Water Quality Monitoring Report v2

Abbey Mills Pumping Station

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Adler & Allan

ENVIRONMENTAL RISK REDUCTION

For and on behalf of:

Thames Water Utilities Limited

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1 EXECUTIVE SUMMARY

Our environmental quality study surrounding Abbey Mills Pumping Station has found that water quality in the River Lea can be classified as 'good/excellent' in accordance with Water Framework Directive classifications. This is exemplary for an urban river catchment of this type.

The largest influence of water quality observed by the study is mainly due to tidal influence of the River Thames estuary. A combination of sonde data and spot sampling highlights that the general water quality is lower during high tide as the poorer quality water from the Thames enters the watercourse.

The study was able to identify that high tide posed the most significant risk to environmental health in the possible event of a discharge from Abbey Mills pumping station. This is due to potential pollutants having a longer residence time within Channelsea Creak and surrounding watercourses in addition to lower water quality from the Thames.

Ongoing monitoring from OHES will utilise this baseline data in addition to sondes, autosamplers and monthly site visits to continue to monitor water quality while ensuring any effluent release from Abbey Mills will be monitored appropriately.

2 INTRODUCTION

This report summarises water quality data retrieved through the deployment of water quality sondes and through monthly spot sampling in the location of Abbey Mills Pumping Station (hereafter referred to as Abbey Mills). The data retrieval began in November 2022 with the intention of establishing the baseline water quality within the watercourses surrounding Abbey Mills.

The aim of this report is to define baseline water quality conditions ahead of major works on the construction of the Thames Tideway Tunnel (Tideway hereafter) which, during storm events, may result in diluted effluent being discharged to the environment from Abbey Mills. This report includes:

- Study area maps with water quality sonde locations
- Graphical representations of the water quality data retrieved by the sondes
- Identification of data trends
- Recommendations for further studies to determine potential risks to the water quality at Abbey Mills

3 PROJECT DESCRIPTION

OHES Environmental Limited (OHES), part of the Adler and Allan Group (A&A), has been commissioned by Thames Water Utilities Limited to complete this project in support of the construction of the Thames Tideway project which is a major upgrade to London's sewerage system. Abbey Mills is integral to the wastewater network project and may have to activate an overflow discharge into the Channelsea River in extreme circumstances during the end phase of the construction of the Tideway.

Abbey Mills is situated in West Ham, east London, south of the Queen Elizabeth Olympic Park. Abbey Mills is bordered by the Channelsea Creek to the east and the Prescott Channel to the west. These channels merge to form the Channelsea River, which then confluences with the River Lea (also known as Bow Creek). From this confluence, the River Lea meanders in a southerly direction for approximately four kilometres (km) before its confluence with the River Thames at Trinity Buoy Wharf, north of Greenwich and upstream of Docklands.

Thames Water is required to establish a water quality baseline for this section of the Thames tidal catchment. With knowledge of the increased risks associated with the proposed upgrades, a long-term monitoring program has been proposed by OHES to establish the baseline water quality conditions in the watercourses surrounding Abbey Mills. A water quality monitoring programme will be operational whilst wastewater network upgrades are being completed on site. This water quality monitoring programme will help establish the impact to water quality should any discharge of diluted effluent take place.

4 METHODOLOGY

A total of three ESNET sondes devices were deployed in November 2022. The locations selected are the Channelsea Creek (TQ 38688 82826), 500m downstream of the confluence with the River Lea (TQ 38360 82419), and upstream of the confluence (TQ 38572 82845). The sondes have been supplied by Meteor Communications (Meteor) with the ongoing review of data and maintenance of the devices being completed in partnership between OHES and Meteor. Each monitoring point was observed for tidal cycles and seasonal trends to build an understanding of the dynamics of the watercourse regarding water quality.

The sondes are recording dissolved oxygen, pH, temperature, electrical conductivity and turbidity every 30 minutes for the duration of the monitoring period. Establishing a baseline for the behaviour of these parameters provides the starting point for the determination of any impact of a discharge to the Channelsea Creek from Abbey Mills. Increased turbidity (i.e. cloudiness of the water) typically indicates a worsening of water quality; associated with suspended solids entrained in the flow, it can affect in-river biota and aquatic life. Reductions in dissolved oxygen (DO) concentrations also indicate a worsening of water quality and can be indicative of pollutants such as wastewater entering the watercourse. Wastewater will be broken down by bacteria which will utilise the effluent as a food source, growing in number, and using oxygen present in the water to respire, this depresses the oxygen levels present. Monitoring of electrical conductivity (EC) within the watercourse provides an understanding of

tidal influence. Tidal patterns will influence water quality directly through saline intrusion but also indirectly through hydrological influence (primarily affecting flow). Increased conductivity will be indicative of saline intrusion.

In addition to the operation of the water quality sondes, four locations are visited monthly for physico-chemical sampling. The four monthly sampling sites were selected for laboratory analysis to replicate the sonde locations, with the addition of a site the River Lea 1km downstream (TQ 38316 81960). In part, the monthly water quality spot sampling, for a total of 14 months, is being conducted to measure key parameters that cannot be recorded by the sondes. Ammoniacal nitrogen is one such parameter and cannot be measured via the sondes due to the brackish nature of the watercourses. Ammonium compounds are present in sewage and are toxic to aquatic life which makes it a key water quality parameter monitored under the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003. The following parameters are also being assessed through the monthly spot sampling; Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), suspended solids, sulphate as SO_4, dissolved orthophosphate (as P). These parameters will be included in long-term trend analysis to help further understand the Channelsea Creek and River Lea system.

A synthesis of both data sets will be used to identify characteristics of the catchment area and its behavior particularly surrounding the influence of tidal extents, and the daily changes in aquatic chemistry. The understanding of these characteristics will support conclusions later in the project surrounding effluent release, and potential environmental effects.

5 RESULTS AND DISCUSSION

5.1 Water quality sondes

On the 9/11/2022, installation of the three sondes was completed and the commencement of readings began at 00:01 10/11/2023 for all sondes and have continued to present. The data in this report is up to and inclusive of 09/05/2023, however, sondes remain active past this point to produce continuous data.

The sonde locations, shown in Figure 1, were chosen to track potential impact of Abbey Mills discharges from its outfall into Channelsea Creek.

