NUTRIENTS

While vital for the survival of all organisms, nutrients can also pose a threat to aquatic life. Surplus nutrients from agriculture and sewage can cause excess growth of plant life and algae in a process called eutrophication. Eutrophication can have various damaging ecological impacts, including low DO, blocking light from the water column, and blooms of toxic blue-green algae.

Right: Upgrades and expansions to Beckton Sewage Treatment Works, pictured, have helped treat sewage and therefore reduce nutrient inputs into the river from London's ever-increasing population.

PHOSPHORUS

Long-term trend: Improving

Short-term trend: Improving

Background

Phosphorus concentrations in rivers all over the UK increased rapidly between 1950 and the late 1980s, primarily because of nutrient-rich sewage and runoff from agriculture entering river systems (Environment Agency 2019a). However, phosphorus concentrations have dramatically reduced since the 1990s. This is largely due to improvements in wastewater treatment across the UK, namely phosphorus removal practices. In the Thames Catchment, the STWs have been managed by Thames Water since 1990. Their investment, along with investment from water companies throughout the UK under direction of the Environment Agency's Water Industry National Environment Programme (WINEP), has enabled widespread reductions in phosphorus across the country. Despite these improvements, high phosphorus concentrations continue to be the most common reason why waterbodies do not meet the European Union (EU) Water Framework Directive (WFD) standard of good ecological potential/status in the UK (Environment Agency 2019a).

Furthermore, the risk posed by high phosphorus concentrations is expected to be heightened in the Tidal Thames because of increasing sewage inputs caused by an increasing population, rising water temperatures due to climate change, and greater stormwater runoff. Nevertheless, improvements in phosphorus concentrations are expected by 2025 in response to WINEP, which sets out environmental requirements for water companies and actions to ensure success.

Analysis

Tidal influence is a major factor affecting nutrient levels in the Tidal Thames. Therefore, the decision was made to focus on the Thames at Teddington – where tidal influence is minimal – as well as monitoring points at the mouths of three freshwater tributaries: the Rivers Lee, Ravensbourne and Darent. These three tributaries were chosen because they had long-term data available, and discharged directly into the Tidal Thames. The water quality data used for this analysis were obtained from the Environment Agency's Water Quality Archive (WIMS). Sampling points closest to the confluences with the Tidal Thames were used, and parameters reflecting measurements of dissolved phosphorus were selected. Recorded phosphorus concentrations over time were then plotted for each tributary; for some tributaries, this went as far back as 1970s, while others began in the 1990s. To assess long- and short-term trends, data for the four rivers were combined and linear regressions were calculated using yearly averages.

To determine the source of phosphorus in the River Thames at Teddington, the 'load apportionment' approach was used (Bowes *et al*. 2008). The phosphorus concentration data were combined with the daily mean flow on the day of sampling. The nearest gauging station was selected, and the mean flow data were obtained from the UK Centre for Ecology & Hydrology's (CEH) National River Flow Archive.

Findings

All rivers showed declines in phosphorus concentrations over the monitoring periods (Figures 2.1–2.4). Some rivers had sudden step reductions in phosphorus such as the Lee in 2012 (Figure 2.2), which usually indicates a rapid improvement due to the introduction of phosphorus removal at a large STW. The smaller tributaries – the Ravensbourne and Darent – have not seen the same dramatic reductions in phosphorus concentrations (Figures 2.3 and 2.4). However, the occasional large peaks that were observed have disappeared in recent years, again suggesting that STW upgrades are eliminating sporadic pollution incidents.

