THREE DECADES OF SURFACE WATER QUALITY CHANGE IN THE RIVER THURNE CATCHMENT

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Managing Carbon and Water in Lowland Landscapes

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Introduction

- **Land use practices** have impacted the River Thurne catchment.
- **Drainage activities** have further altered the catchment in recent decades.
- Resulting in **nutrient runoff and saline intrusion in surface drains** over time (Holman, 1994; Broads Authority, 2022).
- Recent **land management efforts aim to reduce these concentrations** (Broads Authority, 2022).

Hypothesis, Aim and Objectives

➢ **Hypothesis**

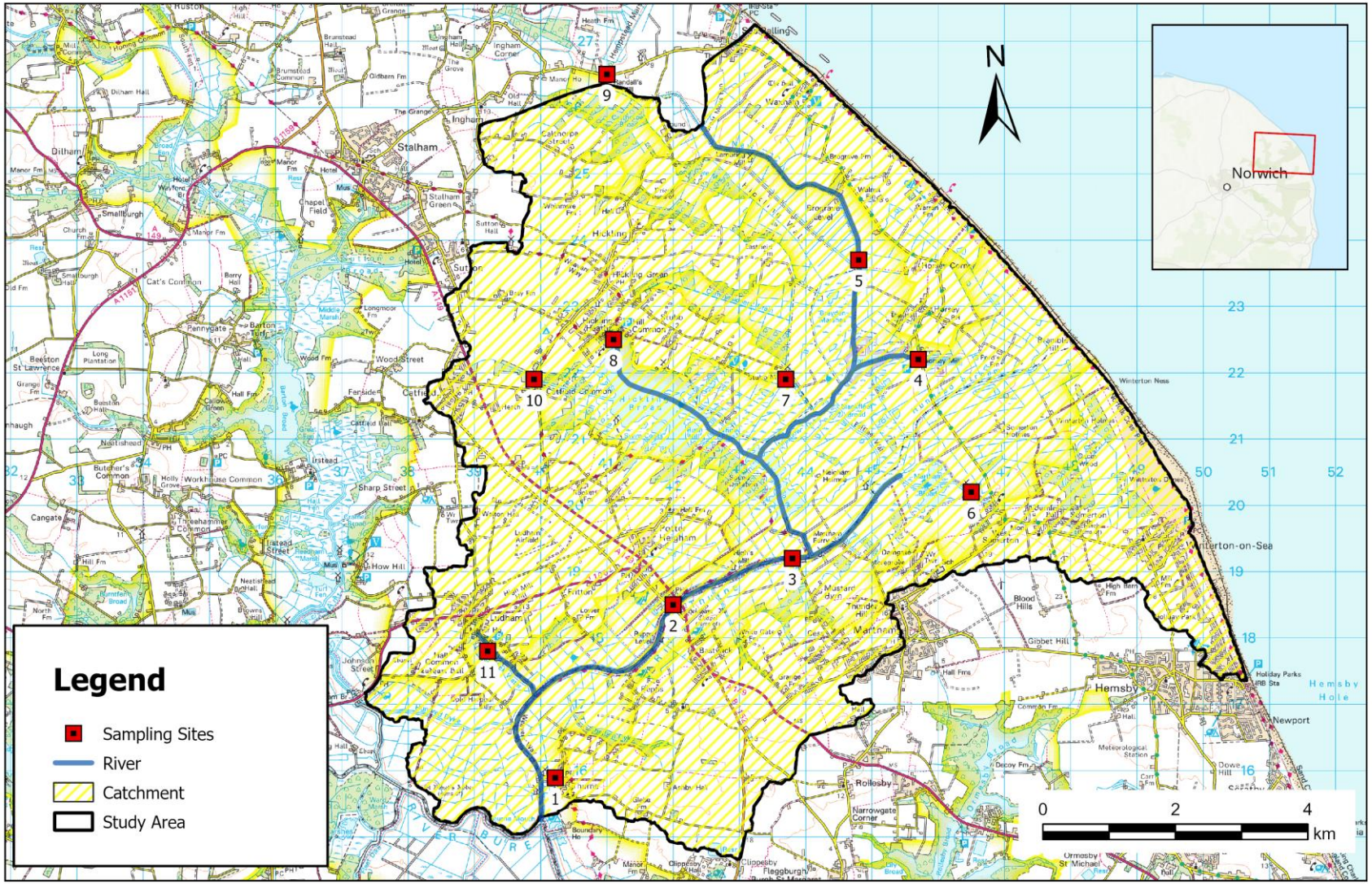
- Changes in land use and water level management practices in recent decades have led to an improvement in the ecological health of the River Thurne system.

➢ **Aim**

- To assess how land management practices have influenced nutrient concentrations and salinity levels in surface waters within the catchment.

➢ **Objectives**:

- To assess land use changes since 1990 using GIS-based spatial analysis.
- To assess the long-term trends in nitrate and phosphorus levels in surface waters using Environment Agency data.
- To assess the salinity distribution trends within surface waters (2025 survey).

