



Monitoring nutrients using sensors – Teifi and Ceredigion coast

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Summary



- Phosphate and nitrate sensors have been installed in the Teifi catchment, along with multiparameter sondes
- First installation in March 2024
- Data beginning to be piped through to WWNMB dashboard
- Data collected, QC'd, analysed and interpreted, alongside additional environmental data sources.
- Marine sites at New Quay and Aberystwyth recently installed



ClearWater Sensors nutrient sensor



**Automated
real-time
water quality
monitoring**

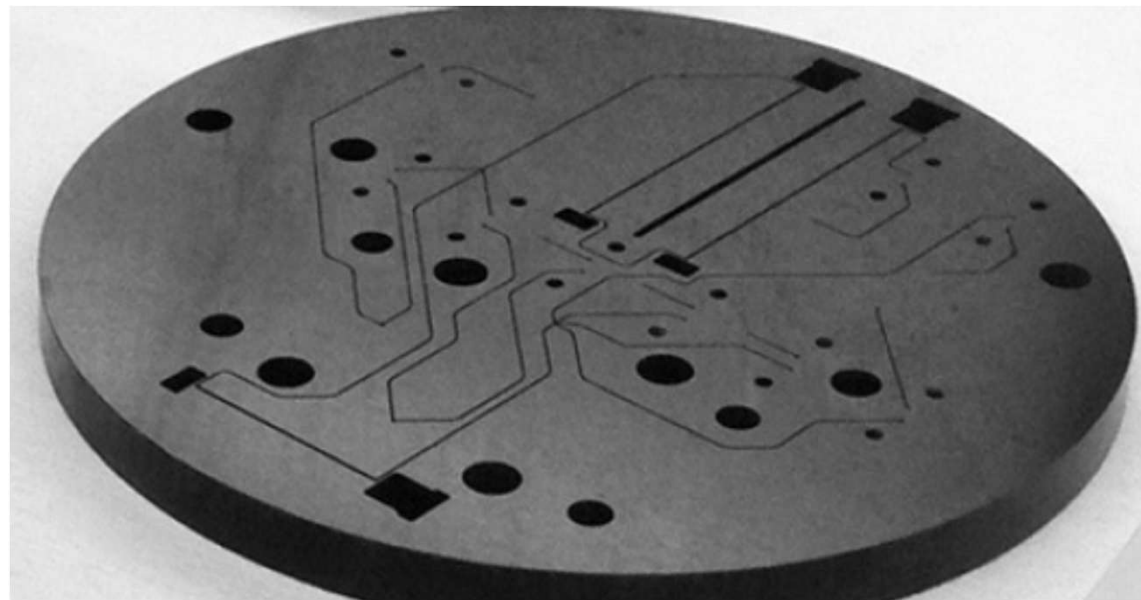
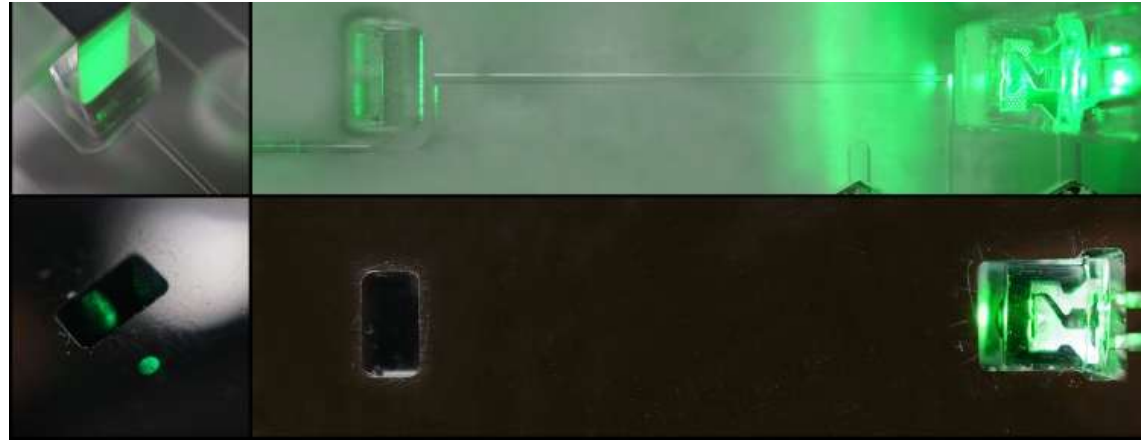
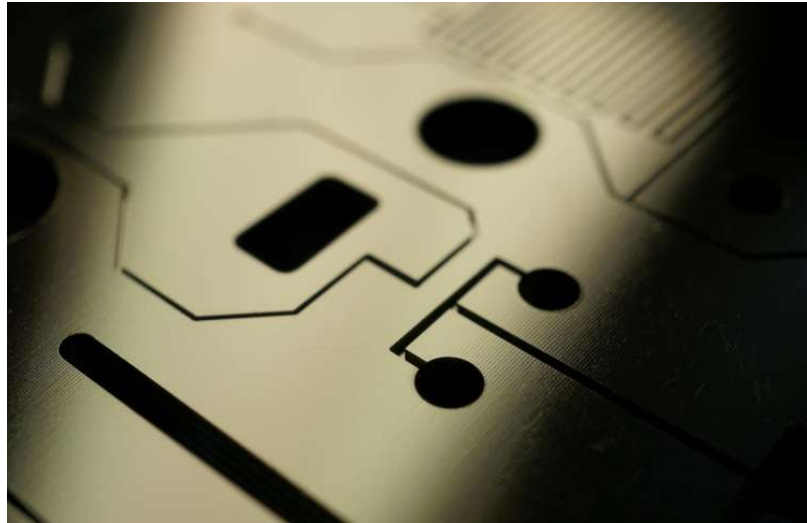
- ⬆ Nitrate
- ⬆ Phosphate
- ⬆ Silicate
- ⬆ Iron
- ⬆ pH

High quality data for long term deployments

- uses state-of-the-art microfluidic Lab-on-Chip technology and onboard standards to virtually eliminate drift
- can be deployed in any water environment
- operates **without** mains power or infrastructure



Microfluidic sensors



Remote Chemistry Monitoring



**Automated
real-time
water quality
monitoring**

-  Nitrate
-  Phosphate
-  Silicate
-  Iron
-  pH

Parameter	CWS Lab-on-Chip Phosphate sensor	CWS Lab-on-Chip Nitrate sensor
Measurement range	0 - 310 µg/L-P	0 - 14 mg/L-N
Temperature range	0 - 35°C	0 - 35°C
Limit-of-detection	1.55 µg/L-P	0.0007 mg/L-N
Power consumption when operating	1.5 W	1.8 W
Sample volume	0.6 ml	0.6 ml
Filter pore size	0.45 µm	0.45 µm
Communications	RS232 and RS485 for M2M. User programmable via USB and Windows GUI	RS232 and RS485 for M2M. User programmable via USB and Windows GUI



Sensor Overview



Key Components

- **Reagent Housing:** Holds reagents and waste bags.
- Reagent bags can be swapped out by removing white tube
- **Sensor Housing:** Contains fluidic manifold, valves, pump, and electronics.



Advantages over other sensors



01

Self-calibrating to avoid analytical drift

02

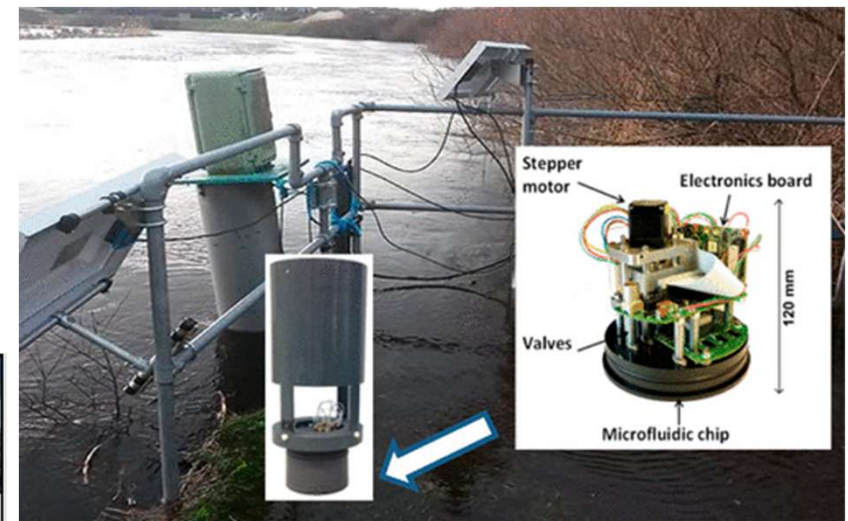
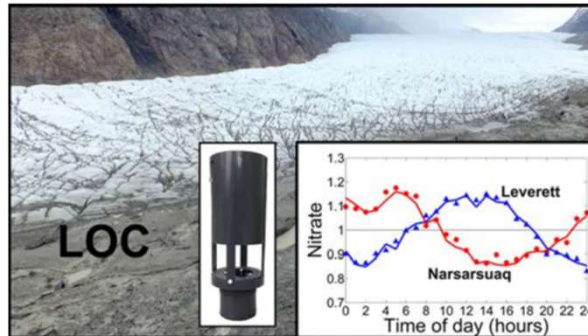
Low limit-of-detection (LOD) so can quantify nutrients in pristine headwaters and coast

03

Work in freshwater and seawater (no depth effect)

Can be deployed almost anywhere

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Integration with autonomy

ClearWater
Sensors



Multiparameter sonde



In Situ AquaTROLL multiparameter sonde

Configured to measure:

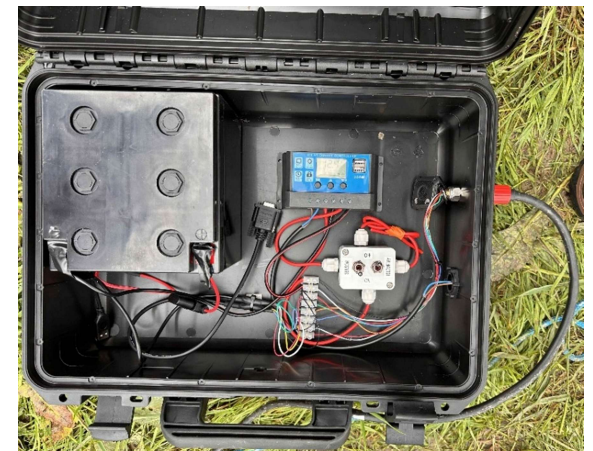
- Conductivity/salinity
- Temperature
- Turbidity
- pH
- Dissolved oxygen

(other parameters available)



Power and telemetry

- Solar charged battery and telemetry unit located in waterproof Peli-case
- Originally used cell-modem telemetry, but now gradually being replaced by Lacuna satellite IoT
- Peli-case should remain above waterline, but this has been a challenge in winter! Upgrading these to be completely watertight



Other data sources



- River discharge data from NRW
- Rainfall data from NRW
- Phosphate and nitrate spot sample data from NRW
- Citizen science data



Deployment methods

- Challenging environments (varying river levels, sediment build-up, turbulent flows)
- Tube in stream normally best approach
- Some sites require specialist protection (stainless steel cages)



Units of measurement



- All nutrient data here (and in report) reported in:
 $\mu\text{g/L-P}$ for phosphate
 mg/L-N for nitrate + nitrite
- Achieves consistency with NRW data



WFD phosphate targets

	High	Good	Moderate	Poor
Phosphate [$\mu\text{g/L-P}$]	16	39	82	326

Phosphate concentrations for categorising the ecological status of freshwater rivers (UKTAG, 2008)



WFD phosphate targets

⚠ SAC Compliance Targets

This catchment has official SAC compliance targets. Targets are shown as orange dashed lines on charts when relevant parameters are displayed.