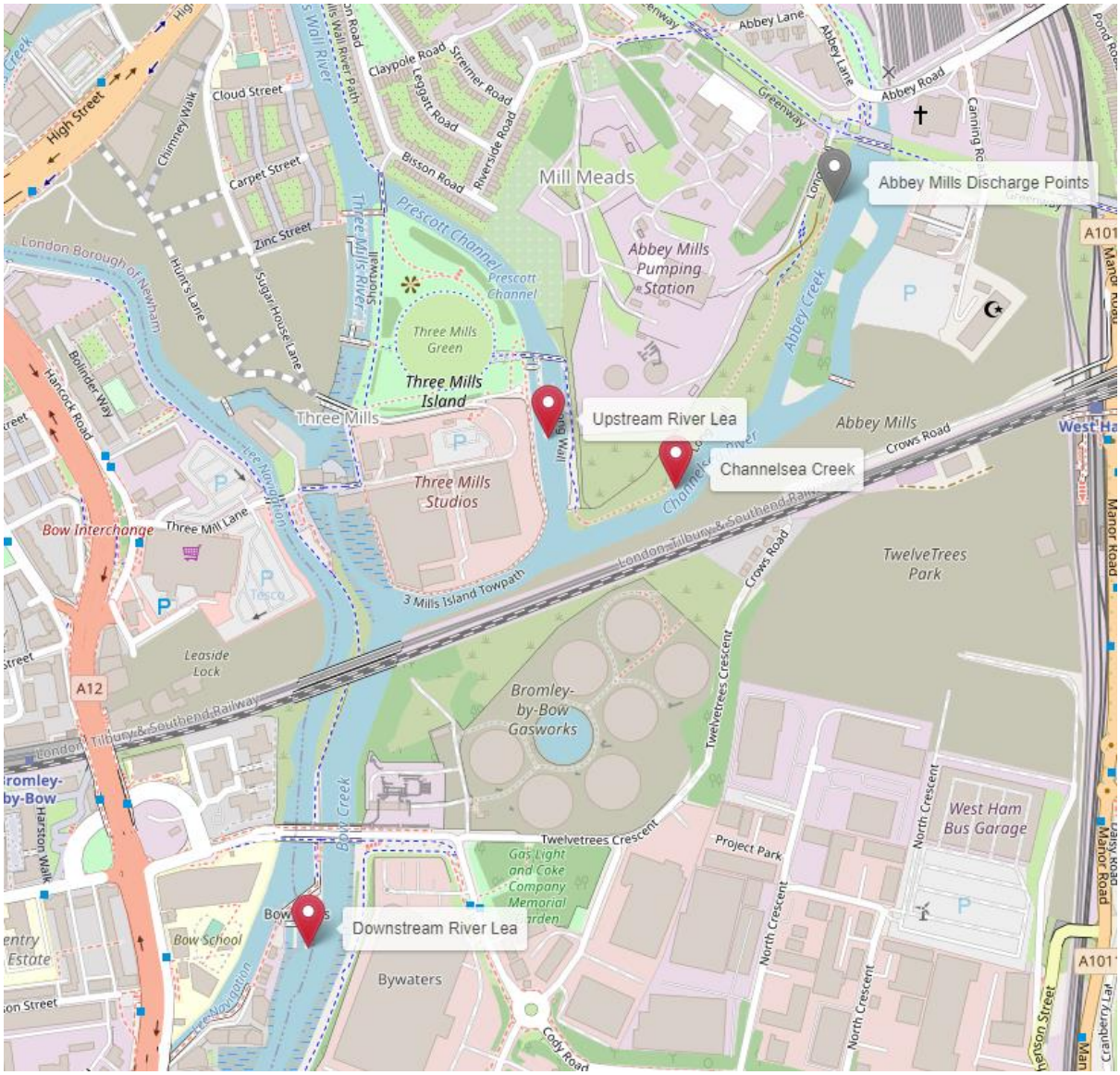

Figure 1 - Water quality sonde locations in the River Lea and Channelsea Creek.

5.1.1 Electrical Conductivity

Electrical conductivity measurements taken from all three sondes suggest that there is the large daily shifts indicative of the tidal cycle (Figure 2). The upstream and downstream sondes in the River Lea measure a daily change of approximately 600 (ppm) suggesting a change from brackish water to fresher water. This change, at approximately 4–7-hour intervals, is indicative of the tidal cycle and salt water intrusion. During these cycles, the conductivity reading from the Channelsea Creek sonde is seen to drop to a negligible value at low tide. This is indicative of the sonde no longer being submerged in water. This relationship between conductivity and tidal extent is indicative of high or low tide. The drying of the Channelsea Creek sonde, while at low tide, confirms a tidal extent which falls below the Channelsea sonde

location under normal conditions. Therefore, a conclusion can be made that during low tide, if there were to be a discharge from Abbey Mills, this would be the main source of water and flow in the Channelsea Creek.

Figure 2 highlights there can be exceptions to the draining of the Channelsea Creek with the second and third low tides during this time period reducing to only 800 ppm. This is a reduced conductivity level compared to the high tide level in the Creek but above the dry sensor readings. This could be indicative of a rainwater draining to the Channelsea Creek, leading to greater depth and flow of freshwater.. During periods of wet weather, we could therefore expect elevated levels of flow, and therefore aiding diluting capacity for any discharge from Abbey Mills, within Channelsea Creek at low tide.

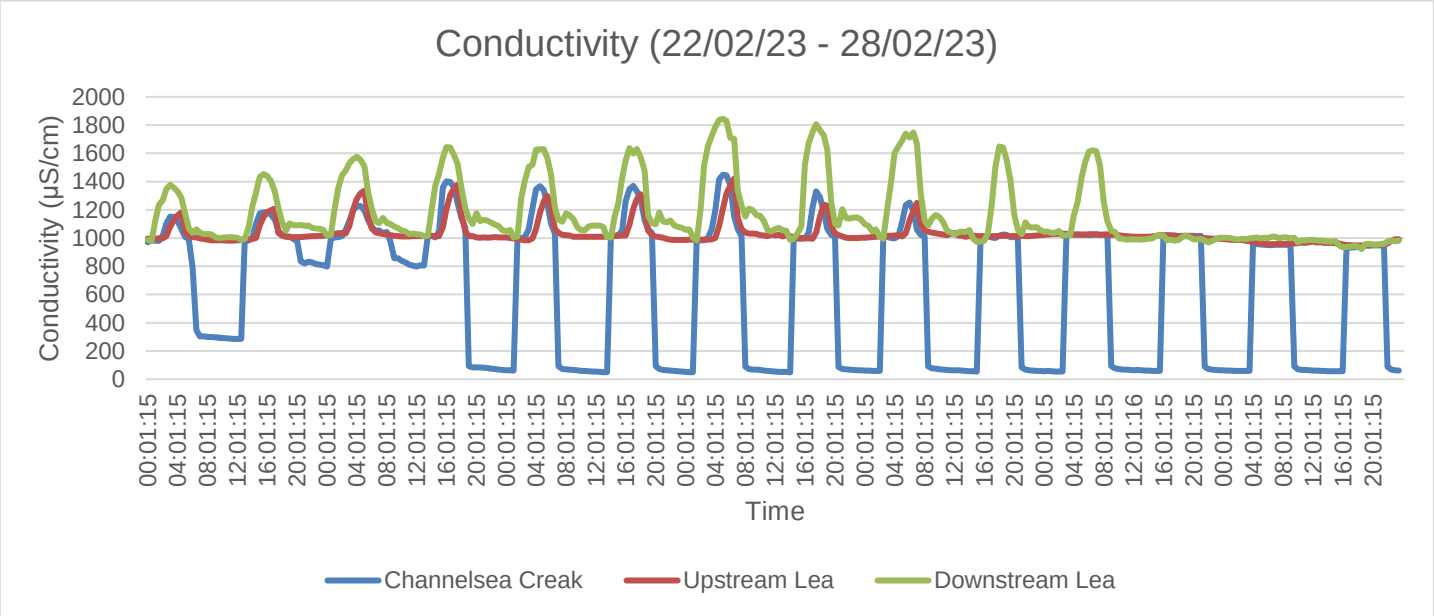

Figure 2 - Electrical conductivity readings from 22/02/23 to 28/02/23, recorded by the sondes positioned around Abbey Mills Pumping Station.

5.1.2 Dissolved Oxygen

Dissolved Oxygen (DO) is an important measure of overall watercourse health as it can indicate the presence of a pollutant in the watercourse**.** Figure 3 display a three-day period which exhibits typical DO characteristics across the sondes. The missing data from the Channelsea Creek is due to the sensor not being covered by water at low tide.