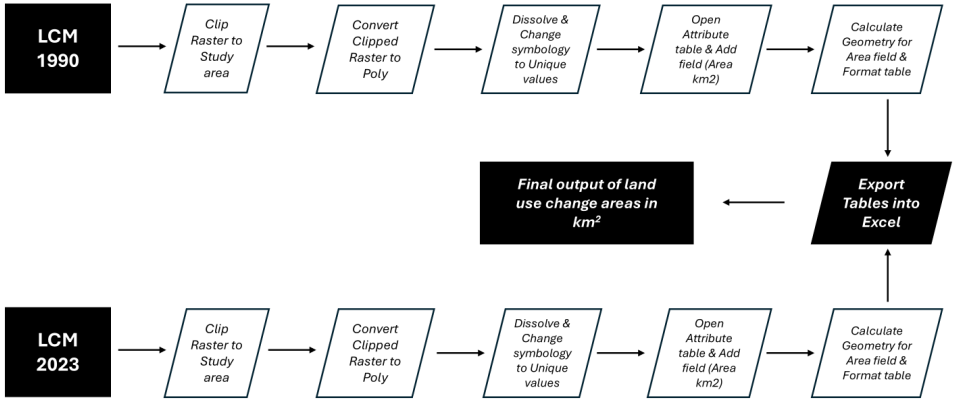


Study area showing the Thurne catchment and sampling point locations

Site number	Location	Comment
1	Thurne	River Thurne 1 km upstream of confluence with River Bure.
2	Potter Heigham	River Thurne downstream of the old road bridge.
3	Martham	River Thurne 200 m downstream of confluence with Heigham Sound.
4	Horsey	Drainage channel adjacent to land drainage pump leading to Horsey Mere.
5	Brograve	Waxham New Cut drainage channel. Presence of ochre.
6	Somerton	Drainage channel leading to Martham Broad.
7	Stubb	Drainage channel adjacent to land drainage pump. Presence of ochre on channel banks.
8	Hickling	Hickling Staithe boat mooring leading to Hickling Broad.
9	Randall's Mill	Drainage channel on north side of road bridge. Presence of ochre.
10	Catfield	Catfield Dyke drainage channel adjacent to drainage pump. Presence of algal bloom.
11	Ludham	Womack Water downstream of boat mooring leading to River Thurne.

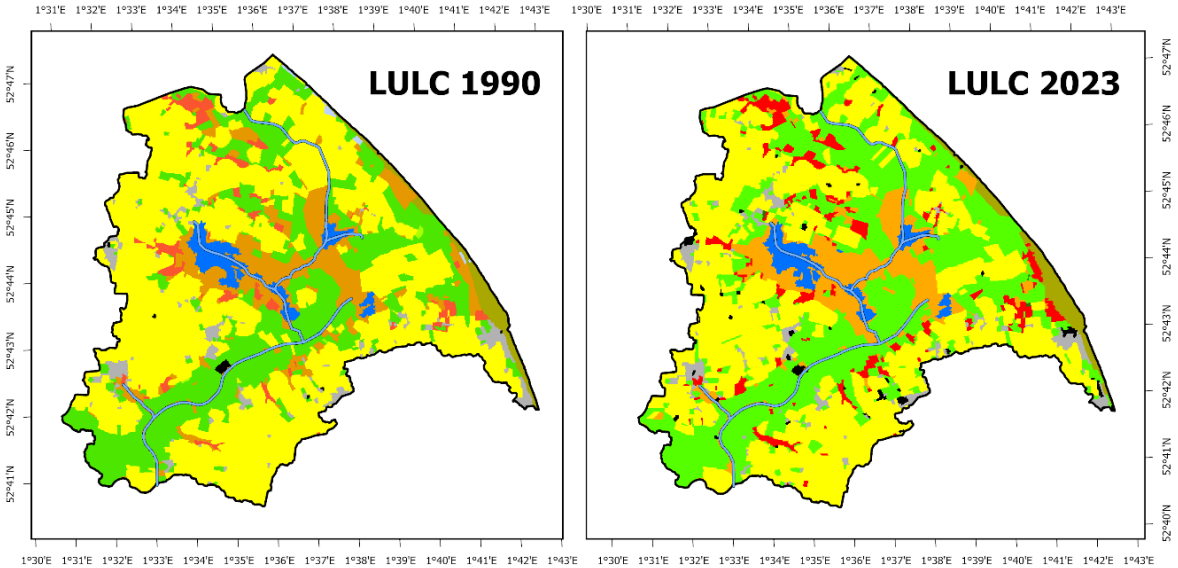
Materials and Methods

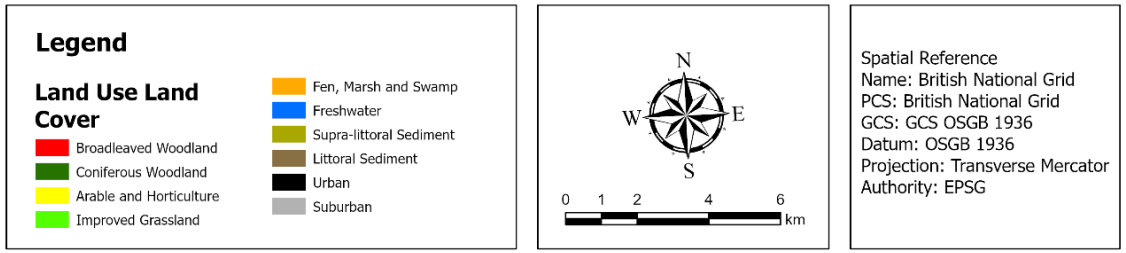
- Land use evaluation of the catchment between **1990** and **2023 undertaken using ArcGIS Pro**.
- Long term dataset (***n* = 5958**) compiled for **nitrate, soluble reactive phosphorus and chloride** across eight sites at weekly to monthly frequencies between 2000 – 2025.
- Temporal trends assessed along with their compliance with **Water Framework Directive (WFD) objectives**.
- Samples from 11 sites analysed for chloride and water stable isotope composition.
- Microsoft Excel (Version 2506) and RStudio version 4.4.2 (2024) were used to analyse data obtained.



