ROADSIDE SEDIMENT TRAP, SALLE PARK ESTATE, NORFOLK

River Wensum DTC

Research Update 4

DECEMBER 2017

Roadside sediment traps protect the River Blackwater

The River Wensum experiences excessive sediment loading which causes an array of detrimental impacts that threaten sustainable ecosystem functioning. In order to determine the provenance of this sediment, a novel sediment fingerprinting technique was employed on the upper reaches of the River Blackwater Tributary between 2012 and 2015 to accurately derive high-temporal resolution (60–120 min) sediment source apportionment estimates throughout the progression of 14 individual storm events. The results identified arable topsoils and, notably, road verges as major contributors of suspended sediment during heavy precipitation events, whilst subsurface sources (i.e. river channel banks and agricultural field drains) dominate sediment supply under lower baseflow conditions.

Furthermore, catchment walkover surveys revealed soil from damaged road verges, field entrances and areas of concrete hardstanding is washed down roads during heavy rainfall events and into roadside ditches where it discharges directly into the river at sediment concentrations of up to 1,500 mg L^{-1}.

In order to tackle the problem, in October 2016 three large roadside sediment traps were constructed on the Salle Park Estate to capture road runoff before it enters the river. The sediment traps were funded by Norfolk Rivers Trust and the Broadland Catchment Partnership through the '*Slow the Flow*' project at a cost of approximately **£15,000**.

The traps act as settling ponds to encourage the entrained sediment to settle out of suspension and allow cleaner water to discharge into the river. Two types of trap design were trialled; a smaller conventional linear pond (approx. 30 m length, 4 m width, 1.5 m depth) with shallow and deep sections to promote enhanced settling over deeper pools; and two larger 'U'-shaped constructions (approx. 50 m length, 7 m wide, 2 m depth) which increase the transit time of water through the trap, dissipating kinetic energy and thus initiating greater sedimentation rates.

To monitor the effectiveness of the sediment traps, new high-resolution turbidity probes were installed upstream and downstream of the site at a bankside monitoring kiosk so that trap performance during rainfall events could be closely monitored. Water and sediment samples from both within the traps and from the trap outflows were also collected on

Wensum Alliance

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DEMONSTRATION TEST CATCHMENTS

The Demonstration Test Catchments (DTCs) are a £7.5 m research platform established by DEFRA in 2010 to investigate the extent to which on-farm mitigation measures can cost-effectively reduce the impact of diffuse water pollution on river ecology whilst maintaining food production capacity.

Four DTCs were established across the UK to provide an evidence base for farming in contrasting agricultural systems. These were:

- River Wensum, Norfolk (arable)
- River Eden, Cumbria (upland)
- River Avon, Hampshire (mixed dairy)
- River Tamar, Devon (livestock)

FURTHER DETAILS:
http://www.wensumalliance.org.uk/

FAST FACTS

7,253 kg

Mass of sediment retained by trap 3 during first 12 months

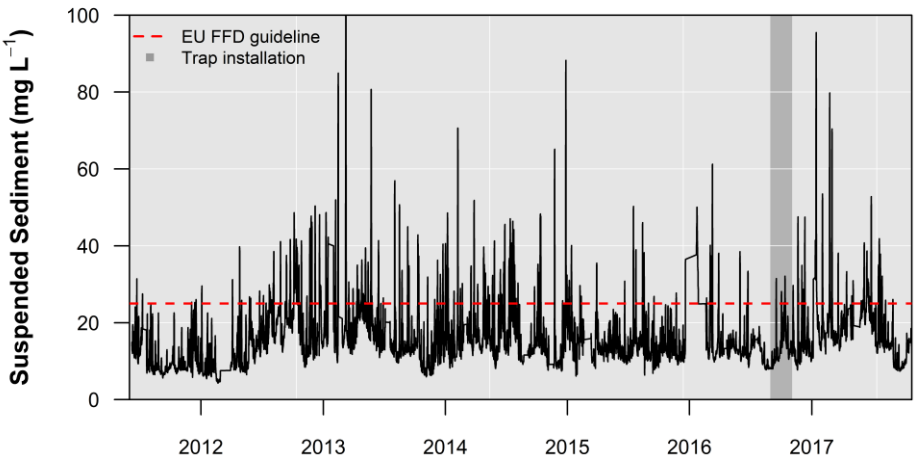

Figure 1: Suspended sediment concentrations recorded in the River Blackwater downstream of the roadside sediment traps before (June 2011 – August 2016) and after (November 2016 – October 2017) trap installation. The European Union Freshwater Fisheries Directive (2006/44/EC) guideline maximum value of 25 mg L^{-1} in waters suitable for salmonid and cyprinid fish populations is also shown.

weekly to monthly intervals and analysed for nitrogen, phosphorus and organic matter concentrations to determine the mass of nutrients being captured and retained by the traps and thus prevented from entering the river. DEFRA's 2014 economic damage costs were then applied to the mass of sediment (£54 per tonne) and phosphorus (£12,790 per tonne) retained as part of a cost-benefit analysis.

