

PHOSPHORUS HEADROOM ASSESSMENT – RIVER DEE – CHESTER WEIR TO CEIRIOG

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SUBJECT:	Phosphorus Headroom Assessment – River Dee – Chester Weir to Ceiriog		
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1. THE RUTHIN ROAD / LOWER BERSE FARM DEVELOPMENT

- 1.1.1. The proposed Ruthin Road / Lower Berse Farm development is located in the River Dee – Chester Weir to Ceiriog water body (Water Body ID: GB11106 7057080) within the catchment of the Afon Dyfrdwy a Llyn Tegid / River Dee and Bala Lake Special Area of Conservation (the ‘SAC’).
- 1.1.2. The development will discharge sewage effluent (‘foul flows’) to Dŵr Cymru Welsh Water’s (‘DCWW’) Five Fords wastewater treatment works (WWTW)¹. The foul flows will slightly increase the phosphorus load discharged to the SAC compared to the baseline status. In addition, the change in land use from agricultural to urban will also slightly increase the phosphorus load discharged to the SAC.

2. RIVER DEE AND BALA LAKE/AFON DYFRDWY A LLYN TEGID SAC

- 2.1.1. NRW’s *Core Management Plan including Conservation Objectives for River Dee and Bala Lake/Afon Dyfrdwy a Llyn Tegid SAC*² (‘the CMP’) specifies conservation objectives that must be met for the waterbody to be classified as being in a ‘favourable condition’.
- 2.1.2. For the River Dee – Chester Weir to Ceiriog water body (ID: GB11106 7057080) the CMP specifies a water quality phosphorus standard of 50 µg/l, which is applicable to both the annual and growing season³ mean phosphorus concentrations (calculated using NRW’s water quality monitoring data).
- 2.1.3. NRW’s 2024 phosphorus compliance assessment for the Dee SAC determined that the River Dee – Chester Weir to Ceiriog water body (ID: GB11106 7057080) was failing⁴ the phosphorus standard of 50 µg/l, with a mean annual phosphorus concentration of 56.5 µg/l.
- 2.1.4. On the basis of this assessment, NRW and the Welsh Government (WG) determined that there was no phosphorus ‘headroom’ available in the river to accommodate the increased phosphorus loads from any new development in the catchment. NRW and the WG concluded that any increase in the phosphorus load discharged to the river from the Wrexham region would worsen the already failing condition status of the waterbody. This has resulted in the *de-facto* implementation of a phosphorus neutrality requirement.

3. NRW PLANNING ADVICE⁵

- 3.1.1. The Conservation of Habitats and Species Regulations 2017 (as amended) (‘the Habitats Regulations’) require the competent authority (which, in the case of phosphorus neutrality, is the Planning Authority⁶), to

¹ Or alternatively, and only if absolutely necessary, a high-performance on-site WWTW.

² https://cdn.cyfoethnaturiol.cymru/673374/river_dee_bala_lake_32_plan.pdf

³ Defined as March to September (inclusive) each year.

⁴ This was based on a very small number of data points containing four large outliers and NRW noted it had ‘low confidence’ in the analysis.

⁵ <https://naturalresources.wales/guidance-and-advice/business-sectors/planning-and-development/advice-for-planning-authorities/advice-to-planning-authorities-for-planning-applications-affecting-phosphorus-sensitive-special-areas-of-conservation/?lang=en>

⁶ In the case of an appeal, the Welsh Ministers rather than the LPA.

undertake a Habitats Regulations Assessment (HRA) to consider whether a plan or project is likely to have a significant effect (a 'likely significant effect' or 'LSE') on a Special Area of Conservation (SAC). This draft Appropriate Assessment is intended to assist the Inspector and the Minister in carrying out their duties.

3.1.2. NRW's guidance requires that development proposals within a SAC river catchment '*must undergo an HRA to determine their impact on the designated site and its features*'. The guidance specifies that the HRA consists of two principal stages:

- '*Test of Likely Significant Effect – this is a screening assessment to determine whether a development has the potential to affect an SAC. Where a likely significant effect can be ruled out, no further assessment under the Habitats Regulations is required.*
- '*Appropriate Assessment – where a proposed development is considered likely to have a significant effect, or such an effect cannot be ruled out, a more detailed assessment of the potential impacts is required. The purpose of the Appropriate Assessment is to assess the implications for the river SAC in view of that site's conservation objectives and thereby determine whether the proposal could have an adverse effect on the integrity of the site*'.

4. SCREENING FOR LIKELY SIGNIFICANT EFFECTS

4.1.1. As the Ruthin Road / Lower Berse Farm development would slightly increase the total phosphorus load discharged to the River Dee – Chester Weir to Ceiriog water body (ID: GB11106 7057080) it is not possible to rule out the development having a Likely Significant Effect on the SAC. A more detailed Appropriate Assessment (AA) is therefore required to inform the decision-making process.

5. APPROPRIATE ASSESSMENT

5.1.1. To determine whether the development could have a LSE on the integrity of the Dee SAC, the current condition of the SAC needs to be considered against the relevant conservation objective, together with an assessment of the potential impacts of the proposed development and cumulative development.

5.2. BASELINE CONDITION ASSESSMENT

5.2.1. The assessment of the current baseline condition of the SAC in relation to phosphorus considers:

- NRW's 2024 phosphorus compliance assessment.
- Alternative sources of more robust compliance assessment data and analysis that demonstrate that the SAC is not failing the phosphorus standard.
- WCBC's separate assessment that the river is not failing the phosphorus standard.
- How much additional phosphorus could be discharged to the river without causing a failure of the phosphorus standard (phosphorus 'headroom').

NRW 2024 PHOSPHORUS COMPLIANCE ASSESSMENT

5.2.2. NRW's 2024 phosphorus compliance assessment for the Dee SAC determined that the River Dee – Chester Weir to Ceiriog water body (ID: GB11106 7057080) was failing the phosphorus standard of **50 µg/l**, with a mean annual phosphorus concentration of **56.5 µg/l**.

5.2.3. However, the 2024 compliance assessment undertaken by NRW and published in March 2025 was based on just 13 phosphorus data points from just one NRW water quality monitoring site – the River Dee at Farndon Bridge. The classification was heavily influenced by a single extreme outlier sample result of **335 µg/l** and three high outlier data points exceeding **100 µg/l**. These outliers are approximately 10 times

and three times higher than the average of the other data points, respectively. While NRW maintains that the outlier values are correct, they assigned a **low confidence** rating to the compliance assessment.

- 5.2.4. A statistical analysis of the Lower Dee phosphorus compliance status is provided in **APPENDIX A**. The analysis considers NRW's 2019 and 2024 River SAC Compliance Assessment, plus NRW (and Environment Agency) phosphorus data spanning January 2020 to January 2026. The analysis identifies that the values of **335 µg/l** and **>100 µg/l** included in NRW's 2024 Compliance Assessment dataset are extreme outliers and should have been excluded from the data analysis. Exclusion of these data points would result in the River Dee – Chester Weir to Ceiriog water body (ID: GB11106 7057080) complying with the phosphorus standard of 50 µg/l and hence remaining in 'favourable condition'.

ALTERNATIVE PHOSPHORUS COMPLIANCE ASSESSMENT DATA & ANALYSES

- 5.2.5. The Environment Agency (EA) use the same monitoring location (Farndon Bridge) and the same methodologies for phosphorus recording and data analysis as NRW. The EA's data set contains 36 records between January 2020 and May 2026. The EA data do not replicate the NRW outlier of 335 µg/l. Except for three records in the range 57 – 97 µg/l, all other data points are below 50 µg/l, with 30 of the records below 30 µg/l of which two are below the analytical limit of detection (<10 µg/l). Once the NRW outliers are removed from the NRW dataset, the NRW and EA data generate comparable annual mean phosphorus concentrations. The 36 data points in the EA dataset generate an annual mean phosphorus concentration of **31.0 µg/l**, demonstrating that the Lower Dee SAC remains below 50 µg/l and is therefore not failing the phosphorus standard.
- 5.2.6. Natural England, as the government's adviser for the natural environment in England, has designated SACs that are in unfavourable condition due to '*exceeded nutrient thresholds*'. The Lower Dee forms part of the border between England and Wales and both jurisdictions therefore share responsibility for management of the river. Four WWTWs in England (Farndon, Tattenhall, Malpas and Whitchurch) discharge into the River Dee – Chester Weir to Ceiriog water body (ID: GB11106 7057080). However, in contrast to NRW, Natural England has not designated this water body as being in unfavourable condition because of excess nutrients. Consequently, Natural England considers the water body to be complying with its conservation objectives and the phosphorus standard, and development on the English side of the border is not restricted by phosphorus neutrality requirements as it is on the Welsh side of the border. It is patently illogical that two governmental nature conservation organisations with joint responsibility for the same water body have adopted diametrically opposed positions despite undertaking the same water quality monitoring programmes and analyses at the same, shared, monitoring location at Farndon Bridge.
- 5.2.7. The EA data has been separately analysed and reported in the 6 July 2026 Wrexham County Borough Council (WCBC) planning committee report⁷. The report concludes that "*when all available phosphorus data from both NRW and the EA are considered together and assessed using NRW's analytical approach, the Lower Dee remains below the phosphorus target.*" The report also states, "*On this basis, the evidence suggests that the Lower Dee should not be considered to be at risk of pollution failing its phosphorus target.*" The WCBC report concludes that "*NRW have been consulted on a draft version of the evidence report and did not challenge the substantive arguments and conclusion that the waterbody can be considered to be passing in light of EA data.*"
- 5.2.8. While it now appears to be accepted that the Lower Dee SAC is not failing the phosphorus standard, the WCBC planning committee report does not quantify the current annual mean phosphorus concentration in the SAC. However, statistical analysis of the various monitoring datasets undertaken on behalf of the Appellant confirms that the annual mean phosphorus concentration in the River Dee – Chester Weir to Ceiriog water body will fall within the following range:

⁷ <https://moderngov.wrexham.gov.uk/documents/g10042/Public%20reports%20pack%2006th-Jul-2026%2016.00%20Planning%20Committee.pdf?T=10&LLL=0>

- **27.2 µg/l to 39.4 µg/l** based on NRW's 2024 Compliance Assessment dataset but excluding the extreme outlier of 335 µg/l.
- **24.1 µg/l to 29.2 µg/l** based on NRW's 2024 Compliance Assessment dataset but excluding the extreme outliers of 335 µg/l and >100 µg/l.
- **25.8 µg/l** based on NRW's 42 data points spanning 30 January 2020 to 13 January 2026 excluding all four extreme outliers.
- **32.2 µg/l** based on the EA's 36⁸ data points spanning January 2020 to May 2026.
- **35.3 µg/l** based on NRW's 42 data points (including the four outliers) plus the EA's 36 data points.