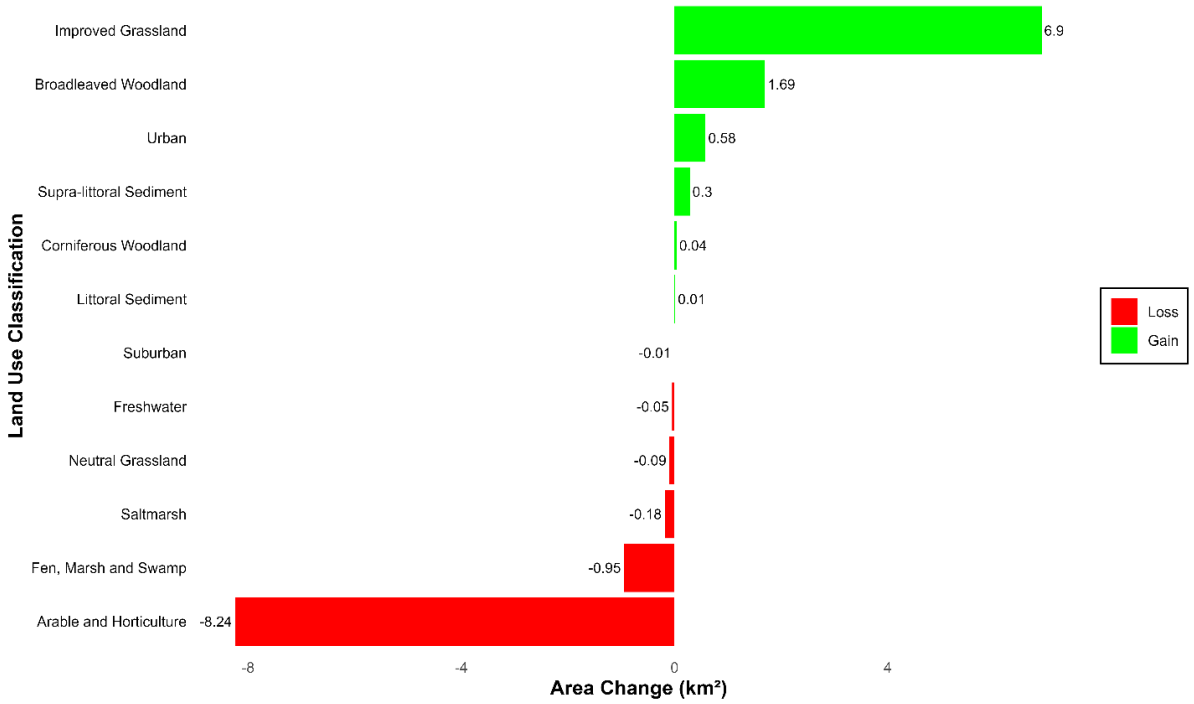
Concentration (mg P L^{-1})	Concentration (mg N L^{-1})	WFD Status
< 0.036	< 0.8	High
> 0.036 to 0.069	> 0.8 to 3.6	Good
> 0.069 to 0.173	> 3.6 to 5.6	Moderate
> 0.173 to 1.003	> 5.6 to 11.3	Poor
> 1.003	>11.3	Bad