Trap retention

Retention rates were solely calculated for trap 3 as this was the trap which received the vast majority (>80%) of the road runoff. After the first 12 months of operation, trap 3 retained 7,253 kg of sediment, 400 kg of organic carbon and 11.6 kg of total phosphorus **(Table 1)**. In comparison, the River Blackwater 800 m downstream of the traps exported just 6,300 kg of suspended sediment during this same period (2016-2017), compared to an average annual export of 15,000 kg during the previous 5 years (2011-2016). This indicates that trap 3 has successfully reduced sediment load into the River Blackwater by ~50%.

Table 1: Trap 3 retention rates and economic damage costs for the first 12 months of operation (November 2016 – October 2017).

Parameter	Retention (kg/year)	DEFRA damage cost (£/year)
Sediment	7,253	392
Total phosphorus	11.6	148
Organic carbon	400	-
		Total £540

The damage costs associated with this retention were £392 for sediment and £148 for phosphorus, thus giving a total damage cost mitigated by trap 3 of £540 per year. With trap 3 costing ~£5,000 to construct, this mitigated damage cost would imply a payback time of 9 years.

River impacts

Initial monitoring results for the river reveal a slightly more complex picture to sediment trap performance due largely to the very dry conditions experienced within the catchment since trap installation (November 2016 – October 2017).

Mean suspended sediment load transported by the River Blackwater downstream of the traps was 58% lower post-installation (6,300 kg/year) than pre-installation (15,000 kg/year), revealing less sediment was being lost from the catchment **(Table 2)**. However, this reduced load was in part due to reduced mean river flows which were 62% lower after the traps were installed (10.2 L/s) than the average river flow for the preceding 5 years (26.5 L/s; 2011-2016).

These reduced flows in turn impacted upon average suspended sediment concentrations **(Figure 1)** which were 14% higher post-installation (18.2 mg/L) than recorded pre-installation (15.9 mg/L). This is likely due to lower water levels having the effect of concentrating the particulate material being carried downstream. Mean turbidity values were similarly 17%

Sediment trap 1

Sediment trap 2

Sediment trap 3

Road runoff

FAST FACTS

£540

Damage cost mitigated by trap 3 for sediment and phosphorus

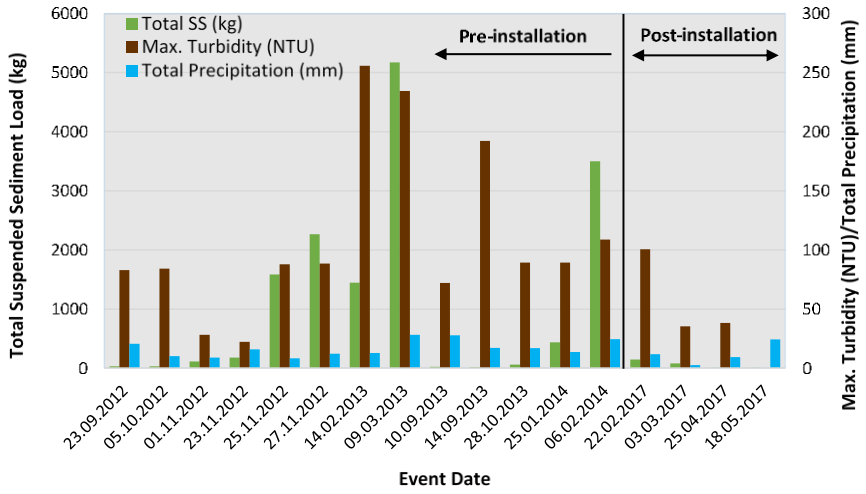

Figure 2: Total suspended sediment load and maximum turbidity values recorded in the River Blackwater downstream of the sediment traps during 18 precipitation events (13 prior to trap installation, 5 post installation) between 2012 and 2017.

higher post-installation (11.6 NTU) relative to pre-installation (9.9 NTU).

Nevertheless, focussing solely upon data collected during heavy rainfall events **(Figure 2)** revealed a reduction in both total suspended sediment load and maximum turbidity values downstream of the traps, with turbidity values not exceeding 100 NTU since the trap installation

Furthermore, additional sediment fingerprinting research carried out since trap installation revealed an overall decrease in sediment source contributions from damaged road verges downstream of the traps and an increase in relative contributions from eroding river channel banks, thus confirming the traps are capturing road runoff material during storm events. Contributions from arable topsoil material (also transported along roads) varied highly between different storm events, but in general topsoil contributions were significantly lower after trap installation than previously recorded.

Future work

Further monitoring of turbidity levels and suspended sediment concentrations in the River Blackwater will need to be conducted across of wider range of flow conditions before a robust and realistic assessment of trap performance on the river itself can be made. In particular, it is expected that trap performance will improve further once vegetation establishes itself on and within the sediment traps. The vegetation will act to stabilise the currently exposed banks of the traps, thus reducing the risk of erosion, and will also increase resistance to water flow through the traps, thus reducing kinetic energy and promoting increased sedimentation.

Further updates on trap performance will be released in 2018.

Table 2: Average flow, turbidity, suspended sediment concentration and sediment load in the River Blackwater 800 m downstream of the roadside sediment traps.

Mean parameter	Pre-installation Jun' 11 – Aug' 16	Post-installation Nov' 16 – Oct' 17
Flow (L s^{-1})	26.5	10.2
Turbidity (NTU)	9.9	11.6
Suspended sediment (mg L^{-1})	15.9	18.2
Sediment load (kg y^{-1})	15,000	6,300

FOR MORE INFORMATION

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