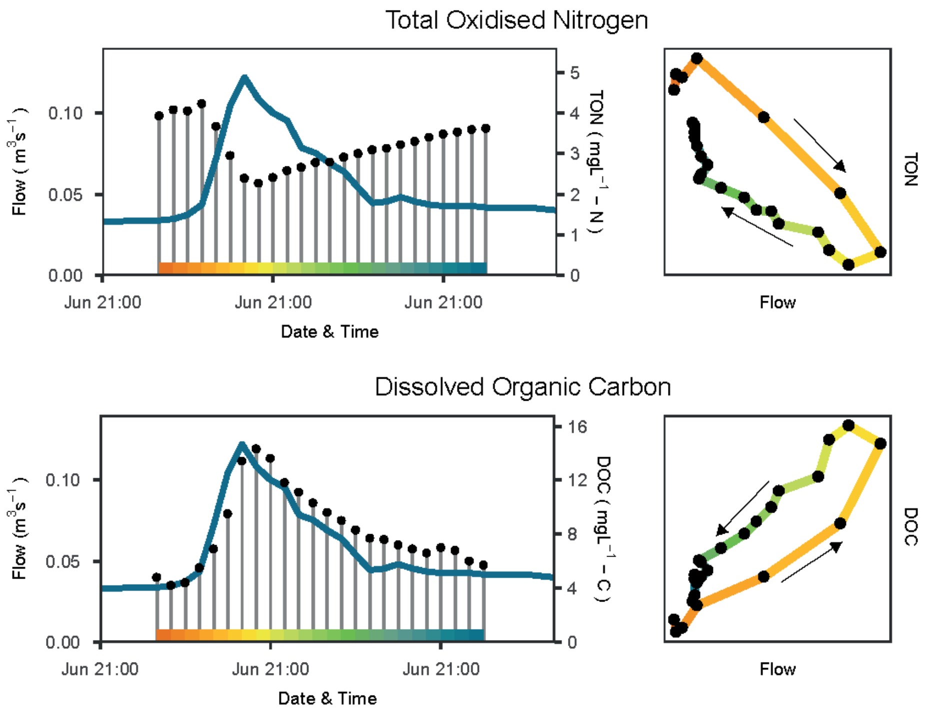

Figure 9 Relationship between flow ($m^3 s^{-1}$) and water quality parameters (i.e. Dissolved Organic Carbon and Total Oxidised Nitrogen) for one rainfall event in the Sancreed Brook sub-catchment, with associated hysteresis loop.

Blue-green algae and nutrient content in the reservoir

Algal blooms have been identified as an issue in Drift reservoir. Spot samples collected by SWW at the water treatment works (Figure 10A) show the occurrence of summer algal peaks in Drift reservoir, which was identified as problematic and costly for the water treatment works. Peaks in 2015 and 2016 were particularly prominent, however, their amplitude seems to decrease in the subsequent years. Figure 10B shows the overwhelming presence of cyanobacteria during these peaks whilst other species are only noticeable at other times. Cyanobacteria have been identified as particularly problematic in Drift reservoir due to its significant impact on the treatment process.

In addition, the reduction in nutrient concentrations in the reservoir was an objective of Upstream Thinking. However, the result of the spot samples in raw water at the WTW (Figure 11) shows that nutrient concentrations remained high. For phosphorus, samples consistently fell outside of the WFD target indicting good status (i.e. above 15.76 µg L⁻¹); TON concentrations showed a seasonal pattern, going below the 2 mg-N L⁻¹ in the autumn-winter. Neither nutrient shows a clear sign of improvement. This particular result is likely to be linked with the existing nutrient content of the reservoir, which is clearly high, as a legacy of nutrient inputs in previous years. However, in addition, recent levels of input to the reservoir during rainfall events (Figure 11) above these levels are likely to have contributed to the currently high nutrient content of the reservoir.