Results – Land use





Land use area evaluation



Land use area change analysis

Discussion – Land use

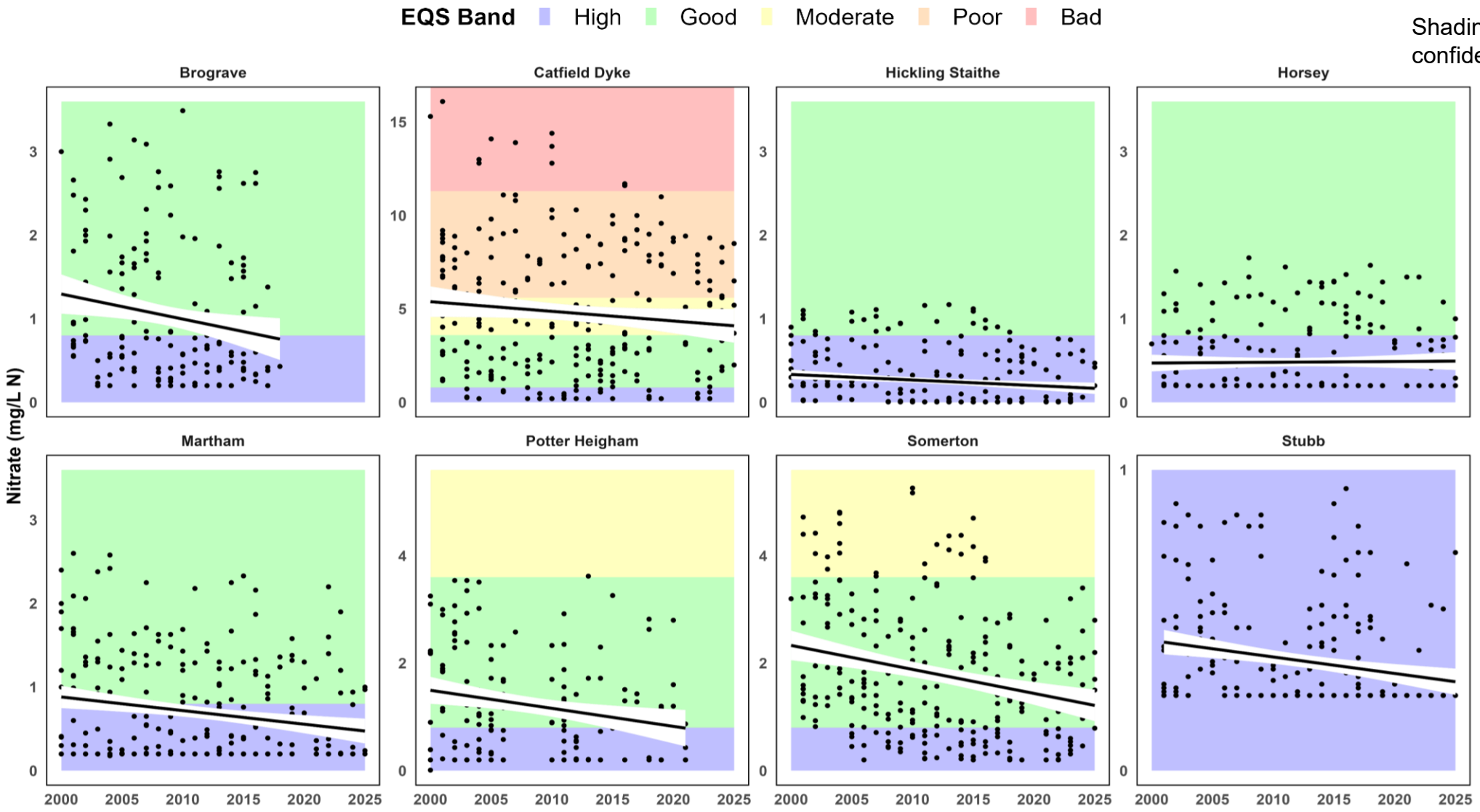
- **Arable decline (1990 – 2023):** from 52.8% → 43.6% (≈ 9.2% reduction).
- Driven by **agri-environmental policies** that promoted conversion to grassland in areas of reduced economic viability for arable farming.
- **Agri-environmental schemes** promoted conversion to grassland (≈ 8% efficiency nationally) (Gosling *et al.,* 2017).
- **Spatially,** most change in **northern areas**, linked to sea proximity, floodplains and drainage increasing salinity (Brograve, Horsey, Martham Broads).
- These changes **support biodiversity and ecological health** in parts of the Norfolk Broads.

Land Use	1990 Area (km^2)	Area (%)	2023 Area (km^2)	Area (%)	ΔArea (km^2)
Broadleaved Woodland	2.53	2.8	4.23	4.7	1.694
Coniferous Woodland	0	0	0.04	0.04	0.035
Arable and Horticulture	47.45	52.8	39.21	43.6	-8.242
Improved Grassland	22.60	25.1	29.49	32.8	6.898
Neutral Grassland	0.09	0.10	0.00	0.0	-0.094
Fen, Marsh and Swamp	10.05	11.2	9.11	10.13	-0.947
Freshwater	2.242	2.5	2.196	2.4	-0.045
Supra-littoral Sediment	1.84	2.04	2.14	2.38	0.299
Littoral Sediment	0.006	0.01	0.02	0.02	0.010
Saltmarsh	0.18	0.20	0.00	0.00	-0.183
Urban	0.14	0.16	0.72	0.8	0.578
Suburban	2.78	3.10	2.77	3.1	-0.006

