



ChessWatch:

Observations on a Citizen Science approach to catchment management

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- The River Chess is a groundwater-fed, chalk stream in South East England (UK), under unprecedented pressure from over-abstraction, urbanisation and climate change.
- The River Chess currently fails to meet good ecological status.
- Citizen Scientists have been active in the catchment for 9 years carrying out riverfly monitoring due to concerns about low flows, water quality and poor fish populations. They also carry out monthly flow monitoring and maintain four water quality sondes.



- The community-led [ChessWatch](#) project is designed to raise public awareness of threats to the River Chess and involve the public in river management activities using a sensor network as an engagement platform.
- In 2019 four water quality sensors were installed in the river to provide stakeholders with real-time water quality data (15-minute intervals) to support catchment management activities. The probes record water level, dissolved oxygen, pH temperature, turbidity, chlorophyll-a and tryptophan. Here we show preliminary results from the temperature and dissolved oxygen sensors.
- The dataset from the project is intended to support future decision-making in the catchment as part of the five-year '[Smarter Water Catchments](#)' approach led by Thames Water.

Quote from a ChessWatch 'sensor guardian':

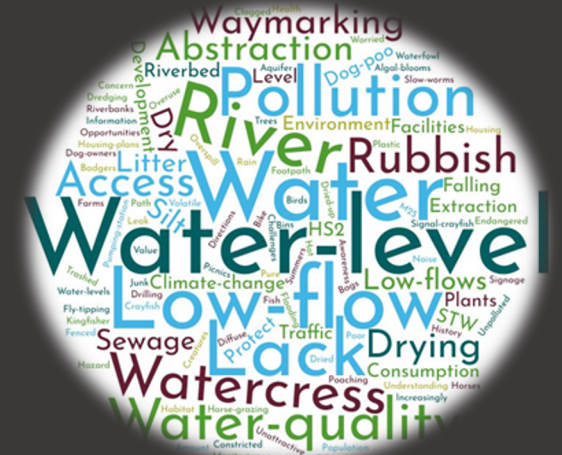
'it has been good to be able to get involved in the project and feel that I am making at least some level of contribution to something that I care about.'

Participatory mapping exercise held at public events in the catchment

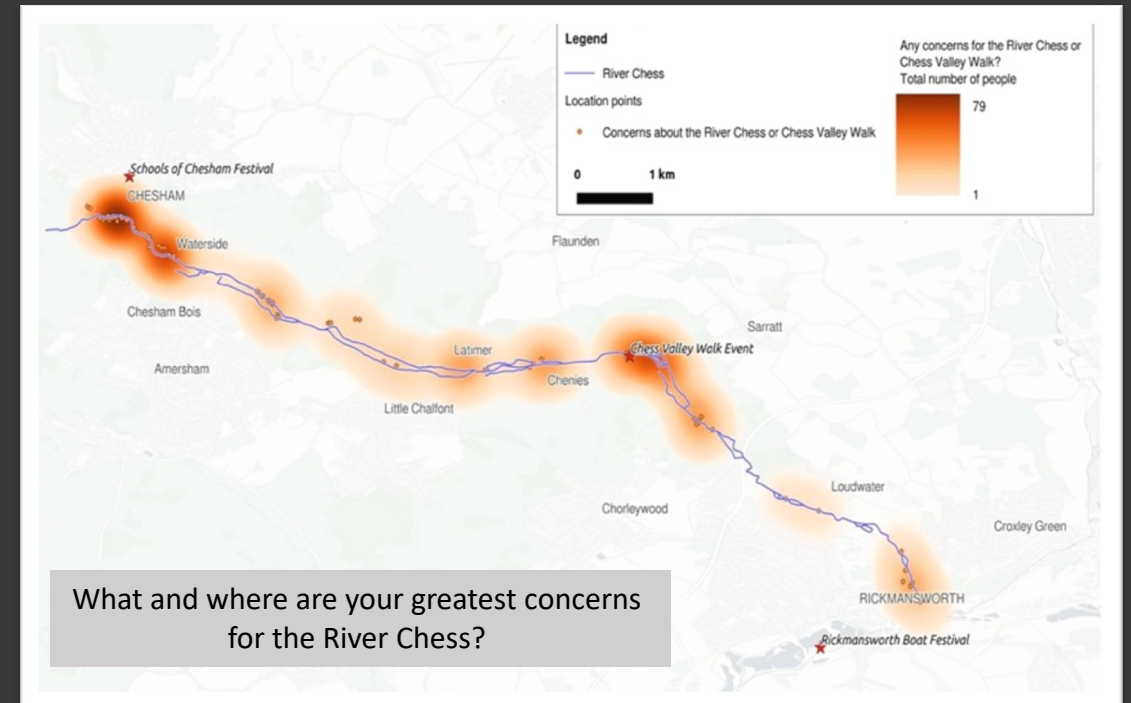
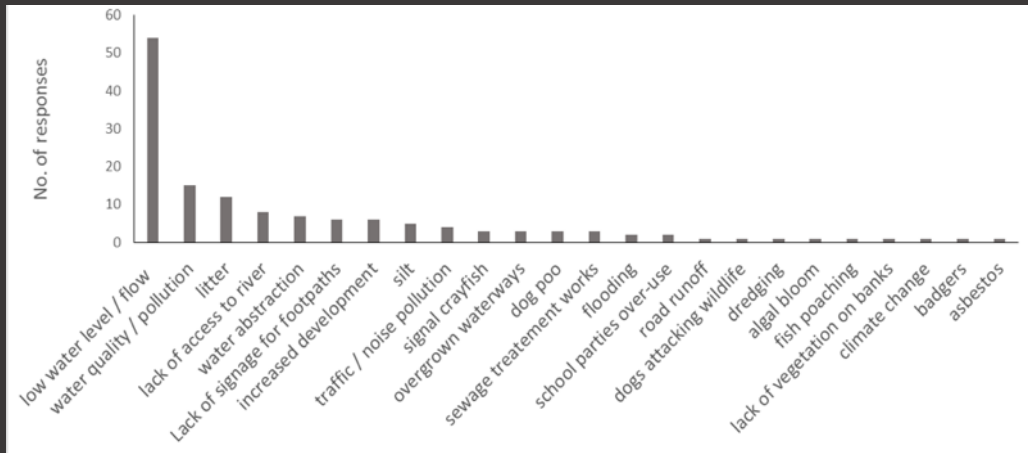
In Summer 2019 we held a participatory mapping exercise at five local community events to capture how local stakeholders value the river, and any concerns they had for river health.