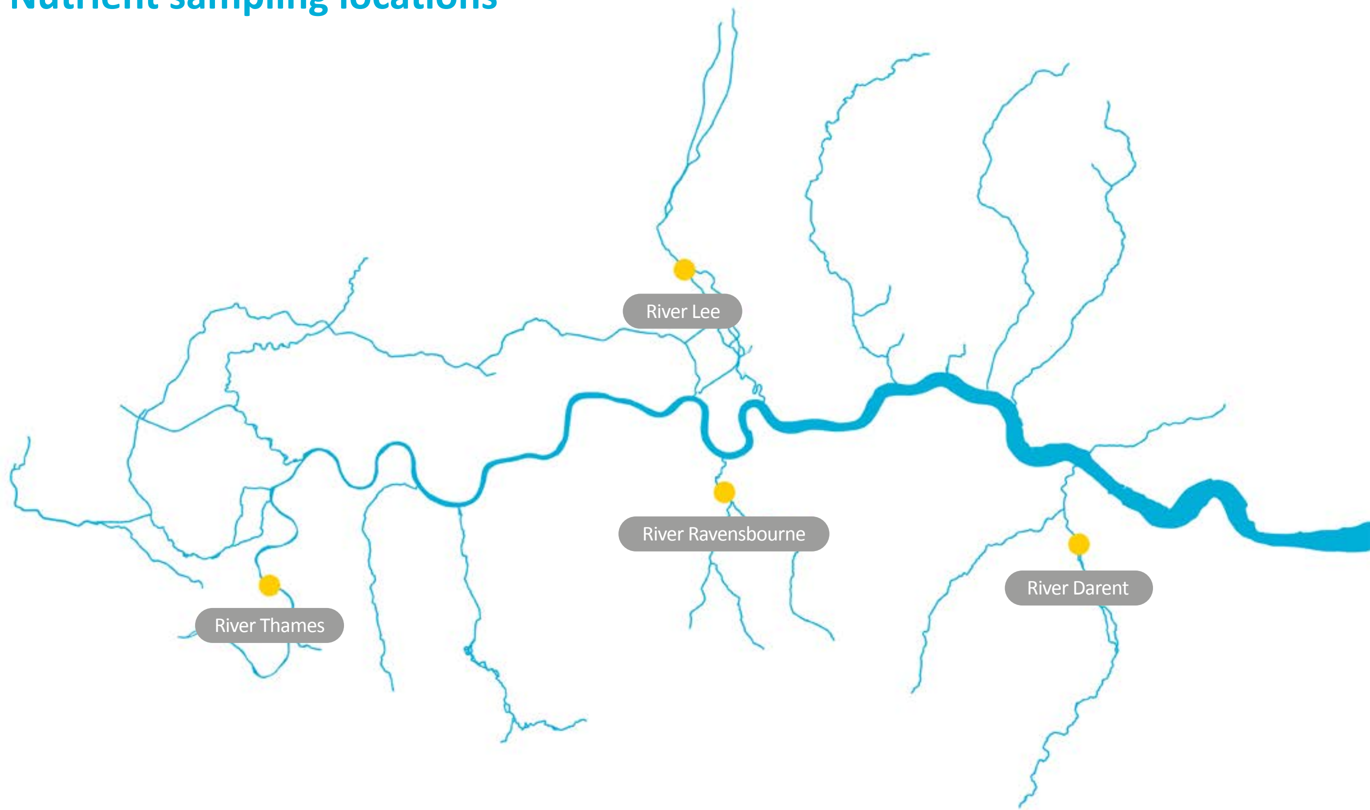
Overall yearly averages were used to calculate long- (1990 to 2020) and short-term (2010 to 2020) trends. Statistically significant long- (p-value = 9.82E-13) and short-term (p-value = 0.05) decreasing trends were found, demonstrating environmental improvement. This improvement is further observed in the decline in average daily phosphorus loads being deposited into the Tidal Thames from monitored tributaries (Figure 2.6). Despite the decline in phosphorus, chlorophyll

– a pigment found in algae – has shown no signs of decline, suggesting there has been no decrease in algal blooms.

The River Thames at Teddington had a sudden reduction in phosphorous concentrations in 2007. This likely indicates the introduction of STW phosphorus removal at multiple towns and cities in the freshwater catchment throughout the 2000s. This was further confirmed when comparing phosphorus concentrations to flow data, which showed that phosphorus concentrations have declined in recent decades during low-flow conditions (Figure 2.5). Rivers that are dominated by inputs from STW (known as 'point sources') always have their highest concentrations during low flow, because of a lack of dilution of the constant inputs from STW (Bowes *et al*. 2008). By the 2010s, phosphorus concentrations were lower, even at low flows, showing a much decreased contribution from sewage effluents.

Despite the observed improvements in phosphorus concentrations, WFD data from 2016 (most recent available data) showed that both the River Lee and the River Ravensbourne in the sampling areas received 'Poor' status for phosphorus concentrations, and the River Thames at Teddington received 'Moderate' status. The River Darent was the only one of the four to achieve an acceptable level of phosphorus, with the best possible 'High' status.

