SOUTH CUMBRIA RIVERS TRUST
UK and Ireland Lakes Conference

Challenges of restoring natural function, improving water quality and lake hydrology. An example from Elterwater, Cumbria

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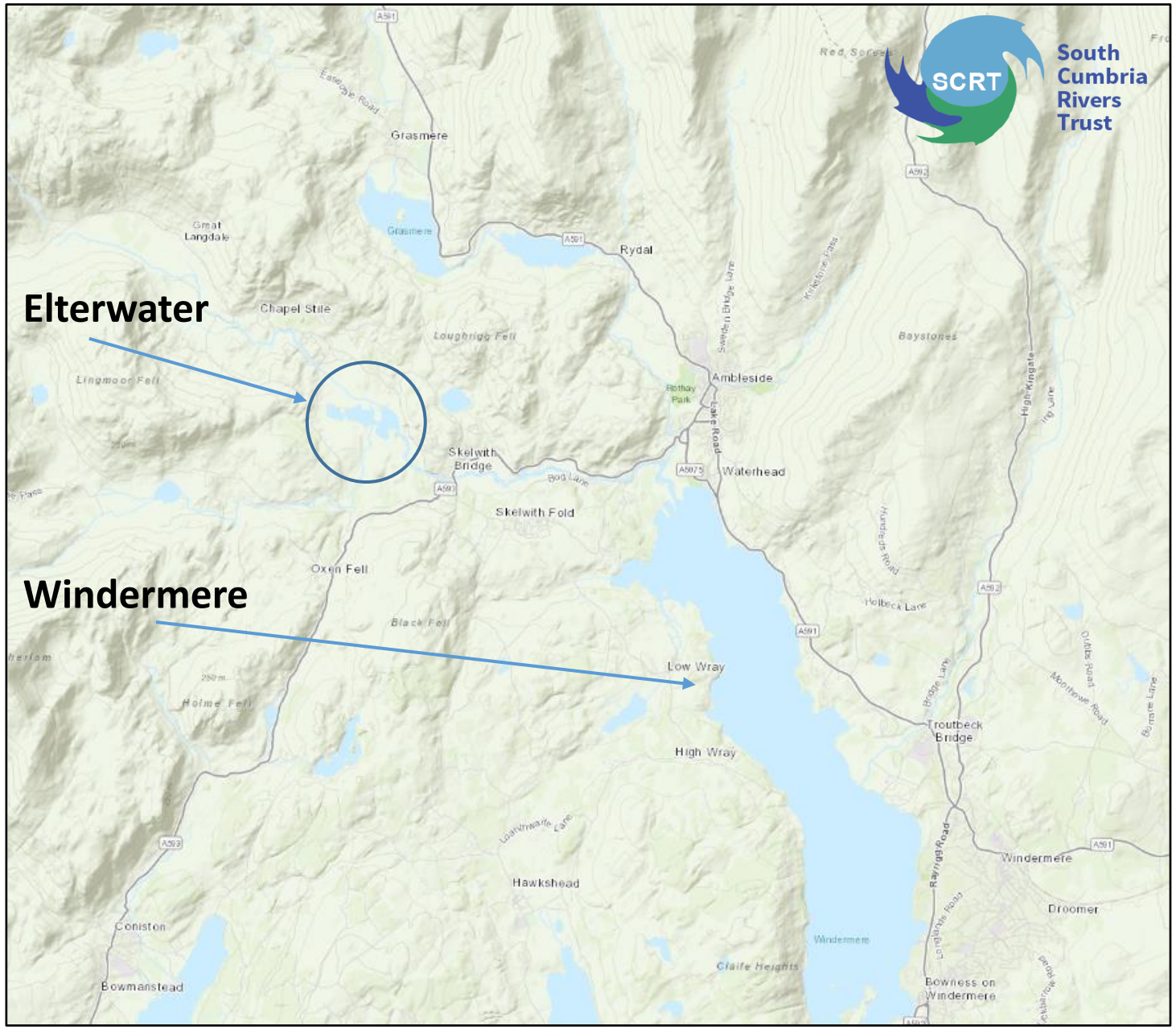
Elterwater

- Within the World Heritage Lake District
- A Site of Special Scientific Interest due to its nationally important lake edge vegetation communities
- Lake itself largely un-disturbed by tourism



Overview:

- Elterwater's inner basin received the discharge from Elterwater sewerage works from 1974 – 1999
- Residual phosphate residues in the sediment have led to algal blooms in inner and middle basin
- Residence time is estimated >50 days
- SSSI is 'un-favorable declining'
- Other impacts include physical modifications to the inflows of Great Langdale Beck and Little Langdale Beck which bypassed middle basin.