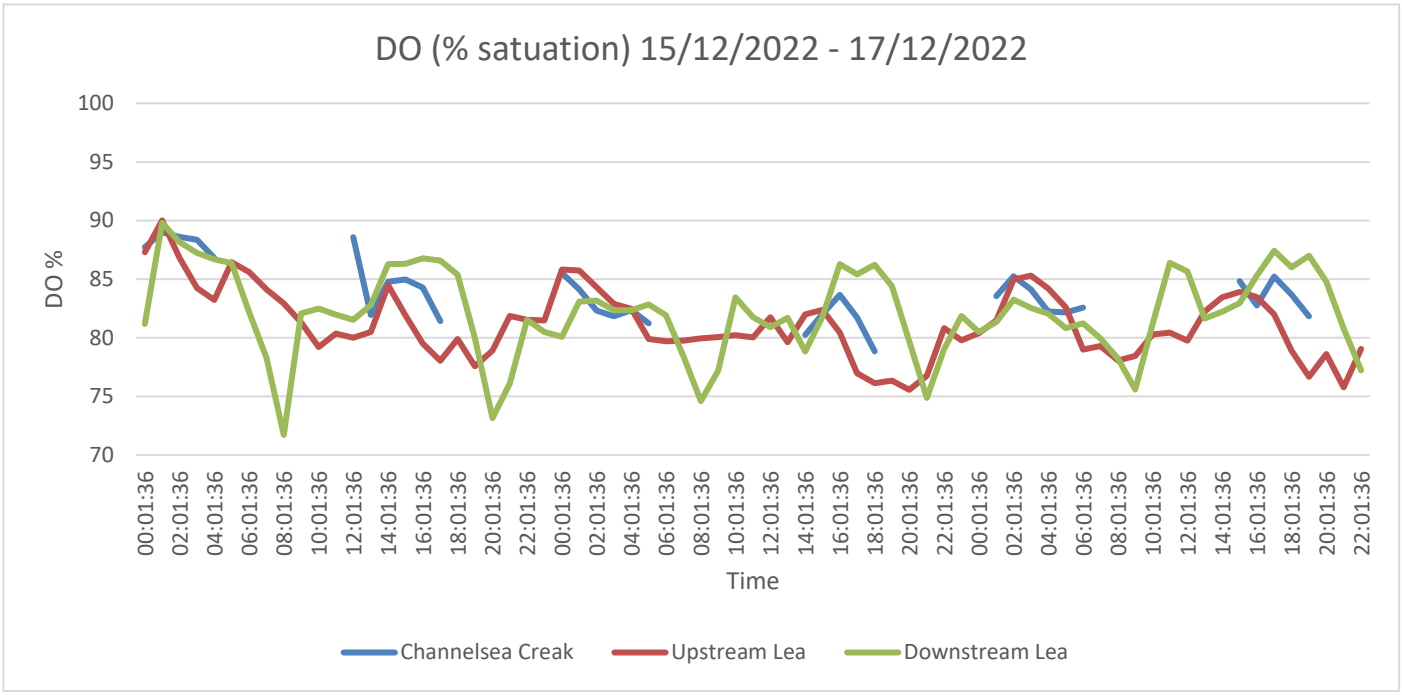

Figure 3 - Dissolved oxygen (%) readings from 15/12/22 to 17/12/22, recorded by the sondes positioned around Abbey Mills Pumping Station.

Typically, there is not significant difference in DO between sondes at any given point and time (+/- 10% saturation) suggesting a well-mixed environment without major changes in water quality between sites. Without major changes from upstream to downstream, it can be concluded that the Channelsea Creek does not currently have a large impact on the water quality in the River Lea.

A longer term trend observed in DO is a steady increase in the River Lea from when the sondes were installed in November (average 81% saturation) to May (average 125% saturation) (Figure 4). This increase in DO is potentially due to increases in temperature and sunlight on the watercourse promoting in-river photosynthesis. Increases of this kind would be expected to continue into the summer. Therefore, the expected baseline DO will increase linearly with the data trend as the expected in-river photosynthesis will continue into late summer, hence increasing the DO. This means that observations of DO at the time of any effluent ingress should be compared to the appropriate season within the baseline dataset.

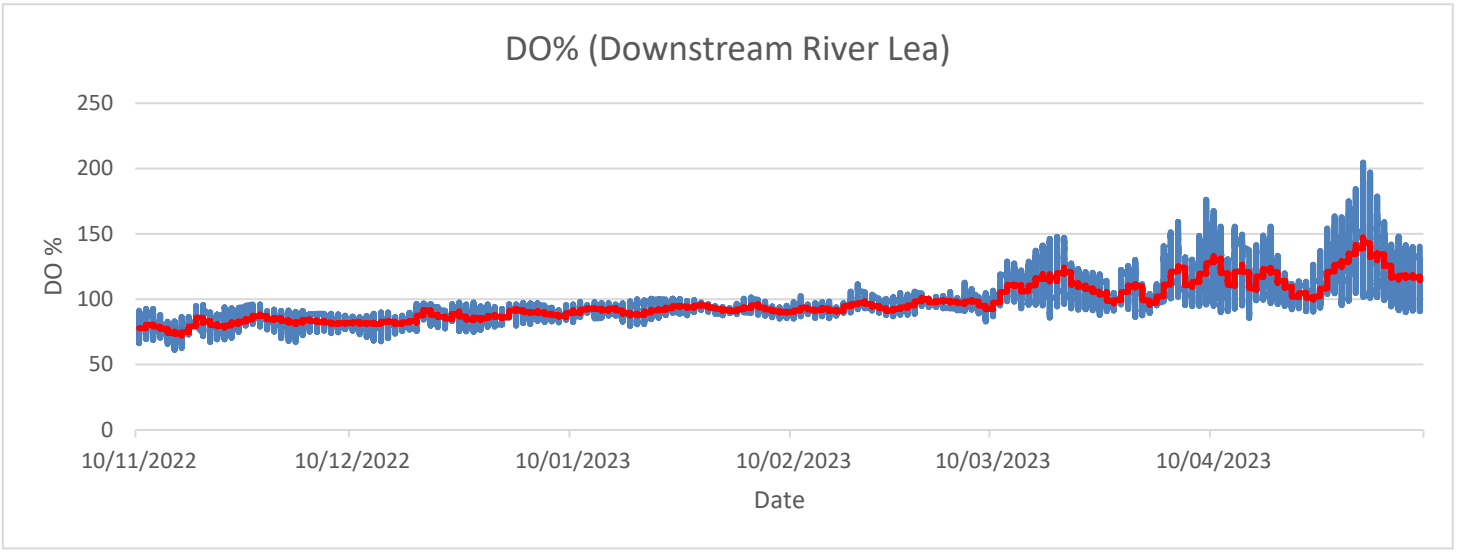

Figure 4 - Dissolved oxygen (%) readings from the Downstream River Lea location. Blue line represents daily range while red line is daily average.

DO in the River Lea also has a tidal cycle shown by a typical spring daily fluctuation in Figure 5. The lower DO between 12:01 – 18:01 & 01:01 – 07:01 corresponds to periods of high tide. This would suggest that the DO of water entering the Lea is lower when coming from the Thames than when it is flowing downstream from the catchment. This means that tidal influence on DO must be considered before drawing conclusions on the impact of any discharges from Abbey Mills when the network upgrades are being completed. The typical reduction in DO is 20-40% saturation and 2-4 mg/l between high and low tide.

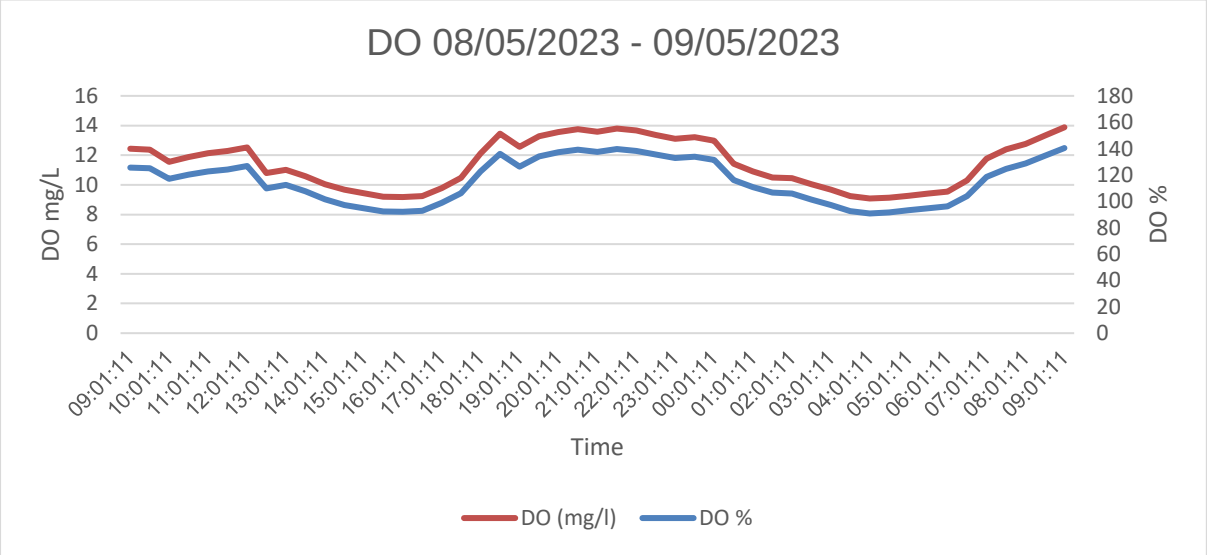

Figure 5 - DO % saturation and mg/l recorded at the downstream River Lea location 08/05/2023 – 09/05/2023.