GB110062043564 dissolved oxygen	85 %	WFD standard
GB110062043564 nitrate	11.3 mg/L-N	WFD standard
GB110062043564 ph	6.5 pH units	WFD standard
GB110062043564 phosphate	20 µg/L-P	SAC threshold

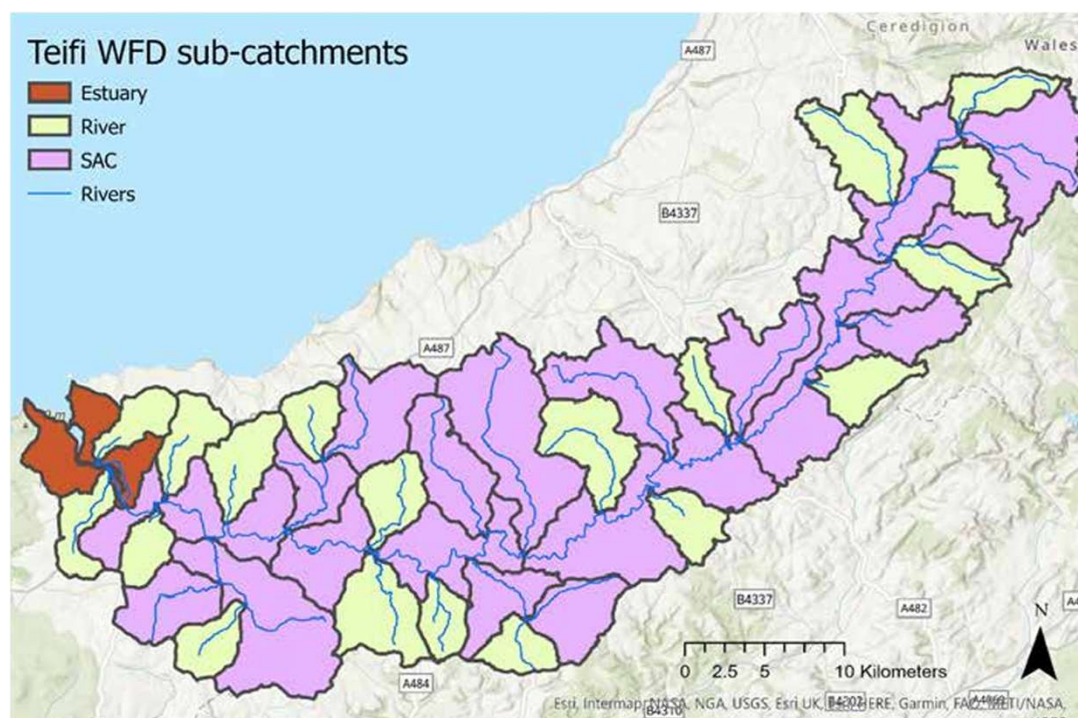
Moderate	Poor
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0.25	1
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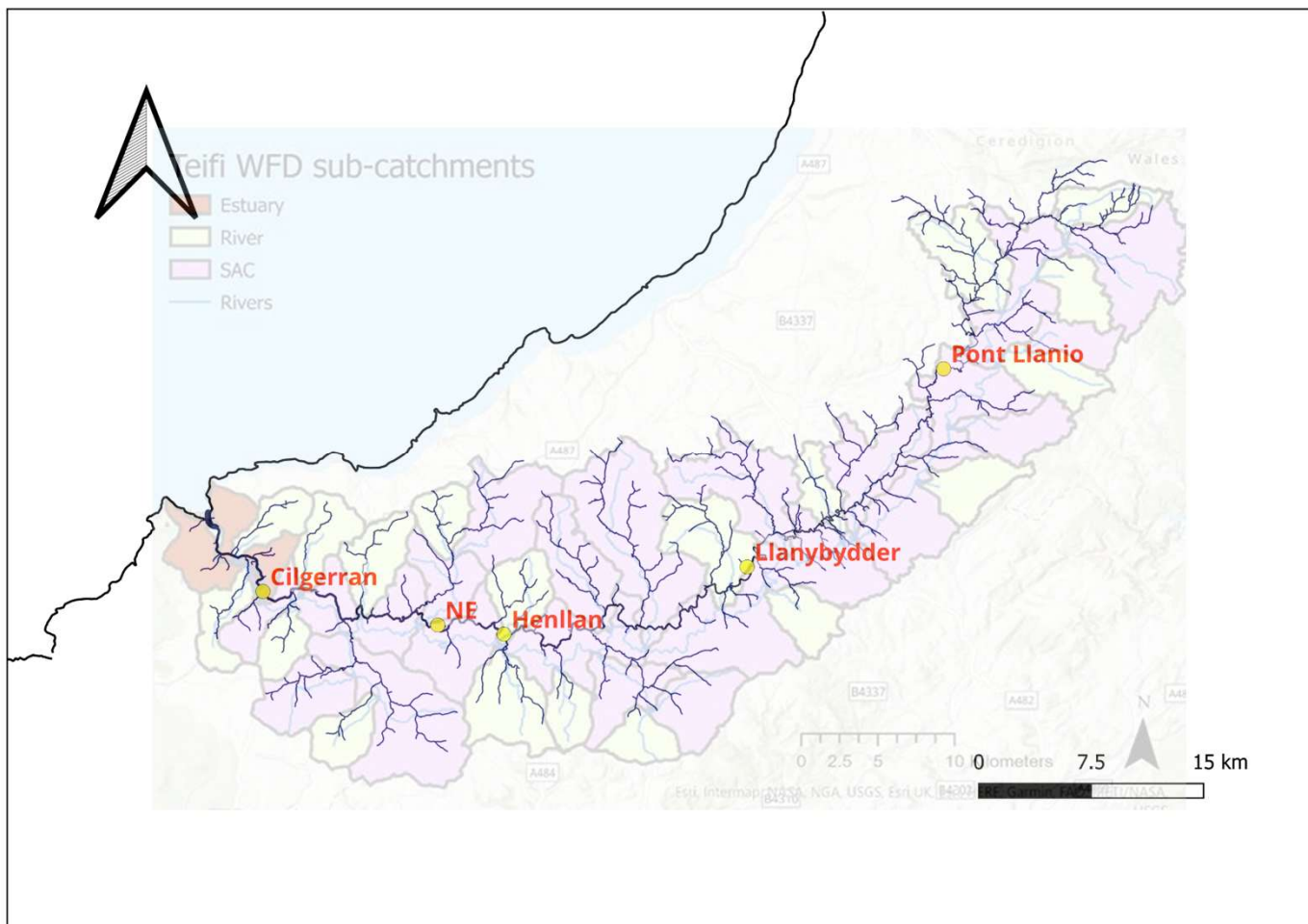
82	326
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ecological status