Map showing aerial photography of Elterwater.

Aims & Objectives:

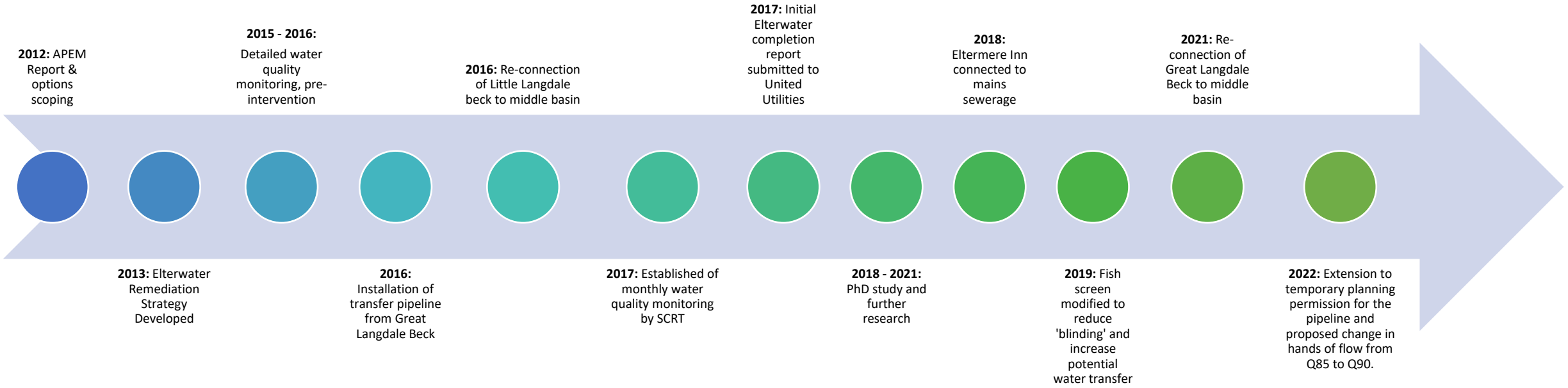
- Reduce P levels to 15µg/l: SSSI favourable condition & WFD standard for ‘good’. (In 2012 results were 19-23µg).
- Reduce the residence time in inner and middle basins
- Reduce the effects of stratification
- Return natural processes to the system

Steps taken so far:

- Feasibility study to assess options. Solution identified and funded by UU under the National Environment Programme.
- Installed a pipeline to transfer clean well-oxygenated water to the inner basin
- Re-connected Little Langdale beck to middle basin
- Created shallow scrapes to facilitate reconnection of Great Langdale beck to middle basin
- Removal of INNS (Japanese knotweed, Himalayan balsam, skunk cabbage all present)

Timeline of activity

10 years of restoration work.



Options review:

APEM 2012

Management Option	Nutrient Reduction Effectiveness	Probability of Success	Speed of Ecosystem Response	Environmental Impact	Community/ Social Impact	CAPEX	OPEX	Sustainability
Do Nothing	Zero	Zero	>5 - 14 years for an obvious recovery	Non-compliance with WFD water quality target post-2015. Likely on-going deterioration in SSSI condition.	Adverse, from on-going deterioration of site condition.	Zero	Zero	A low-impact option but unlikely to halt or reverse site condition deterioration.
Catchment Source Control	Very high for point sources (Sites 9 & 10). Less effective (moderate) for diffuse sources but can reduce diffuse sediment source 'hot spots'	Low in isolation but an important component in an overall suite of measures.	>1 - 5 years	Beneficial improvements in water quality. No adverse impacts predicted. Likely to assist with aiming to achieve WFD compliance.	Beneficial to the wider community if early engagement sought. Potentially adverse response from landowners/residents affected by improvement notices/enforcement.	Low Landowners and residents may incur costs.	Low, for routine monitoring & inspections	Very high. Natural England and Environment Agency already acting to rectify point source inputs to the Inner basin.
Sediment Nutrient Inactivation	Very high – can remove 90% of OP from the water column, and claimed to lock up sediment P for up to 10 years.	Moderate to high – but may require frequent re-treatment.	>1 – 3 years assuming high concentration of OP is taken up quickly and sediment P is locked up immediately.	Potentially adverse from addition of foreign materials into a natural environment with nature conservation designations. Could assist with aiming to achieve WFD compliance by 2015.	Uncertainty of adding chemicals to a natural lake. Beneficial impact from rapid response to treatment. Stakeholder acceptance could be compromised if viewed as a sticking plaster option rather than tackling fundamental causes.	Moderate to high depending on sediment depth treated. ~£50k per 0.1 m of sediment depth treated in the Inner basin. >£200k per 0.5 m of sediment depth treated in the Inner basin.	Repeated application may be required every 3 – 10 years.	Moderate to high cost, repeated applications and experimental nature of this approach result in low sustainability.