5.2.9. Whichever phosphorus monitoring dataset is used the mean phosphorus concentration in the River Dee – Chester Weir to Ceiriog water body (ID: GB11106 7057080) remains substantially below the 50 µg/l phosphorus standard and the SAC therefore remains in favourable condition.

PHOSPHORUS HEADROOM IN THE CHESTER WEIR TO CEIRIOG WATER BODY

5.2.10. As the phosphorus concentration in the River Dee – Chester Weir to Ceiriog water body (ID: GB11106 7057080) remains substantially below the 50 µg/l phosphorus standard, it is possible to increase the phosphorus load discharged to the river without causing a breach of the phosphorus standard. This is referred to as the phosphorus 'headroom'. The headroom can be used to accommodate additional phosphorus loads associated with new development without adversely affecting the integrity of the SAC by triggering a failure of the phosphorus standard. The existing phosphorus load and available phosphorus headroom available in the water body can be estimated using simple mass balance calculations.

$$P_{LOAD} = ((Flow \times 1,000^9 \times 60 \text{ seconds} \times 60 \text{ minutes} \times 24 \text{ hours} \times 365.25 \text{ days}) \times P_{CONC}) / 1,000,000,000^{10}$$

Where:

P_{LOAD} – Total Annual Phosphorus Load (kg/year).

P_{CONC} – Phosphorus Compliance Standard or Annual Mean Phosphorus Concentration (µg/l).

Flow – Mean Flow (m³/s).

- 5.2.11. The water quality monitoring station at Farndon Bridge where the phosphorus concentration data was sampled does not monitor flow. The nearest flow monitoring station to Farndon Bridge is the Dee at Ironbridge (NFRA Station 67027¹¹), which is located approximately 10 km downstream. The catchment area of the Dee at Ironbridge is 1,674km² while the catchment area of the Dee at Farndon Bridge is approximately 1,359km² (based on the FEH webservice¹²), with this difference equating to ~23%.
- 5.2.12. Based on the NRFA data, the mean flow of the Dee at Ironbridge is 38.455 m³/s while the median flow is 22.5 m³/s. Whilst flow is not directly proportional to catchment area, an estimate of the flow at Farndon Bridge can be derived by area weighting the flow estimates from Ironbridge¹³, which generates estimated flow values at Farndon Bridge of:

⁸ The Statistical Analysis of the Lower Dee Phosphorus Compliance Status (refer to the Proof of Evidence of James Ellaway, Appendix A) was completed prior to this headroom assessment and uses the 31 data points available at the time of the analysis, generating a slightly different mean phosphorus concentration of 33.1 µg/year.

⁹ To convert m³/s to litres/second.

¹⁰ To convert µg/year to kg/year.

¹¹ <https://nrfa.ceh.ac.uk/data/station/info/67027>.

¹² <https://fehweb.ceh.ac.uk/Map>

¹³ Calculated as Flow x (1,359km² / 1,674 km²).

- 31.22 m³/s (mean flow).
- 18.27 m³/s (median flow).

- 5.2.13. Using the equation above, these values can be used to determine the maximum theoretical phosphorus load the water body can carry without breaching the phosphorus standard of **50 µg/l**. Based on the mean flow this would be **49,260 kg/yr** and based on the median flow this would be **28,822 kg/year**.
- 5.2.14. By replacing the 50 µg/l with the current annual mean phosphorus concentration in the water body, the current annual phosphorus load (kg/year) can be determined. The difference between this and the theoretical maximum compliant annual phosphorus load is the phosphorus headroom available in the catchment.
- 5.2.15. The annual mean phosphorus concentrations calculated above using the more robust data sets range from **25.8 µg/l** (using all NRW data for 2020 – 2026 excluding all four outliers) to **35.3 µg/l** (using NRW's 42 data points including the four outliers plus the EA's 36 data points). The worst-case mean annual phosphorus concentration is **39.4 µg/l** (using NRW's smaller and less robust 2024 Compliance Assessment dataset and excluding just the extreme outlier of 335 µg/l).
- 5.2.16. A conservative assessment of the current total annual phosphorus load in the SAC at Farndon Bridge can be calculated using the median flow¹⁴ at Farndon Bridge, the range of mean annual phosphorus concentrations, and the equation above. This generates an estimated range from **14,875 kg/year** to **20,352 kg/year**, increasing to a worst case of **22,716 kg/year** (using NRW's smaller and less robust 2024 compliance assessment dataset minus the most extreme outlier).
- 5.2.17. Subtracting these annual phosphorus loads from the theoretical maximum compliant median flow phosphorus load of **28,822 kg/year** indicates that the current phosphorus headroom in the SAC is **13,947 kg/year** to **8,470 kg/year**, with a worst-case estimate of **6,106 kg/year**.
- 5.2.18. The phosphorus headroom is sufficient to enable a significant number of new developments to be brought forward in the catchment without the waterbody failing the phosphorus standard.

5.3. ADDITIONAL PHOSPHORUS LOAD ESTIMATES

RUTHIN ROAD / LOWER BERSE FARM

- 5.3.1. The WG Nutrient Budget Calculator for Special Areas of Conservation in Wales¹⁵ (the 'WG nutrient calculator') has been used to calculate the additional phosphorus load that would be discharged to the Dee catchment from the Ruthin Road / Lower Berse Farm development. The calculator provides a conservative assessment of the load as it specifies a Five Fords WWTW phosphorus discharge concentration of 1.00mg/l when the WWTW is already achieving a permit limit of 0.70 mg/l.
- 5.3.2. The calculated annual phosphorus load for the full development of 1,450 dwellings is **159.23 kg/year** pre-2030. However, the Appellant would only be able to construct and occupy up to 100 dwellings pre-2030. The pro-rated phosphorus load would therefore be up to **11.00 kg/year**. Post-2030, once Five Fords WWTW's lower phosphorus permit limit is considered, the full development phosphorus load would be **105.93 kg/year**¹⁶.

¹⁴ Rather than the mean flow, which would inflate the available headroom.

¹⁵ https://www.gov.wales/sites/default/files/publications/2026-02/nutrient-budget-calculator_1.xlsx

¹⁶ Optimised calculations using a permit limit of 0.70 mg/l and additional bespoke locally-specific input values result in a phosphorus load of approximately 20 kg/year.

ALL OTHER RESIDENTIAL DEVELOPMENTS

- 5.3.3. WCBC provided housing and population projections for residential developments connecting to ten WWTWs¹⁷ in Wales and four WWTWs¹⁸ in England, all of which discharge into the River Dee – Chester Weir to Ceiriog water body (ID: GB11106 7057080). WCBC's population projections were calculated by multiplying the number of dwellings by an occupancy rate of 2.26 residents per unit¹⁹ and have been phased for pre-2030 and post-2030 horizons.
- 5.3.4. The foul flow phosphorus load has been calculated using a per-person water consumption of 120 lpd and the relevant WWTW total phosphorus discharge consent limit (mg/l) as detailed in **Table 1**. The WG nutrient calculator method requires that the calculated loads be uplifted by a 20% precautionary buffer to ensure that the loads are conservative.

Table 1: Estimated Pre-2030 and Post-2030²⁰ Residential Foul Flow Phosphorus Loads to the SAC

WWTW	Pre-2030 P Permit Limit (mg/l)	Pre-2030 Additional Population	Pre-2030 Additional P Load (kg/yr)	Post-2030 P Permit Limit (mg/l)	Post-2030 Additional Population	Post-2030 Additional P Load (kg/yr)
<i>Five Fords²¹</i>	1	3,782	165.8	0.7	9,208	282.5
<i>Gresford</i>	1	319	14.0	1	385	16.9
<i>Cefn Mawr</i>	1	378	16.6	1	533	23.4
<i>Lavister</i>	1	282	12.4	1	307	13.5
<i>Holt</i>	5	88	19.3	5	97	21.3
<i>Penley</i>	5	22	4.8	0.9	22	0.9
<i>Overton</i>	5	102	22.4	5	111	24.3
<i>Mold</i>	5	1,021	223.8	5	1,229	269.3
<i>Buckly (Ty Gwyn)</i>	5	885	193.9	5	885	193.9
<i>Hope</i>	5	348	76.3	5	348	76.3
<i>English WWTWs</i>	5	1,263	276.8	5	2,101	460.4
Total	N/A	8,490	1,025.9	N/A	15,226	1,382.6
Precautionary Uplift			205.2			276.5
Grand Total			1,231.1			1,659.2

- 5.3.5. In addition to the phosphorus load associated with the foul flows from these new developments, there would likely be some additional phosphorus loading associated with the land use change for these developments. There are a range of factors that influence phosphorus loading associated with land use change, including existing land use type, underlying soils and rainfall and it therefore not possible to accurately estimate this loading as part of this assessment. However, using the WG Nutrient Budget Calculator and taking the Ruthin Road development as an example, the land use change results in an additional phosphorus load of approximately 0.04 kg/dwelling/year²². Applying a precautionary approach and doubling this to

¹⁷ In Wrexham County Borough Council and Flintshire County Council.

¹⁸ Farndon, Malpas, Tattenhall & Whitchurch (Shropshire). A conservative approach has been taken to the phosphorus load calculations by adopting a worst-case phosphorus permit limit of 5.00mg/l.

¹⁹ How this was derived is not known.

²⁰ The post-2030 additional population and phosphorus load are cumulative and include the pre-2030 values.

²¹ Excluding the Ruthin Road / Lower Berse Farm as that phosphorus load is calculated separately.

²² 0.038 kg/dwelling is calculated as the future land use phosphorus load (75.55 kg/year) minus the existing land use phosphorus load (20.80 kg/year) divided by the number of dwellings in the development (1,450).

0.08 kg/dwelling/year results in estimates of the additional land use change phosphorus loading of the proposed new dwellings²³ (including the 20% precautionary uplift) as:

- **307.01 kg/year** (pre-2030); increasing to
- **557.57 kg/year** (post-2030).

5.3.6. While these land use change phosphorus loads would be conveyed in surface water and treated through the Sustainable Drainage System (SuDS) the phosphorus removed through the SuDS has not been considered in the values above.

5.3.7. The sum of the foul flow and land use change phosphorus loads (both incorporating the 20% uplift) therefore generates a total additional phosphorus loading associated with the new residential developments of:

- **1,538.11 kg/year** but pro-rated to **153.81 kg/year** (pre-2030) increasing to
- **2,216.77 kg/year** (post-2030).