Respondents were asked to use an aerial map to identify where they felt issues in the river were arising. They also provided short written explanations of the concerns raised. These responses were captured on an online-GIS system to help prioritise intervention activities and inform a 5-yr catchment management plan.

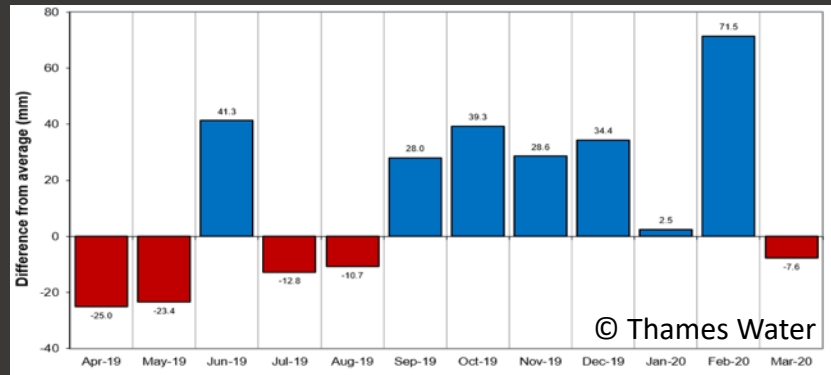


Our 209 questionnaire responses revealed a range of concerns for the River Chess, with low flows and water quality issues linked to abstraction and runoff as notable, critical issues for the public.

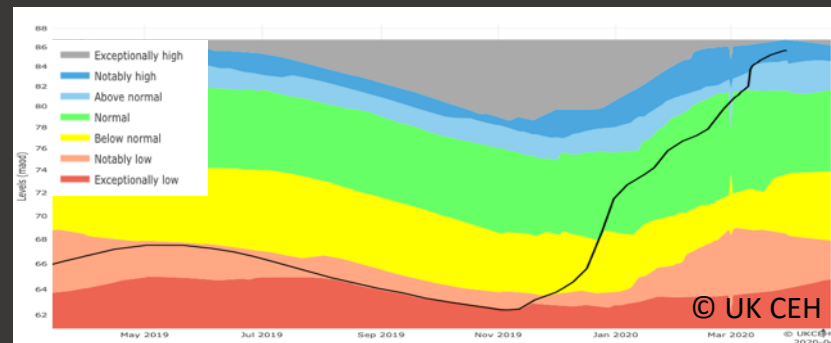


What and where are your greatest concerns for the River Chess?