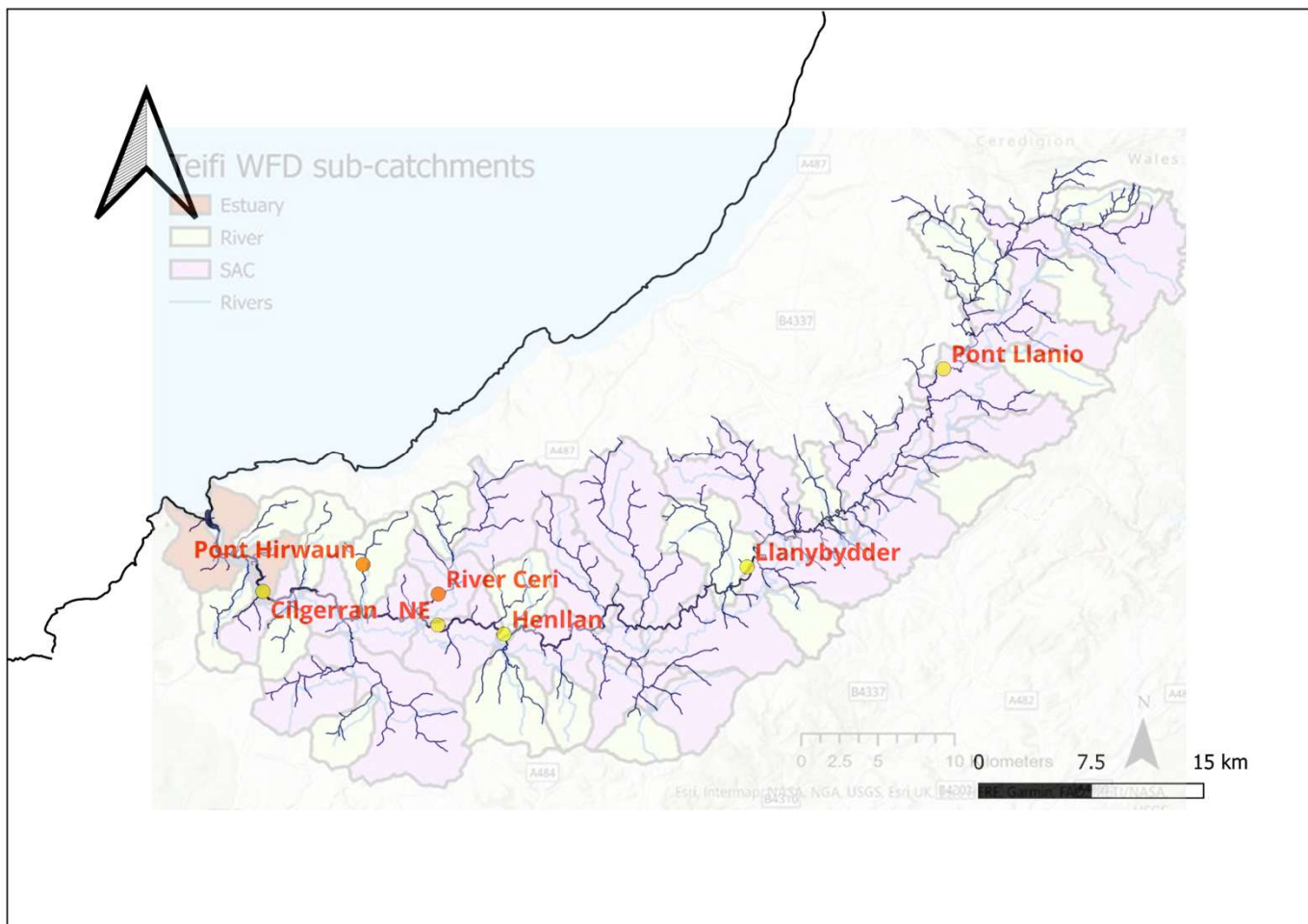




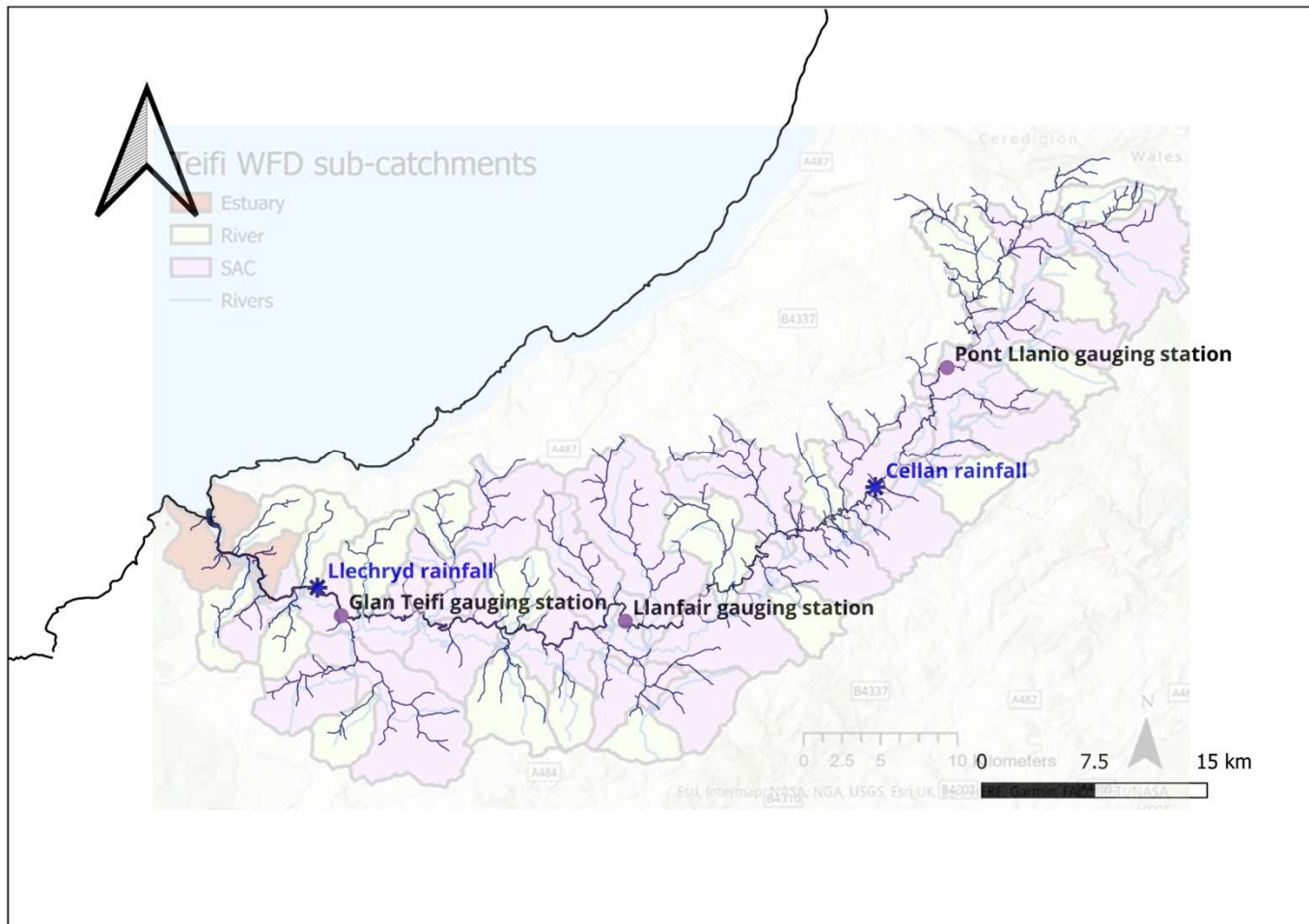
Main river sites



Main river and tributary sites



NRW discharge and rainfall sites



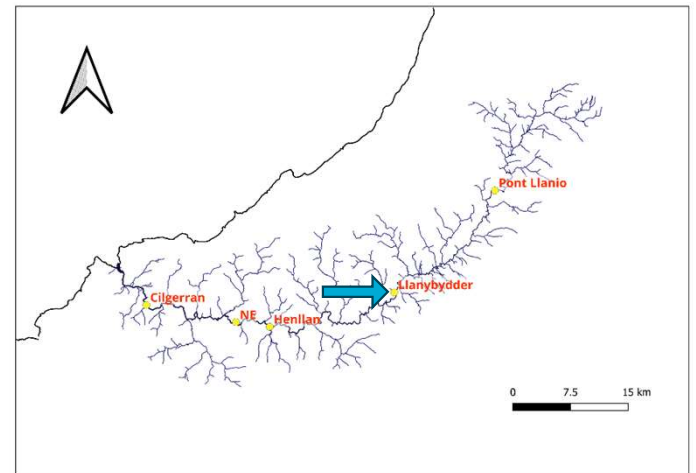
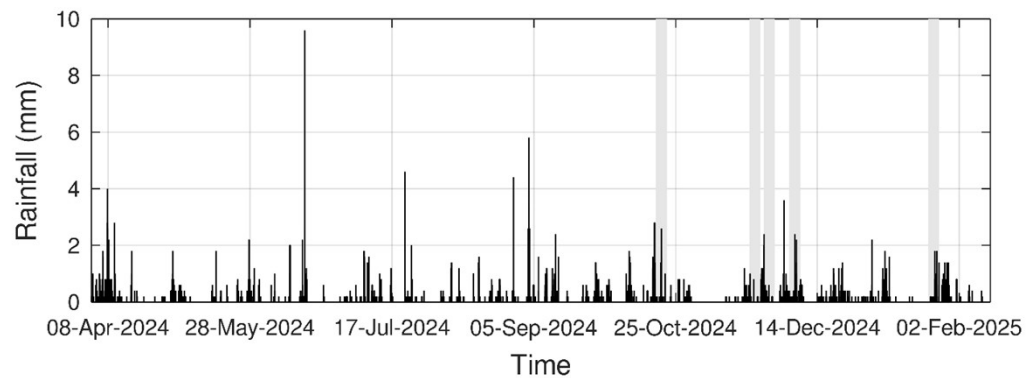
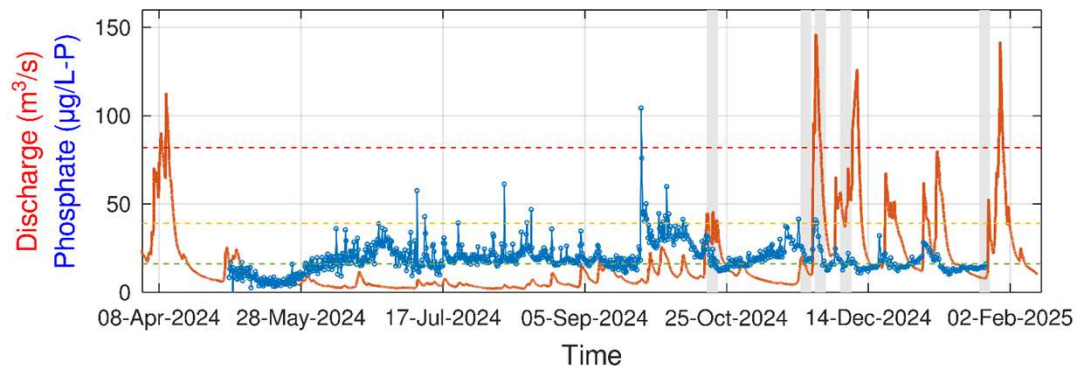
Quality Control of Data



- Automated QC process excludes bad LOC data
- Data can be excluded for a number of reasons (sensor out of water is the main one)
- Sonde data also checked and poor data excluded based on unrealistic conductivity measurements when out of water
- pH sensor calibrated regularly, turbidity sensor cleaned regularly)



Llanybydder



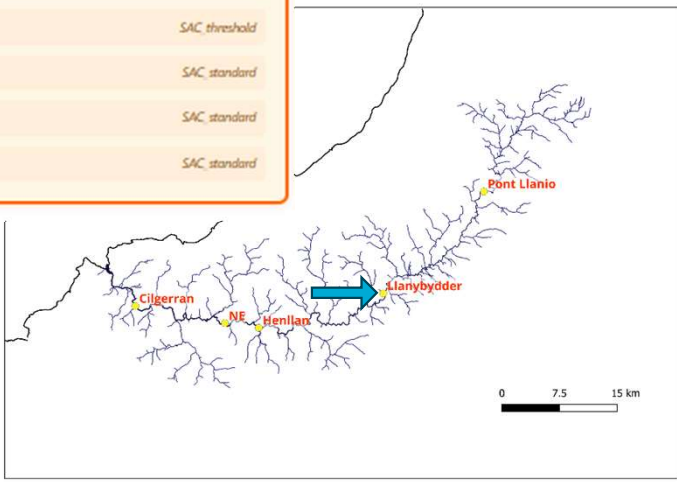
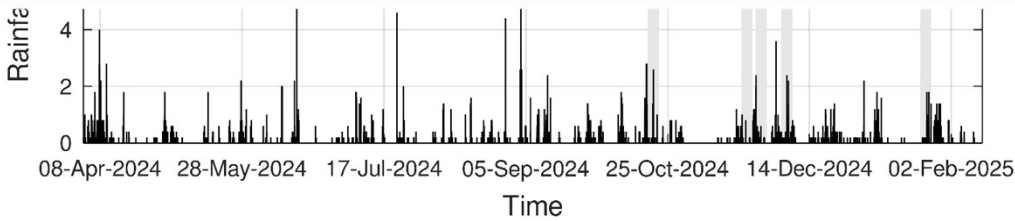
Llanybydder



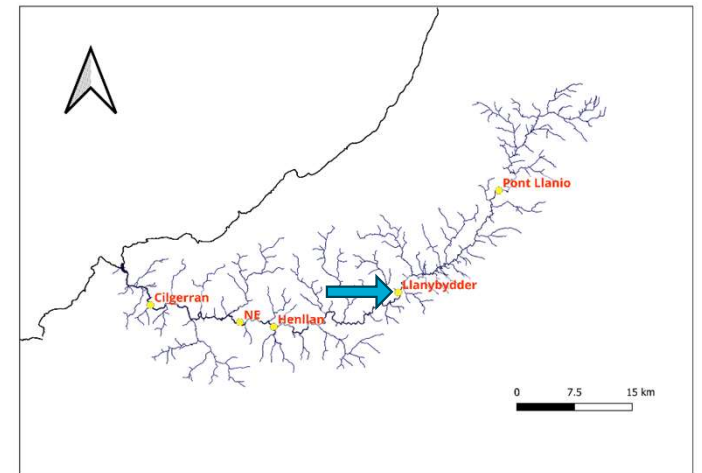
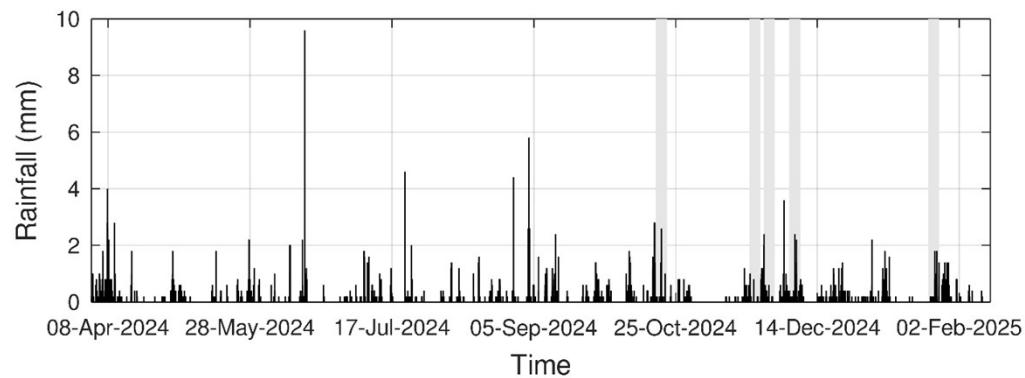
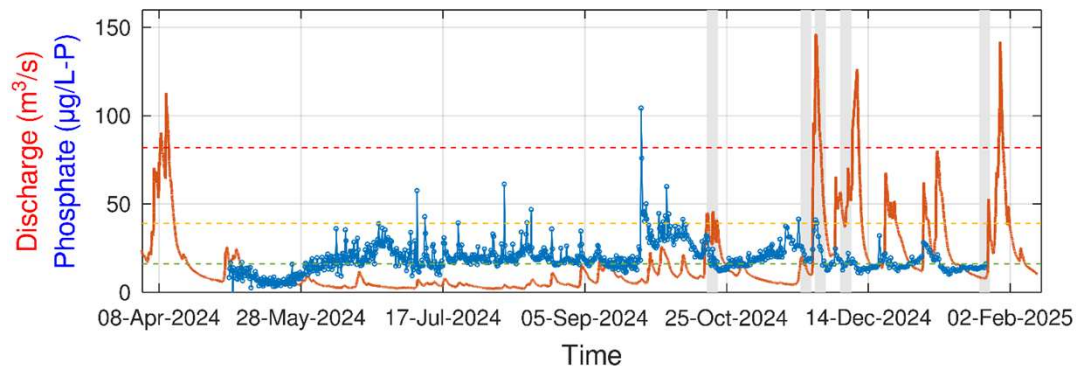
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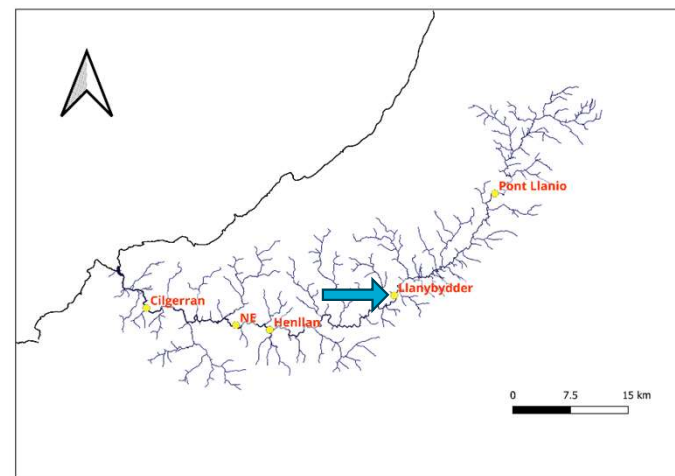
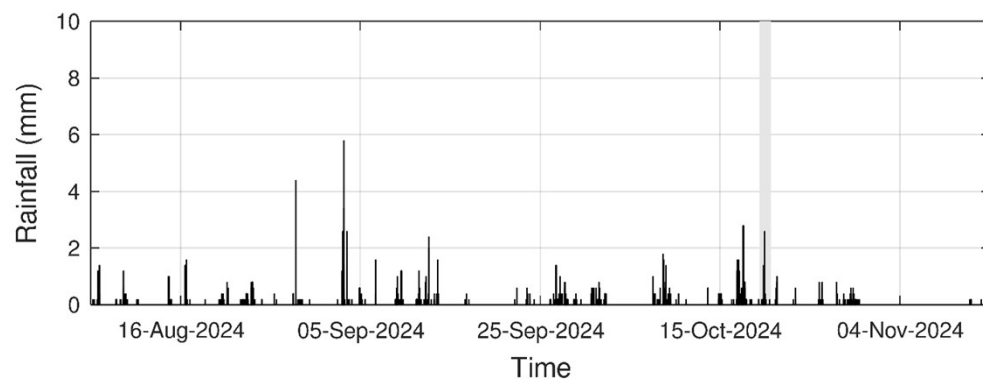
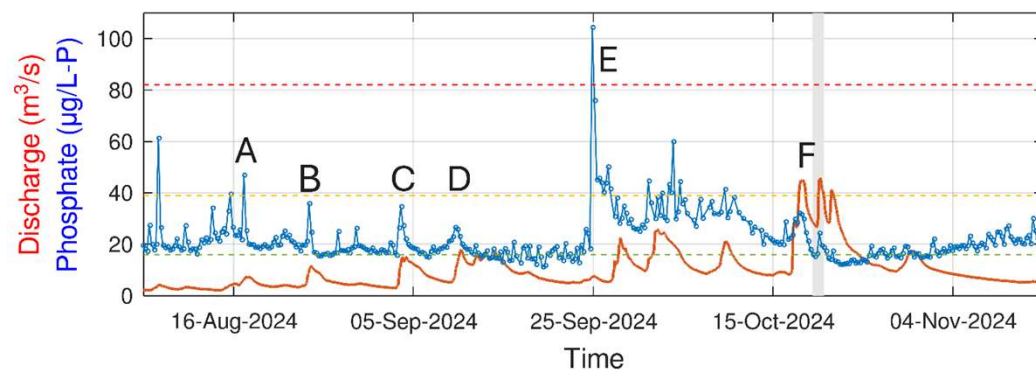
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GB110062043565 ph	6.5 pH units	WFD standard
GB110062043565 phosphate	10 µg/L-P	SAC threshold
GB110062043565 unionised ammonia	25 µg/L	SAC standard
GB110062043565 ionised ammonia	200 µg/L	SAC standard
GB110062043565 conductivity	675 µS/cm	SAC standard