5.1.3 pH

Figure 6 highlights the consistency of pH over a five-month period from November 2022 to March 2023 where the maximum daily variation is 0.2 pH while remaining between 7.35 and 8 averaging 7.6 pH over the five-month period (downstream River Lea). However, from March to May 2023, there is a significant change to a more variable pattern which means the daily change increases to a maximum of 1 pH within the range of 7.5 to 9 pH while averaging 8.1 pH for the three-month Period. The increase in variation and upwards trend in average pH also correlates with a similar trend in DO from March 2023 onwards.

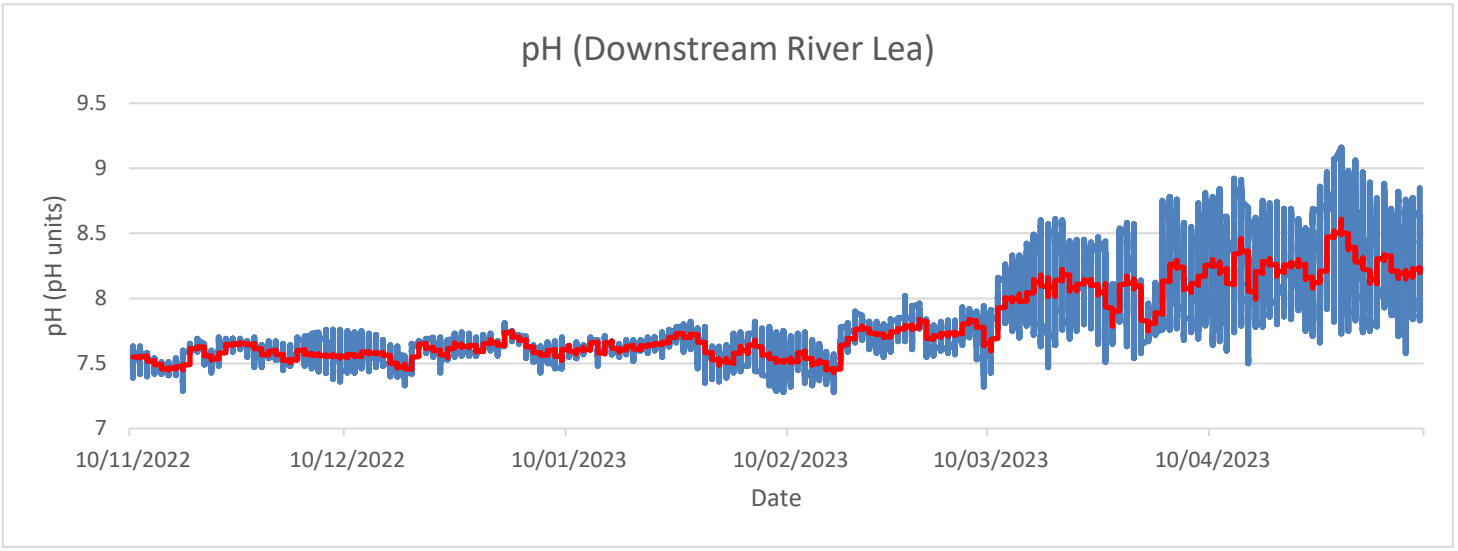

Figure 6 - pH values recorded at the downstream River Lea location.

5.1.4 Turbidity

The turbidity data collected by the sonde at the downstream River Lea location since November 2022 is shown in Figure 7. Turbidity, a measure of clarity, in watercourses is often correlated to periods of heavy rainfall. This is due to increased surface water runoff carrying suspended solids and a higher flow rate in the watercourse disturbing sediment on the bed. The data collected would suggest that this is the case within the catchment as turbidity shows little correlation with tide cycles. Rainfall in Tottenham (north London) highlighted 14.5mm and 2.6mm on 31st March and 1st April, retrospectively (Tottenham Historical Weather, 2023). Figure 8 highlights the potential effect of a heavy rainfall event on the River Lea with decreased electrical conductivity, due to the influx of freshwater, and increased turbidity. Understanding the relationship between turbidity and heavy rainfall events, and the lack of evident influence by tidal cycles, is important for assessing potential impact during the time periods where Abbey Mills is at greatest risk of discharging.

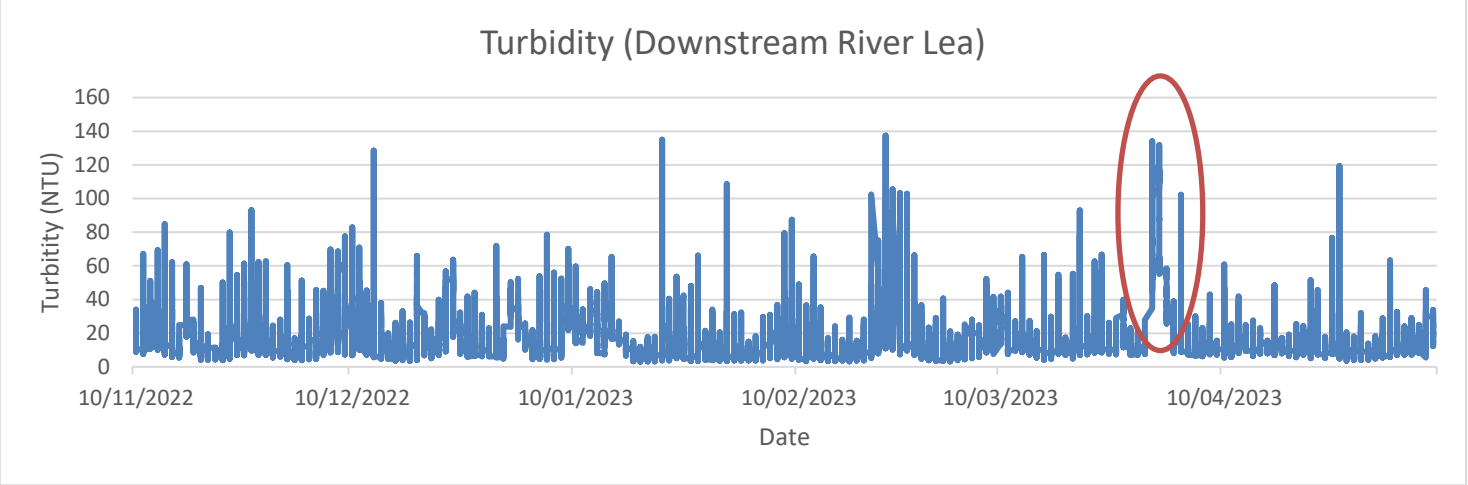

Figure 7 - Turbidity measurements from the downstream River Lea location with a highlighted a period of sustained increased turbidity.