COMMERCIAL DEVELOPMENTS

5.3.8. Phosphorus neutrality calculations don't typically require consideration of new commercial developments and employment sites, unless they are likely to generate a significant intrinsic phosphorus load, as the employees and customers are assumed to live in the same catchment and their foul flow nutrient load is therefore accounted for in the existing and/or future foul flow load calculations. However, Wrexham is located close to the border with England and new commercial developments are likely to attract a proportion of employees and customers who live outside of the Lower Dee catchment. This additional phosphorus load has been estimated based on WCBC-provided forecast commercial developments and employment sites and the estimated (conservative) percentage of customers/users or employees anticipated to travel into the Lower Dee catchment from outside the catchment to work or use the facilities.

5.3.9. The WG nutrient calculator guidance states that users (of the calculator) should "*identify a suitable and appropriately precautionary rate that will need to be agreed by the appropriate LPA*" to account for the percentage of employees and customers who will commute from outside of the catchment. WCBC's data for commercial developments and employment sites included projections of the percentage of users (both employees and customers) of these sites who would normally reside outside of the Lower Dee catchment, with the majority assigned a value of 40% and the remainder assigned a value of 50% – 100%.

5.3.10. The foul loads for the out-of-catchment customers and employees of these commercial developments can be calculated based on the additional population travelling into the catchment and the daily water consumption of the users of these sites. The WG nutrient calculator guidance outlines that "*All water usage values have been set to a default 120 litres/person/day in lieu of any evidence to suggest otherwise. However, it is unlikely that the water usage per person per day in a place of work will be as high as their place of residence.*"

5.3.11. Estimates of water consumption for a range of commercial premise types are detailed in British Water's Flows & Loads 4. However, in the absence of details about the proposed types of commercial developments, the WG nutrient calculator's default value of 120 lpd has been adopted. This is a precautionary approach, to which the 20% precautionary uplift has also been applied. The aggregated number of out-of catchment customers/employees and the associated additional phosphorus loads are presented in **Table 2** for the pre-2030 and post-2030²⁴ horizons.

²³ Dwelling numbers of 3,198 (pre-2030) and 5,808 (pre-2030 & post-2030) calculated by dividing the total additional pre-2030 and pre-2030 and post-2030 population by 2.26.

²⁴ The post-2030 values are cumulative and include the pre-2030 values.

Table 2: Estimate of Additional Phosphorus Load from Out-of-Catchment Customers & Employees

WWTW	Pre-2030 Additional Out- of-Catchment Customers & Employees	Pre-2030 Additional Phosphorus Load (kg/year)	Post-2030 Additional Out- of-Catchment Customers & Employees	Post-2030 Additional Phosphorus Load (kg/year)
Five Fords ²⁵	3,527	154.6	5,255	161.2
Gresford ²⁶	233	20.4	233	10.2
Total	3,760	175.0	5,488	171.4
Precautionary Uplift		35.0		34.3
Grand Total		210.0		205.7

- 5.3.12. The two largest commercial development sites (Western Gateway and Wrexham Industrial Estate) are entirely or mostly located on greenfield sites. Converting existing agricultural land to commercial/industrial land will generate an increase in the phosphorus load discharged to the Lower Dee. Phosphorus export rates for various agricultural land uses (published in the WG nutrient calculator) are provided in **Table 3** below together with the export rate for the commercial/industrial land use to highlight the potential magnitude of the phosphorus load increase on a per hectare basis.

Table 3: Indicative Phosphorus Export Rates for Agricultural and Commercial/Industrial Land Uses

Existing Agricultural Land Use	Phosphorus Export Rate (kg/ha/year)		
	For Agricultural Land Uses	For Commercial/Industrial Land Use	Land Use Change Increase
Cereal	0.31	1.20	0.89
General Cropping	0.18		1.02
Mixed Farming	0.23		0.97
Lowland Grazing	0.16		1.04

- 5.3.13. The Western Gateway development area²⁷ has been estimated using Google Earth as approximately 84,000 m³ or 8.4 hectares. The Wrexham Industrial Estate development proposed by Net World Sports has been reported²⁸ to cover an area of approximately 91 acres or 37 ha. Multiplying the worst-case land use change phosphorus export rate from Table 3 by the total estimated development area (45.4 ha) indicates that the land use change element of these two developments could result in the generation of an estimated additional phosphorus load of **47.1 kg/year**. While a proportion of this load could be removed through the SuDS this has not been considered in this assessment.
- 5.3.14. It is assumed there will not be a land use change element of phosphorus loading associated with the remainder of the smaller employment sites as they are likely to be infill development on brownfield sites.

²⁵ Five Fords WWTW phosphorus discharge permit limit is 1.00 mg/l (pre-2030) and 0.70 mg/l (post-2030).

²⁶ Gresford WWTW phosphorus discharge permit limit is defined as 2.00 mg/l in the WG nutrient calculator but 1.00 mg/l effective from 28 June 2023 by <https://naturalresources.wales/guidance-and-advice/business-sectors/planning-and-development/advice-for-planning-authorities/phosphorus-limits-on-environmental-permits-for-waste-water-treatment-work-discharges/?lang=en>. To provide a conservative assessment we have adopted values of 2.00 mg/l (pre-2030) and 1.00 mg/l (post-2030).

²⁷ https://haveyoursay.tfw.wales/western-gateway-wrexham?fbclid=IwY2xjawldhaJleHRuA2FibQlxMAABHVfBLdrBLUGmBM3YSei_4Koe4DSBFGDTsgBkVO_M0Af9KyVcaMBMFJF99g_aem_QnkDZpF9S_Bm7lxg8OszxQ

²⁸ <https://www.leaderlive.co.uk/news/25772004.plans-major-development-wrexham-industrial-estate/>

- 5.3.15. Including the land use change load, the commercial and employment developments will therefore generate an estimated additional phosphorus load to the SAC of **257.1 kg/year** pro-rated to **25.71 kg/year** (pre-2030) and **252.8 kg/year** (post-2030).

5.4. ASSESSMENT OF IMPACTS ON THE LOWER DEE SAC

RUTHIN ROAD / LOWER BERSE FARM

- 5.4.1. The pro-rated pre-2030 phosphorus load would be up to **11 kg/year**. Post-2030, once Five Fords WWTW's lower phosphorus permit limit is considered, the full development phosphorus load would be **105.93 kg/year**²⁹.
- 5.4.2. The current total annual phosphorus load in the SAC is estimated to range from **14,875 kg/year** to **20,352 kg/year**, increasing to a worst case of **22,716 kg/year**. **Table 4** demonstrates that the development's additional phosphorus load represents a very small proportion of the current phosphorus load in the SAC.

Table 4: Ruthin Road / Lower Berse Farm Phosphorus Load Compared to Existing Phosphorus Load in the SAC

Existing Phosphorus Load Scenario	Existing Phosphorus Load (kg/year)	Ruthin Road / Lower Berse Farm Phosphorus Load (kg/year)		Development Load as Proportion of Existing Phosphorus Load (%)	
		Pre-2030	Post-2030	Pre-2030	Post-2030
Most Likely – Upper Range	14,875	11.00	105.93	0.07%	0.71%
Most Likely – Lower Range	20,352			0.05%	0.52%
Worst-Case	22,716			0.05%	0.47%

- 5.4.3. The current phosphorus headroom in the SAC is **13,947 kg/year** to **8,470 kg/year**, with a worst-case estimate of **6,106 kg/year**. The additional phosphorus load from the development is therefore a very small proportion of the available phosphorus headroom in the SAC, ranging from less than **0.20%** (pre-2030) to post-2030 values of **0.76%** to **1.25%** for the most likely headroom values, and **1.73%** for the worst-case headroom scenario, as presented in **Table 5**.

Table 5: Ruthin Road / Lower Berse Farm Phosphorus Load Compared to Phosphorus Headroom in the SAC

Headroom Scenario	Phosphorus Headroom (kg/year)	Ruthin Road / Lower Berse Farm Phosphorus Load (kg/year)		Development Load as Proportion of Phosphorus Headroom (%)	
		Pre-2030	Post-2030	Pre-2030	Post-2030
Most Likely – Upper Range	13,947	11.00	105.93	0.08%	0.76%
Most Likely – Lower Range	8,470			0.13%	1.25%
Worst-Case	6,106			0.18%	1.73%

- 5.4.4. The development's annual phosphorus load can also be assessed for its impact on the annual mean phosphorus concentration in the SAC:
- The estimated median flow value at Farndon Bridge is 18.27 m³/s; this equates to 576,557,352,000 litres per year.

²⁹ Using the WG Nutrient Budget Calculator default values; reducing to approximately 20 kg/year using bespoke values.

- The development's pre-2030 phosphorus load of up to 11.00 kg/year equates to 11,000,000,000 µg/year.
- Dividing the load (in µg/year) by the flow (in litres per year) confirms that the development would increase the existing SAC mean annual phosphorus concentration by up to **0.02 µg/l**³⁰ pre-2030 and just **0.18 µg/l** post-2030.

5.4.5. The analytical limit of detection reported in the EA dataset is 0.01 mg/l or 10.00 µg/l. The increase in the mean annual phosphorus concentrations is therefore substantially below the limit of detection and is *de minimis*.

ALL RESIDENTIAL & COMMERCIAL DEVELOPMENT

5.4.6. The cumulative impact of all residential and commercial developments³¹ has been assessed together with the phosphorus loading of the proposed development at Ruthin Road. It has been assumed that a maximum of 10% of the total development load would be generated pre-2030. The pre-2030 and post-2030 additional phosphorus loads are presented in **Table 6**.

Table 6: Cumulative Residential & Commercial Development Additional Phosphorus Loads

Development	Additional Phosphorus Load (kg/year)	
	Pre-2030	Post-2030
Ruthin Road / Lower Berse Farm	11.00	105.93
All Other Residential Developments	153.81	2,216.77
All Commercial Developments	25.71	252.80
Total Additional Phosphorus Load	190.52	2,575.50

5.4.7. **Table 7** confirms that the pre-2030 cumulative additional phosphorus load would be less than **1.3%** of the existing phosphorus load in the SAC, while the post-2030 load ranges between **11.34%** and **17.31%**.