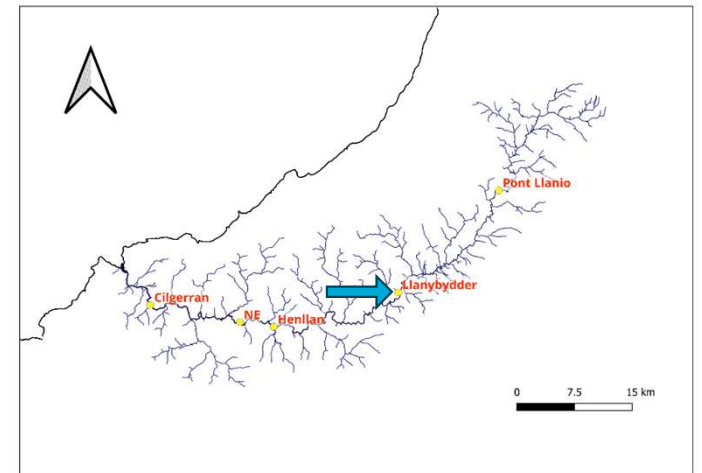
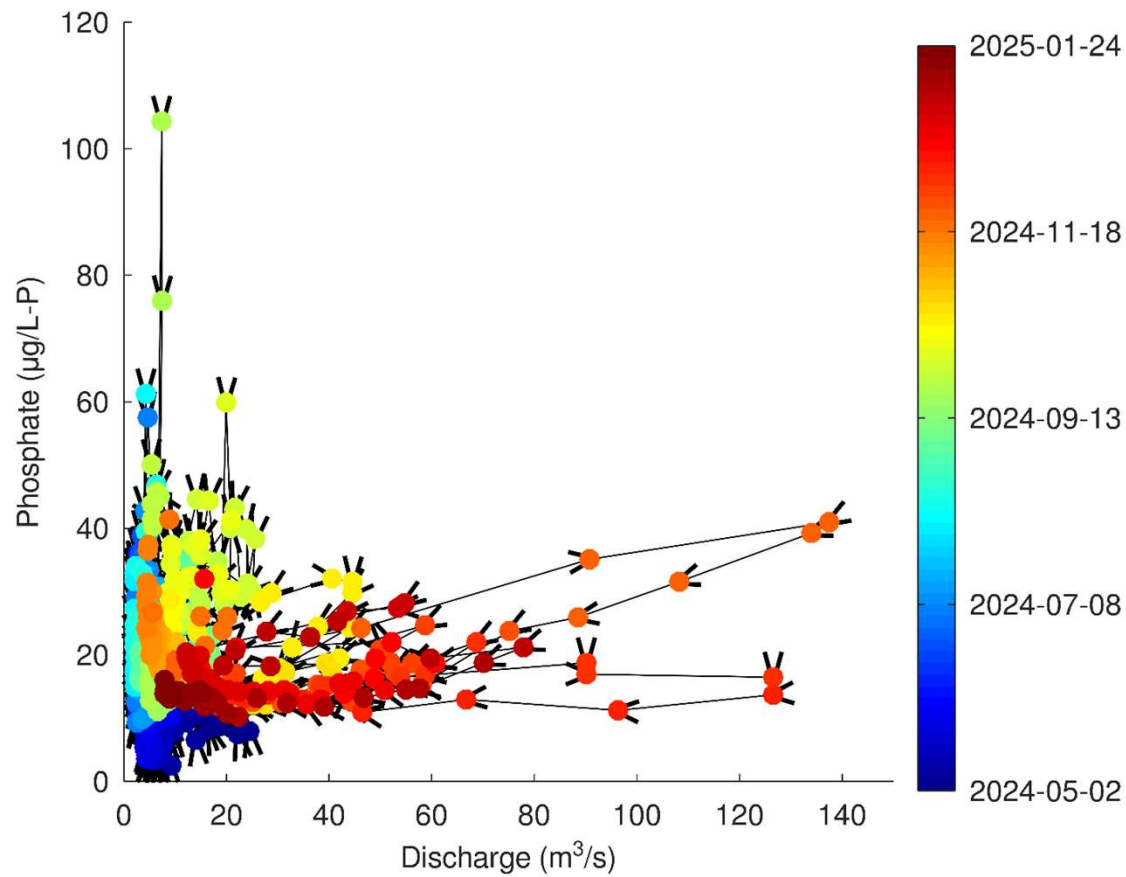
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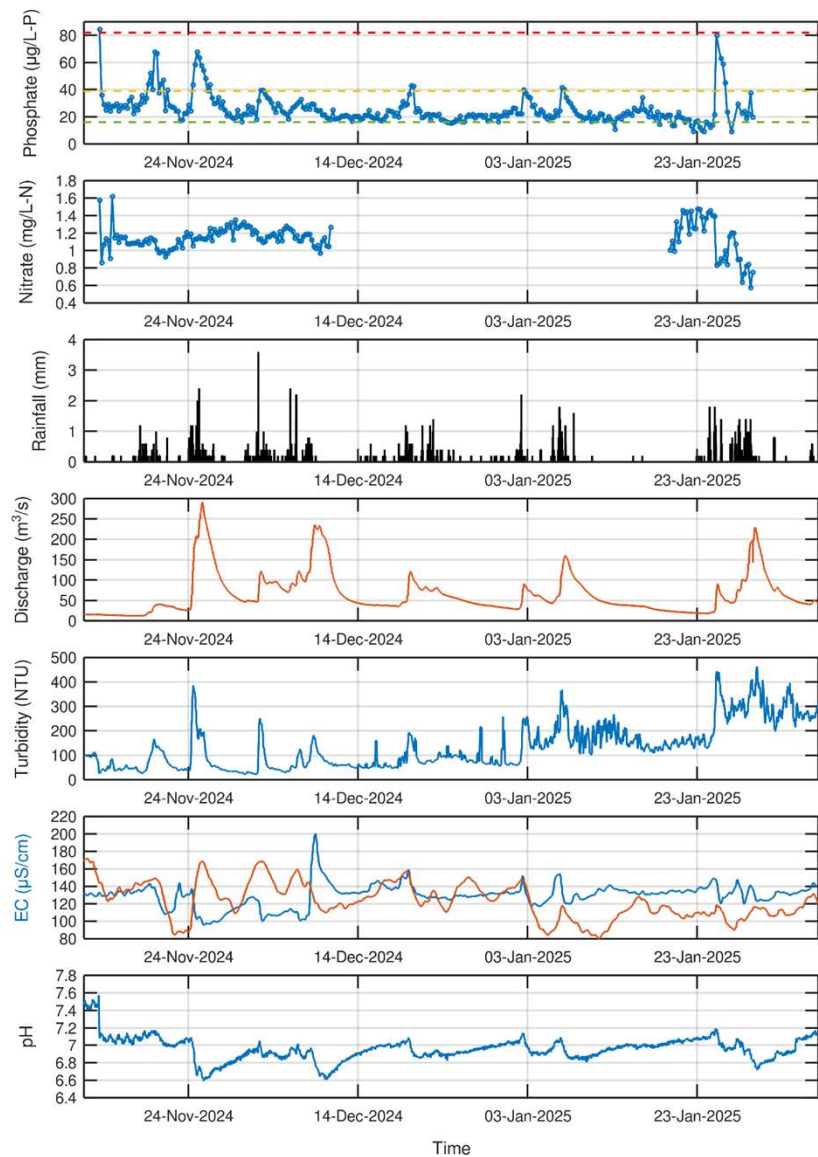
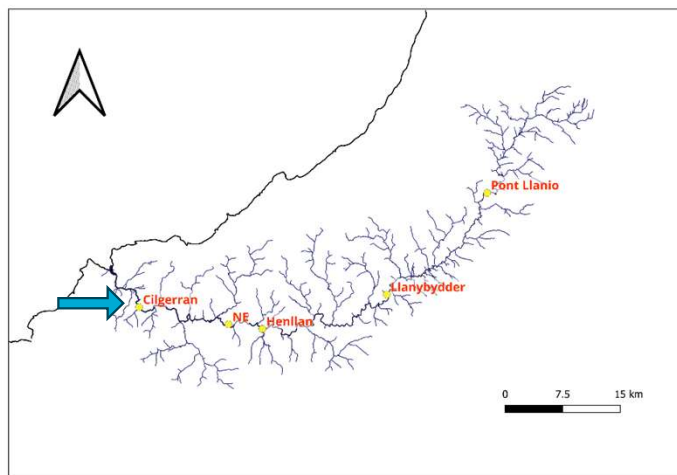
Llanybydder



Llanybydder



Cilgerran



later
SENSORS

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GB110062043563 dissolved oxygen

