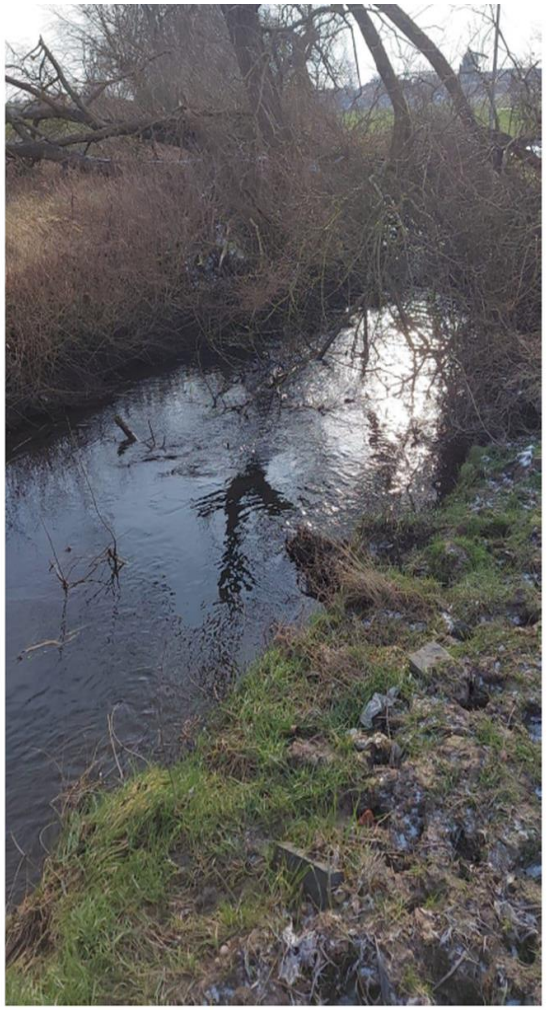
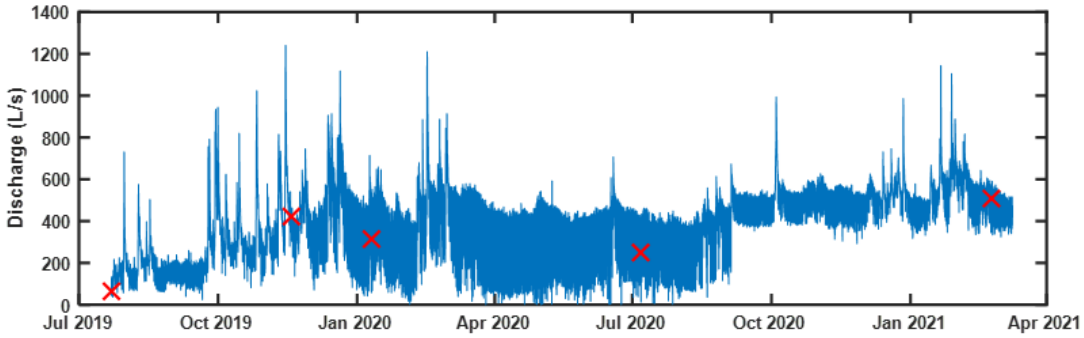
UNIVERSITY OF BIRMINGHAM

Microplastic accumulation in streambed sediment downstream of a wastewater treatment plant in response to dynamic flow conditions



Jen Drummond,Uwe Schneidewind, Nicolai Brekenfeld, Holly Nel, Lee Haverson, Anna Kukkola, Greg Sambrook-Smith, Stefan Krause