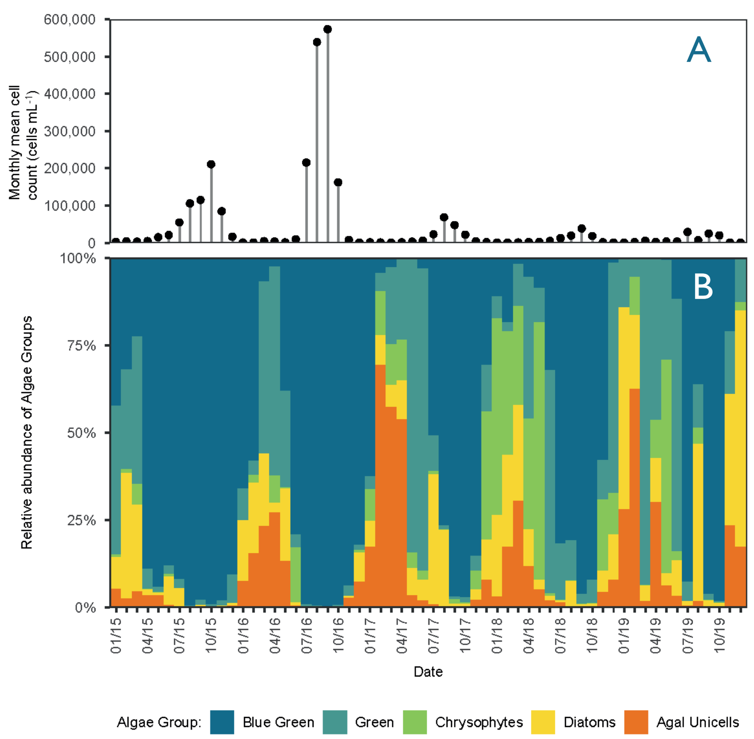

Figure 10 Monthly averages of total algal blooms (A) with corresponding abundance of species (B) between 2014 and 2019 in the raw water at Drift WTW.

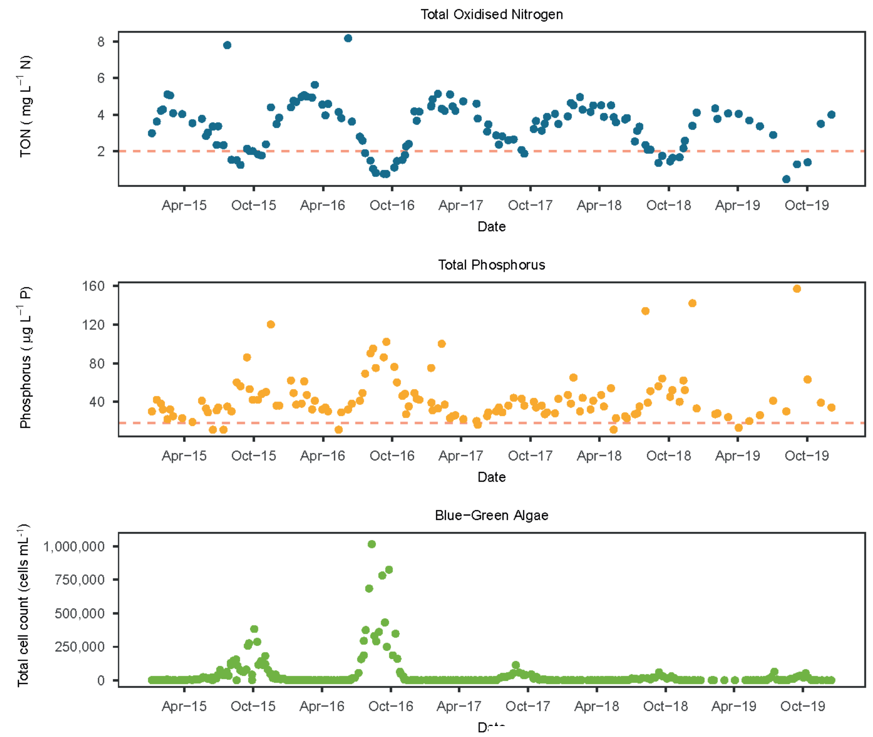

Figure 11 Total Oxidised Nitrogen (top), Phosphorus (middle) and blue-green algae cell count (bottom) between 2014 and 2019 in raw water at Drift WTW; red lines indicate the exceedance limit for each nutrient concentrations in the catchment.

In reservoirs, geosmin which causes taste and odour problems in drinking water, can originate from algae die-back. We would therefore expect increased concentrations of geosmin to occur after algal blooms. Interestingly, geosmin data (Figure 12) shows that this is not necessarily the case. This is, for example, noticeable with peaks in algae occurring in Autumn 2016 that do not result in a significant increase in geosmin; conversely, a number of geosmin peaks seem to occur and be unrelated to algal blooms. This means that geosmin could originate from sources in catchment, i.e. from soil, although a more in depth study would need to be carried out to draw firm conclusions.