85 %

WFD_standard

GB110062043563 nitrate

11.3 mg/L-N

WFD_standard

GB110062043563 ph

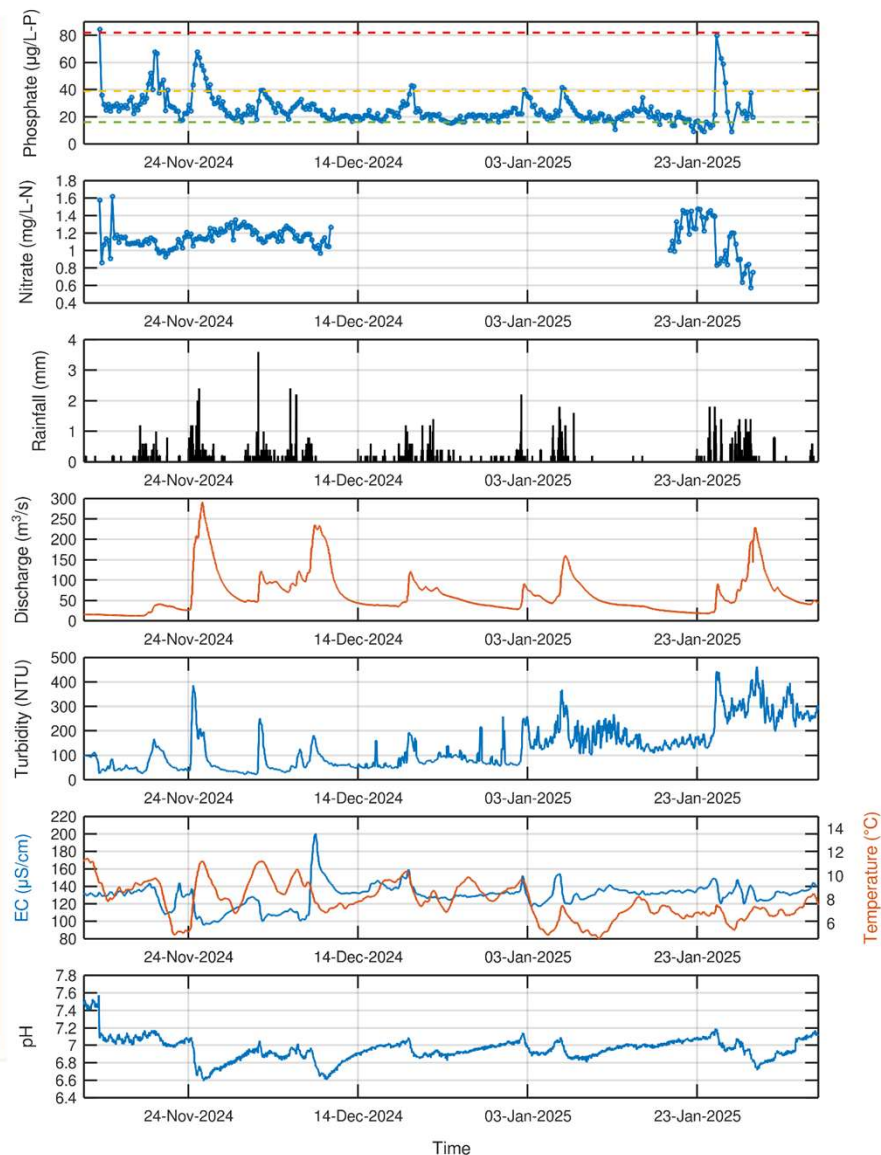
6.5 pH units

WFD_standard

GB110062043563 phosphate

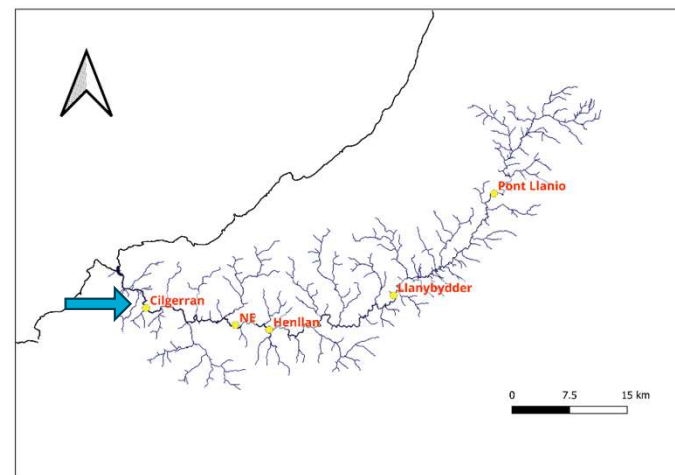
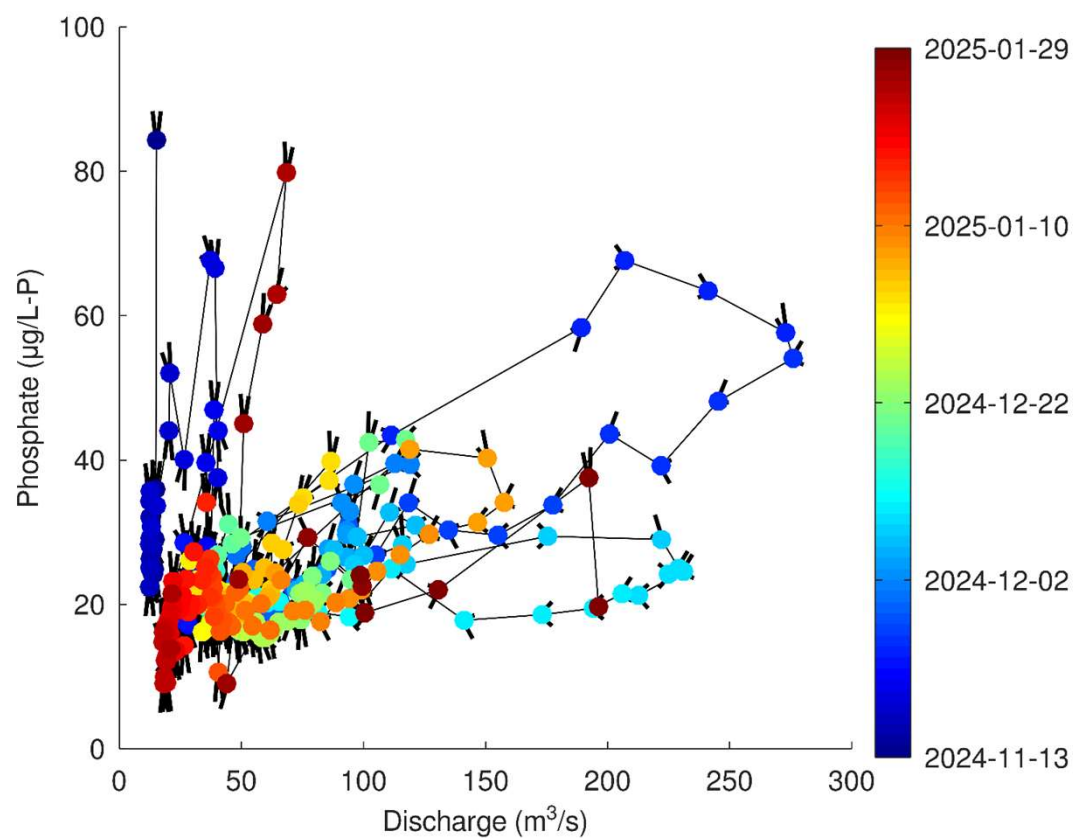
20 µg/L-P