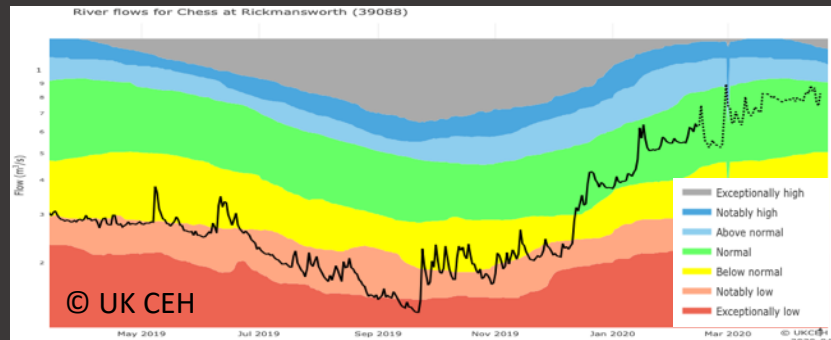
Rainfall, groundwater and flow conditions during our monitoring campaign (April 2019-2020)



Thames Area Monthly Rainfall Totals above or below 136yr average (mm)



Groundwater Levels in the Chilterns (Stonor Park) April 2019 – April 2020*

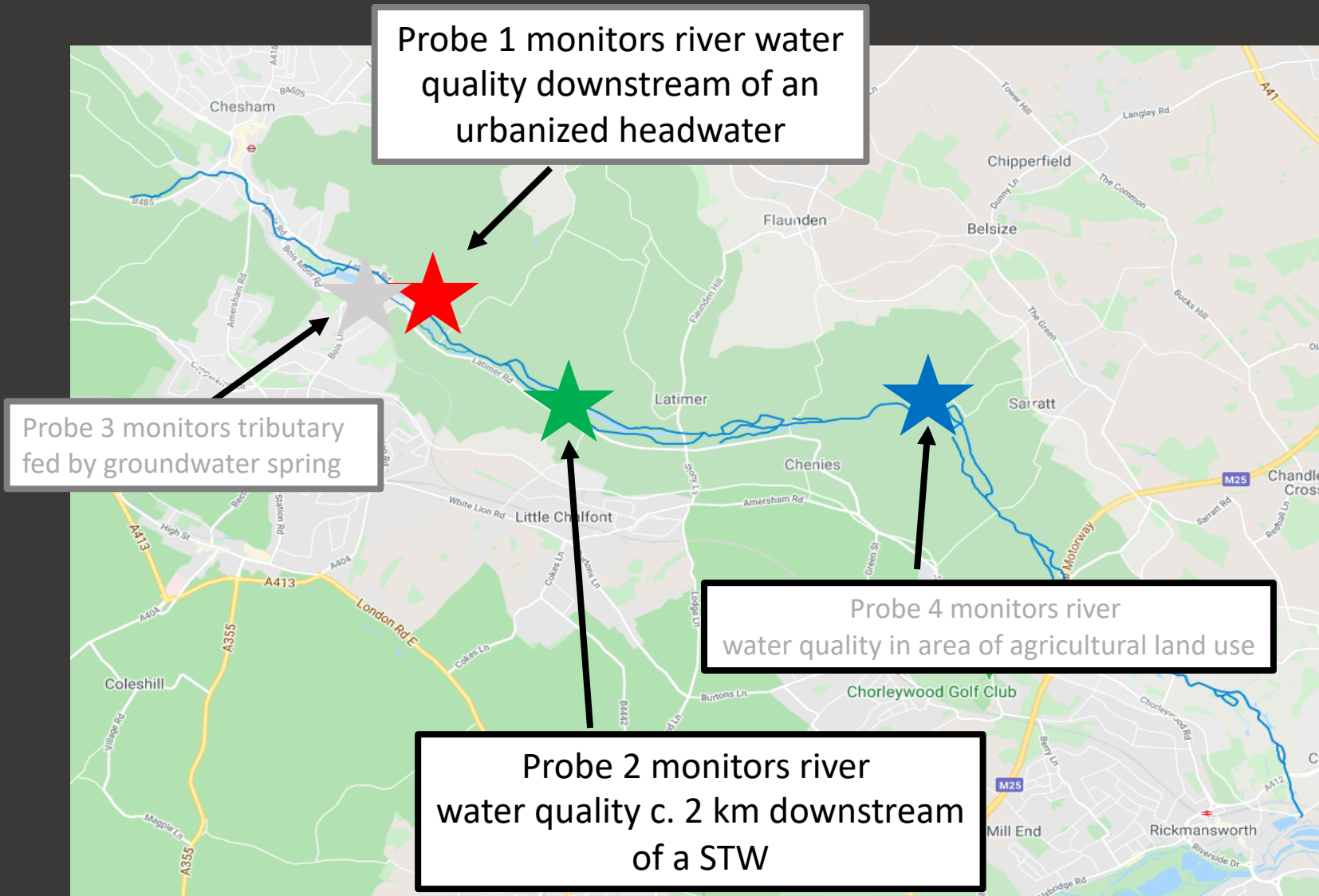


Discharge for River Chess (Rickmansworth) April 2019 – April 2020*

- Our monitoring to date has covered a period of drought with below-average rainfall to an autumn and winter of above-average rainfall characterised by high intensity rainfall events.
- Chiltern chalk streams are groundwater-fed so groundwater level is an important control on river flow. Groundwater in the region is abstracted for public water supply. Groundwater levels were notably to exceptionally