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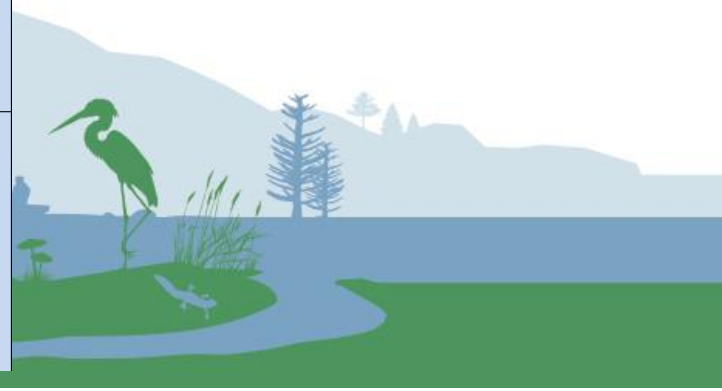
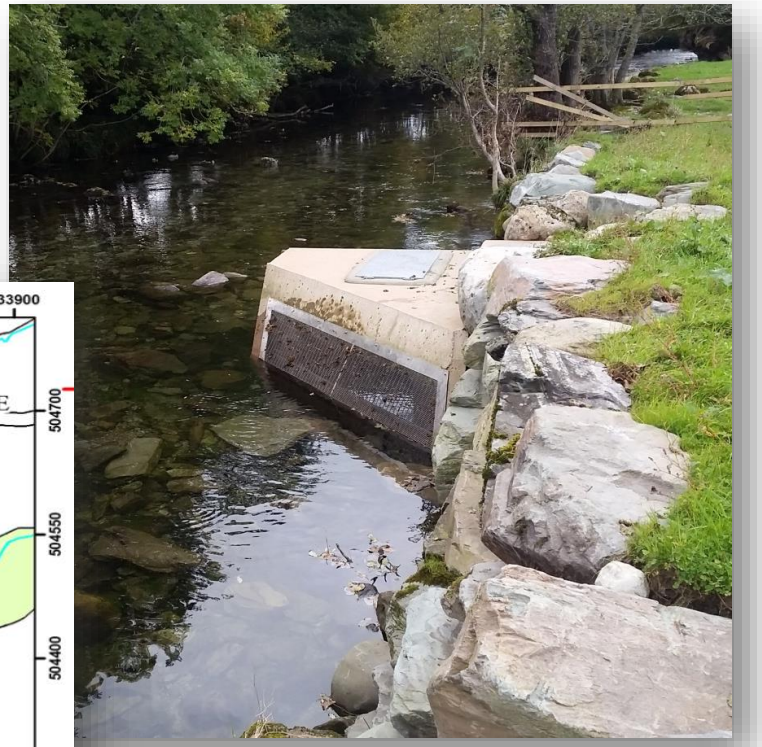
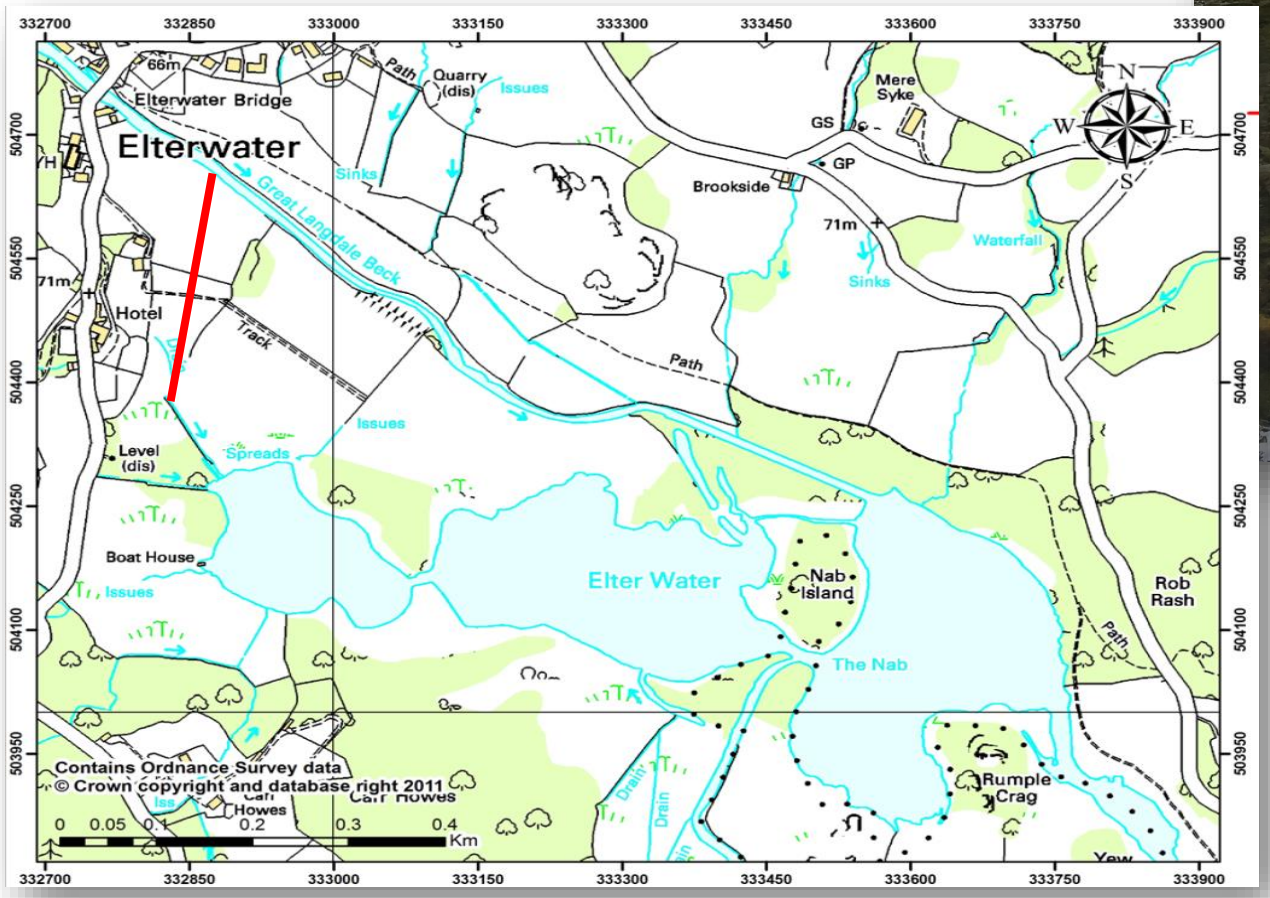
Bio-manipulation	Variable and difficult to accurately predict.	Low to moderate, requires continual management.	>2 - 5 years.	Environmentally benign unless non-native zebra mussels are introduced.	May receive community support as a low-impact option.	Moderate, to account for purchase of fish stock	Moderate – will require annual monitoring, management and possible replenishment of fish stocks	Moderate cost, uncertainty regarding nutrient reduction effectiveness, and likely low probability of success reduces the sustainability of this option.
Sediment Removal	Variable – some projects are highly successful while others are not. Difficult to determine factors for success and thus predict outcomes.	Moderate, but some evidence suggests that sediment nutrient concentrations can rapidly return to pre-dredging levels.	>1 – 3 years.	Adverse impacts include damaging the lake lining, sediment disturbance, construction of large dewatering lagoons, sediment disposal to landfill, nutrient leakage. Potential short term adverse impacts to habitats, protected species, and SSSI values. Could assist with aiming to achieve WFD compliance.	Potential difficulty with sludge dewatering, reuse or disposal options. Potentially adverse aesthetics of dredging activity. Impacts to habitats, protected species and SSSI issues.	>£100k for 2,000 m^3 of high-P sediment in the Inner basin. >£1M and >£2M for removal of 1 m depth throughout Inner and Middle basins respectively. Sediment dewatering costs to be determined. Sediment disposal to landfill - estimated cost approximately £120/tonne.	Zero (but may require subsequent dredging as sediment once again accumulates over time)	Potentially sustainable if successful but likely high carbon cost for sediment dewatering and disposal, plus adverse impacts (including to SSSI and adjacent land) reduce the sustainability of this option.
Inflow Re-configuration	High to very high depending on flushing rate.	High to very high.	>1 – 3 years assuming thermal stratification and sediment nutrient release prevented or minimised immediately.	Likely to assist with aiming to achieve WFD compliance. Potential impact of flushing nutrients to Outer basin (compromising	Restoring natural flow regime to Middle basin likely to be received positively. Increasing flushing of	Very high (>£500k) depending on extent of assessment & engineering required.	Low	A high cost but sustainable long-term option if impacts to Windermere are not significant.