Results – Nitrate

Line = trend

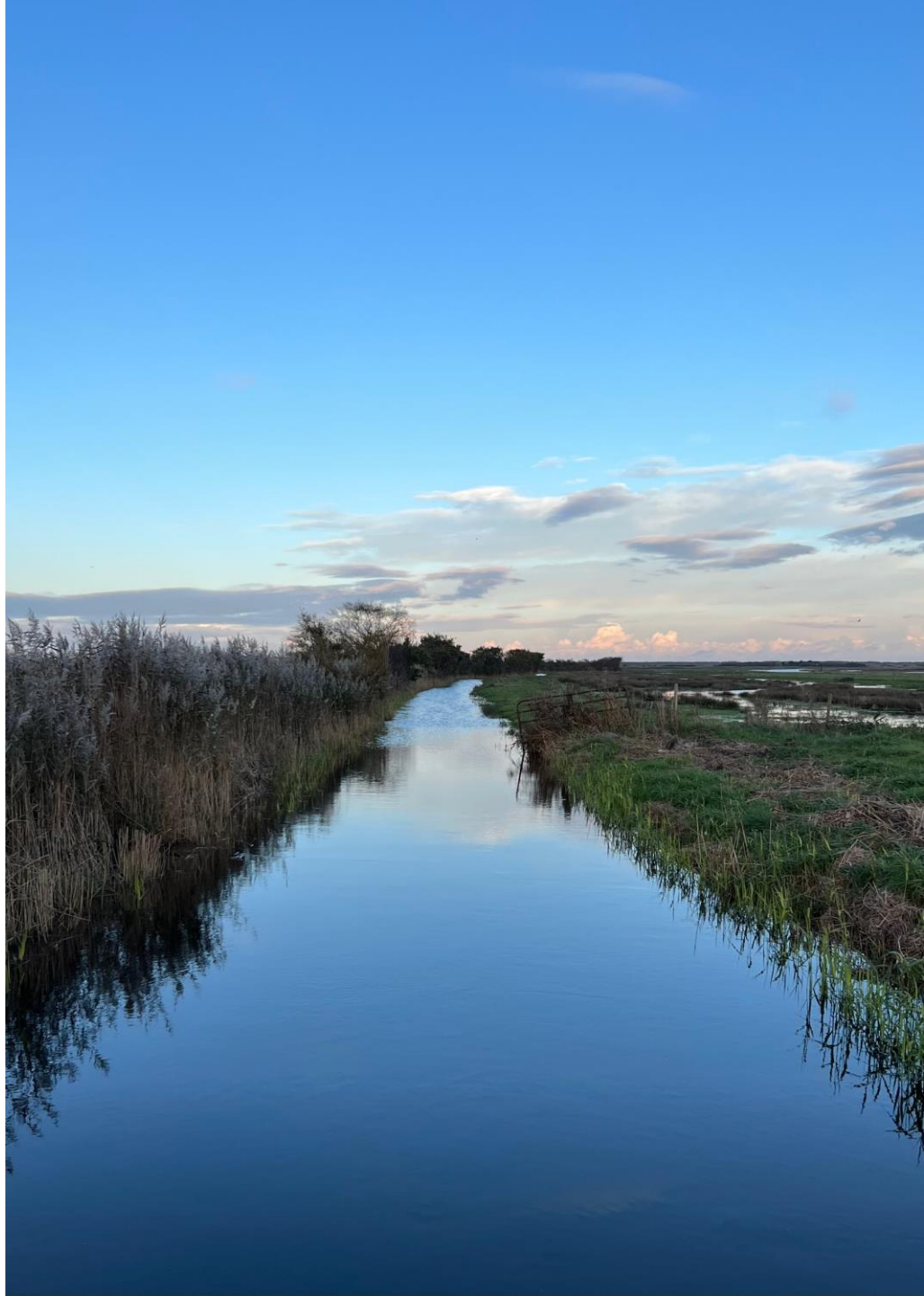
Shading = 95% confidence interval



Nitrate trend for the period 2000 – 2025 and compliance with EQS bands

Discussion – Nitrate

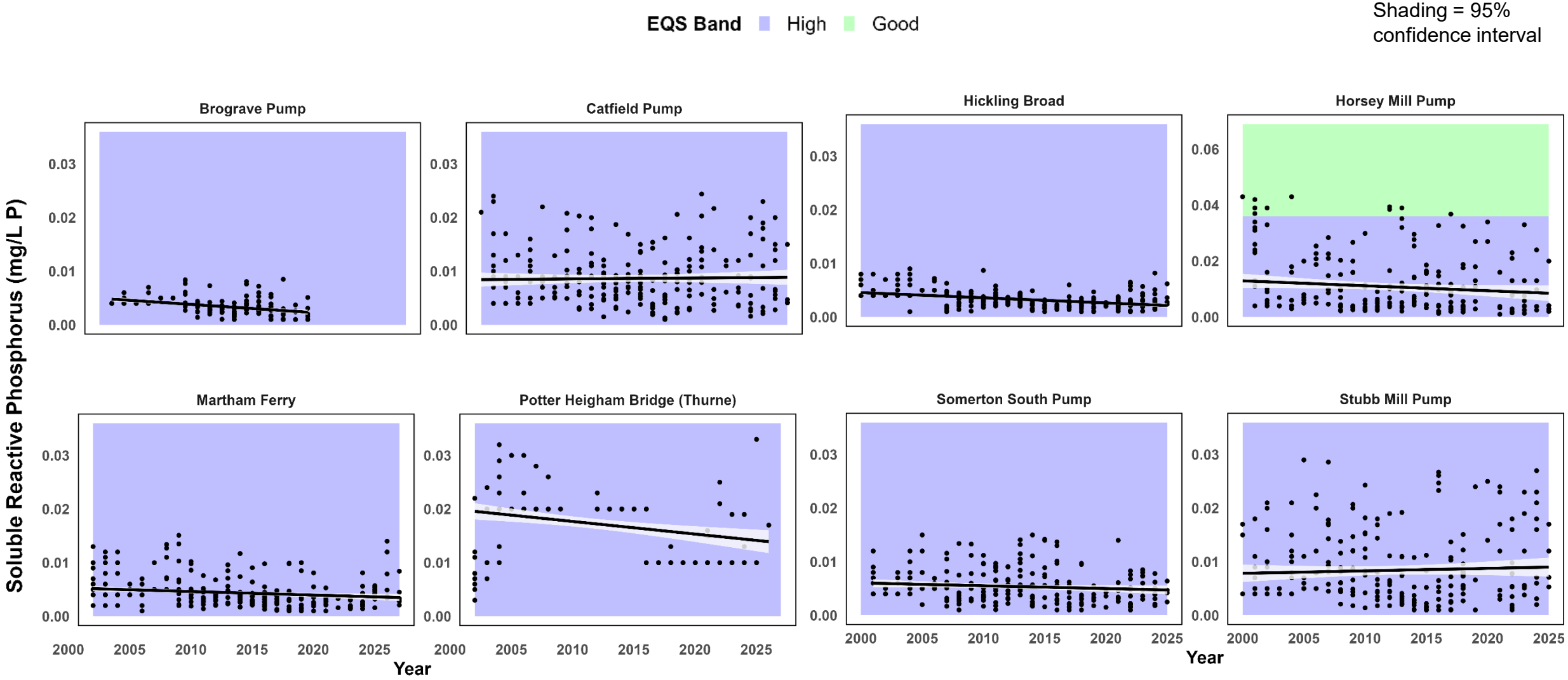
- **Significant decreases** at Brograve, Hickling, Martham, Potter Heigham, Somerton and Stubb ($p < 0.05$).
- **Non-significant decreases** at Catfield Dyke and Horsey ($p > 0.05$).
- Declines linked to **land use change,** conversion of arable to **grassland and woodland.**
- **Reduced fertiliser use from these conversions lowers nitrate** in drains (Schilling & Spooner, 2006; Heppell et al., 2017).
- Most sites (Brograve, Hickling Staithe, Horsey, Martham and Stubb) remain in the **high – good bands**.
- Somerton and Potter Heigham have **improved since 2015**, moving from **moderate** to **high – good** status (EA, 2017).
- Catfield Dyke remains **poor due to high nitrate levels** (EA, 2017).
- Overall, catchment is in **good condition**, with Catfield Dyke as the main exception.