low at the beginning of the project in spring and summer 2019, and are now notably high. This marked intra-annual range in levels is similar to that observed in 2014.
- River flow was exceptionally low in summer 2019 and has now recovered to the normal range in response to the rise in groundwater levels.
- These types of variation could become a more frequent occurrence due to the impacts of climate change on summer temperatures, groundwater recharge and rainfall patterns^{1,2}.

*UK Water Resources Portal, UKCEH: <https://eip.ceh.ac.uk/hydrology/water-resources/>

Locations of sensors in River Chess from April 2019 – 2020



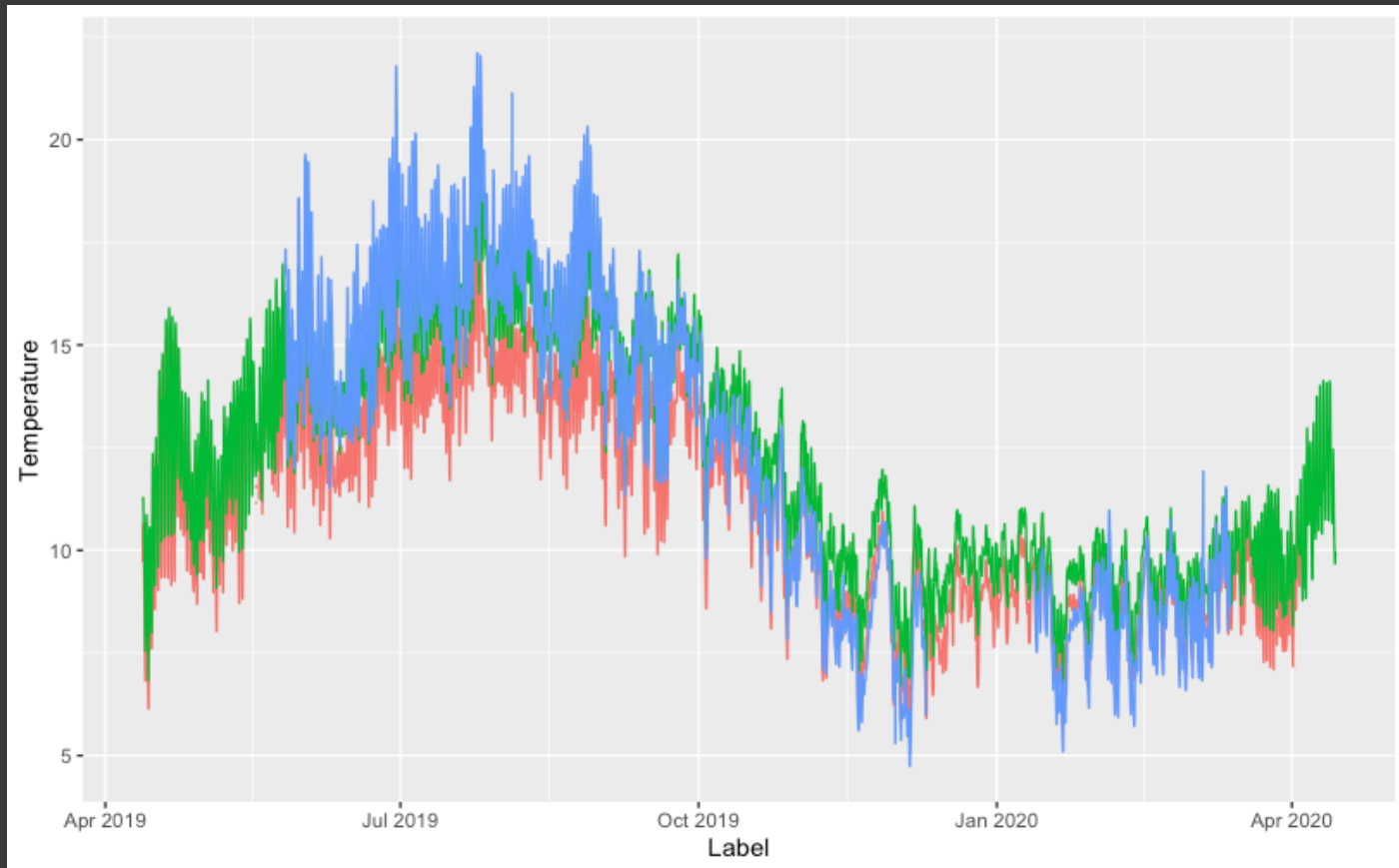
The River Chess is located in the South East of England with a catchment that contains a mix of urban and rural land uses.