Transfer Pipeline





Transfers clean well-oxygenated water from Great Langdale beck into the Inner basin of Elterwater.

Temporary abstraction licence.

Installed in Jan 2016.

Paleochannel reconnections

Little Langdale Beck

Channel diverted in 1850s

Old channel silted and vegetated

Channel reconnected in 2016

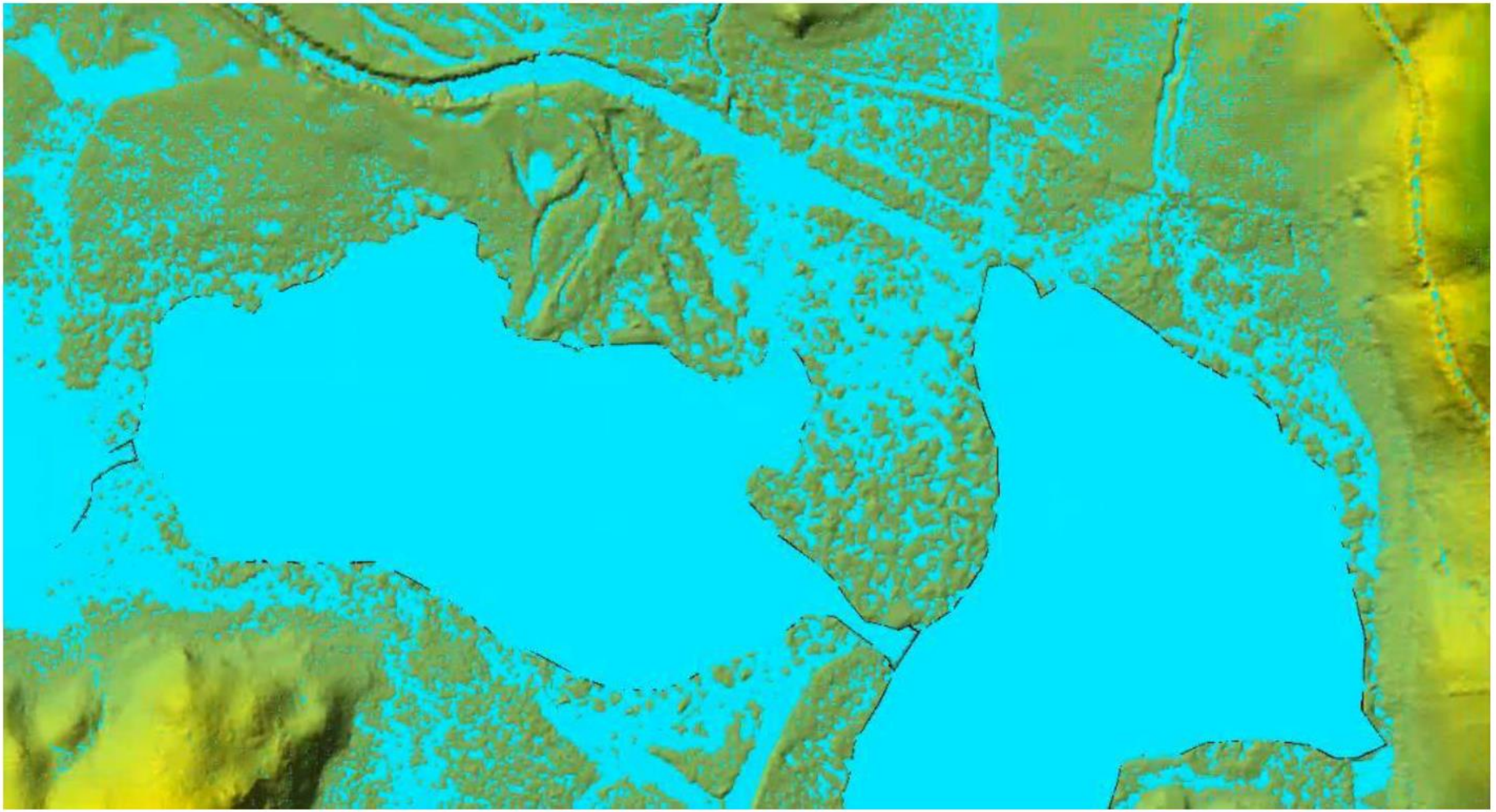


Figure 3.2. Rainfall inundation map of the Elter Water fan zone.