Results – Soluble reactive phosphorus

Line = trend

Shading = 95% confidence interval



Trend in SRP for the period 2000 – 2025 and compliance with EQS bands

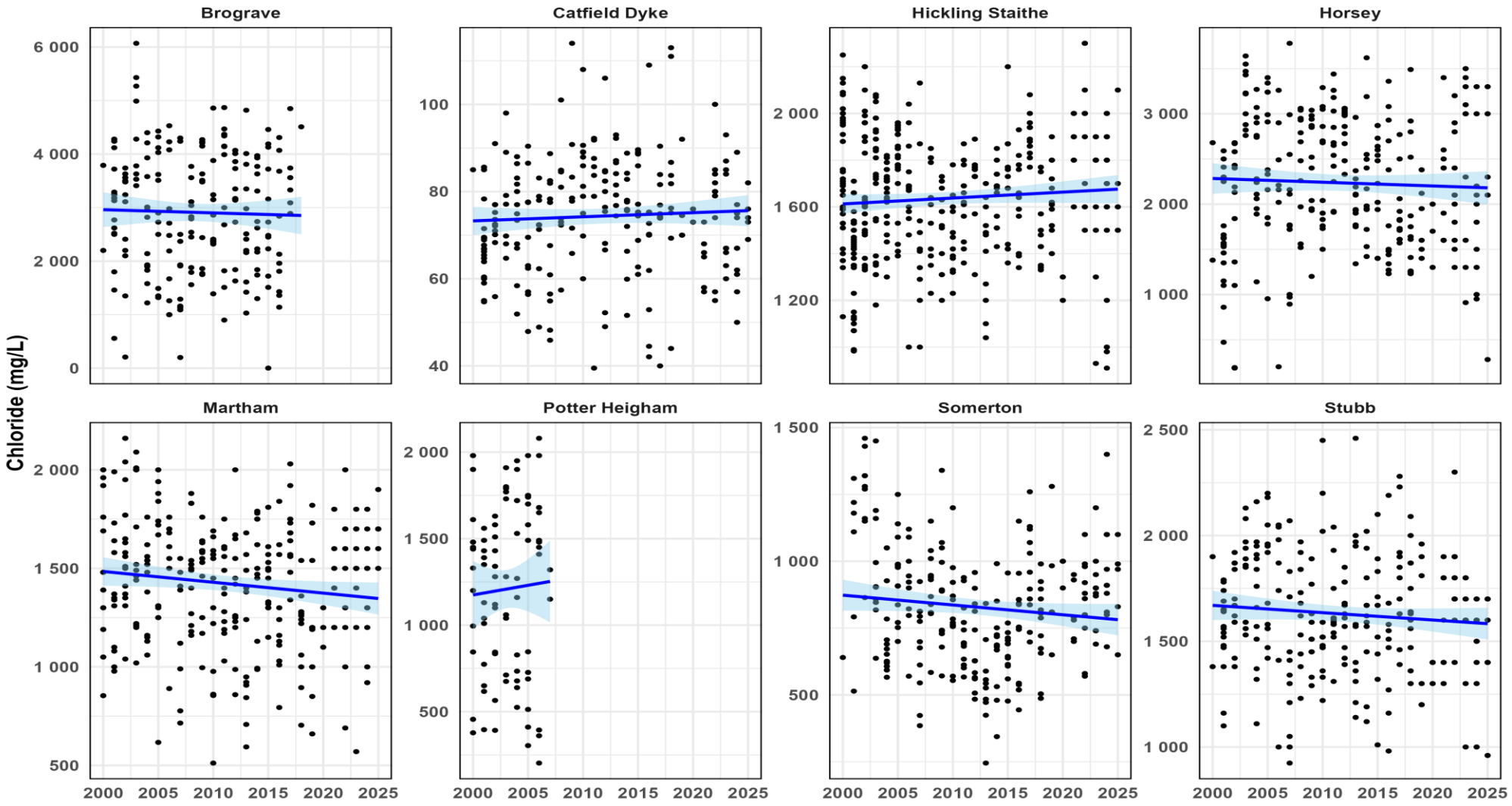
Discussion – Phosphorus

- All eight monitoring sites are well within the desirable quality standards of "good to high", with most sites experiencing relative stability over the period.