Sensor locations were chosen to explore the river environment from the urbanised source in Chesham, through rural land use to the confluence with the River Colne at Rickmansworth.

2 km

<https://www.qmul.ac.uk/chesswatch/interactive-map-of-river-chess/>

Variations in Temperature (°C) in River Chess from April 2019 – 2020



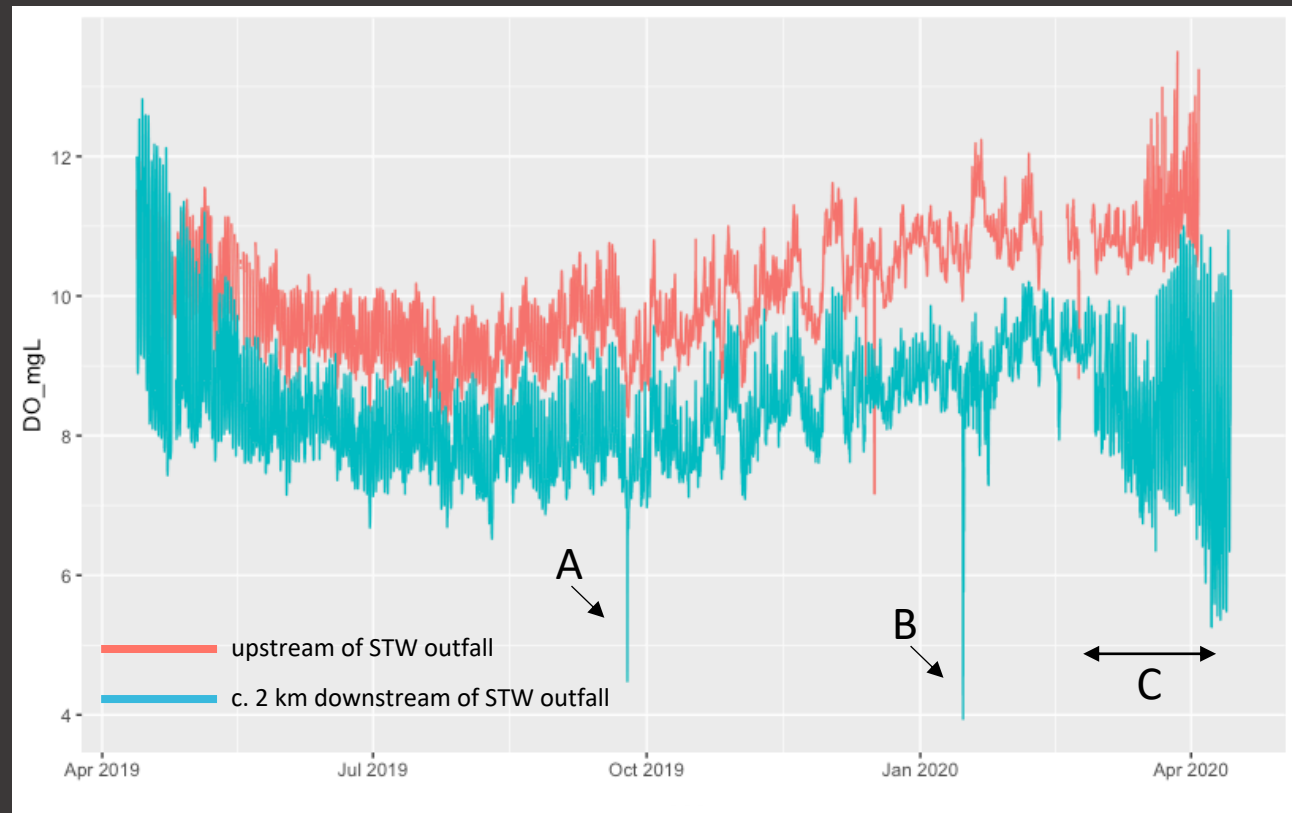
Probe 1

Probe 2

Probe 4

- Our data has enabled stakeholders to better understand changes in temperature in the river water during a hot summer of notably low flows.
- Chalk streams are described as having stable temperature regimes, but our data shows marked diurnal variations exacerbated by low flows.
- Water temperatures exceeded 20°C in unshaded reaches during hot weather in summer when water levels in the river are low (< 30 cm depth). Low flows and prolonged elevated temperatures such as these will stress fish such as brown trout and affect recruitment success of fish such as grayling³.
- Water temperatures above 15°C combined with low oxygen conditions can affect egg development (< 9 mgL⁻¹), and be lethal to Brown Trout (< 5 mgL⁻¹).