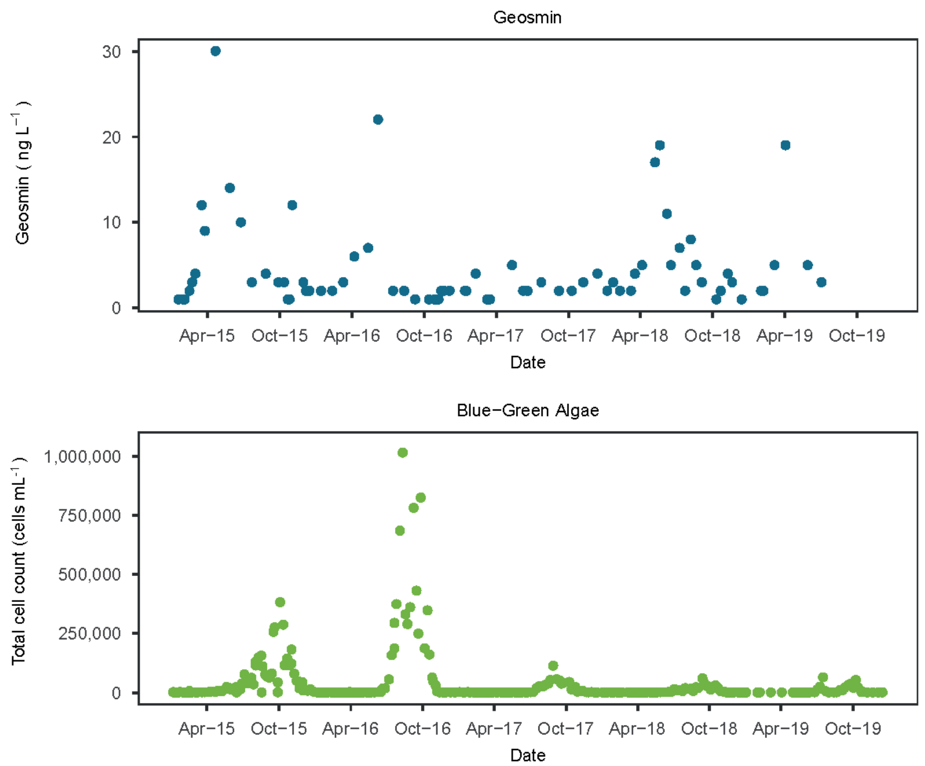

Figure 12 Geosmin (top) and blue-green algae concentrations (bottom) between 2015 and 2019 in raw water at Drift WTW.

Overall, the reduced amplitude of blue-green algal blooms since 2017 is a positive result for the Upstream Thinking objectives. More investigations in the coming years will enable us to identify the importance of climate, within reservoir dynamics and input of nutrients in the catchment in driving algal blooms. This should enable us to better quantify the benefit brought by catchment management to reservoirs and reduce algal blooms and associated water treatment costs.

Pesticide detections within the catchment

Another concern in the catchment has been pesticides getting to the reservoir. Chemcatchers were used to get a better understanding of concentrations at specific times of the year, i.e. 6 weeks in the spring and 6 weeks in the autumn. Chemcatcher deployments in the Drift catchment show a high number of compounds detected (i.e. up to 8 compounds for Drift reservoir, 6 for the Newlyn River, and 7 for the Sancreed Brook). In all locations, 2,4-D, Fluroxypyr and Trychlopyr represents the majority of the compounds detected (Figure 13). These compounds are routinely used as pesticides on farmland.

The total number of detections per site and deployment period ranged between 4 and 15 (Table 1). There is also a slight decrease in the overall number of detections in the Drift reservoir between the first half of the project (Spring 2016 to Spring 2017) and the second half (from Autumn 2017). Although this difference is not statistically significant, it is positive.

High flow in the Newlyn River; Photo by Paul Henderson.

		Spring 16	Autumn 16	Spring 17	Autumn 17	Spring 18	Autumn 18
Total number of detections	Sancreed brook	9	13	4	N/A	N/A	N/A
	Newlyn river	13	9	9	N/A	N/A	N/A
	Drift WTW	15	15	14	7	13	9
Nb single exceedances >100 ng L^{-1}	Sancreed brook	0	0	0	N/A	N/A	N/A
	Newlyn river	0	0	0	N/A	N/A	N/A
	Drift WTW	0	0	0	0	0	0
Exceedance over 500 ng L^{-1}	Sancreed brook	0	0	0	N/A	N/A	N/A
	Newlyn river	0	0	0	N/A	N/A	N/A
	Drift WTW	0	0	0	0	0	0
Max value (ng L^{-1})	Sancreed brook	8	22	1	N/A	N/A	N/A
	Newlyn river	3	4	2	N/A	N/A	N/A
	Drift WTW	3	9	2	5	4	2
Total number of compounds	Sancreed brook	4	6	2	N/A	N/A	N/A
	Total number of compounds	5	3	4	N/A	N/A	N/A
	Drift WTW	5	5	5	3	5	4

Table 1 Summary of pesticide detections in the Drift catchment between spring 2016 and autumn 2018. The blue shading indicates a severity scale separately applied to each parameter, from light blue (low) to dark blue (high); N/A indicates that no deployments were carried out.

Cattle in the Sancreed Brook; Photo by Paul Henderson.

Certain compounds are also sporadically detected, such as metaldehyde (found in slug pellets) in Spring 2016 in all three locations, and PCP (weed killer) in Spring 2018 only (although the monitoring period of the feeder streams stopped in Autumn 2017).

With an overall maximum concentration of 22 ng L^{-1} in the Sancreed Brook, no site had a single detection above the regulatory limit of 100 ng L^{-1} (in treated water), or a cumulated concentration over 500 ng L^{-1}, which is very positive.

Figure 13 Relative abundance (%) of chemicals detected between Spring 2016 and Autumn 2018 at Drift reservoir, and between Spring 2016 and Spring 2017 for the Newlyn River and the Sancreed Brook.