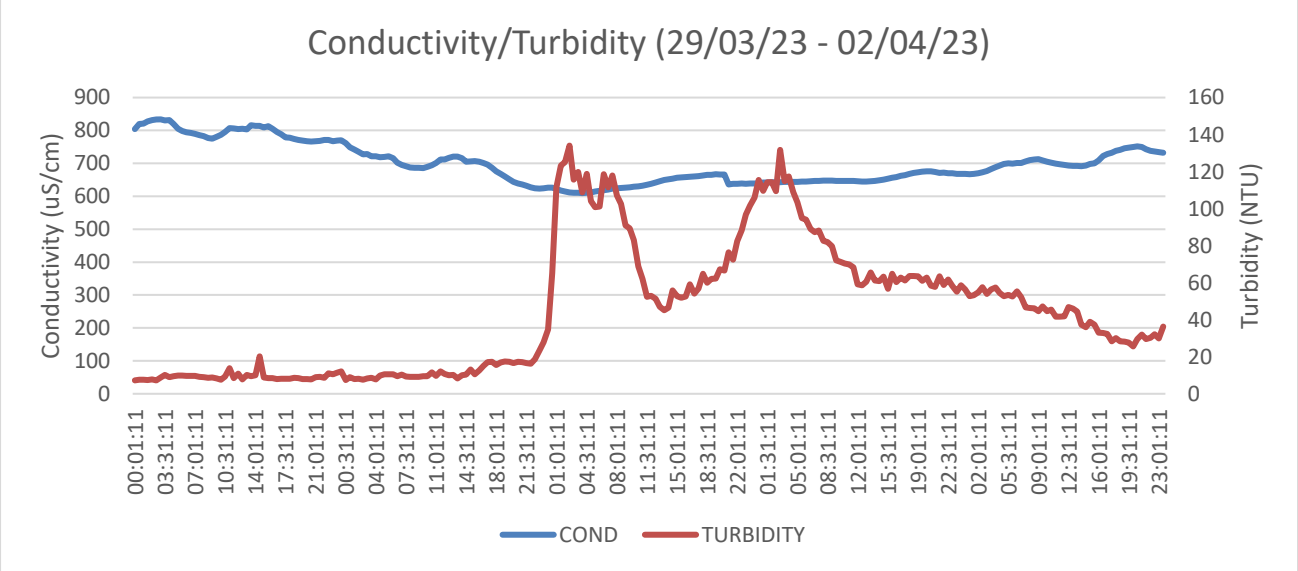

Figure 8 - Conductivity and turbidity measured at the downstream River Lea location between 25/03/23 – 28/03/23.

5.1.5 Temperature

Temperatures in the watercourse (Figure 9) remain constant between the two River Lea locations highlighting flow up and down the Channelsea Creek has little influence. The temperature does not exhibit explicit patterns of daily warming and cooling in sunlight hours. The tidal cycles also do not correlate with temperature change as the data suggests they do not move in tandem. Seasonal changes in temperature exhibit cooling during the winter with an increase in temperature approaching spring, with an expectance of this to continue in an upwards trend into the summer period. Temperature does not move outside of the 'high' quality standard threshold (≤25°C for cyprinid rivers) as guided by the Water Framework Directive. Understanding this baseline trend in water temperature of the river Lea will allow for an assessment of any thermal effects of a discharge from Abbey Mills. Temperature may

exacerbate the effects of an effluent release, should it occur during a period of high temperature, as the toxicity of total ammonia increases with increasing temperatures. This is because, within total ammonia, the balance between unionised ammonia (NH_3) and ammonium (NH_4^+) is weighted towards the more toxic form NH_3 as temperature increases. Conversely, therefore, at lower temperatures a greater proportion of the total ammonia will be the less toxic form NH_4^+.

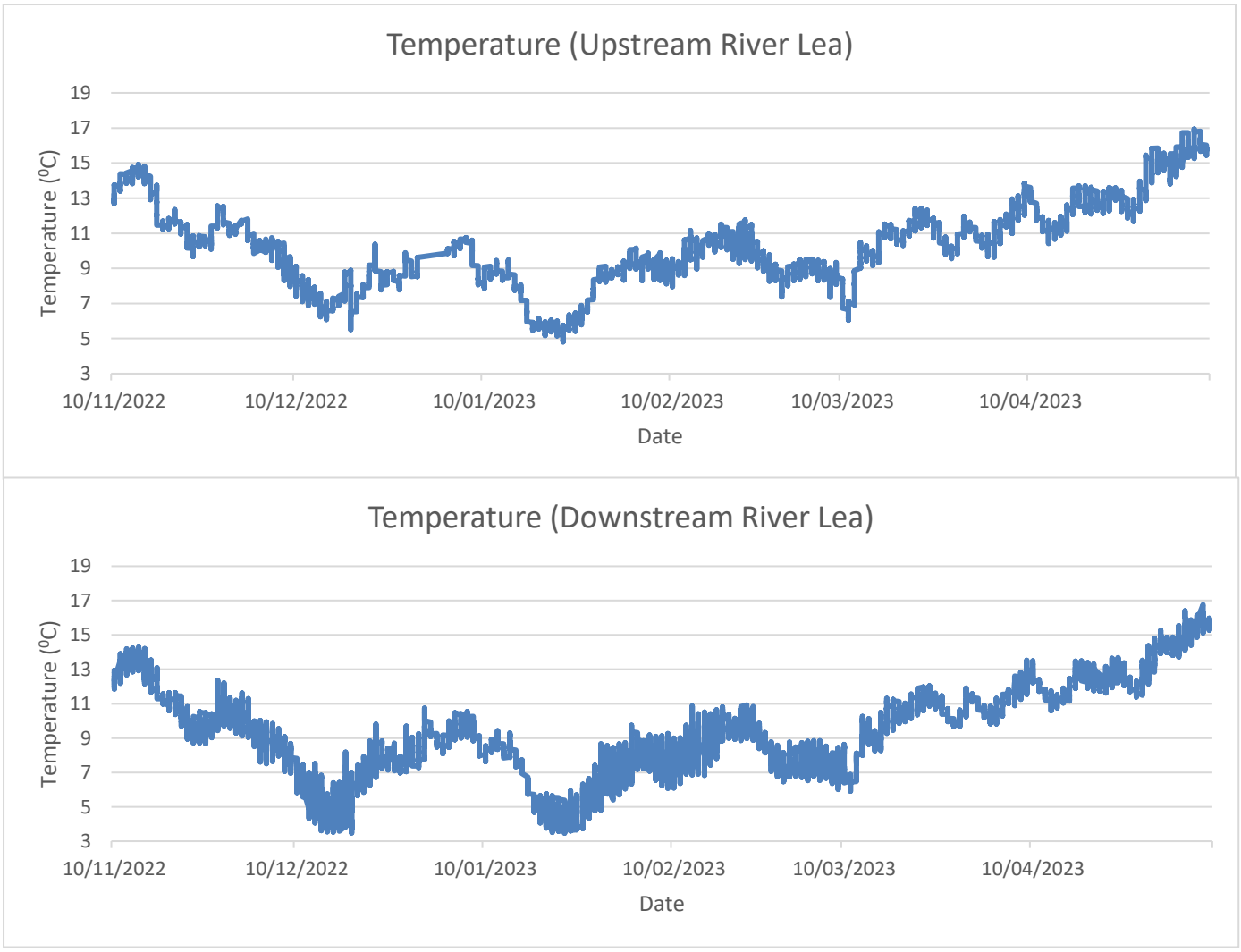

Figure 9 - Temperature measurements from the upstream and downstream River Lea locations between 10/11/22 – 09/05/23.