Table 7: Cumulative Residential & Commercial Development Additional Phosphorus Load Compared to Existing Phosphorus Load in the SAC

Existing Phosphorus Load Scenario	Existing Phosphorus Load (kg/year)	Cumulative Residential & Commercial Phosphorus Load (kg/year)		Cumulative Development Load as Proportion of Existing Phosphorus Load (%)	
		Pre-2030	Post-2030	Pre-2030	Post-2030
Most Likely – Upper Range	14,875	190.52	2,575.50	1.28%	17.31%
Most Likely – Lower Range	20,352			0.94%	12.65%
Worst-Case	22,716			0.84%	11.34%

5.4.8. **Table 8** expresses the cumulative additional phosphorus load as a percentage of the current phosphorus headroom in the SAC. The cumulative additional phosphorus load from all development in the catchment ranges from less than **3.2%** (pre-2030) to **42.18%** (post-2030) of the available headroom. However, all of the development could be delivered whilst leaving a large headroom buffer and without triggering a breach of the phosphorus standard.

³⁰ The already *de minimis* increase in the mean annual phosphorus concentration would be substantially lower if the calculation used the mean rather than the median annual flow.

³¹ Development data provided by WCBC.

Table 8: Cumulative Residential & Commercial Development Phosphorus Load Compared to Phosphorus Headroom in the SAC

Headroom Scenario	Phosphorus Headroom (kg/year)	Cumulative Residential & Commercial Phosphorus Load (kg/year)		Cumulative Development Load as Proportion of Phosphorus Headroom (%)	
		Pre-2030	Post-2030	Pre-2030	Post-2030
Most Likely – Upper Range	13,947	190.52	2,575.50	1.37%	18.47%
Most Likely – Lower Range	8,470			2.25%	30.41%
Worst-Case	6,106			3.12%	42.18%

- 5.4.9. The cumulative development phosphorus load can also be assessed for its impact on the annual mean phosphorus concentration in the SAC:
- The estimated median flow value at Farndon Bridge is 18.27 m³/s; this equates to 576,557,352,000 litres per year.
 - The pre-2030 cumulative development phosphorus load of 190.52 kg/year equates to 190,521,000,000 µg/year.
 - Dividing the load (in µg/year) by the flow (in litres per year) confirms that the pre-2030 cumulative development load would increase the existing SAC mean annual phosphorus concentration by up to **0.33 µg/l**³², increasing to **4.47 µg/l** post-2030.
- 5.4.10. The analytical limit of detection reported in the EA dataset is 10.00 µg/l. The increase in the mean annual phosphorus concentration is therefore substantially below the limit of detection. The magnitude of the increase in the phosphorus concentration would not trigger a breach of the phosphorus standard regardless of the adopted baseline phosphorus concentration, which ranges from **25.8 µg/l** to **35.3 µg/l** with a worst-case concentration of **39.4 µg/l**.

6. SUMMARY

- 6.1.1. This assessment has demonstrated that there is currently significant phosphorus headroom available within the SAC, ranging from **13,947 kg/year** to **8,470 kg/year**, with a worst-case estimate of **6,106 kg/year**.

6.2. RUTHIN ROAD / LOWER BERSE FARM

- 6.2.1. The additional phosphorus load from the Ruthin Road / Lower Berse Farm development is up to **11.00 kg/year** (pre-2030) and **105.93 kg/year** (full development post-2030)³³. The pre-2030 load is less than **0.20%** of the available phosphorus headroom, while the post-2030 load is less than **1.73%**. The additional loads would result in an increase in the SAC's current mean annual phosphorus concentration of up to **0.02 µg/l**³⁴ (pre-2030) and just **0.18 µg/l** post-2030. The analytical limit of detection reported in the EA dataset is 10.00 µg/l. The increase in the mean annual phosphorus concentration is therefore substantially below the limit of detection. The impact of the Ruthin Road / Lower Berse Farm development on the conservation status and integrity of the SAC is therefore considered to be *de minimis*.

³² The increase in the mean annual phosphorus concentration would be substantially lower if the calculation used the mean rather than the median annual flow.

³³ Using the WG Nutrient Budget Calculator default values; reducing to approximately 20kg/year using bespoke input values.

³⁴ The already *de minimis* increase in the mean annual phosphorus concentration would be substantially lower if the calculation used the mean rather than the median annual flow.

6.3. ALL RESIDENTIAL & COMMERCIAL DEVELOPMENT

- 6.3.1. The phosphorus load generated from all residential and commercial development in the catchment is **190.52 kg/year** (pre-2030) and **2,575.50 kg/year** (post-2030). These loads account for less than **3.2%** (pre-2030) and **18.47% to 42.18%** (post-2030) of the available phosphorus headroom in the SAC. All of the development could be delivered whilst leaving a large headroom buffer and without triggering a breach of the phosphorus standard.
- 6.3.2. The cumulative development loads would increase the existing SAC mean annual phosphorus concentration by up to **0.33 µg/l**³⁵ pre-2030 rising to **4.47 µg/l** post-2030. The increase in the mean annual phosphorus concentration is therefore substantially below the analytical limit of detection (10 µg/l).
- 6.3.3. The magnitude of the increase in the phosphorus concentration would not trigger a breach of the phosphorus standard regardless of the adopted baseline phosphorus concentration, which ranges from **25.8 µg/l** to **35.3 µg/l** with a worst-case concentration of **39.4 µg/l**.

7. CONCLUSIONS

- 7.1.1. The Ruthin Road development has been subject to a Habitats Regulations Assessment to consider whether it would have a Likely Significant Effect on the River Dee – Chester Weir to Ceiriog water body (Water Body ID: GB11106 7057080) in the Afon Dyfrdwy a Llyn Tegid / River Dee and Bala Lake Special Area of Conservation.
- 7.1.2. The HRA *Test of Likely Significant Effect* identified that the development has the *potential* to affect an SAC through a small increase in the phosphorus load discharged to the water body. As a Likely Significant Effect could not be ruled out, the development was screened in for an Appropriate Assessment.
- 7.1.3. The Appropriate Assessment detailed in this document provides a more detailed assessment of the potential impacts. It assesses *‘the implications for the river SAC in view of that site’s conservation objectives’* and determines *‘whether the proposal could have an adverse effect on the integrity of the site’*.
- 7.1.4. **The conclusion of the Appropriate Assessment is that:**
 - **The proposed Ruthin Road / Lower Berse Farm development will not have a Likely Significant Effect** on the conservation status or integrity of the River Dee – Chester Weir to Ceiriog water body (ID: GB11106 7057080) in the Afon Dyfrdwy a Llyn Tegid / River Dee and Bala Lake SAC.
 - **The cumulative residential and commercial development in the catchment would also not have a Likely Significant Effect** on the conservation status or integrity of the River Dee – Chester Weir to Ceiriog water body (ID: GB11106 7057080) in the Afon Dyfrdwy a Llyn Tegid / River Dee and Bala Lake SAC.

³⁵ The increase in the mean annual phosphorus concentration would be substantially lower if the calculation used the mean rather than the median annual flow.



APPENDIX A

STATISTICAL ANALYSIS OF THE LOWER DEE PHOSPHORUS COMPLIANCE STATUS

STATISTICAL ANALYSIS OF THE LOWER DEE PHOSPHORUS COMPLIANCE STATUS

DATE:	17 August 2026	CONFIDENTIALITY:	Confidential
SUBJECT:	Statistical Analysis of the Lower Dee Phosphorus Compliance Status		
PROJECT:	Ruthin Road	AUTHOR:	Orla Clarke / Ciaran McGuckin
CHECKED:	David Smith	APPROVED:	James Ellaway

1. DATA SOURCES ANALYSED

- 1.1.1. The River Dee – Chester Weir to Ceiriog water body has an SAC phosphorus compliance standard of <50 micrograms per litre (µg/l). The Compliance Assessment of Welsh River SACs against Phosphorus Targets¹ (hereafter, the ‘2019 SAC Rivers Compliance Assessment’; published in January 2021) assessed the waterbody as complying with the standard based on a total of 60 phosphorus data points, 28 from Natural Resources Wales (NRW) Monitoring Site ID: 671 (River Dee at Farndon Bridge) and 32 from Site ID: 689 (unknown location²).
- 1.1.2. The data relied upon in the 2019 SAC Compliance Assessment were obtained from NRW3 and are included in this analysis. Data has been retrieved for two sites, Site ID: 671 and Site ID: 689. This data covers March 2017 – September 2019. For each site, data has been retrieved and assessed using aggregated raw data for the Whole Year and for the Growing Season (defined by NRW as March to September inclusive).
- 1.1.3. The 2024 SAC Rivers Compliance Assessment published by NRW in March 2025 assessed the River Dee – Chester Weir to Ceiriog water body as failing the phosphorus standard. The assessment was based on just 13 phosphorus data points from just one site, Site ID: 671 (River Dee at Farndon Bridge), over the period from January 2020 to December 2023⁴. NRW has not confirmed which 13 data points were used in the compliance assessment but did provide⁵ Figure 1.1 below showing three results clustered above 100 µg/l and one near 350 µg/l.
- 1.1.4. As NRW has not confirmed which of the data points in Figure 1.1 constitute the 13 data points used in their 2024 SAC Compliance Assessment it has not been possible to definitively replicate their calculations⁶. Instead, data has been obtained for Site ID: 671 (Farndon Bridge) for the period January 2020 – January 2026⁷ to investigate the longer-term phosphorus concentrations.

¹ <https://cdn.cyfoethnaturiol.cymru/693025/compliance-assessment-of-welsh-sacs-against-phosphorus-targets-final-v10.pdf?rmode=pad&v=1d6f0188dbd19b0>

² Site S689 is not contained in NRW's Water Quality Archive Data for the period covering 1 January 2000 to present day.

³ NRW Compliance Assessment of Welsh River SACs against Phosphorus Targets Raw Data (<https://cdn.cyfoethnaturiol.cymru/693039/sac-phosphorus-assessment-data.xlsx?rmode=pad&v=1d6f0bd272faf50>; accessed January 2026).

⁴ In contrast to the 2019 assessment, NRW does not appear to have confirmed which 13 data points they rely on for the 2024 compliance assessment.

⁵ via Wrexham County Borough Council

⁶ However, by calculating the rolling average from 13 consecutive data points, starting from the elevated value of 110 µg/l on 30 January 2020 (the first data point in Figure 1.1), and rolling forward by one data point each time, similar values (ranging from 51.4 µg/l to 63.6 µg/l) have been generated.