Monitoring

Sampling programme:

- Pre-intervention – fortnightly sampling across three basins
- Post – intervention - Monthly samples in inner basin and at outfall

<u>Post-Intervention:</u>

- Phosphorus monitoring
- Chlorophyll and turbidity monitoring
- Water quality parameter monitoring at depth
- Water level monitoring through transfer pipe

- Repeat sediment survey was undertaken in 2019.

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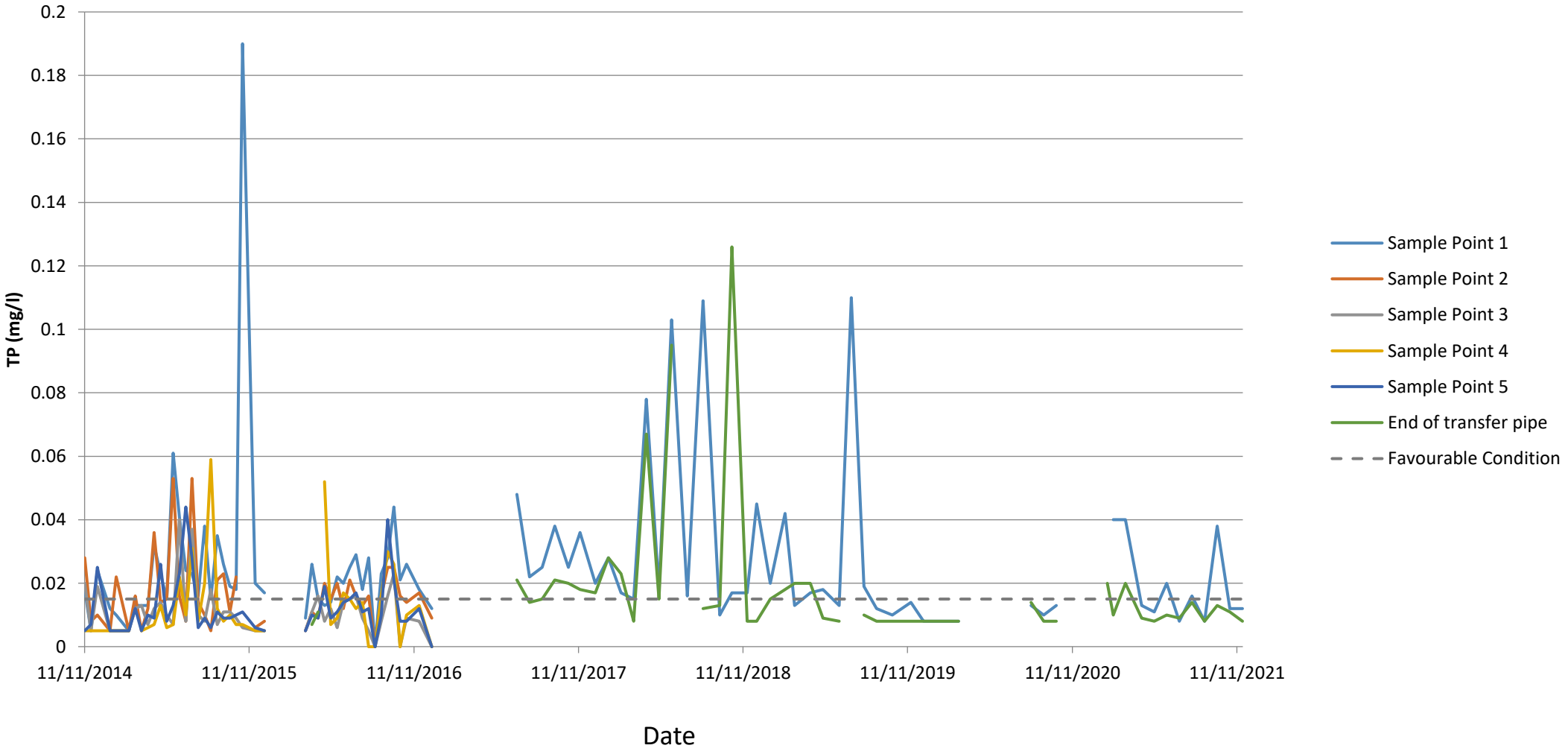
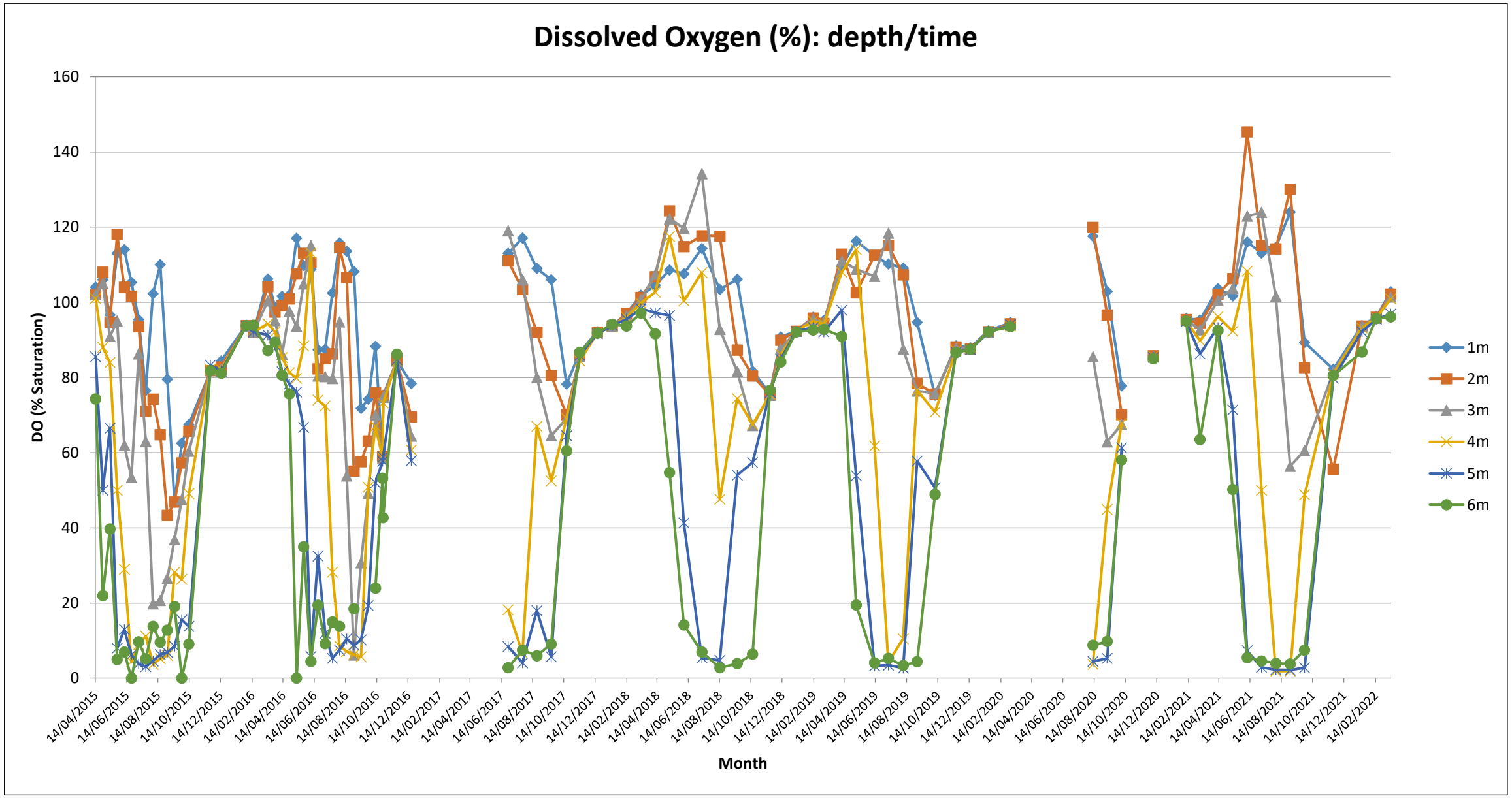
Total Phosphorus