5.2 Water Quality Laboratory Analysis

As previously stated, monthly spot sampling to retrieve surface water samples for laboratory analysis has been completed in conjunction with the water quality sonde deployment. The key intention of this is to provide ammoniacal nitrogen data for the watercourse as the brackish (saline) environment does not allow for the measurement using sonde sensor technology. In addition to ammonia, other chemical compounds were identified as useful metrics of water quality and included within the chemical testing suite. To help ensure comparative data

retrieval, the sampling locations chosen were in close proximity to the sonde locations plus an additional sample location, approximately 1km downstream of the Abbey Mills discharge points. The EA's Common Incident Classification Scheme (CICS) (EA, 2016) considers an impact to water quality, 1km downstream of a point source pollution, as one of the criteria for categorising an incident as a serious (Category 1 or 2) pollution. The spot sampling data from this location adds to the robustness of the baseline dataset in the event of a discharge from Abbey Mills. The sampling locations are shown in Figure 10**.**

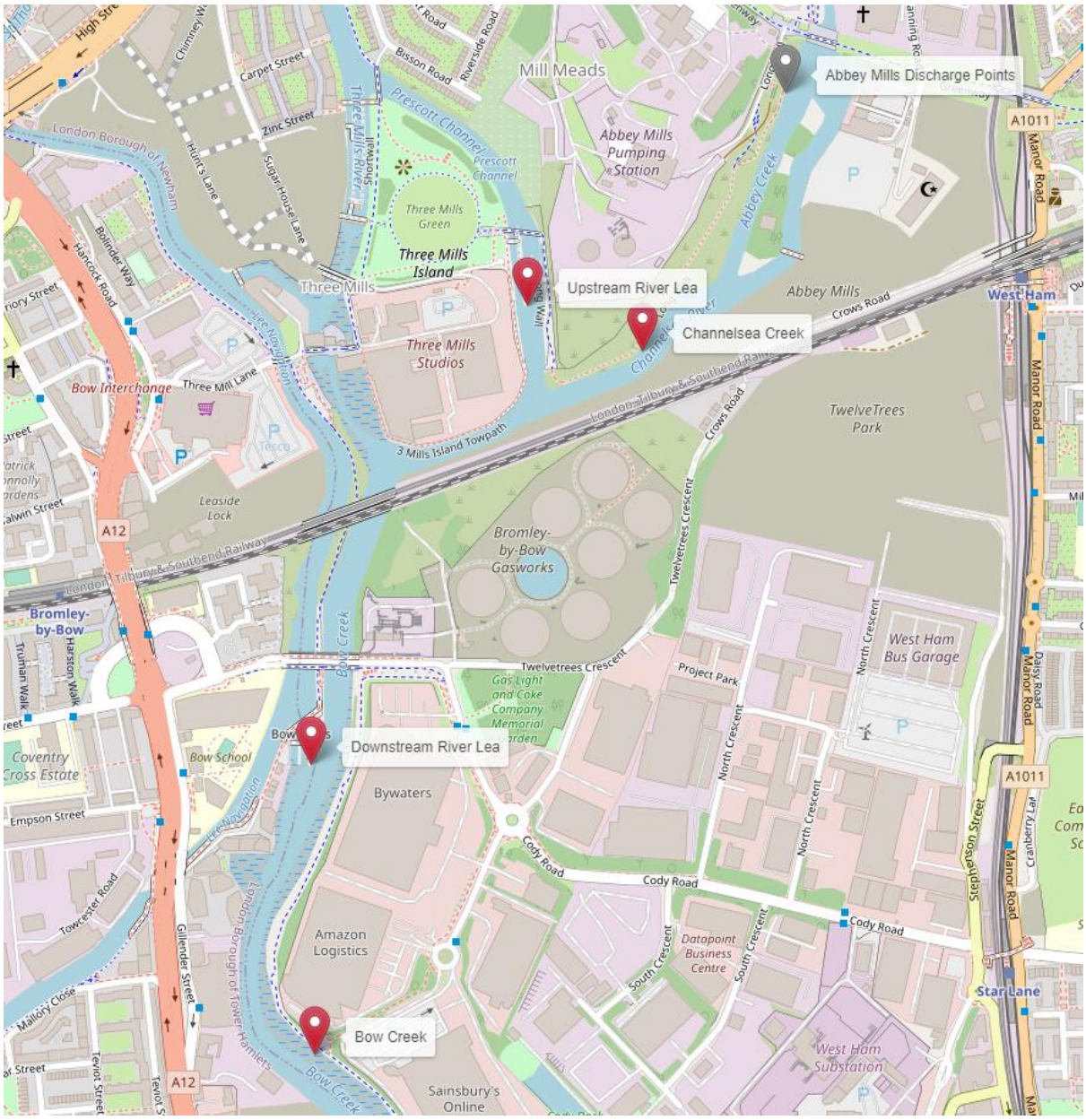

Figure 10 - Monthly spot sample locations in the Channelsea Creek and River Lea.

5.2.1 Ammoniacal Nitrogen

Although naturally present in watercourses due to the decay of organic matter, ammoniacal nitrogen is often used as a key indicator of foul water pollution due to the elevated levels present in wastewater. If Abbey Mills were to discharge wastewater into the watercourse

during the network upgrades, the effluent will be storm water diluted foul water and therefore likely to have elevated ammonia levels. Ammoniacal nitrogen is also referenced as a key water quality indicator in the Water Framework Directive due to its eutrophication effects on watercourses.

Ammoniacal nitrogen concentrations from the four sample sites, shown in Figure 11, show low variability for most dates sampled. All results on each sampling occasion, apart from 14/12/22, were indicative of 'high' standard for ammonia under the WFD. A sample could not be collected from the Channelsea Creek location on 18/01/22 due to an access issue.

A potential cause for the anomalous results on 14/12/22 could be due to the time at which the samples were collected, as this was the only set of samples taken during an incoming high tide from the Thames rather than flow downstream from the River Lea catchment. During this sample run water quality for ammonia, in accordance with the WFD, indicates 'good' quality for Channelsea Creek and Bow Creek (350 µg/l & 490 µg/l, retrospectively). Results for the downstream River Lea location are indicative of 'moderate' quality with 630 µg/l for ammonia while upstream in the River Lea remains of 'high' standard. This trend does not follow a continuous decrease in quality towards the River Thames as Bow Creek is closest to the Thames but not the highest concentration. On the basis that an incoming tide brings elevated ammonia into the River Lea, there is the potential that assessing the impact of an Abbey Mills discharge during high tide would be obscured. However, more sampling at high tide is required to establish whether this is a true pattern.

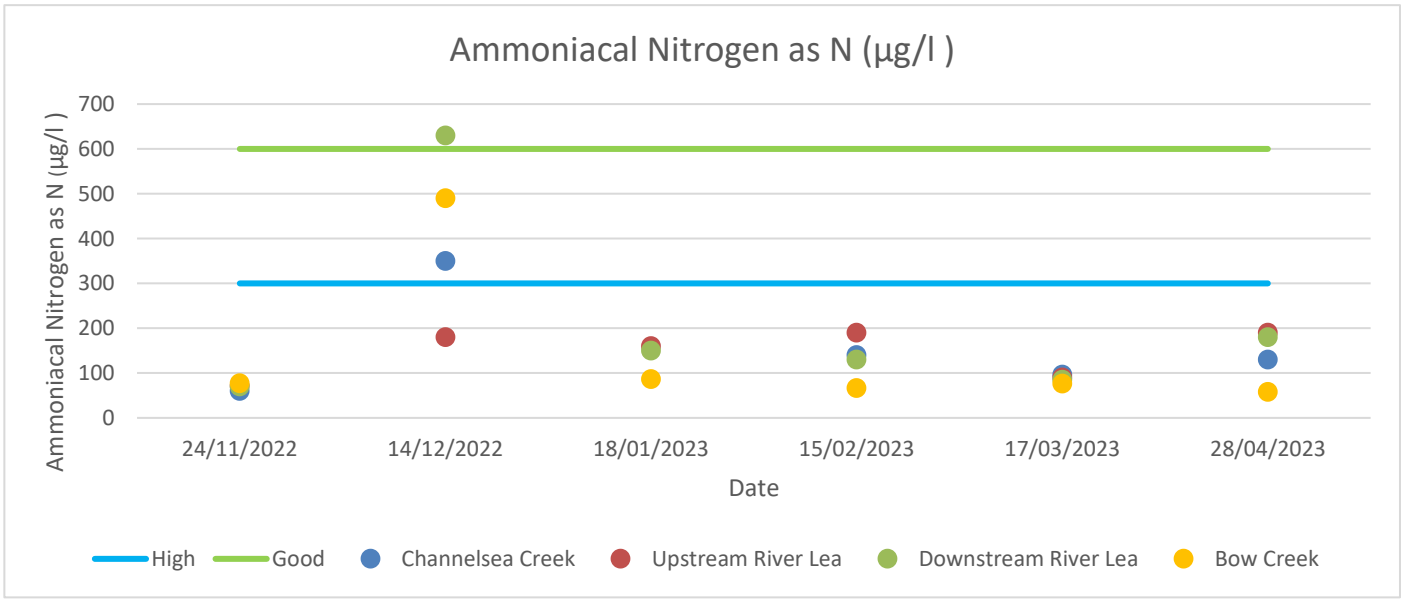

Figure 11 - Ammoniacal nitrogen as N (µg/l) results from monthly spot sampling at Abbey Mills, with comparison to Water Framework Directive environmental quality standards.