Variations in dissolved oxygen concentration (mgL^{-1}) in River Chess from April 2019 – 2020



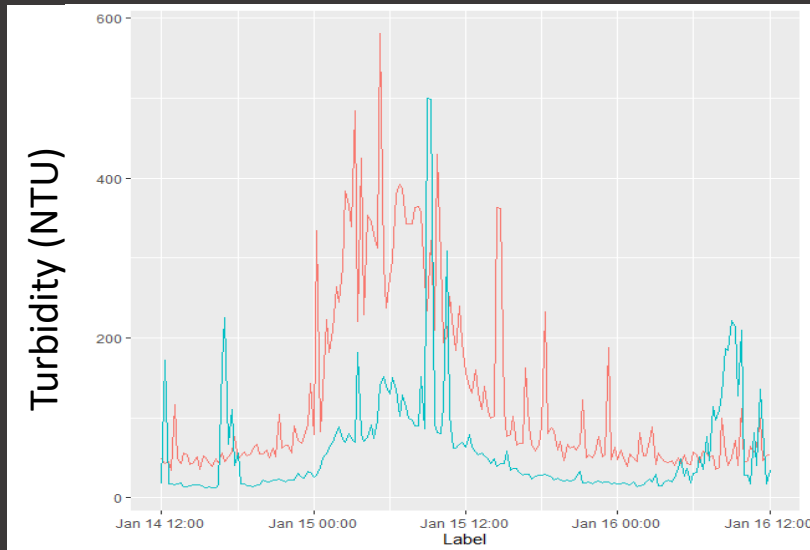
Storm tank discharge
at STW Outfall

From September to March 2020 five **high-intensity rainfall events** caused intermittent storm tank discharge to the river. Our sensors show that not every storm tank discharge event has had the same effect on oxygen status, but some events (A and B) are characterised by a marked transient drop of 3 to 5 hours duration in dissolved oxygen concentrations in the river.

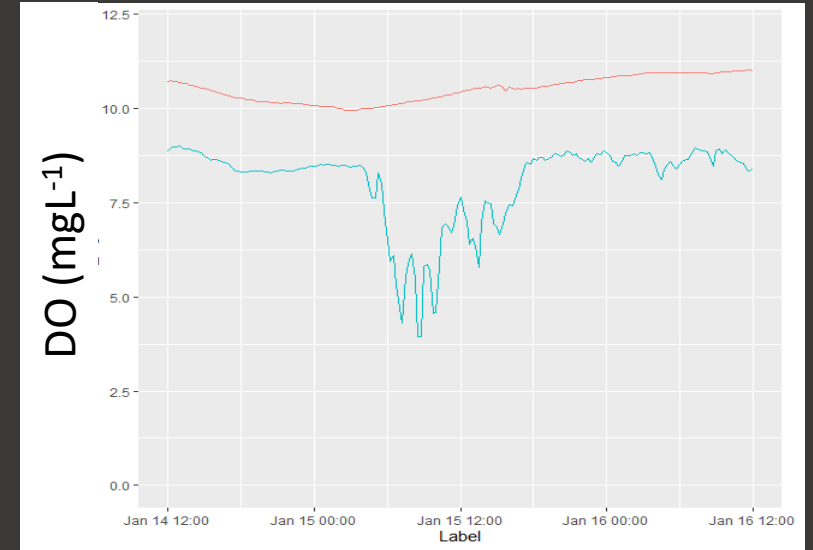
Since February 28th 2020 **groundwater ingress due to high groundwater levels** has caused daily discharge of storm tanks from the local sewage treatment works (C). Our sensors show that this activity has caused a gradual decline in oxygen concentration in the river, and that this effect extends over 2 km below the outfall. The diurnal range in oxygen concentration has also increased due to changes to river metabolism.