Nutrient sampling locations



Thames phosphorus

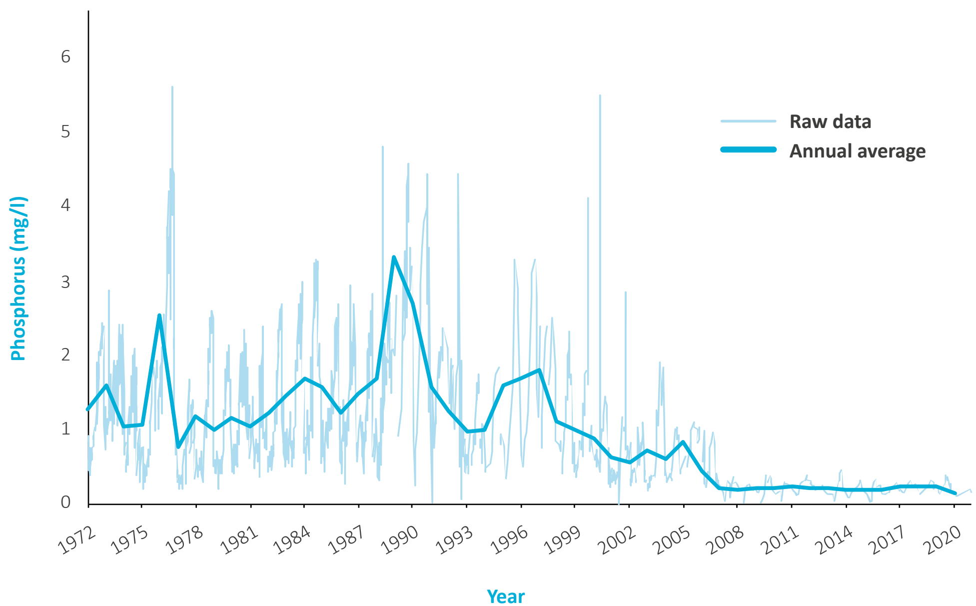


Figure 2.1: Phosphorus concentrations in the River Thames at Teddington.

Lee phosphorus

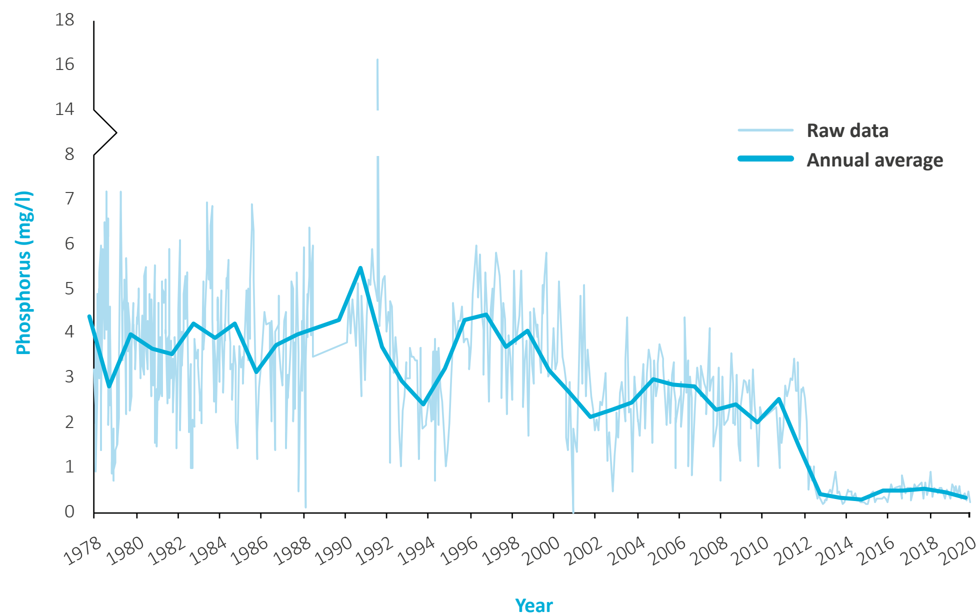


Figure 2.2: Phosphorus concentrations in the River Lee, near its Thames confluence.