SAC_threshold

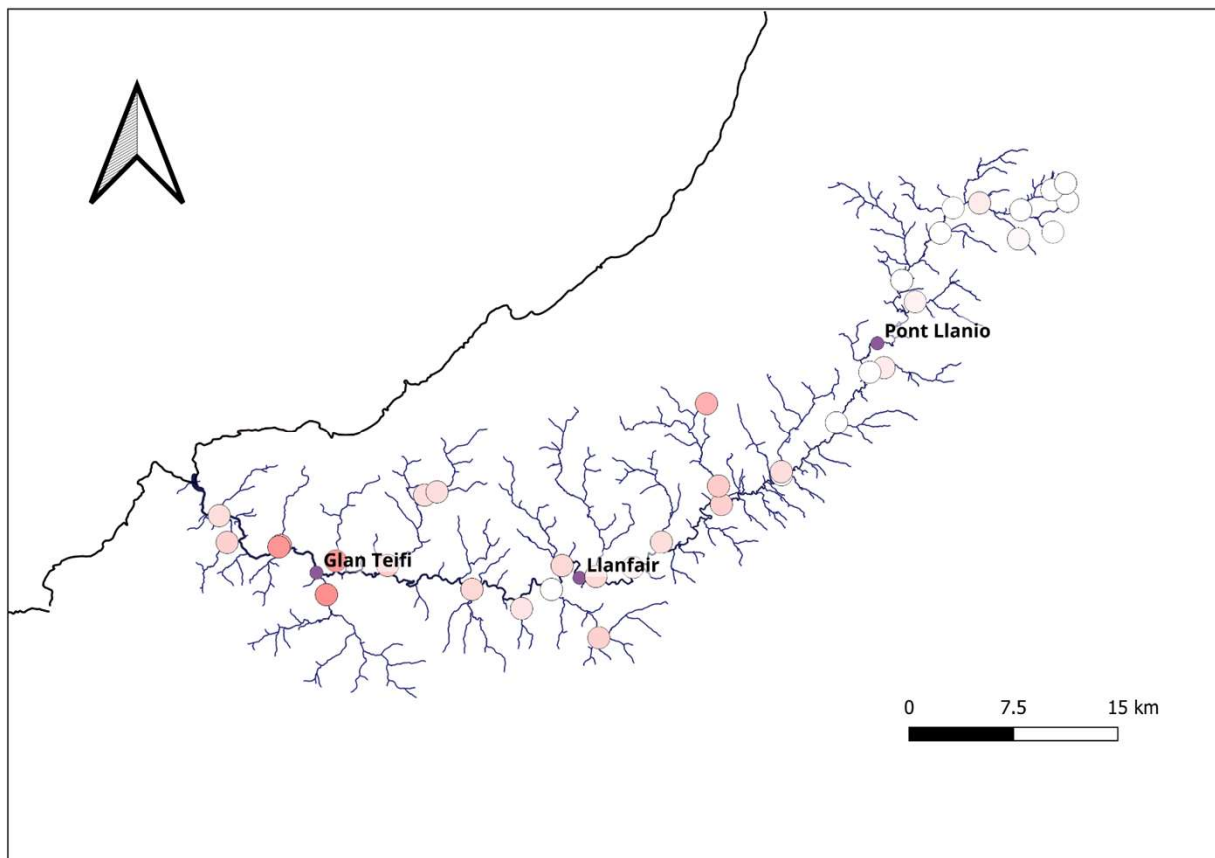


later
SENSORS

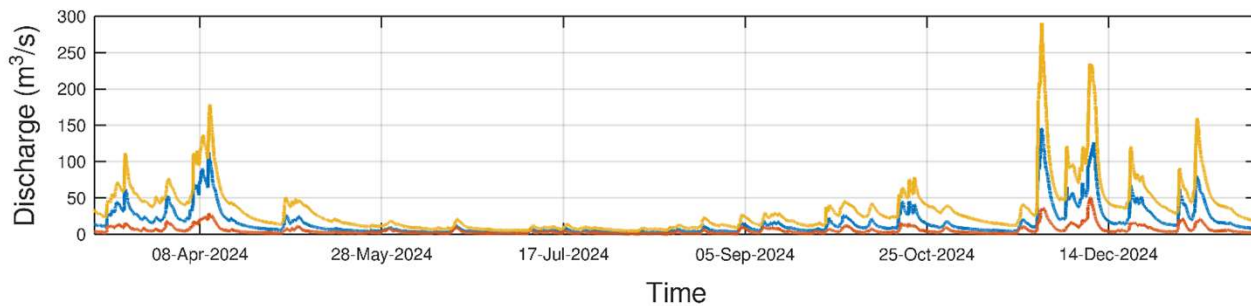
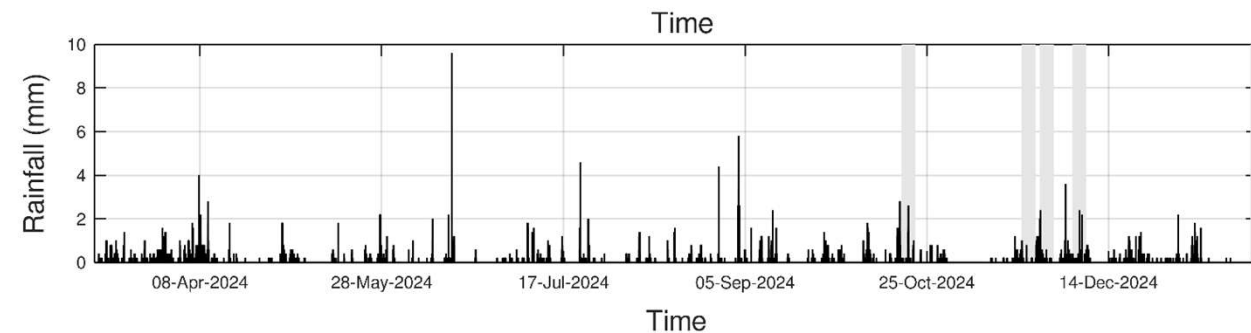
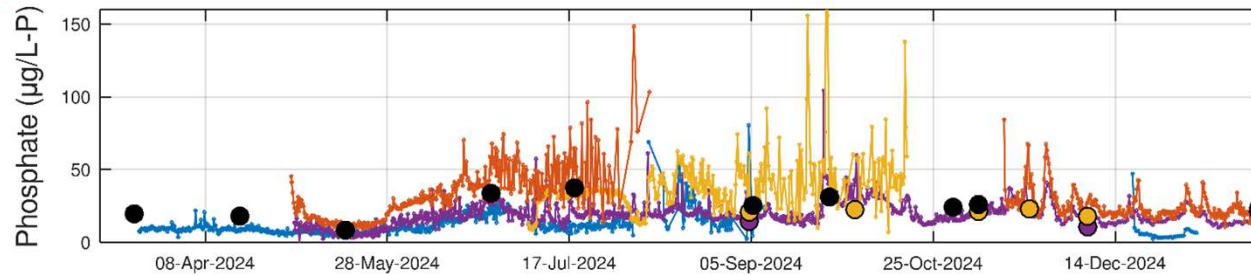
Cilgerran



NRW samples

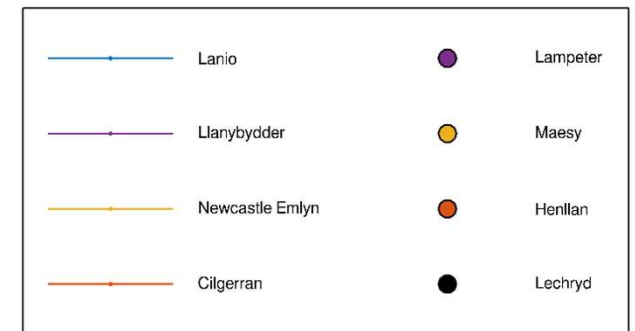


Main river phosphate data (all sites)

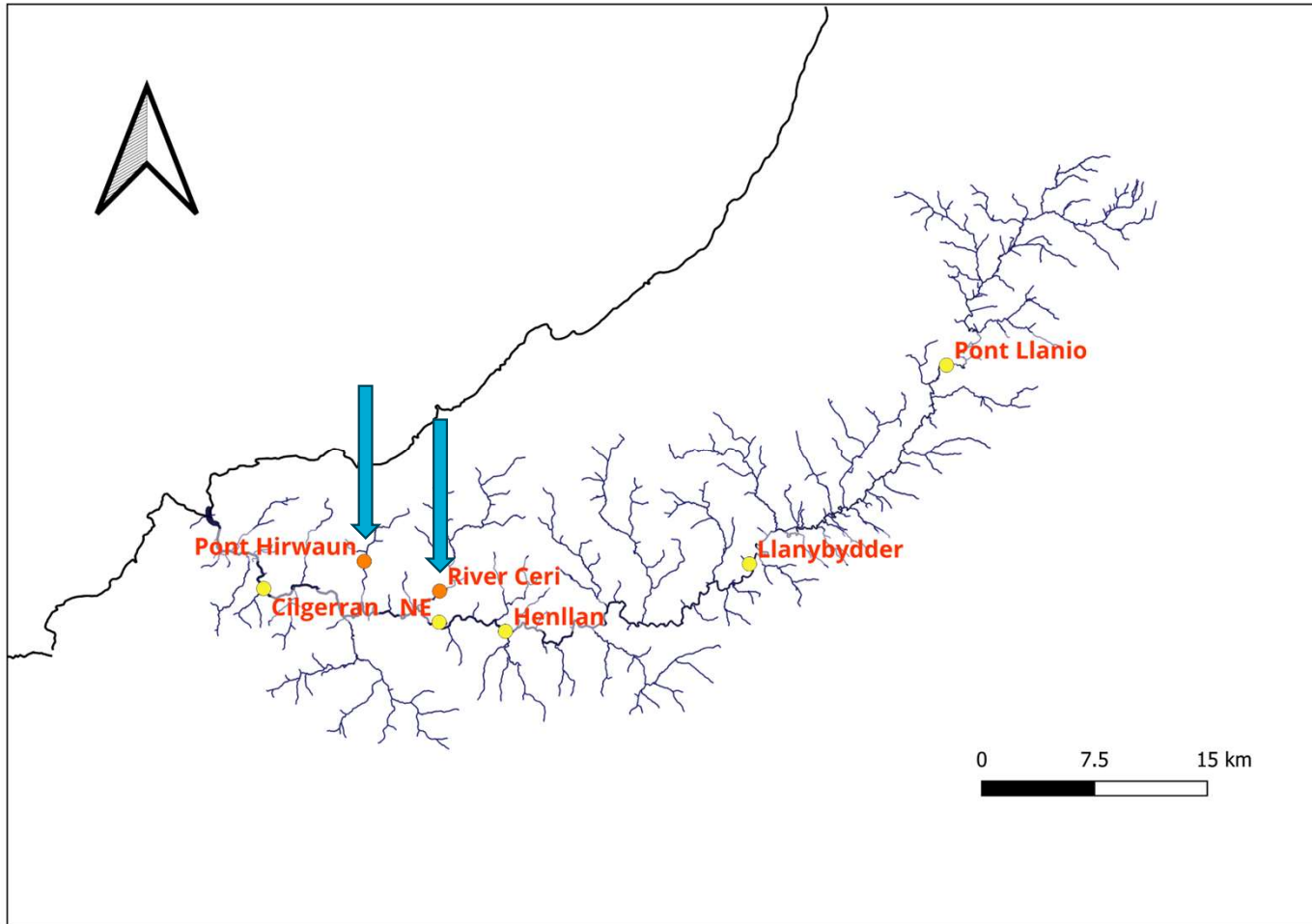


CWS sensors

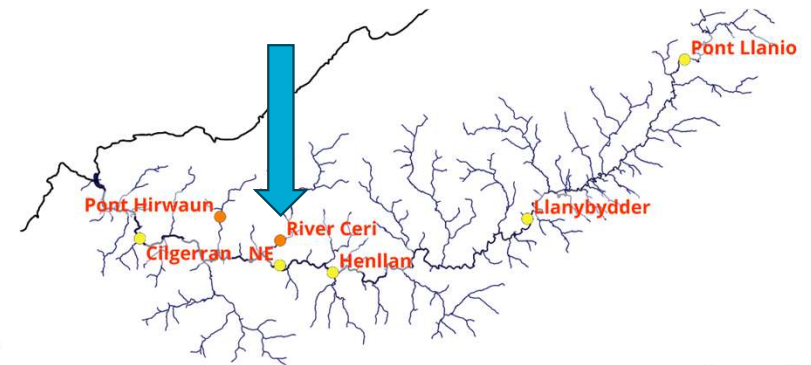
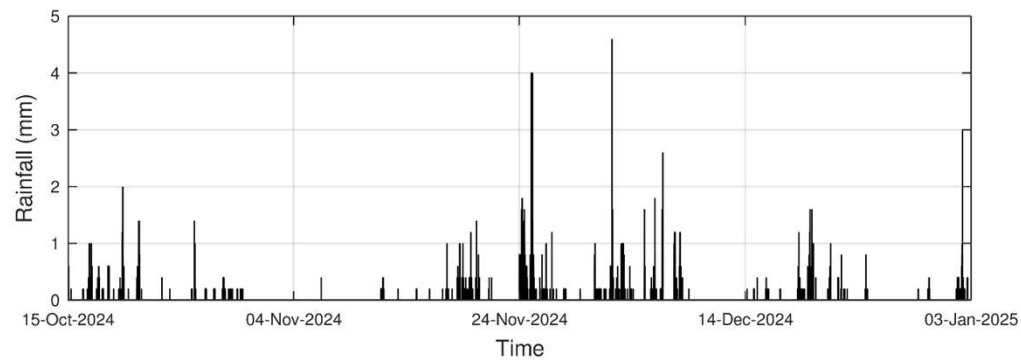
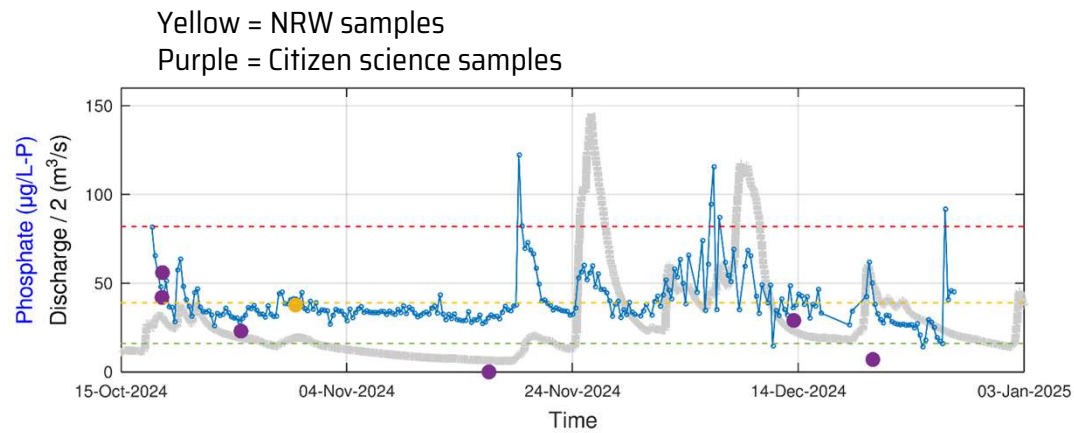
NRW samples



Tributary sites



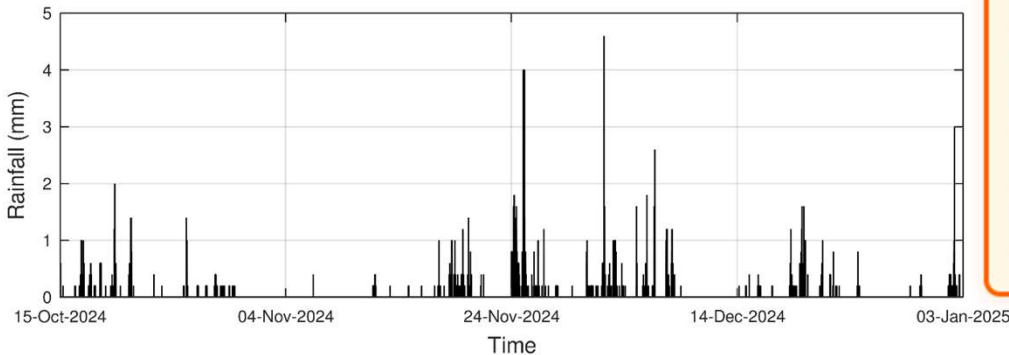
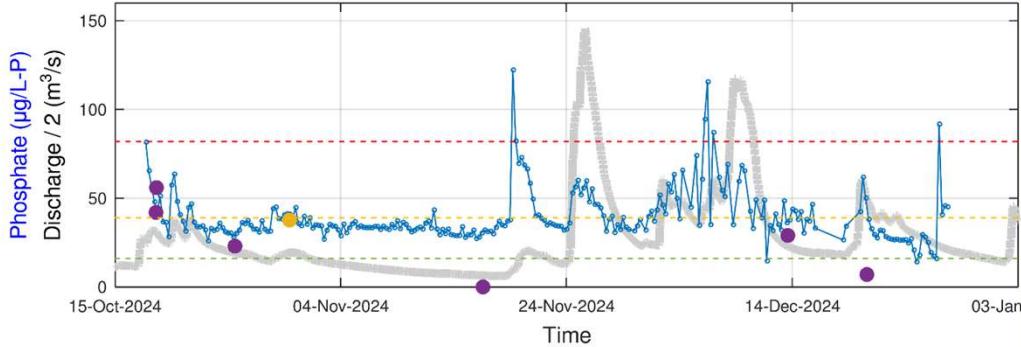
River Ceri