⁷ <https://naturalresourceswales.sharefile.eu/share/view/s137b47af533f42eb871b4e9f7dba2725/focdf0b7-aa50-4812-9abb-512d376c1933>, accessed January 2026

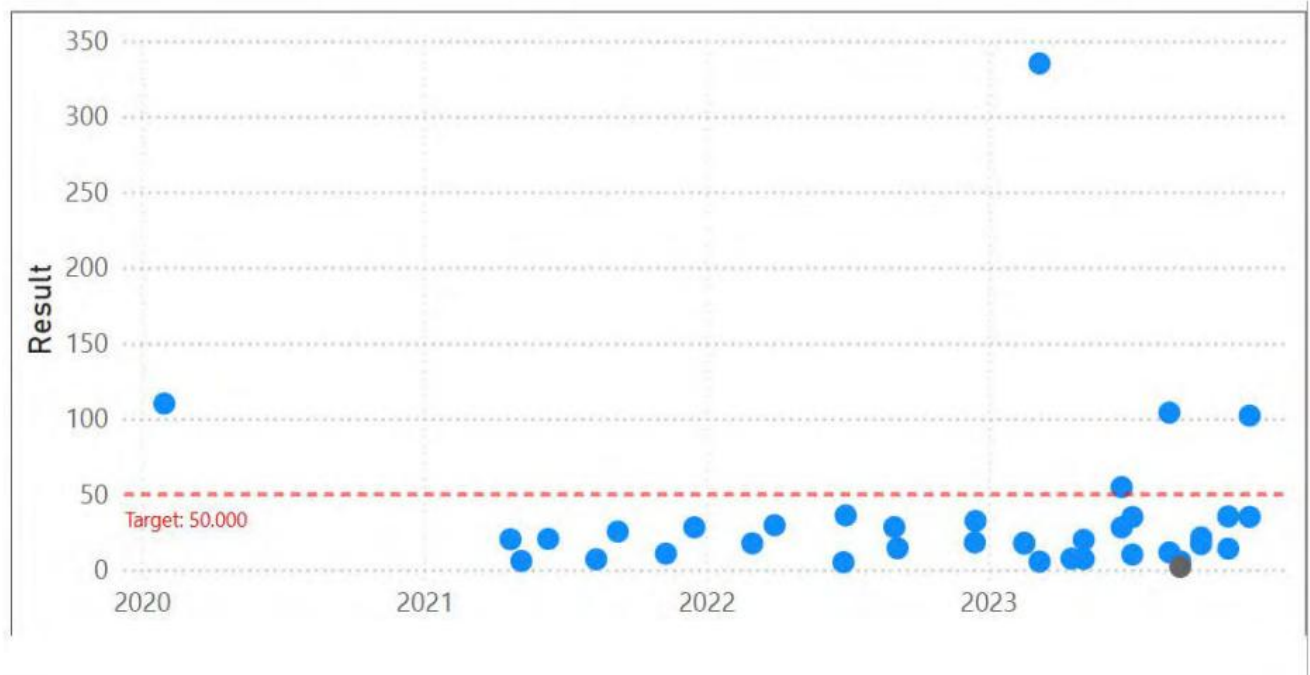


Figure 1.1 – NRW Phosphorus Monitoring Data 2020 – 2023

- 1.1.5. The lower Dee forms part of the border between Wales and England. NRW's Site ID: 671 (River Dee at Farndon Bridge) is located directly opposite the Environment Agency's ('EA') Site NW-88017214 (River Dee at Farndon Bridge). Orthophosphorus data was therefore also obtained from the EA's Water Quality Explorer⁸ for the period 17 January 2020 to 1 January 2026 to provide a comparison against NRW's data for the same period.

2. DATA SUMMARY

2.1. 2019 SAC RIVERS COMPLIANCE ASSESSMENT DATA 2017 – 2019

- 2.1.1. Figure 2.1 shows the distribution of Raw Data for Sites 671 and 689 over the period 2017 – 2019 as used by NRW in their 2019 SAC Rivers Compliance Assessment. The distribution of the data for site 671 is highly positively skewed, while the distribution of the data for site 689 is moderately positively skewed.
- 2.1.2. Figure 2.2 presents boxplots showing the distribution of raw data for 2017 to 2019. Boxplots summarise the spread of data using quartiles: the box represents the interquartile range (IQR), or the middle 50% of values; the central line shows the median; and points beyond the whiskers indicate values that are unusually distant from the main distribution. They provide a quick visual check of potential outliers and overall variability. For Site 671, the boxplot identifies several outliers above the upper whisker, indicating unusually high values in the dataset. Site 689 has several values near the upper end of the distribution, suggesting a cluster of observations close to the maximum, although fewer are formally classified as outliers.

⁸ <https://environment.data.gov.uk/water-quality/sampling-point/NW-88017214>, accessed January 2026

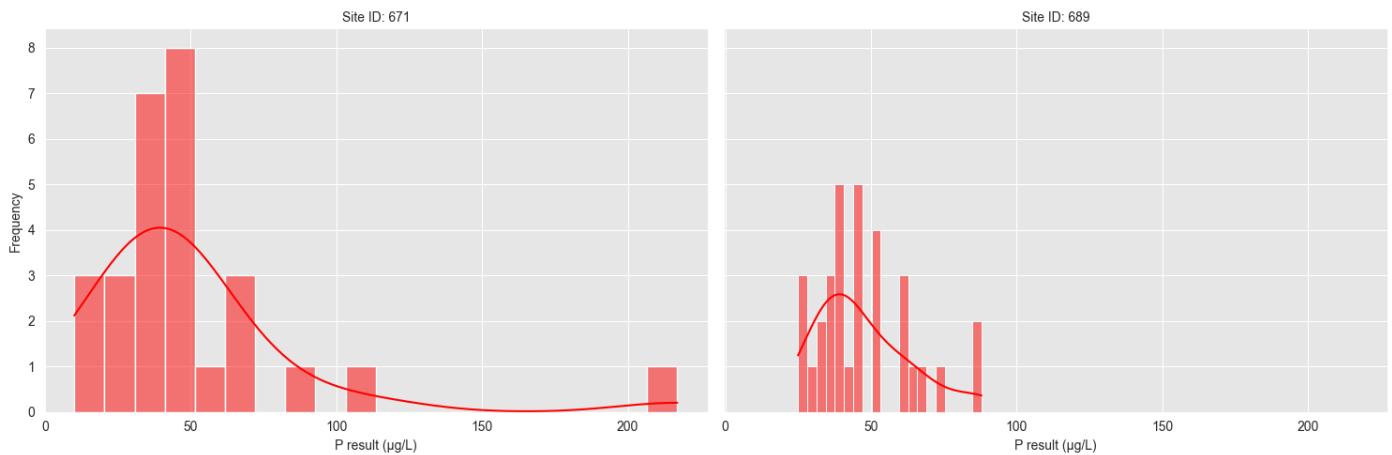


Figure 2.1 – Raw Water Quality Data Distribution

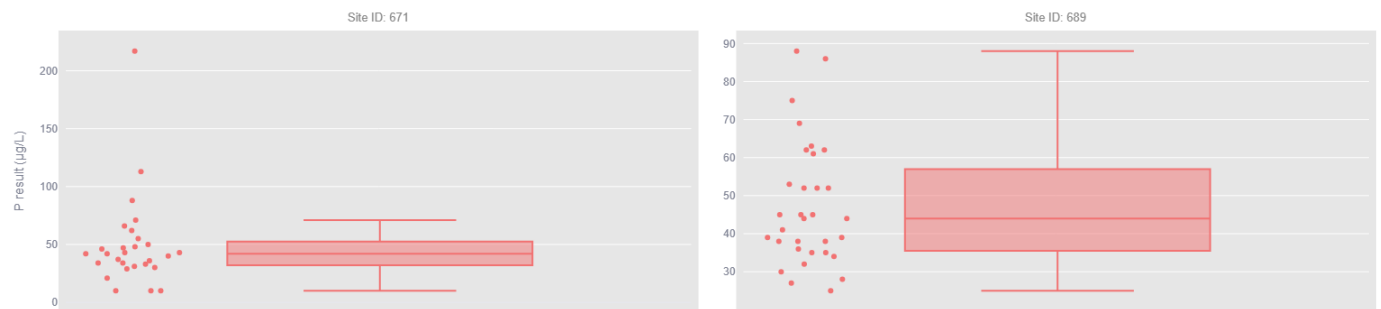


Figure 2.2 – Raw Water Quality Data Boxplots

2.1.3. Figure 2.3 displays the Normal Q-Q plots for Raw Data for 2017 to 2019. Normal Q-Q plots are used to compare observed values to a normal distribution. If points follow the reference line, the data distribution is close to normal. Systematic curvature or large departures at the ends of the reference line indicate skewness, heavy tails or possible outliers. In alignment with the boxplot findings, both sites demonstrate departures from normality in the upper tail of the distribution. These deviations are indicative of the presence of extreme values, particularly at Site 671, reinforcing the interpretation of high-value outliers for this site.

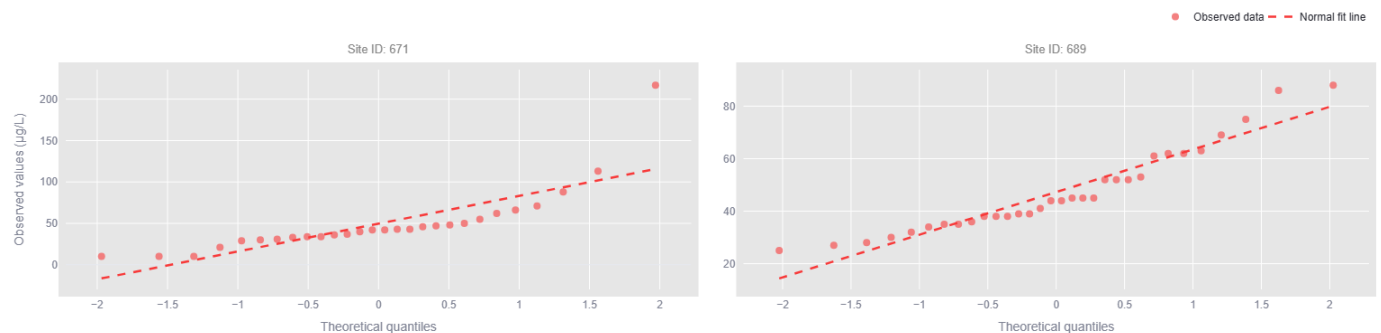


Figure 2.3 – Raw Water Quality Data Normal Q-Q Plots

2.1.4. The mean phosphorus concentration for Site ID: 671 is 49.57 µg/l with a median value of 42.00 µg/l, from 28 samples.