Darent phosphorus

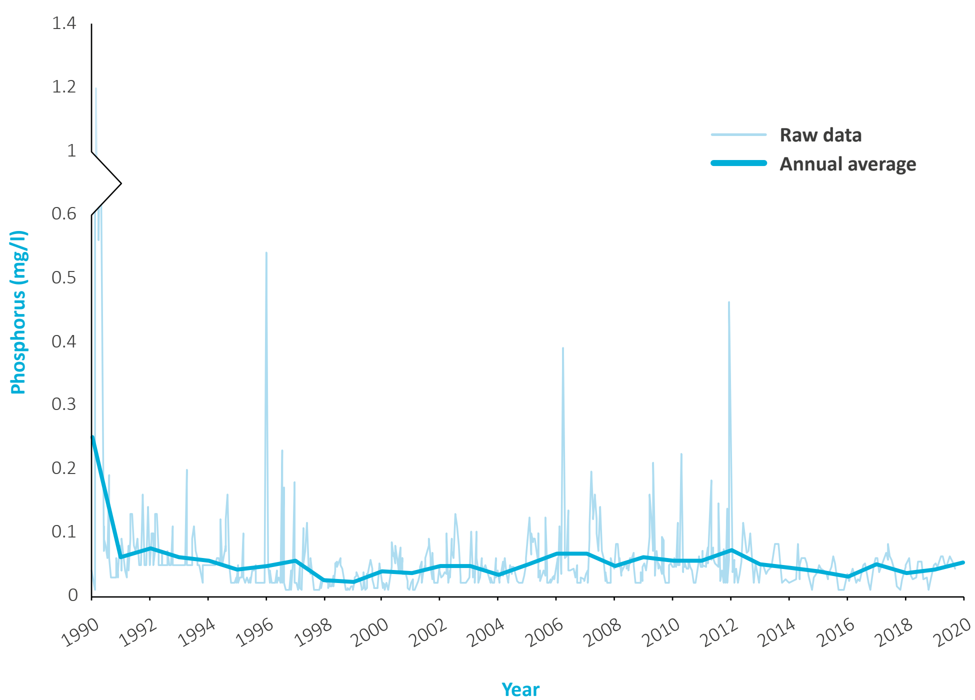


Figure 2.3: Phosphorus concentrations in the River Darent, near its Thames confluence.

Ravensbourne phosphorus

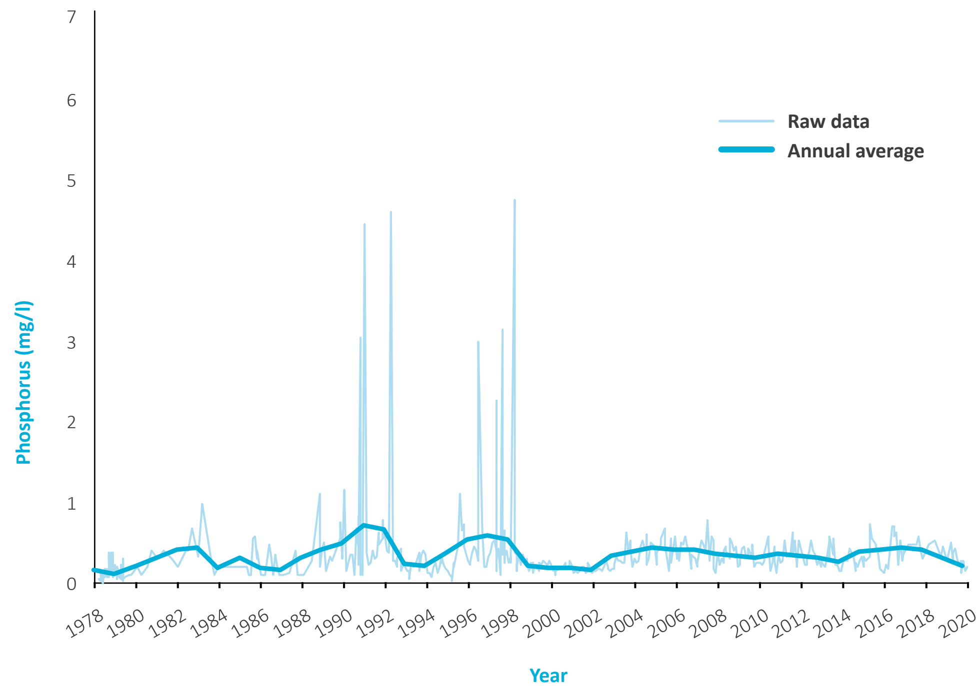


Figure 2.4: Phosphorus concentrations in the River Ravensbourne, near its Thames confluence.