Results – Chloride

Blue = trend

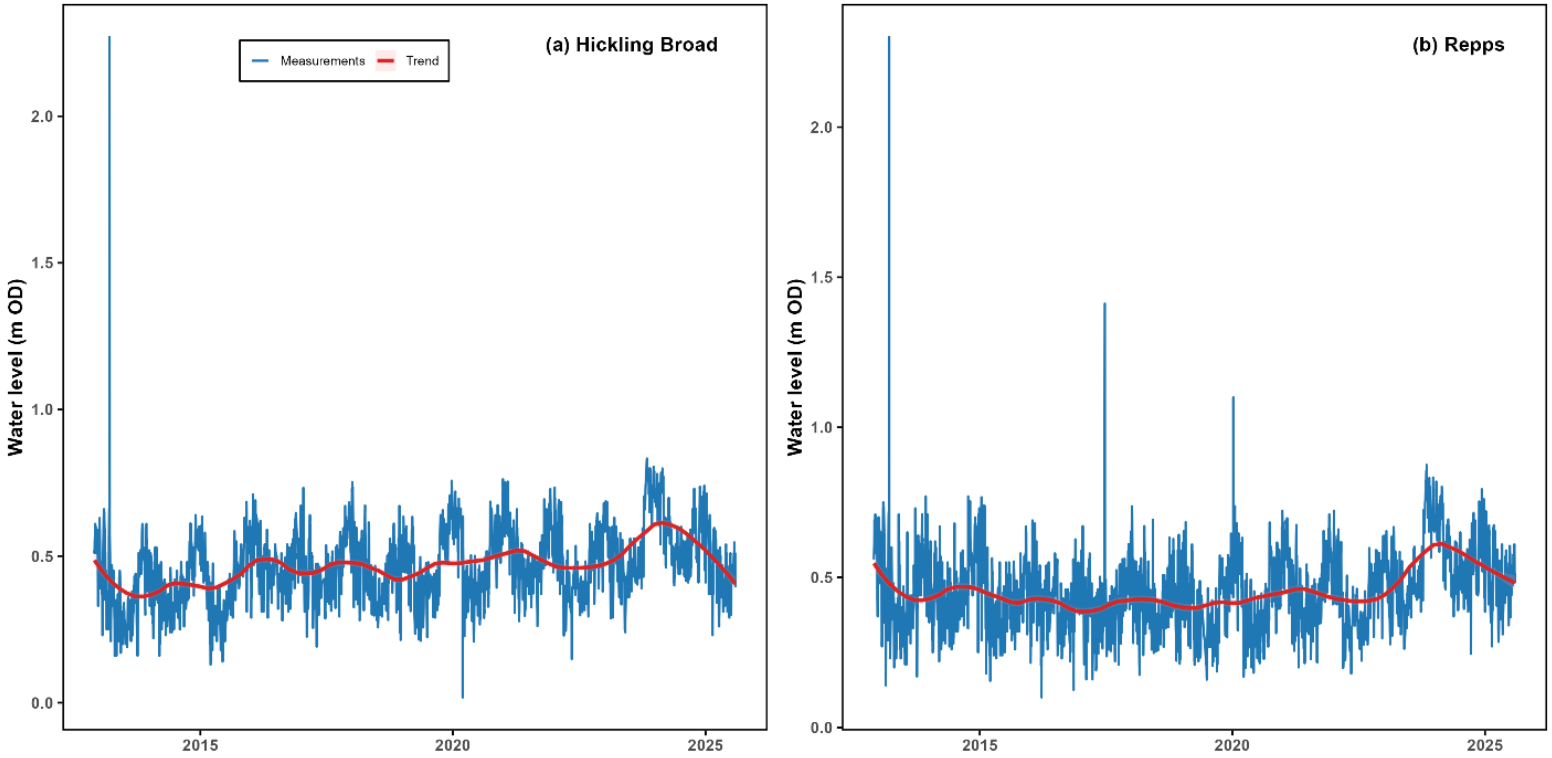
Light blue shading = 95% confidence interval



Trend analysis of chloride levels over the period 2000 – 2025

Discussion – Chloride

- **Stable concentrations** at Horsey, Martham, Somerton and Stubb (minimal reductions, not significant).
- **Increases** at Brograve, Hickling, Catfield Dyke and Potter Heigham (largest at Potter Heigham), but **not significant** ($p > 0.05$).
- Patterns suggest **localised saline intrusion** from any change in the water level management.