0 7.5

River Ceri

Yellow = NRW samples
Purple = Citizen science samples

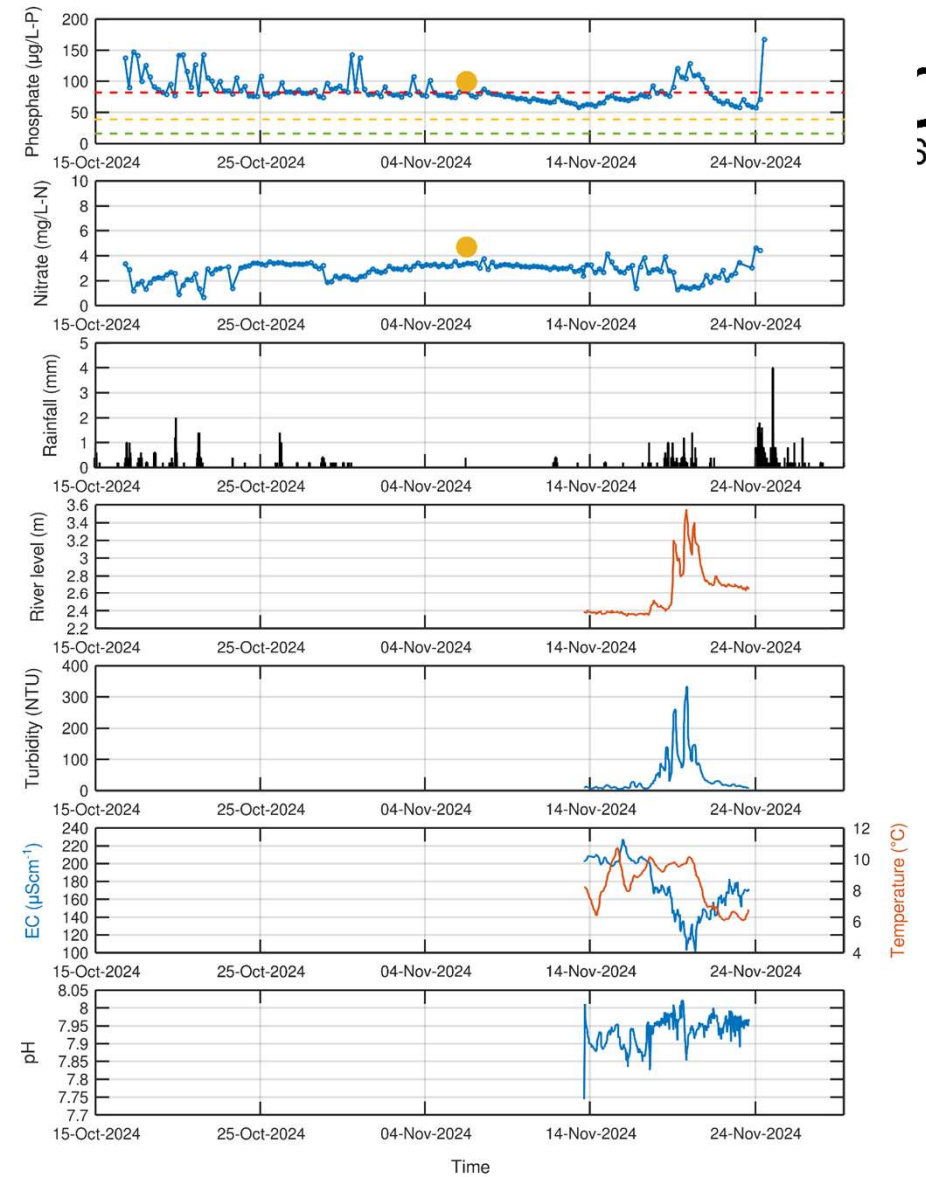
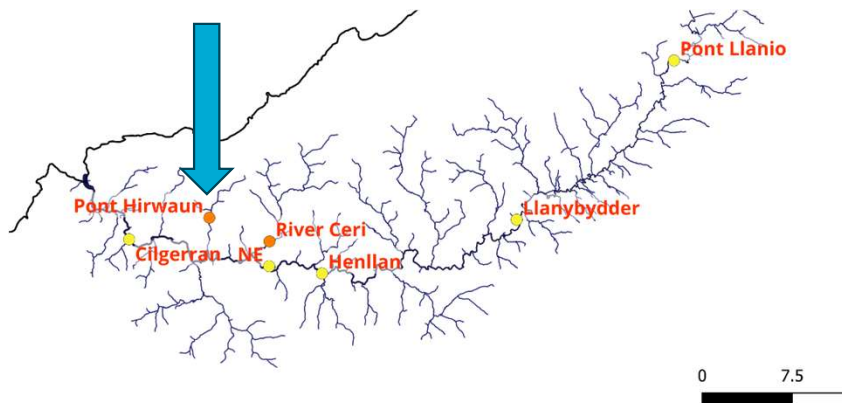


⚠ SAC Compliance Targets

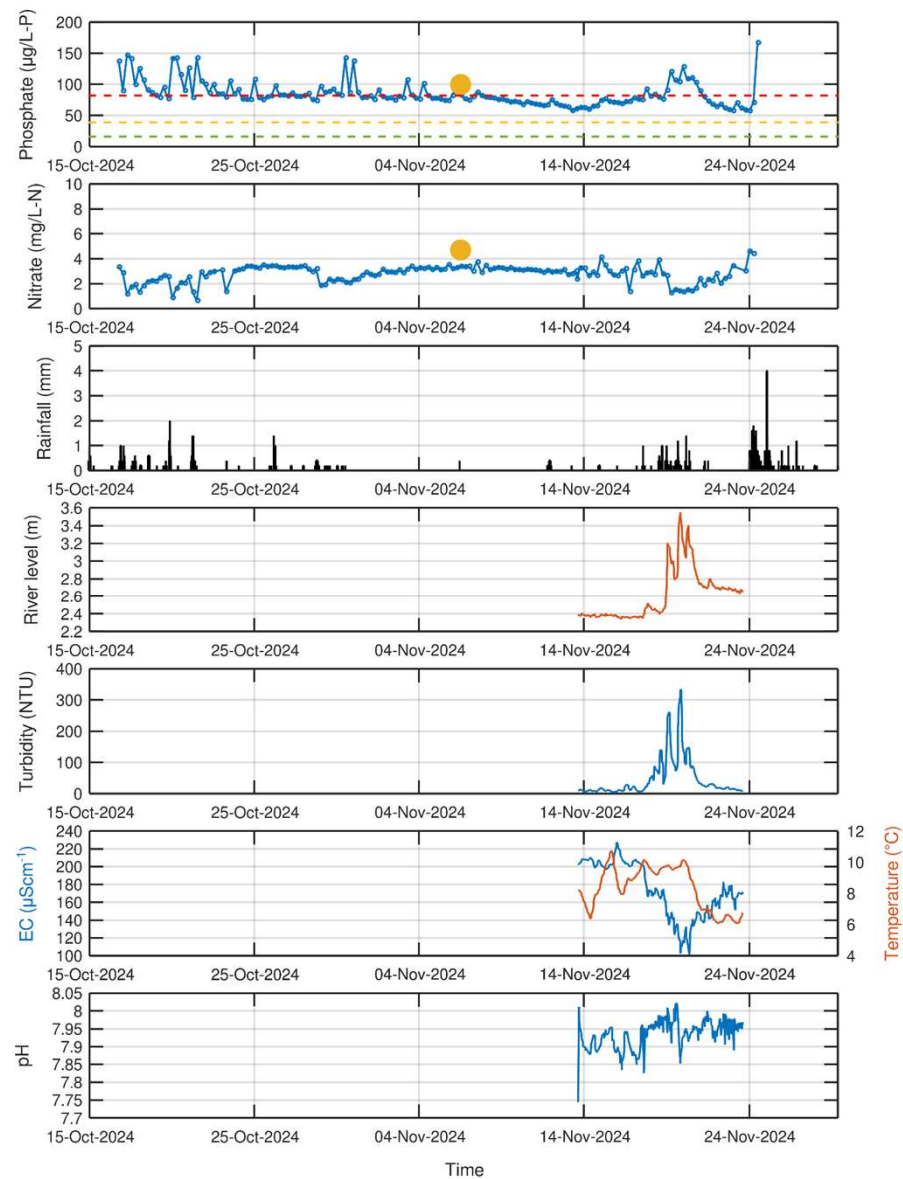
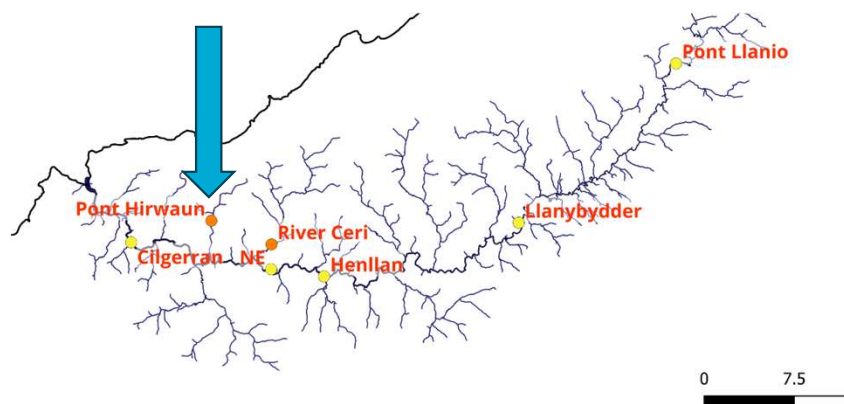
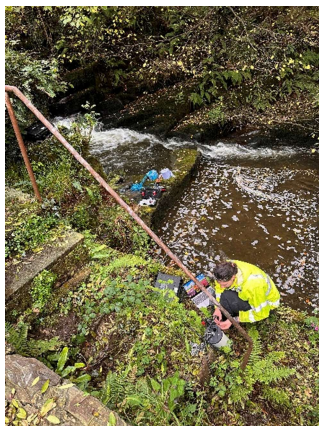
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GB110062039110 ph	6.5 pH units	WFD_stand
GB110062039110 phosphate	40 $\mu\text{g/L-P}$	SAC_thresh
GB110062039110 unionised ammonia	25 $\mu\text{g/L}$	SAC_stand
GB110062039110 ionised ammonia	200 $\mu\text{g/L}$	SAC_stand
GB110062039110 conductivity	650 $\mu\text{S/cm}$	SAC_stand

Ponthirwaun



Ponthirwaun



Summary of data

Upstream



Site	Mean	Minimum	Maximum	No. of measurements	Order (upstream to downstream)
Pont Llanio	11.78	2.26	80.63	622	1
Llanybydder	19.2	3.30	104.4	906	2
Newcastle Emllyn	31.7	2.29	82.3	226	3
Cilgerran	30.6	9.1	148.6	660	4

Downstream



Summary of data

Site	Mean	Minimum	Maximum	No. of measurements	Order (upstream to downstream)
Pont Llanio	11.78	2.26	80.63	622	1
Llanybydder	19.2	3.30	104.4	906	2
Newcastle Emllyn	31.7	2.29	82.3	226	3
Cilgerran	30.6	9.1	148.6	660	4
Afon Ceri	39.5	14.2	122.3	400	-
Ponthirwaun	90.7	19.3	300.1	223	-



Nutrient dashboard



West Wales Catchment Monitoring Portal
Part of the West Wales Nutrient Management Board's Integrated Monitoring Programme
Catchment-scale water quality and nutrient monitoring across West Wales

Welcome to the West Wales Nutrient Management Board Monitoring Analytics Platform
Water quality and nutrient monitoring across West Wales

 **River Monitoring**

River level monitoring and historical trend analysis across multiple catchments, providing essential data for flood risk assessment and water resource management.