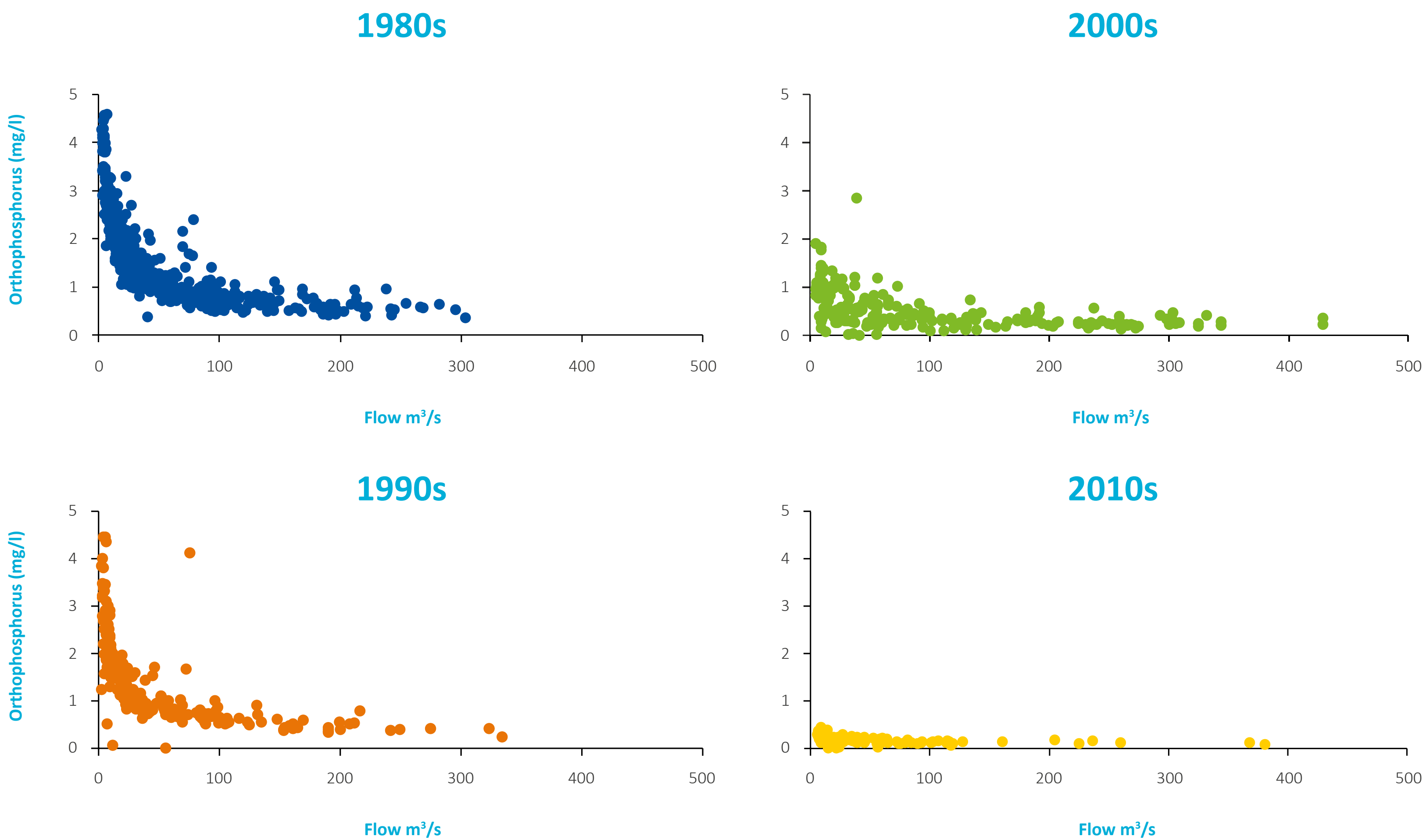


Figure 2.5: Thames orthophosphate (or reactive phosphorus) plotted against flow at the time each sample was taken. The samples taken in the 1980s and 1990s are largely sewage-dominated, with high orthophosphate concentrations occurring at low flow, while high flows see low concentrations. This demonstrates that the source of orthophosphate during this time was likely a point source from a STW. In the 2000s and 2010s, we see reduced orthophosphate concentrations.