2.1.5. The mean phosphorus concentration for Site ID: 689 is 47.28 µg/l with a median value of 44.00 µg/l, from 32 samples.

- 2.1.6. These results were used by NRW in their 2019 SAC Rivers Compliance Assessment to determine that the River Dee – Chester Weir to Ceiriog water body (Water Body ID GB111067057080) was complying with the phosphorus standard.

2.2. 2024 SAC RIVERS COMPLIANCE ASSESSMENT DATA 2020 – 2026

- 2.2.1. As it has not been possible to replicate NRW's 2024 SAC Rivers Compliance Assessment analysis of 13 data points between 2020 and 2023, Figure 2.4 instead show the distribution of data for NRW's Farndon Bridge (Site ID: 671) raw data from January 2020 – January 2026. The distribution of the data is highly positively skewed. It is important to note that the elevated values above 100 µg/L were all included in NRW's 2020 – 2023 data set used in their 2024 Compliance Assessment.

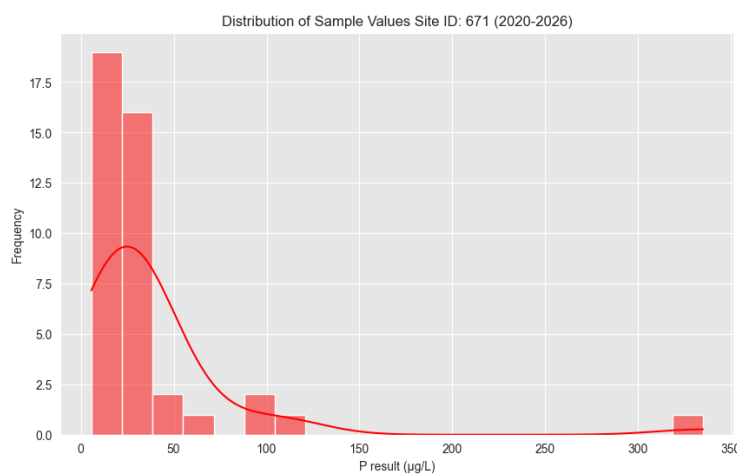


Figure 2.4 – Farndon Bridge January 2020 – January 2026 Data Distribution

- 2.2.2. Figure 2.5 illustrates the boxplot for Site ID: 671 for 2020 – 2026. The plot reveals multiple outliers above the upper whisker, including three values greater than 100 µg/l and a notably extreme value of 335 µg/l, indicating substantial deviation from the central tendency. All of the elevated values above 100 µg/L were included in NRW's 2020 – 2023 data set used in their 2024 Compliance Assessment.

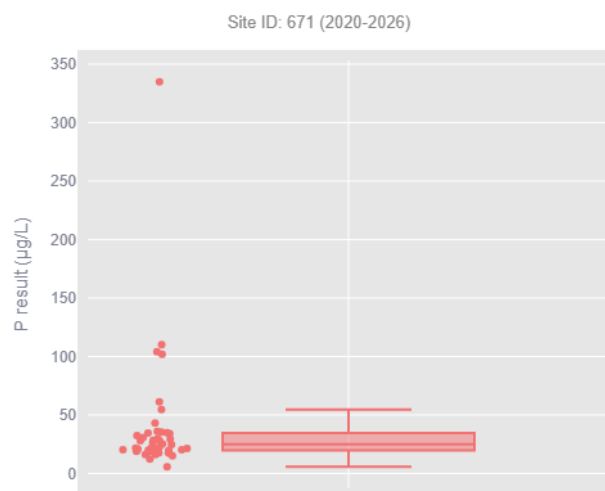


Figure 2.5 – Farndon Bridge January 2020 – January 2026 Data Boxplot

- 2.2.3. Figure 2.6 presents the Normal Q-Q plot for Site ID 671 for 2020 – 2026. The plot demonstrates marked departures from the reference line in the upper tail, further confirming the presence of extreme values.

All of the elevated values above 100 µg/L were included in NRW's 2020 – 2023 data set used in their 2024 Compliance Assessment.

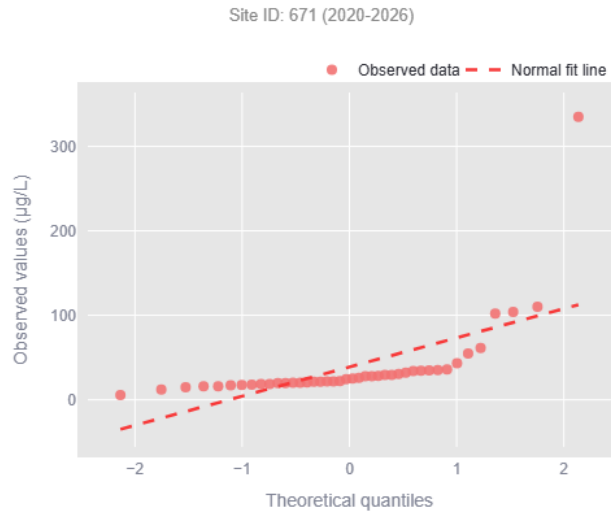


Figure 2.6 – Farndon Bridge January 2020 – January 2026 Data Normal Q-Q Plot

- 2.2.4.** The mean phosphorus concentration for Site 671 for the 2020 to 2026 period was 38.86 µg/L with a median value of 25.00 µg/L, from 42 samples. In comparison, the mean concentration reported in NRW's 2024 SAC Rivers Compliance Assessment was 56.5 µg/L.

2.3. EA FARNDON BRIDGE DATA 2020 – 2026

- 2.3.1.** Figure 2.1 – Raw Water Quality Data Distribution shows the distribution of data for EA Site NW-88017214 (River Dee at Farndon Bridge) from January 2020 – January 2026. The distribution of the data is highly positively skewed although the data range is much smaller than in the NRW dataset, with the maximum value being below 100 µg/L compared to the maximum value of 335 µg/L in NRW's data.

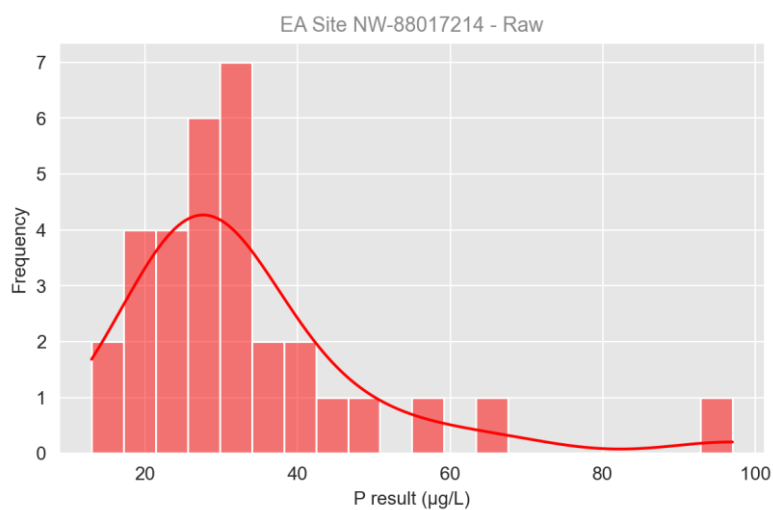


Figure 2.7 – EA Site NW-88017214 January 2020 – January 2026 Raw Data Distribution

- 2.3.2.** Figure 2.8 presents the boxplot for EA Site NW-88017214 for January 2020 – January 2026. The plot reveals that three values are above the top whisker, and this indicates that they might be outliers.

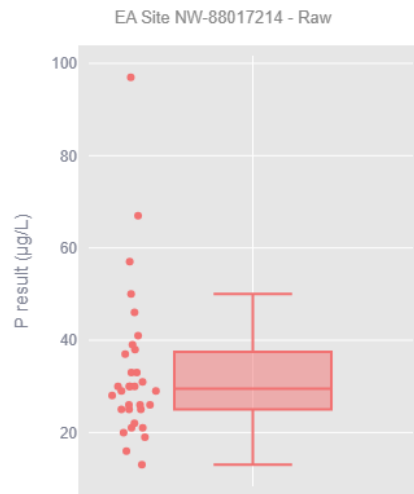


Figure 2.8 – EA Site NW-88017214 January 2020 – January 2026 Raw Data Boxplot

2.3.3. Figure 2.9 presents the Normal Q-Q plot for EA Site NW-88017214 for January 2020 – January 2026. The plot demonstrates an extreme departure from the upper tail of the reference line.

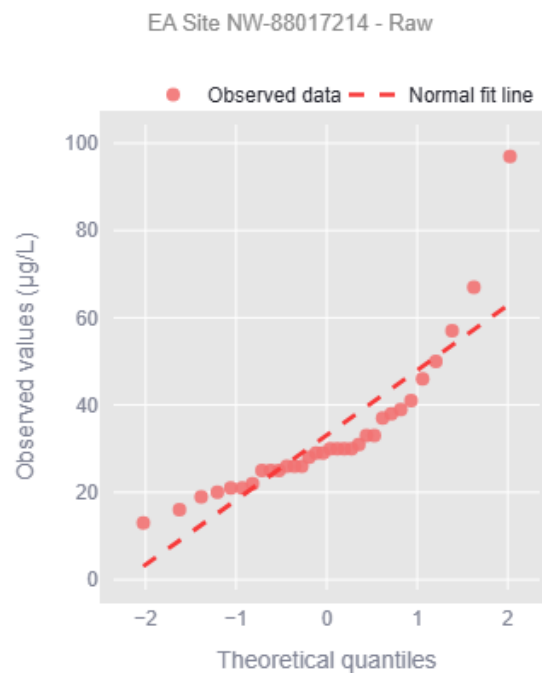


Figure 2.9 – EA Site NW-88017214 January 2020 – January 2026 Raw Data Normal Q-Q Plot

2.3.4. The mean phosphorus concentration for EA Site NW-88017214 during 2020 – 2026 was 33.12 µg/L with a median value of 29.50 µg/L, from 32 samples.

2.4. Summary

2.4.1. Table 2.1 contains a summary of the statistics for the raw datasets analysed above plus NRW's 2024 SAC Rivers Compliance Assessment.