Dissolved Oxygen (%): depth/time
DO (% Saturation)
160
140
120
100
80
60
40
20
0
14/04/2015
14/06/2015
14/08/2015
14/10/2015
14/12/2015
14/02/2016
14/04/2016
14/06/2016
14/08/2016
14/10/2016
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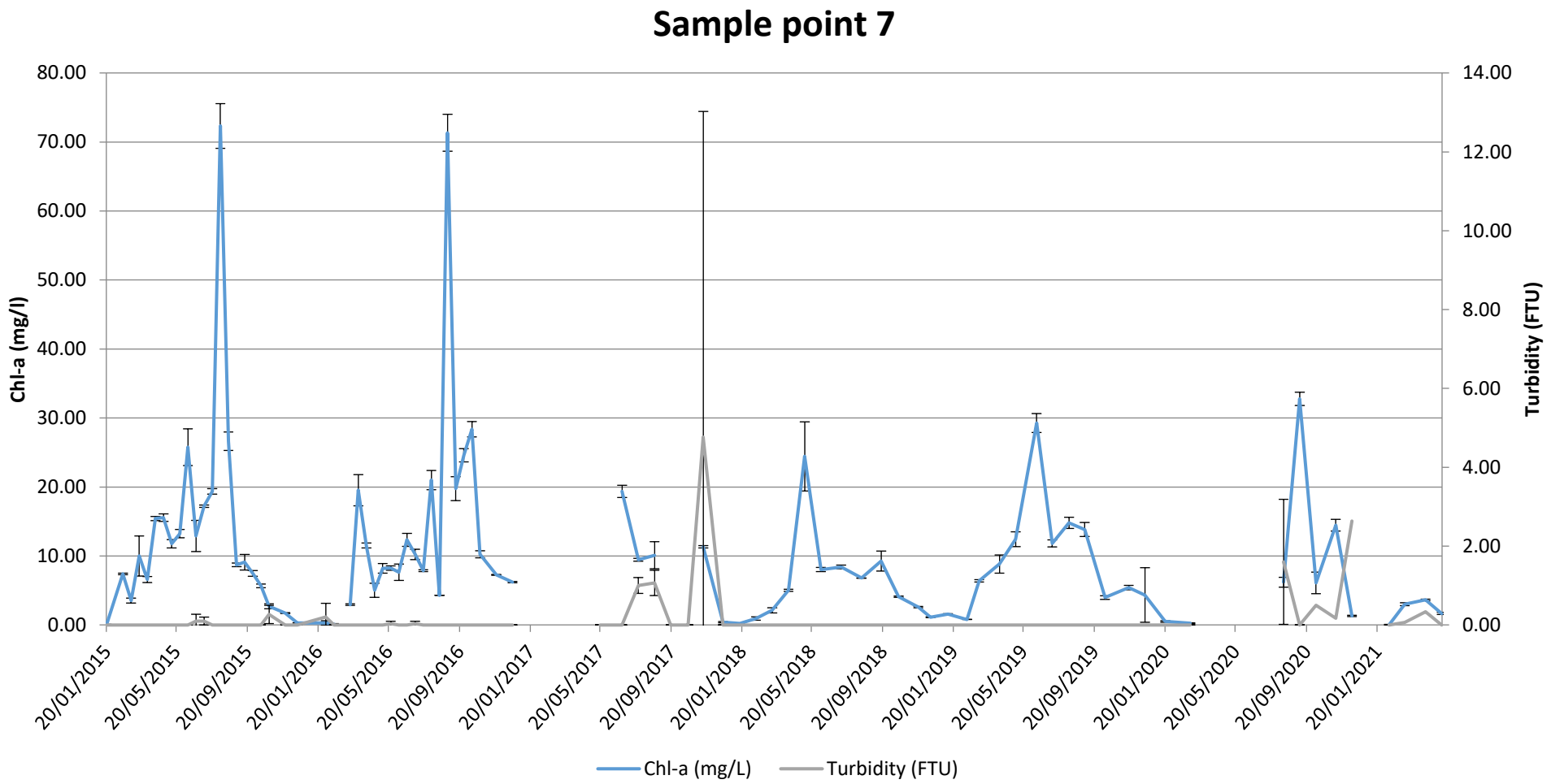
14/12/2020
14/02/2021
14/04/2021
14/06/2021
14/08/2021
14/10/2021
14/12/2021
14/02/2022
Month
1m
2m
3m
4m
5m
6m

Chlorophyll- a – Middle of Inner Basin



Next Steps

- Installation of large woody debris into Great Langdale beck to aid connection of scrapes.
- Altering the hands off flow for the transfer pipe to extend the period we can abstract water, especially during summer months.
- On-going monitoring until 2025 and repeat sediment survey.
- Review data and decommissioning of pipeline

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THANK YOU

ANY QUESTIONS?

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