Average daily orthophosphorus loads to the Thames Estuary

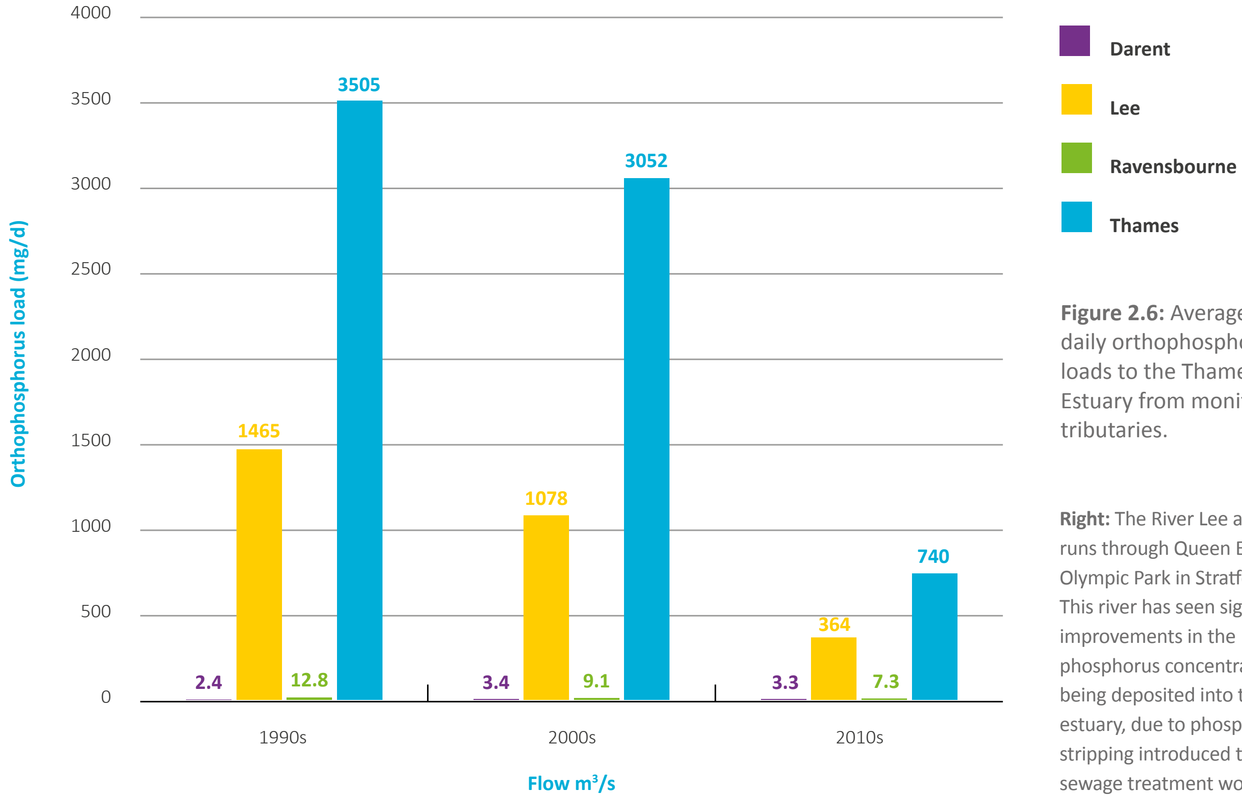


Figure 2.6: Average daily orthophosphorus loads to the Thames Estuary from monitored tributaries.

Right: The River Lee as it runs through Queen Elizabeth Olympic Park in Stratford. This river has seen significant improvements in the phosphorus concentrations being deposited into the estuary, due to phosphate stripping introduced to nearby sewage treatment works.

NITRATE

Long-term trend: Deteriorating

Short-term trend: Data stable

Background

Nitrate is another nutrient that contributes significantly to eutrophication not only in freshwater, but also in marine, coastal and estuarine environments. The Environment Agency has identified industrial and sewage effluent as the main source of nitrate in London waterbodies, with urban runoff determined to be the secondary source (Environment Agency 2019b). In all other regions across the UK, the main source of nitrate is agriculture, because of the common use of nitrate-rich fertilisers. This contrast shows the extreme impacts that London's high population and industry have on its waterbodies. While nitrate removal plants at STW have been installed in select locations in the UK, broader installation has not occurred largely due to cost considerations.

Analysis

The water quality data used for this analysis were obtained from WIMS. The sampling points that were used in the phosphorus analysis were selected here as well: the River Thames at Teddington, and monitoring points closest to the mouths of three freshwater tributaries – the Rivers Lee, Ravensbourne and Darent. Recorded nitrate levels over time were plotted for each tributary, as well as annual averages. For some tributaries, data went as far back as the 1990s, while others began in the 2000s. To test for statistically significant long- and short-term trends, data for the four rivers were combined, yearly averages were calculated and linear regression models were fitted.

Findings

According to the data, annual averages of nitrate concentrations in the larger rivers (Thames, Figure 2.6 and Lee, Figure 2.7) were higher on average than in the smaller tributaries (Ravensbourne and Darent). It is interesting to note that none of the tributaries analysed have experienced any major spikes in nitrate concentrations in the past ~20 years (Figures 2.6–2.9).[4] This could potentially be due to overall improvement and expansion of STW.