Table 2.1 – Data Summary Statistics

Site ID	Mean (µg/L)	Median (µg/L)	Sample Size
671 – 2019 SAC Rivers Compliance Assessment Data (2017 – 2019)	49.57	42.00	28
689 - 2019 SAC Rivers Compliance Assessment Data (2017 – 2019)	47.28	44.00	32
671 - 2024 Rivers Compliance Assessment Data (2020 – 2023)	56.5	-	13
671 - Raw Data (2020 – 2026)	38.86	25.00	42
NW-88017214 - Raw Data (2020 – 2026)	33.12	29.50	32

3. OUTLIER ANALYSIS METHODOLOGY

- 3.1.1. Having reviewed the raw data distribution, an outlier screening assessment was undertaken as part of a statistical quality assurance process to identify observations that are materially inconsistent with the overall distribution of the dataset. The objective of this assessment was to support the identification of anomalous or extreme values. It is important to note that all the data analysed come from relatively small sample sizes, so removing any values should be approached carefully. This analysis is intended to identify possible outliers and assess the sensitivity of the mean estimates to their removal.
- 3.1.2. Outliers were assessed using Tukey's Interquartile Range (IQR) method, based on the conventional definition of the lower and upper quartiles. The first quartile (Q1) and third quartile (Q3) were defined as the 25th and 75th percentiles of the dataset respectively, representing the central dispersion of the data.
- The interquartile range (IQR) was calculated as the difference between Q3 and Q1 ($IQR = Q3 - Q1$). Two sets of outlier thresholds were then derived to distinguish between mild and extreme outliers, consistent with established statistical practice⁹:
 - **Mild outliers** were defined using a multiplier (k) of 1.5, with lower and upper bounds calculated as:
 - Lower bound: $Q1 - 1.5 \times IQR$
 - Upper bound: $Q3 + 1.5 \times IQR$
 - **Extreme outliers** were defined using a multiplier (k) of 3.0, with lower and upper bounds calculated as:
 - Lower bound: $Q1 - 3.0 \times IQR$
 - Upper bound: $Q3 + 3.0 \times IQR$
- 3.1.3. Observations falling outside the mild outlier thresholds ($k = 1.5$) were flagged as potential outliers, indicating values that are moderately distant from the central distribution. Observations falling outside the extreme outlier thresholds ($k = 3.0$) were classified as extreme outliers, representing values that are statistically distant from the main body of the data.

⁹ ScienceDirect, *Interquartile Range*, available at: <https://www.sciencedirect.com/topics/computer-science/interquartile-range>

4. OUTLIER ANALYSIS RESULTS

4.1. 2019 SAC RIVERS COMPLIANCE ASSESSMENT DATA 2017 – 2019

4.1.1. The results of the outlier analysis are presented in Figure 4.1. Analysis of the 2019 SAC Rivers Compliance Assessment data (2017 – 2019) indicates that:

- For Site ID: 671 where $k = 1.5$ values above 79.38 $\mu\text{g/L}$ or below 4.38 $\mu\text{g/L}$ should be considered outliers.
- For Site ID: 671 where $k = 3$ values above 107.50 $\mu\text{g/L}$ or below -23.75 $\mu\text{g/L}$ should be considered extreme outliers.
- For Site ID: 689 where $k = 1.5$ values above 83.88 $\mu\text{g/L}$ or below 6.88 $\mu\text{g/L}$ should be considered outliers.
- For Site ID: 689 where $k = 3$ values above 112.75 $\mu\text{g/L}$ or below -22.0 $\mu\text{g/L}$ should be considered extreme outliers.

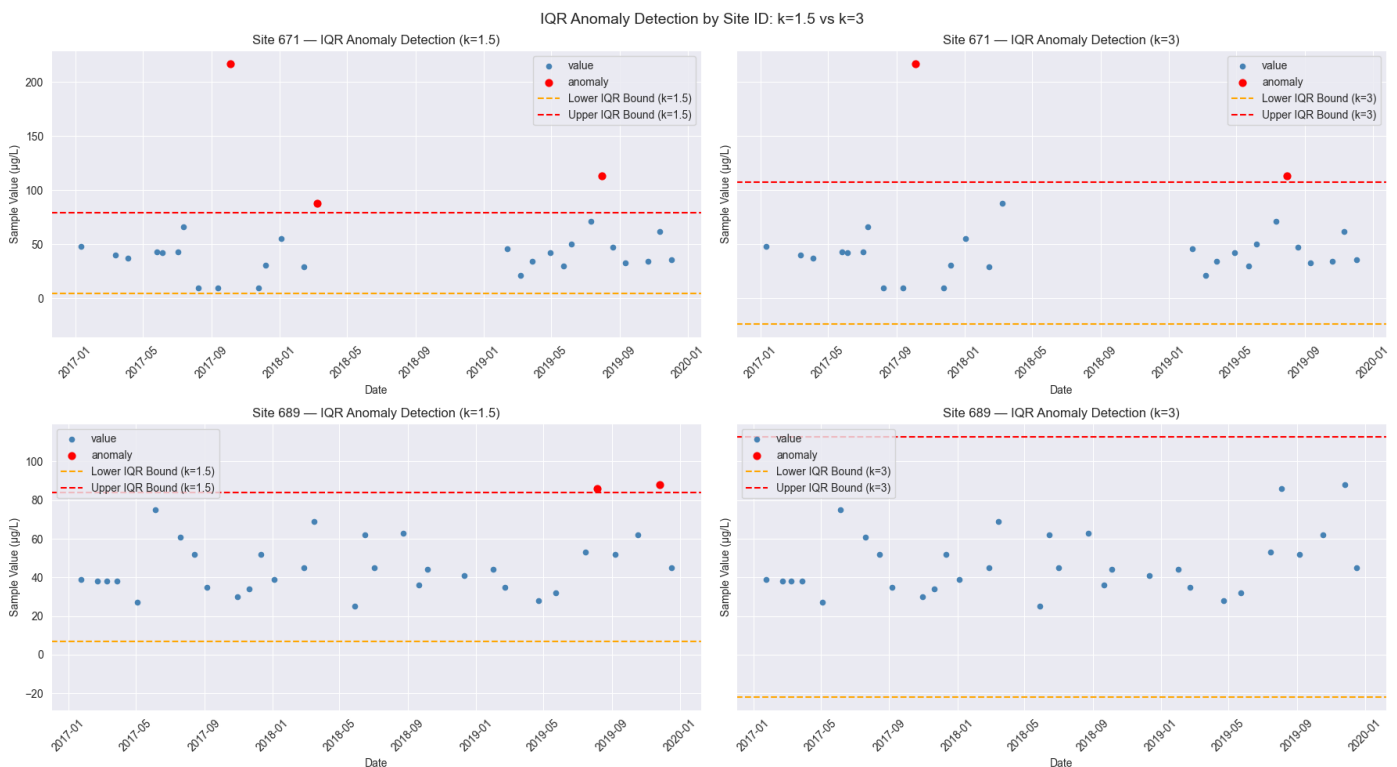


Figure 4.1 – 2021 SAC Rivers Compliance Assessment Data (2017 – 2019) Outlier Assessment Results

4.1.2. The outlier data points are summarised in Table 4.1, which also compares the revised mean phosphorus concentration with the outliers removed compared to the values when the outliers are included (as reported in NRW's 2019 SAC Rivers Compliance Assessment).

Table 4.1 – 2019 SAC Rivers Compliance Assessment Data (2017 – 2019) Outlier Results

SITE_ID	k	Outliers Identified	Outlier Values (µg/L)	Mean Phosphorus Concentration (µg/L)	
				Outliers Included (2019 SAC Rivers Compliance Assessment)	Outliers Removed
671	1.5	3	217, 113, 88	49.57	38.80
671	3	2	217, 113	49.57	40.69
689	1.5	2	88, 86	47.28	44.63
689	3	0	-	47.28	47.28

4.1.3. Removing the outliers results in a significant reduction in the mean phosphorus concentration at both monitoring locations. This indicates that the River Dee – Chester Weir to Ceiriog water body had a substantially lower phosphorus concentration over the period 2017 – 2019, and hence greater headroom to the phosphorus standard, than recognised in NRW's 2019 SAC Rivers Compliance Assessment.

4.2. NRW FARNDON BRIDGE DATA 2020 – 2026

4.2.1. The results of the outlier assessment are presented in Figure 4.2. Analysis of the NRW Site ID: 671 raw data for 2020 – 2026 indicates that:

- Where $k = 1.5$ values above 56.41 µg/L or below -2.09 µg/L should be considered outliers.
- Where $k = 3$ values above 78.35 µg/L or below -24.02 µg/L should be considered extreme outliers.

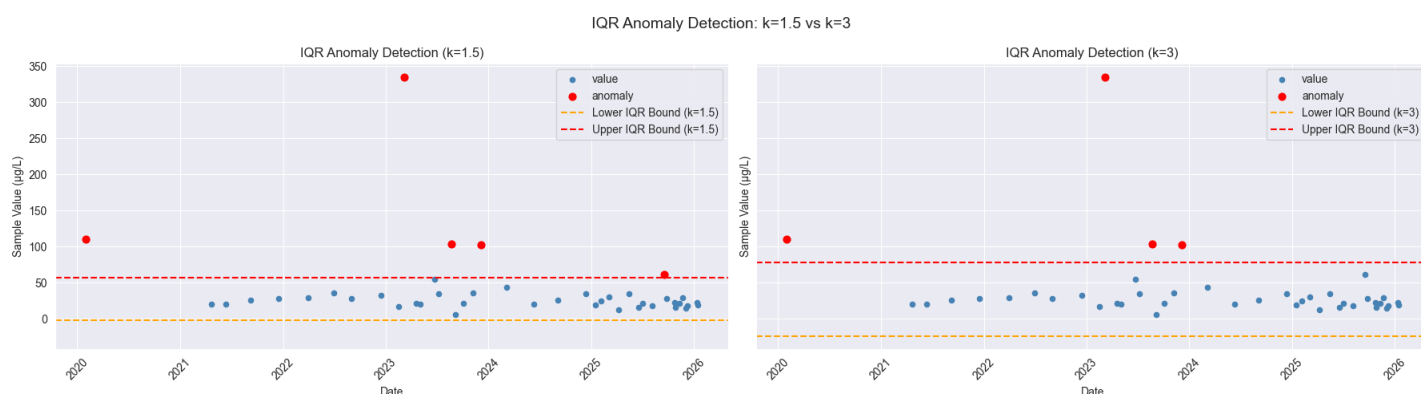


Figure 4.2 – NRW Site 671 Farndon Bridge Raw Data 2020 - 2026 Outlier Assessment Results

4.2.2. Revised mean phosphorus concentrations with identified outliers removed are presented in Table 4.2 and compared to the reported mean in the 2024 SAC Rivers Compliance Assessment and that of the full 2020 – 2026 dataset (both including outliers).