What are the potential implications of these dissolved oxygen concentrations (mgL^{-1}) for river health?

We have seen a transient oxygen drop due to storm tank discharge in response to high-intensity rainfall



— upstream of STW outfall
— c. 2 km downstream of STW outfall

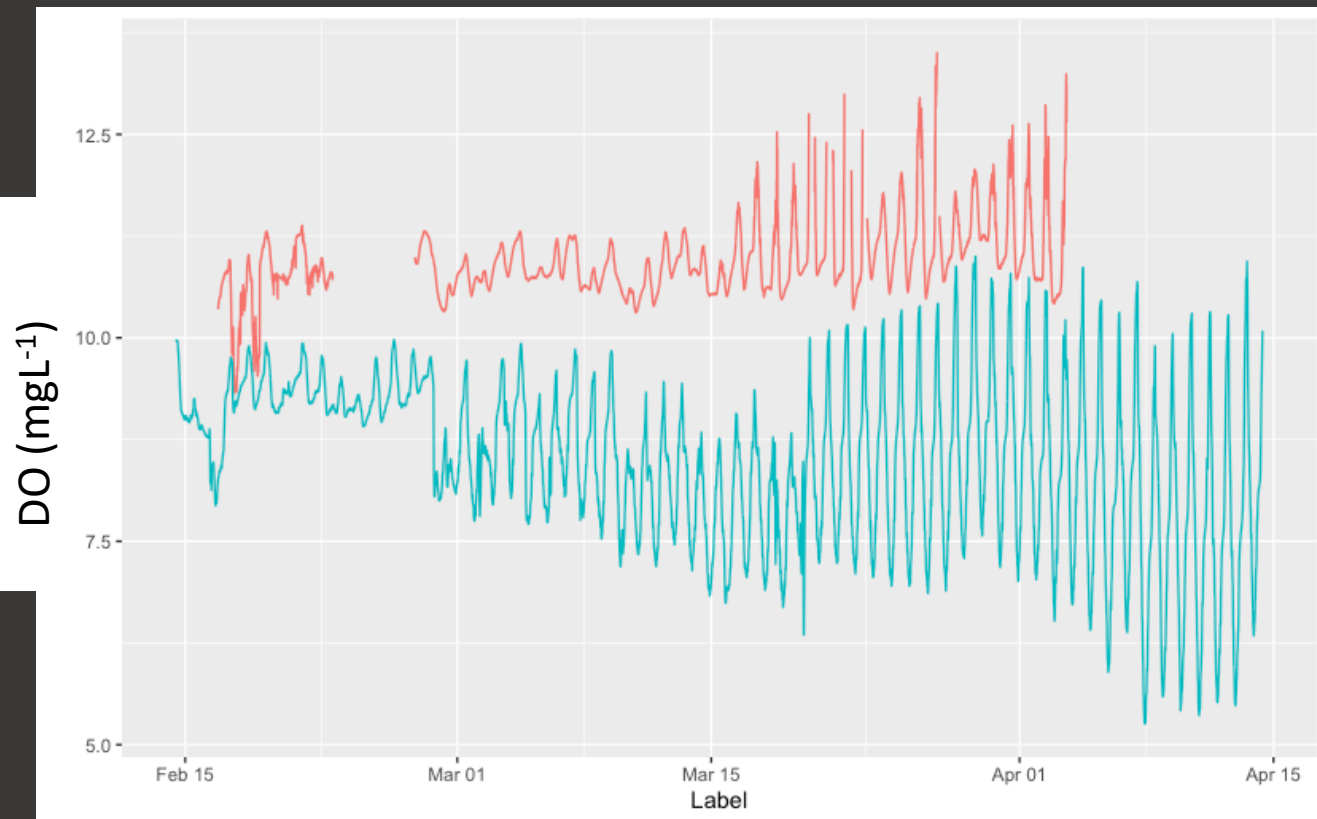


High rainfall-intensity events such as occurred on Jan 15th caused increases in turbidity both upstream and downstream of the sewage treatment works. Road runoff from paved areas in addition to untreated effluent from the sewage treatment work caused increases in suspended sediment in the river. This material settles out on the riverbed and can infill gravels (i.e. cause colmation⁴).