While the absence of spikes in nitrate concentrations in recent years can be considered an improvement, overall long-term trends (2000–2020) show a gradual increasing trend in average nitrate levels (p-value = 2E-05), which indicates a deterioration in environmental quality. Promisingly, however, there was no statistically significant short-term (2010–2020) trend, suggesting that concentrations have stabilised.

[4] The peaks in nitrate concentrations that have occurred are likely to be linked to storm events.

Thames nitrate

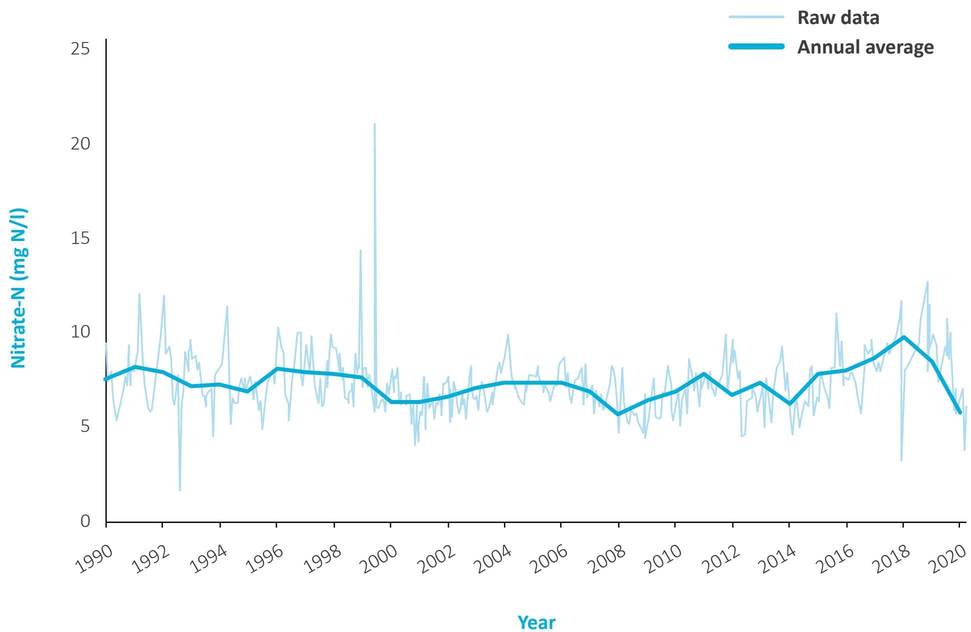


Figure 2.6: Nitrate concentrations in the Thames at Teddington.

Lee nitrate

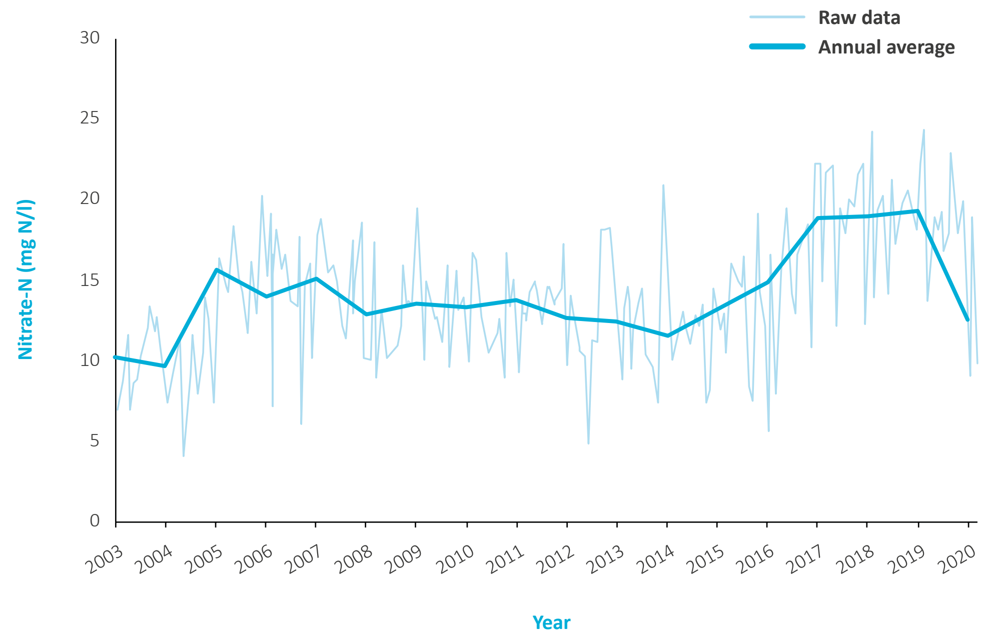


Figure 2.7: Nitrate concentrations in the River Lee.