Table 4.2 – NRW Site 671 Farndon Bridge Data 2020 - 2026 Outlier Results

SITE_ID	k	Outliers Identified	Outlier Values (µg/L)	Mean Phosphorus Concentration (µg/L)		
				Outliers Included (2024 SAC Rivers Compliance Assessment)	Outliers Included (2020 – 2026 Data)	Outliers Removed
671	1.5	5	335.00, 110.00, 104.00, 102.00, 61.30	56.5	38.86	24.86
671	3	4	335.00, 110.00, 104.00, 102.00	56.5	38.86	25.82

- 4.2.3. The mean phosphorus concentration (38.86 µg/L) using the full 2020 – 2026 data set *including* outliers is almost 20 µg/L lower than the mean (56.5 µg/L) reported by NRW in their 2024 SAC Rivers Compliance Assessment. This shows the extreme influence of the 2024 data set consisting of only 13 data points of which four were highly elevated outliers, which may not be representative of typical conditions and inflated the reported mean concentration.
- 4.2.4. Removing the outliers from the 2020 – 2026 data set results in mean phosphorus concentrations (of 24.86 – 25.82 µg/L) that are 13 – 14 µg/L lower than that of the full 2020 – 2026 data set and 30 – 32 µg/L lower than the mean reported by NRW in their 2024 SAC Rivers Compliance Assessment. This again confirms the large influence of the four extreme outliers even on the larger data set for the period 2020 to 2026.
- 4.2.5. As the four extreme outliers were all included in the dataset used by NRW for their 2024 SAC Rivers Compliance Assessment¹⁰ it is clear that the River Dee – Chester Weir to Ceiriog water body had a substantially lower mean phosphorus concentration over the period 2020 – 2023 than reported by NRW.

4.3. EA FARNDON BRIDGE DATA 2020 – 2026

4.3.1. Analysis of the EA Site NW-88017214 data for 2020 – 2026 (refer Figure 4.3) indicates that:

- Where k = 1.5 values above 55.62 µg/L or below 6.62 µg/L should be considered outliers.
- Where k = 3 values above 74.00 µg/L or below -11.75 µg/L should be considered outliers.

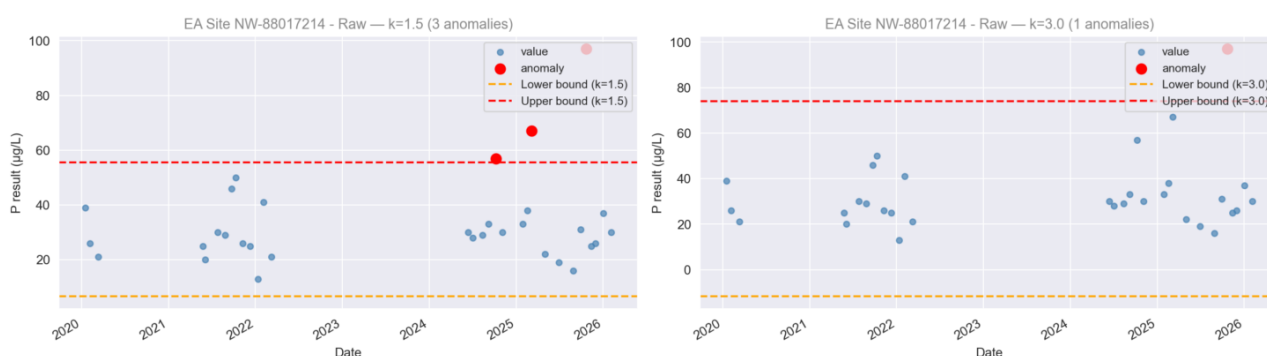


Figure 4.3 – EA Site NW-88017214 Data 2020 - 2026 Outlier Assessment Results

¹⁰ Although it remains unknown which 13 data points NRW used.

- 4.3.2. Revised mean phosphorus concentrations with identified outliers removed are presented in Table 4.3 and compared to the reported mean in NRW's 2024 SAC Rivers Compliance Assessment and that of the EA's full 2020 – 2026 data set (both including outliers).

Table 4.3 – EA Site NW-88017214 Data 2020 - 2026 Outlier Results

SITE_ID	k	Outliers Identified	Outlier Values (µg/L)	Mean Phosphorus Concentration (µg/L)		
				Outliers Included (2024 SAC Rivers Compliance Assessment)	Outliers Included (2020 – 2026 Data)	Outliers Removed
EA Site NW-88017214 Raw	1.5	3	97, 67, 57	56.5	33.12	28.93
EA Site NW-88017214 Raw	3	1	97	56.5	33.12	31.07

- 4.3.3. The mean phosphorus concentration (33.12 µg/L) for the EA's full 2020 – 2026 data set including outliers is over 23 µg/L lower than the mean (56.5 µg/L) reported by NRW in their 2024 SAC Rivers Compliance Assessment. This shows the extreme influence of NRW's 2024 data set consisting of only 13 data points, of which four were highly elevated outliers whose representativeness of typical conditions is uncertain.
- 4.3.4. Removing the outliers from the EA's 2020 – 2026 data set results in slightly lower mean phosphorus concentrations (of 28.93 – 31.07 µg/L) that are 25 – 27 µg/L lower than the mean reported by NRW in their 2024 SAC Rivers Compliance Assessment. This again confirms the extreme influence of the four extreme outliers contained in NRW's 2024 SAC Rivers Compliance Assessment data set.
- 4.3.5. Removing the outliers from the EA data set results in only a small (2 – 4 µg/L) reduction in the mean phosphorus concentration compared to the mean containing the outliers. This highlights the greater data consistency and smaller data range in the full EA dataset when compared to NRW's more variable data set used for their 2024 SAC Rivers Compliance Assessment.
- 4.3.6. The removal of outliers results in the mean phosphorus concentration at Farndon Bridge during the period 2020 – 2026 being much (23 – 27 µg/L) lower than the mean reported in the 2024 SAC Rivers Compliance Assessment. On this basis, the analysis indicates that the River Dee – Chester Weir to Ceiriog water body therefore complied with the phosphorus standard of 50 µg/L and had significant phosphorus headroom.

5. CONCLUSIONS

5.1.1. Table 5.1 summarises the mean values for all raw data, and for the data with outliers removed using k-values of 1.5 and 3, respectively.

Table 5.1 – Analysis Summary

Site ID	Raw Data			Removal of Outliers Identified with IQR k = 1.5		Removal of Outliers Identified with IQR k = 3	
	Mean (µg/L)	Median (µg/L)	Sample Size	Mean (µg/L)	Sample Size	Mean (µg/L)	Sample Size
671 – 2019 SAC Rivers Compliance Assessment Data (2017 - 2019)	49.57	42.00	28	38.80	25	40.69	26
689 - 2019 SAC Rivers Compliance Assessment Data (2017 - 2019)	47.28	44.00	32	44.63	30	47.28	32
671 - 2024 SAC Rivers Compliance Assessment Data (2020 – 2023)	56.5	-	13	-	-	24.1 – 29.2 ¹¹	13
671 - Raw Data (2020 - 2026)	38.86	25.00	42	24.86	37	25.82	38
NW-88017214 - Raw Data (2020 - 2026)	33.12	29.50	32	28.93	29	31.07	31

5.1.2. The NRW and EA 2020 – 2026 data sets (*including* outliers) generate mean phosphorus concentrations at Farndon Bridge of 38.86 µg/L and 33.12 µg/L, respectively. These results alone clearly demonstrate that the River Dee – Chester Weir to Ceiriog water body complies with the phosphorus standard of 50 µg/L by a large margin. Even without consideration of potential outliers, this indicates that NRW's 2024 SAC Rivers Compliance Assessment incorrectly determined that the water body was failing the phosphorus standard.

5.1.3. Excluding outliers from the dataset yields mean values that are more closely aligned with the median of the original raw data. This adjustment reduces the influence of extreme observations that can disproportionately affect measures of central tendency and variability. However, caution should be exercised when removing a large number of these outliers, as the small sample size makes it difficult to determine whether these extreme values are indicative of genuine variability within the data or the result of measurement error.

5.1.4. However, the outlier analysis has identified the following extreme outliers (with a threshold of k = 3.0) in the data sets:

- NRW's 2019 SAC Rivers Compliance Assessment: 217 µg/L and 113 µg/L.

¹¹ A range is provided as NRW has not identified which of the 13 data points in their 2020 – 2023 data set they relied upon in their 2024 SAC Rivers Compliance Assessment. The range has been calculated using the average of 13 consecutive data points, starting at the first data point and rolling on by one data point in each iteration, *excluding* the four extreme outliers of 335 µg/L, 110 µg/L, 104 µg/L and 102 µg/L.

- NRW's 2024 SAC Rivers Compliance Assessment: 335 µg/L, 110 µg/L, 104 µg/L and 102 µg/L.
- NRW's 2020 – 2026 Data: 335 µg/L, 110 µg/L, 104 µg/L and 102 µg/L.
- EA's 2020 – 2026 Data: 97 µg/L.

5.1.5. Excluding these extreme outliers reduces the mean phosphorus concentrations to:

- NRW's 2019 SAC Rivers Compliance Assessment: **40.69 µg/L** (Site 671) and **47.28 µg/L** (Site 689).
- NRW's 2024 SAC Rivers Compliance Assessment¹²: **24.1 µg/L** to **29.2 µg/L**.
- NRW's 2020 – 2026 Data: **25.82 µg/L**.
- EA's 2020 – 2026 Data: **31.07 µg/L**.

5.1.6. The analysis provides compelling evidence that the River Dee – Chester Weir to Ceiriog water body (Water Body ID GB111067057080) complied with the phosphorus standard throughout the period 2019 to 2026.

5.1.7. Had the 2024 SAC Rivers Compliance Assessment data set been appropriately quality assured by NRW, it is likely that the River Dee – Chester Weir to Ceiriog water body (Water Body ID GB111067057080) would have been determined as complying with the phosphorus standard.

5.1.8. This analysis suggests that NRW's 2024 SAC Rivers Compliance Assessment may have classified the River Dee – Chester Weir to Ceiriog water body (Water Body ID GB111067057080) as failing the phosphorus standard because of a dataset that was strongly influenced by a small number of elevated values.

¹² A range is provided as NRW has not identified which of the 13 data points in their 2020 – 2023 data set they relied upon in their 2024 SAC Rivers Compliance Assessment. The range has been calculated using the average of 13 consecutive data points, starting at the first data point and rolling on by one data point in each iteration, *excluding* the four extreme outliers of 335 µg/L, 110 µg/L, 104 µg/L and 102 µg/L.