5.2.2 Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD)

COD describes the amount of oxygen required to chemically oxidise the organic material and inorganic nutrients, such as ammonia and nitrate, present in water, while BOD represents the amount of oxygen consumed by bacteria and other microorganisms while they decompose organic matter. Both these parameters are therefore used to measure general water quality as they can indicate the presence of pollution in a watercourse.

Figure 12 and Figure 13 show the COD and BOD results from the sampled sites, with BOD remaining largely stable, in the region of 2 and 3 mg/l, while COD is much more variable. The largest variation in COD was noted at all sample sites on 14/12/22 which correlates with increase in ammonia and therefore potentially due to incoming high tide. However, on this date, there was not a corresponding increase in BOD at all sites. This would indicate that water on 14/12/22 contains a significant fraction of non-biodegradable material. BOD appears in the Water Framework Directive as a marker for water quality and concentrations for each categorisation are shown on Figure 13. All but one sample remain in the 'high' quality specification for BOD (<4 mg/l). April's sample at Bow Creak is the one sample which is categorised as 'moderate' quality under the WFD.

Figure 12 - Chemical Oxygen Demand (COD) (mg/l) results from the monthly spot sampling at Abbey Mills.

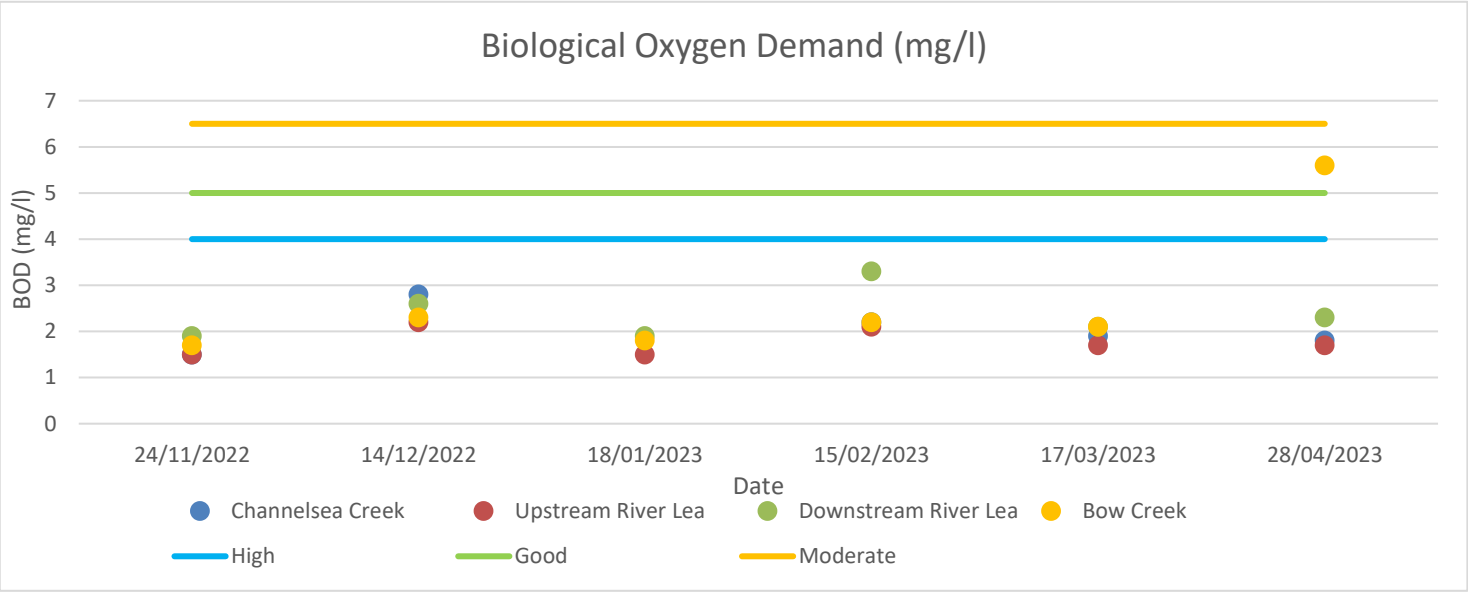

Figure 13 - Biochemical Oxygen Demand (BOD) (mg/l) results from the monthly spot sampling at Abbey Mills.

The variable COD is indicative of an urban drainage catchment whereas in a more rural setting, the surface water runoff would more likely influence BOD and there would be relatively stable COD. It is common in high-density urban areas, such as West Ham, with a legacy of heavy industry for pollution from a variety of sources to enter the watercourse. However, with a relatively stable BOD established thus far, any impact of a discharge from Abbey Mills, which would likely have an elevated BOD, may be clearly measured.

Bow Creak, during the April 2023 site visit, shows a BOD reading approximately three times greater than the other sites in the same visit (Figure 13). This is likely due to the influence of a pollution source further downstream than the three sites immediately surrounding Abbey Mills. This further highlights the potential for other sources of pollution within the catchment.

5.2.3 Dissolved orthophosphate (as P)

Dissolved orthophosphate (Figure 14), also commonly known as dissolved inorganic phosphorus (P) or soluble reactive phosphorus, is a pollutant to watercourses which can cause eutrophication of rivers and increase the likelihood of harmful algal blooms (Slomp, C.P. 2011). Within unpolluted streams, P concentration is typically 25 µg/l which can increase two to four times in periods of rainfall. P can increase to concentrations of 50-100 µg/l from agricultural runoff and up to 1000 µg/l for wastewater. (Wetzle, 2001). Elevated phosphorus stimulates biological activity as it fertilises in river algae and plant life. Increases in biomass within the stream is typically associated with an increase of BOD as decay of dying biomass increases. This increase in BOD is often observed with a several day lag when biologically available phosphorus is released without other pollutants. If wastewater containing phosphorus enters the watercourse there is usually no lag in BOD response as decomposition of nutrients is already taking place.