 **Nutrient Analysis**

Nutrient monitoring including phosphate and nitrate concentrations, supporting environmental protection and sustainable farming practices.

 **Water Quality Monitoring**

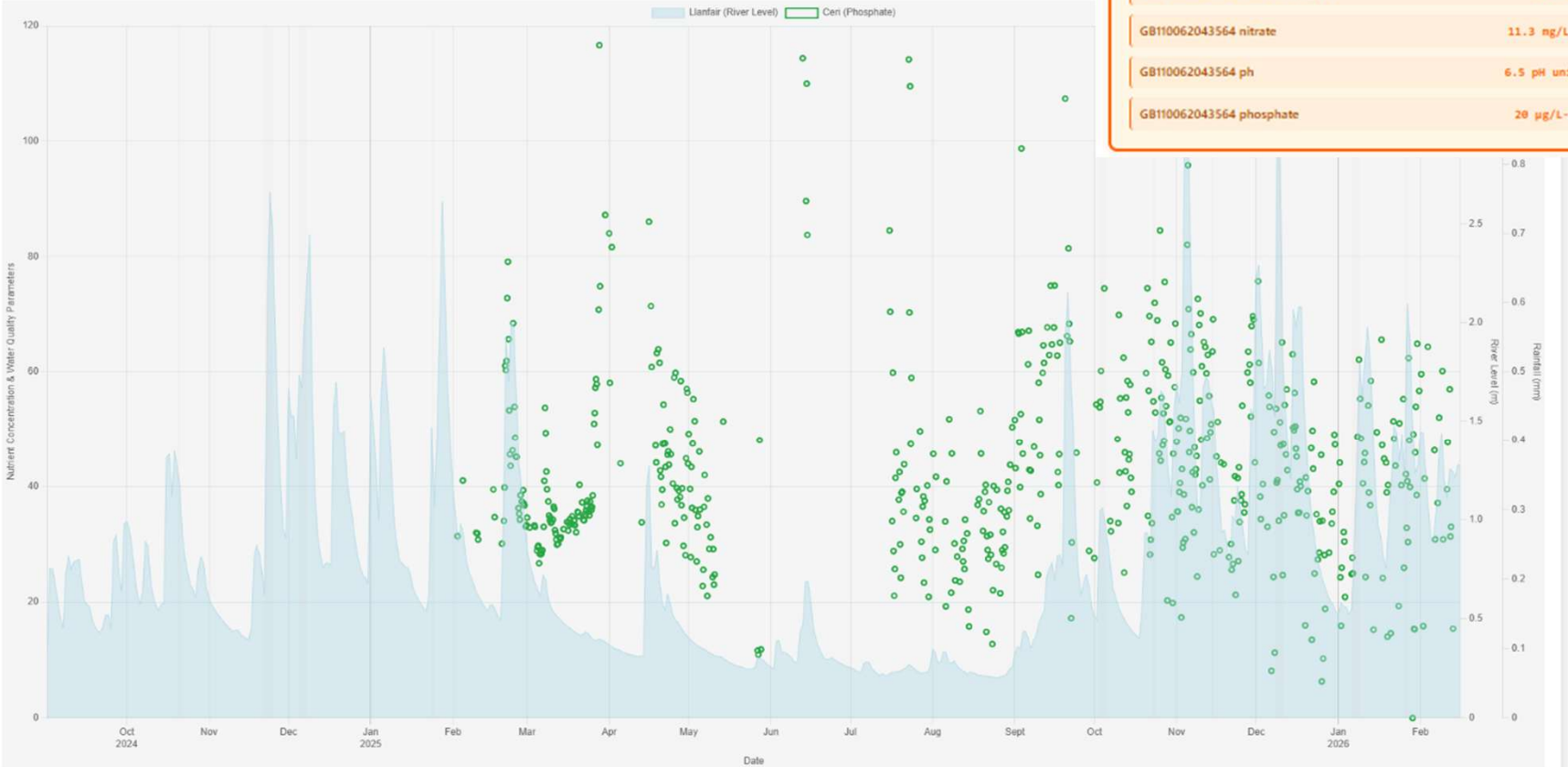
Water quality measurements including pH, conductivity, turbidity, and dissolved solids from AquaTROLL sensors providing comprehensive water chemistry analysis.



Nutrient dashboard

Teifi - Afon Clettwr to Afon Ceri (Water Catchments) - SAC Compliance - Data Analysis

Integrated Sensor Data - Water Quality (Left) & Environmental (Right)



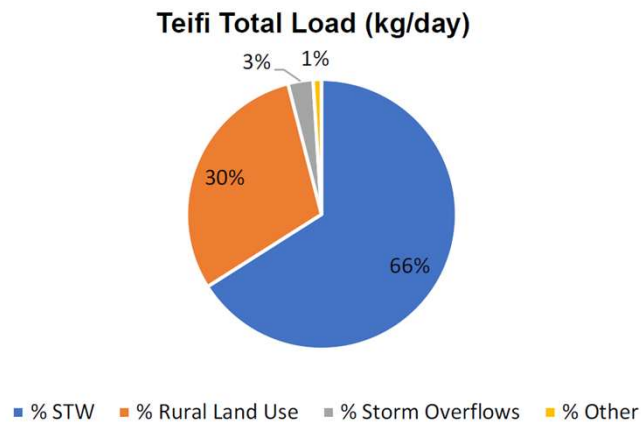
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GB110062043564 phosphate	20 µg/L-P	SAC_threshold

Sewage or agricultural runoff?

Welsh Water 2023 source apportionment model



- Suggests 66% P load from sewage. Likely not the case during storms.
- Would expect to see baseline levels drop as WwTW P mitigation methods adopted, but not peaks.



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Coastal monitoring



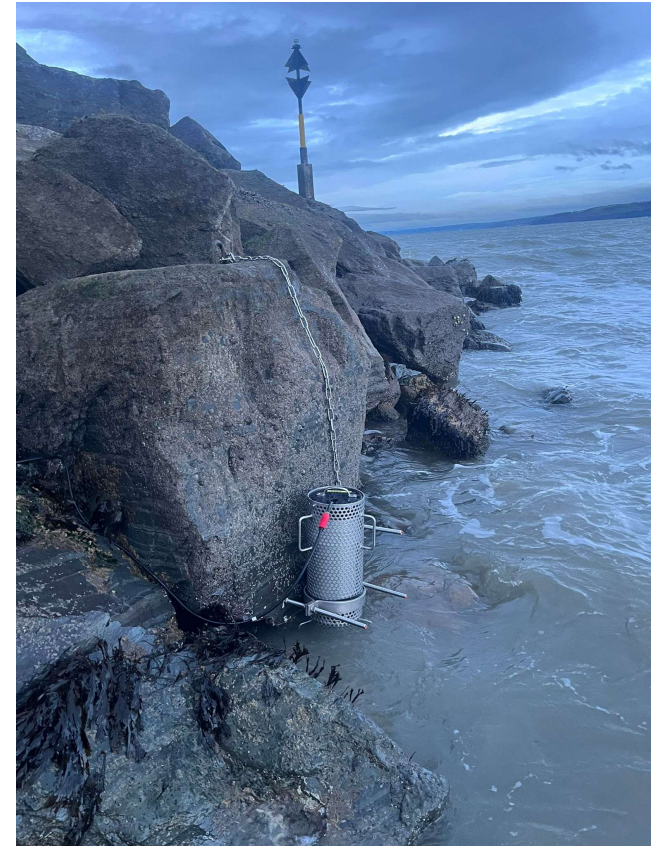
Aberystwyth



Coastal monitoring



New Quay



Ammonia sensor – coming soon

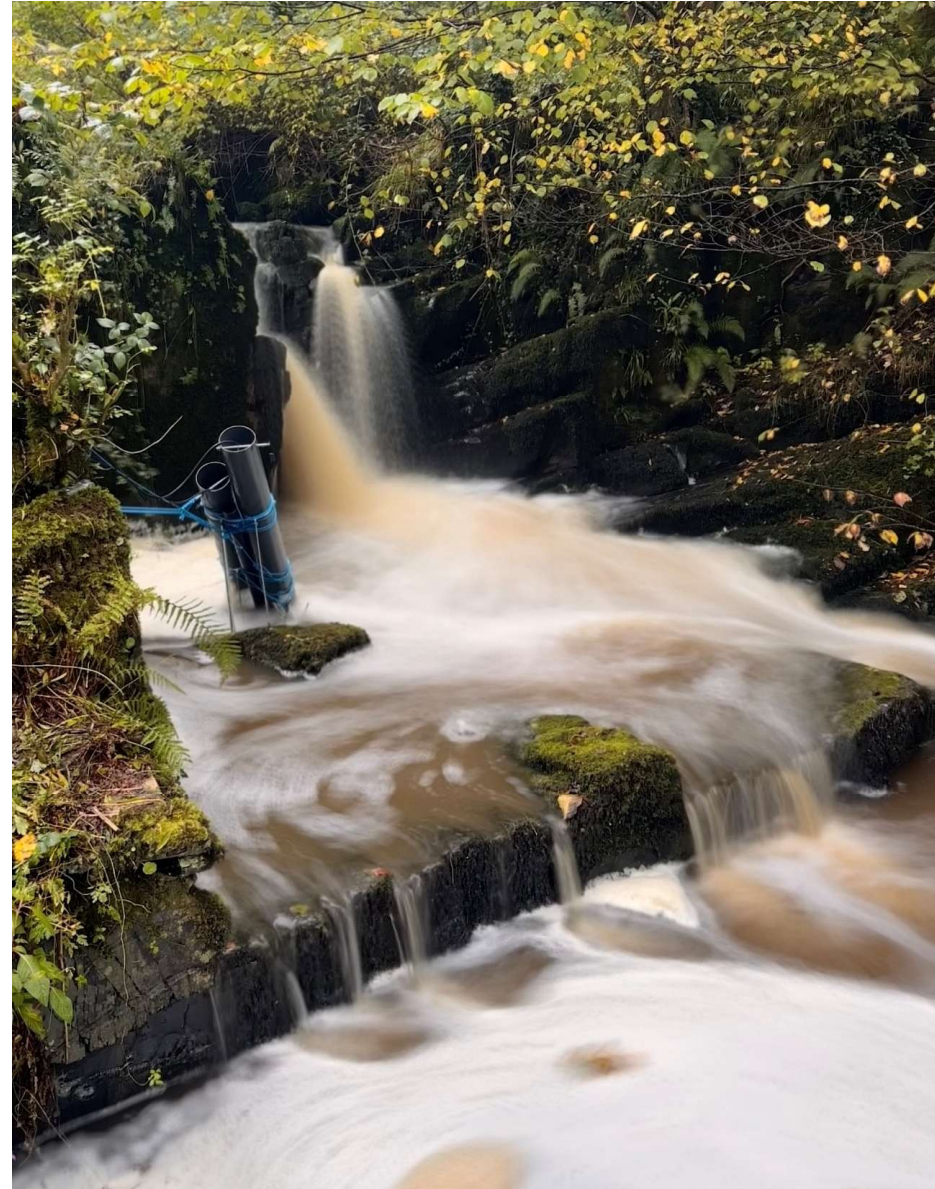


- Works in seawater and freshwater, measuring very low levels
- Microfluidic wet chemical approach – accurate and sensitive but no frequent calibration required.
- Existing ammonia sensors require recalibration approx. every 2 to 6 weeks – this one doesn't.
- Aiming to trial at one of the existing monitoring sites mid-2026.



Main findings

- Phosphate frequently exceeding SAC compliance targets
- Phosphate rapidly mobilized into the stream during storm events - nearby sources and a lack of buffering capacity
- Subsequent storms produced smaller phosphate peaks
- The two tributaries we monitor showed higher phosphate concentrations than the main flow of the Teifi.
- Riverbed sediments are a significant source of legacy P, which can be resuspended during high flow events
- Phosphate concentrations change rapidly - spot samples alone are a risky method for ensuring compliance





Thank you



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