Darent nitrate

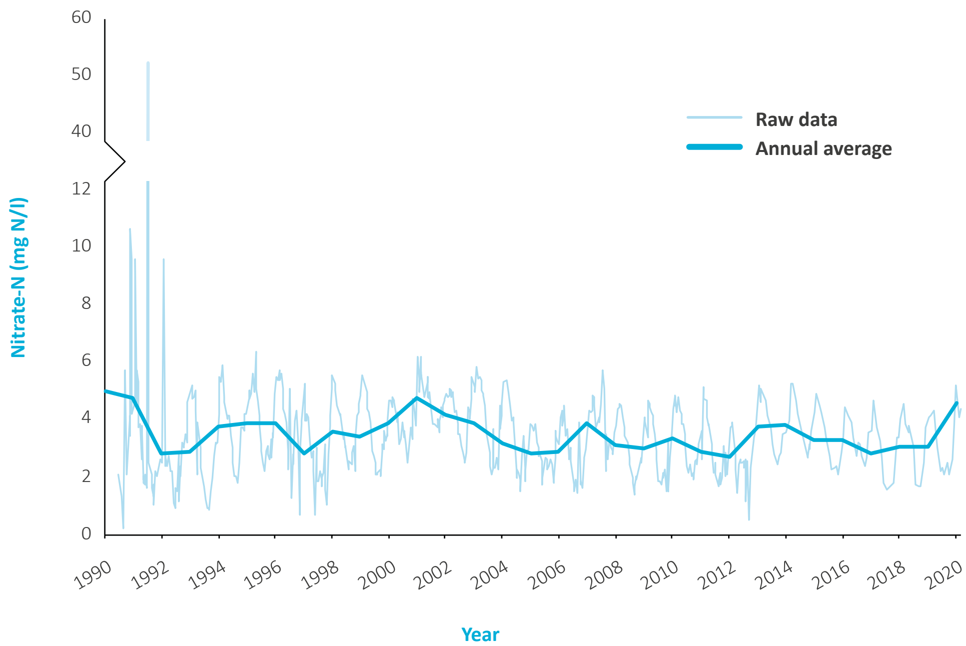


Figure 2.8: Nitrate concentrations in the River Darent.

Ravensbourne nitrate

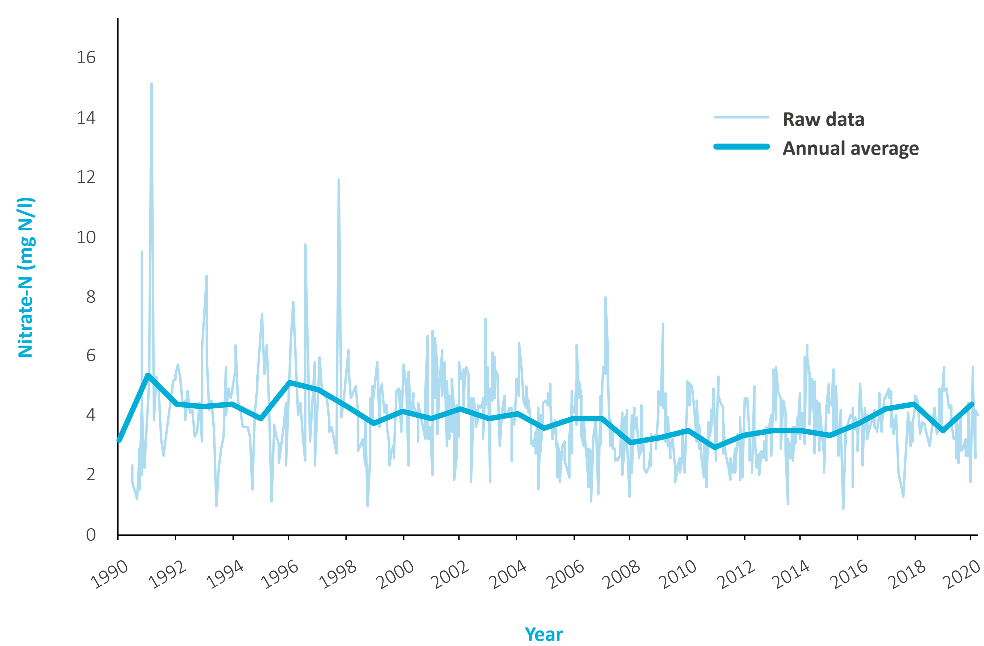


Figure 2.9: Nitrate concentrations in the River Ravensbourne.