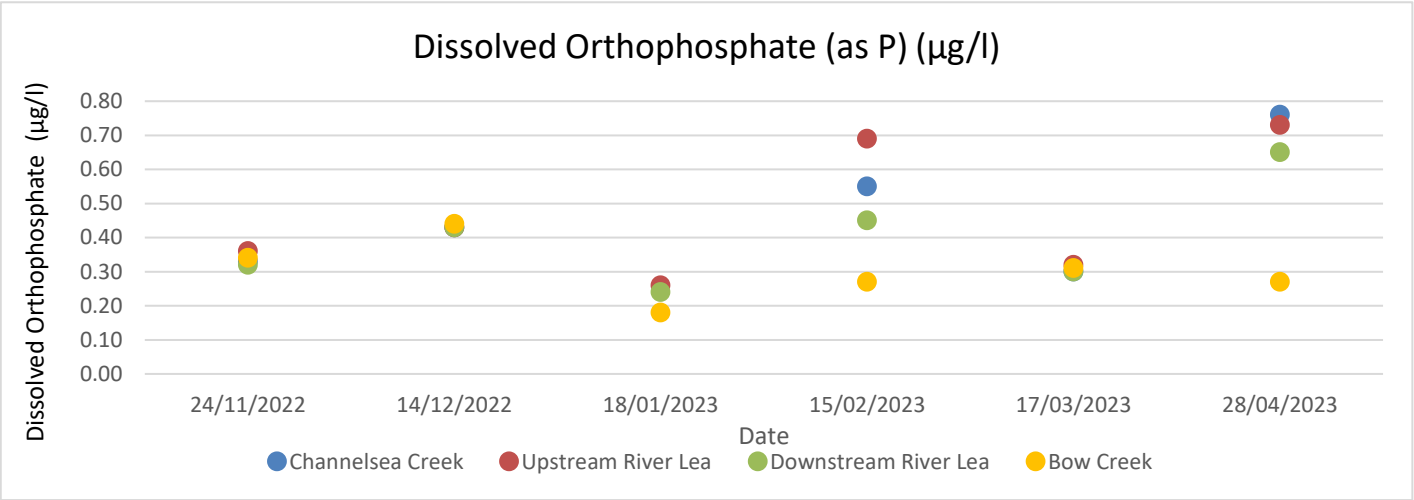

Figure 14 - Dissolved orthophosphate (as P) (µg/l) results from the monthly spot sampling at Abbey Mills.

5.2.4 Sulphate at SO_4

Sulphates are present in watercourses from both human and natural sources. Human sources include treatment works, fertilizer leaching and wetland draining where as natural sources are mineral weathering and organic matter decay.

The impacts of increased SO_4 concentrations can have consequences on the structure and functioning of freshwater ecosystems. This can be in the form of lowering of pH in combination with enhanced mobility of heavy metals as well as nutrients and sulphide toxicity. The Water Framefore Directive has no guideline concentration set for sulphate concentration in rivers, however UK drinking water has standards to be below 500 mg/l.

Sulphate as SO_4 remain similar at each site for each date sampled (Figure 15) and all readings remain between 55-105 mg/l which is within drinking water requirments. Sulphate concentration also does not look to correlate with the other parameters measured.

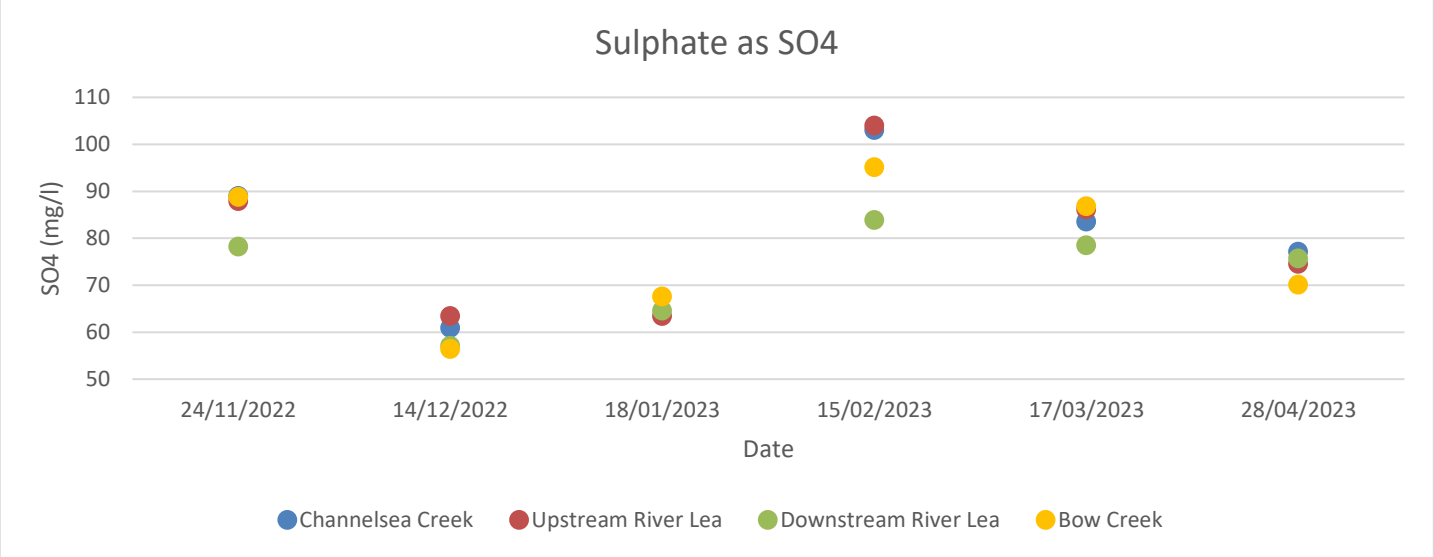

Figure 15 - Sulphate as SO_4 (mg/l) results from the monthly spot sampling at Abbey Mills.

6 CONCLUSION AND RECOMMENDATIONS

OHES, part of the A&A Group were instructed by Thames Water to establish baseline water quality in the watercourses surrounding the Abbey Mills Pumping Station. This water quality investigation was initiated to understand the characteristics and patterns within the water quality data which could be used to then assess the impact of any wastewater discharges from Abbey Mills. This data has also been used to establish and understand risk within the catchment. Various water quality parameters have been identified and analysed for tidal and seasonal patterns. Additional information has been provided for said trends and suggestions for what can be inferred from them regarding water quality and risk factors.

In situ sonde data has confirmed the tidal influence on water quality and conductivity measurement as an indicator of saline intrusion. Tidal cycles have been identified as a significant influence of the water quality within the catchment as the dissolved oxygen, ammoniacal nitrogen and COD parameters are impacted.

Tidal patterns and the bearing on these water quality parameters, would highlight variable risk of impact from a wastewater discharge at high and low tide levels. The variance is due to factors such as residence time and dilution within in the Channelsea Creek at different states of the tide. The risk associated with potential discharges at high tide are that there will be an increase the residence time of pollutants in the nearby aquatic environment as the retention of pollutants near the pumping station is increased with reduced flow towards the estuary (Anabela Oliveira, 2020). This, however, may be offset by the increased dilution from a greater volume of water being present in the creek.

The reverse is true for conditions at low tide, any wastewater discharge would drain away to the River Lea and Thames estuary waterbody at a faster rate, but the concentration of pollutants would be higher as the dilution factor within the channel would be lower making it potentially more harmful to the environment. However, an important factor to consider is the potential timing of a wastewater discharge. Abbey Mills is most likely to discharge during wet weather periods, this means that the dilution factor will be higher within the creek and the residency time would be lower at low tide.

The study has found no major issues surrounding water quality in and around Channesea Creak and the surrounding watercourses. The determinants assessed which are also referenced the Water Framework Directive (WFD) would suggest that the watercourse lies within the ‘good to excellent’ category. For other determinants not found in the WFD there were no significant concerns identified. Channelsea Creak and surrounding watercourses could therefore be considered as a good quality urban river system.

Ecological surveys of the area however suggest that historical urban influence has produced a habitat synonymous with eutrophication. The proximity of the habitat type to Abbey Mills and its outfalls, is likely to be influential as it is highly productive, largely derived from detritus and organic material. Moreover, the structure of the sediment itself can also be influenced by pollutants and organic/nutrient enrichment, often associated with sewage outfalls or eutrophic rivers’ (Ecological survey, OHES 2023). This would suggest that current water quality is good/ excellent however historical influence of industry and spills has influenced, and continues to

influence, the surrounding area. Supplementing this project, auto-sampling devices have been deployed at A Station and F Station within Abbey Mills to garner an understanding of the quality of a potential discharge and therefore allow for further interpretation of the potential impact a discharge from Abbey Mills may have on the receiving watercourse. Furthermore, OHES and A&A have established response plan for hydrogen peroxide dosing in the event of a discharge to help mitigate effects of pollutants on DO and overall water quality.

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