River water levels at Hickling Broad (Northern) and Repps (Southern) showing the trend of hydrology and tidal influences in the Thurne catchment area (2012 – 2025). **Source:** River levels UK (https://riverlevels.uk/)

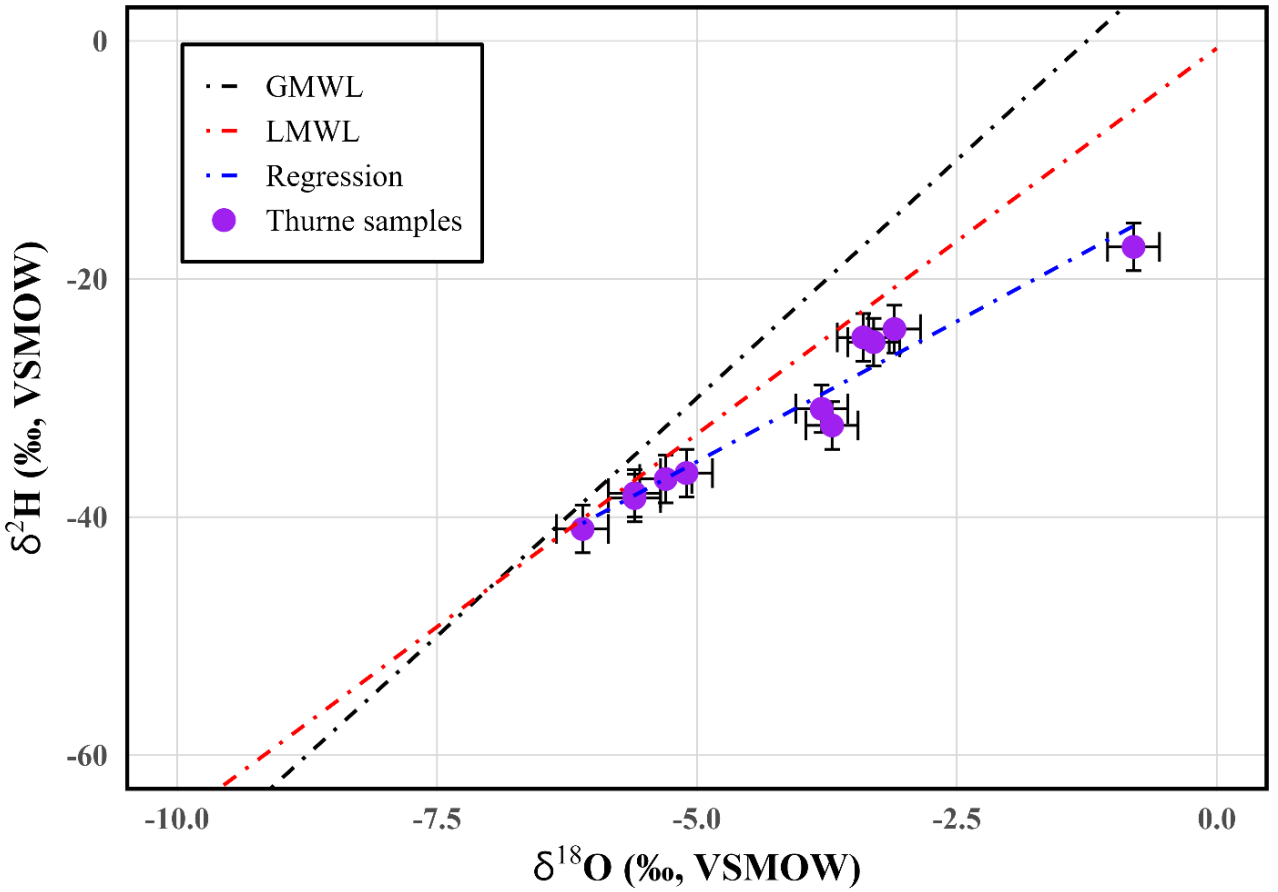
Results and Discussion – Stable Isotopes

Chloride concentrations, isotopic signatures ($\delta^{18}O$ and $\delta^{2}H$) and saline fractions for 11 surface drains within the Thurne catchment in 2025

Sample	Cl- (mg/L)	$\delta^{18}O$ (‰VSMOW)	$\delta^{2}H$ (‰VSMOW)	Fraction (saline)
1	265	-5.6	-38.4	0.01
2	407	-5.3	-36.8	0.02
3	823	-3.8	-30.9	0.04
4	3757	-3.4	-24.9	0.20
5	4609	-3.3	-25.3	0.24
6	899	-5.6	-38.0	0.05
7	2744	-3.1	-24.0	0.14
8	2055	-0.8	-17.3	0.11
9	2099	-5.1	-36.8	0.11
10	204	-6.1	-41.0	0.01
11	671	-3.7	-32.3	0.03

$$f_{saline} = (Cl_{mix} - Cl_{fresh}) / (Cl_{saline} - Cl_{fresh})$$

Two-component mixing model (Hiscock & Bense, 2021)



$\delta^{2}H$ vs. $\delta^{18}O$ signatures of catchment samples together with the GMWL and LMWL. Also included is the slope of the samples together with error bars, indicating the precision of the analytical method (±0.25 for $\delta^{18}O$ and ±2 for $\delta^{2}H$)

Conclusions

- **9.2% reduction in arable** land area, particularly in **northern catchment areas**. Driven by **agri-environmental policies**.
- Nitrate trend analysis **shows all 8 sites significantly decreasing**, except for Catfield dyke and Horsey.
- Decreasing areas mainly located in **the upper Thurne area responding to changing land use**.
- Phosphorus **within the desirable quality standards of "good to high"**, with most sites experiencing relative stability over the period.
- Relative **stability observed for salinity levels**, with apparently **no change due to any change in water level management**.
- **Salinity enriched by evaporation from dry weather conditions in 2025**.


thank
you

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