Above the STW the turbidity has little effect on dissolved oxygen levels, but downstream of the STW we see a marked decrease in dissolved oxygen. This is due to the organic nature of untreated sewage and shows the classic 'oxygen sag' associated with gross pollution events in a river. These events may change biochemical oxygen demand in the gravels causing low oxygen conditions for fish eggs (e.g. bullhead, trout).

What are the potential implications of these dissolved oxygen concentrations (mgL^{-1}) for river health?

We have seen a gradual decline in oxygen due to daily storm tank discharge arising from groundwater ingress



The gradual decline in oxygen concentrations suggest that organic material settling on the riverbed is changing the river metabolism and enhancing respiration. Photosynthesis during the day enables oxygen levels to recover during daylight hours. The overall effect on ecology will depend on the duration of repeated discharge (our data shows the effect of 52 days of daily storm tank discharge).

The challenge now is to link these oxygen data to measurements of effect on river health - such as riverfly monitoring data.

— upstream of STW outfall
— c. 2 km downstream of STW outfall

Successes and challenges of the ChessWatch project from a stakeholder perspective

Our preliminary data is providing a more detailed picture of water quality in the upper reaches of the River Chess and there is more analysis to come. Initial reflections are as follows:

Successes

Citizen scientists have a greater understanding of how water quality varies in space and time along the river and feeling of engagement with the issues.

The project has provided a detailed, shared water quality dataset that provides a before-intervention baseline for the group.

Increased understanding of river water quality dynamics that helps develop management guidance for the river and helps River Chess Association respond to water quality incidents.

Challenges

Improving real-time visualisation and dissemination of this dataset for interested stakeholders including the public living in the catchment.

Improved dissemination needs to be accompanied by rapid data cleaning, interpretation and guidance. How best to achieve this?

Linking this dataset to measures of ecological health in the river during a period of land use and climate change.

Management plans arising from sensor data

Summer temperatures in the water may be problematic for a range of fish (e.g. trout and grayling species). These temperatures arise from a combination of high air temperature and low flows. Management activities are needed to address both of these issues. Providing increased riparian cover may be an option to explore.

A public water company in the catchment has started to reduce groundwater abstraction. Flow monitoring and the sensor data offers a means of monitoring the effects (flow frequency and magnitude) that decreased abstraction has on flows in ungauged upper reaches of the catchment where flows are ephemeral. Reduced abstraction offers opportunities to re-instate resilient flows in headwaters of the River Chess.

The greatest variations in dissolved oxygen concentrations in the river arise from the operation of the sewage treatment works. Issues of storm tank discharge due to both high intensity rainfall events and groundwater ingress should be addressed.

Road runoff is transporting fine sediment to the river in the upper reaches with the potential for colmation of gravels which requires further investigation.

Morphological improvements to the river channel and corridor offer opportunities to improve natural turbulence and fish refuges to help oxygen concentrations.

References

¹Kay, AL, Bell VA, Guillod BP, Jones RG & Rudd AC (2018) National-scale analysis of low flow frequency: historical trends and potential future changes, *Climate Change*, 147:585-599.

²Bloomfield JP, Marchant BP & McKenzie AA (2019) Changes in groundwater drought associated with anthropogenic warming. *Hydrology and Earth System Sciences*, 23: 1393-1408.

³Basic T, Britton JR, Cove, RJ, Ibbotson AT & Gregory SD (2018) Roles of discharge and temperature in recruitment of a cold-water fish, the European grayling *Thymallus thymallus*, near its southern range limit, *Ecology of Freshwater Fish* : 27: 940-951.

⁴Wharton G, Mohajeri SH & Righetti M (2017) The pernicious problem of streambed colmation: a multi-disciplinary reflection on the mechanisms, causes, impacts and management challenges. *WIREs Water* 4:e1231. doi:10.1002/wat2.1231.