EGU 2022

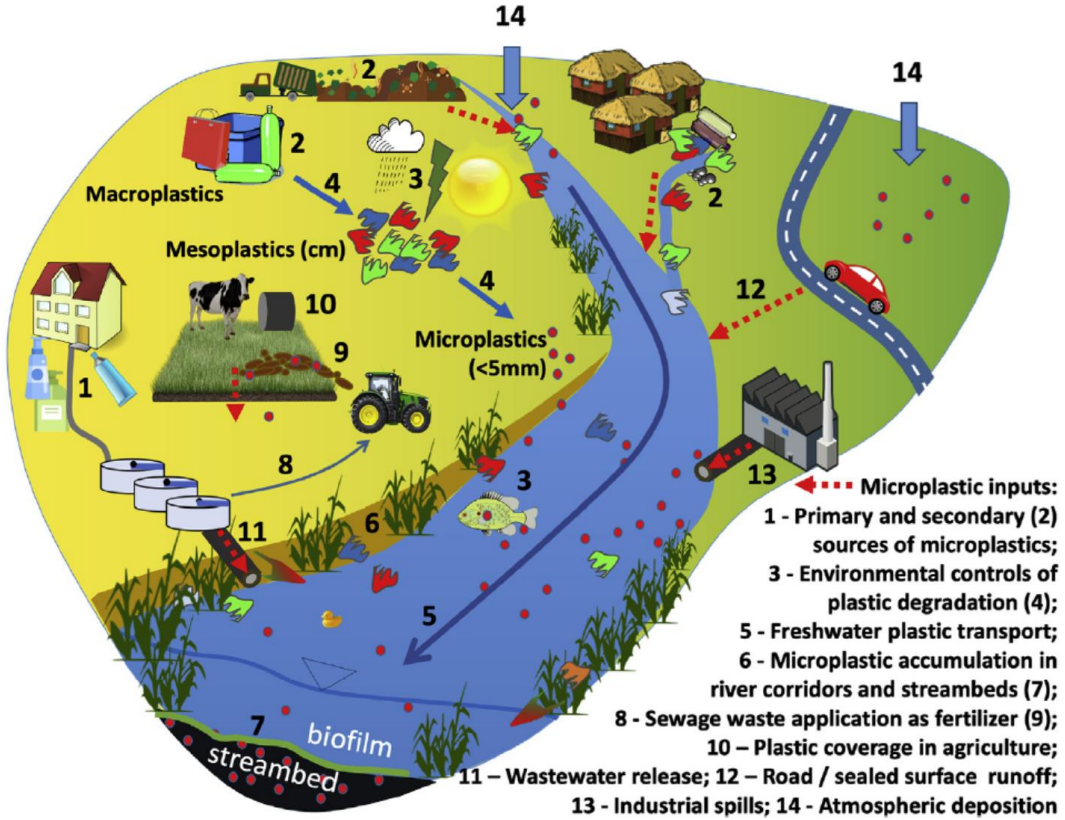


@jddrummo

Motivation

- Wastewater treatment plant (WWTP) effluents are point sources of microplastics (1 – 1000 µm).

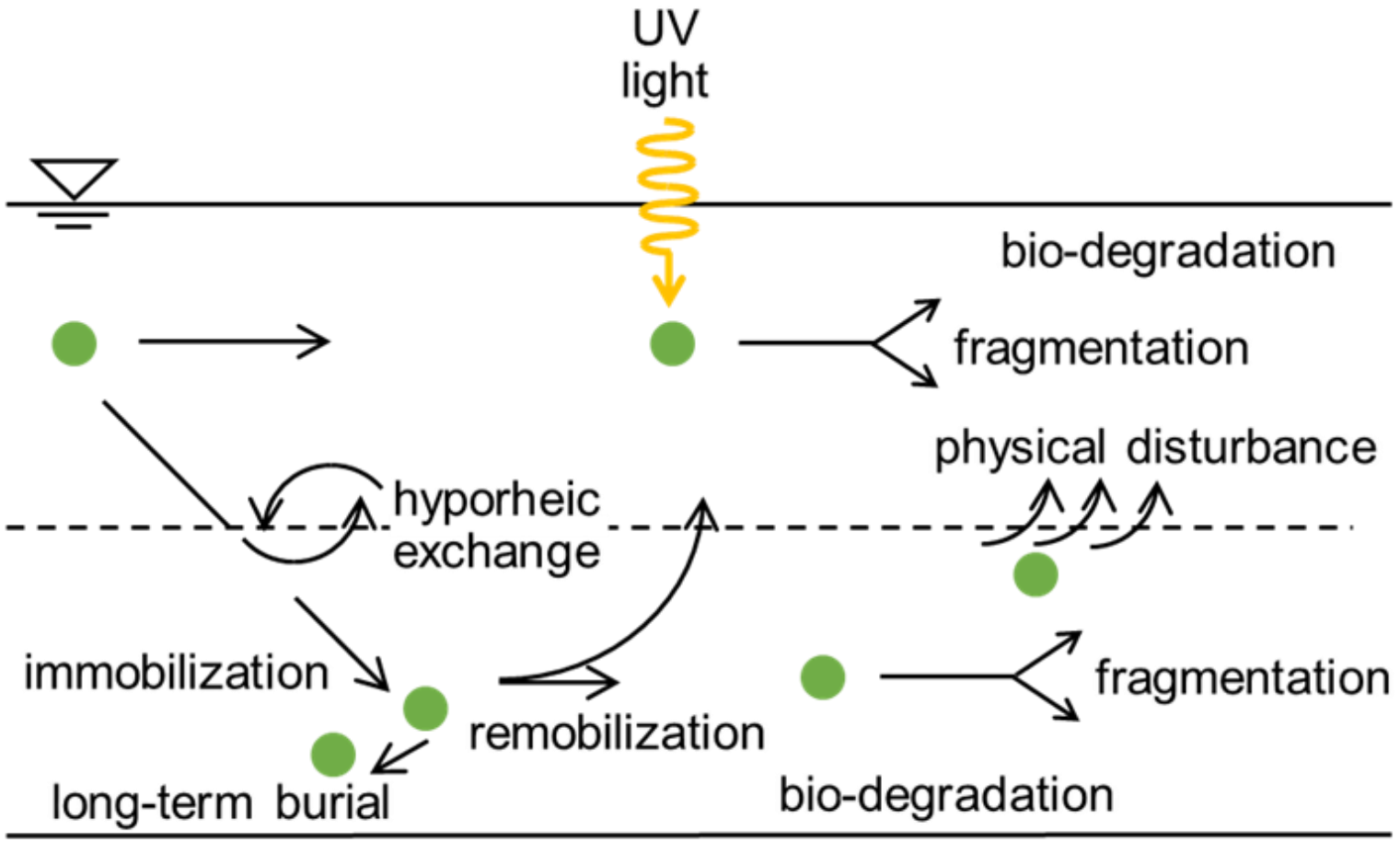
- Microplastic persistence is a function of transport processes during baseflow and stormflow



Krause et al. 2021 *Environmental Pollution*

Hypothesis: The combination of *field sampling* and *modeling* can provide a continuous estimate of microplastic concentrations in surface water and sediments to predict microplastic fate in streams.

Microplastic transport and retention in streams

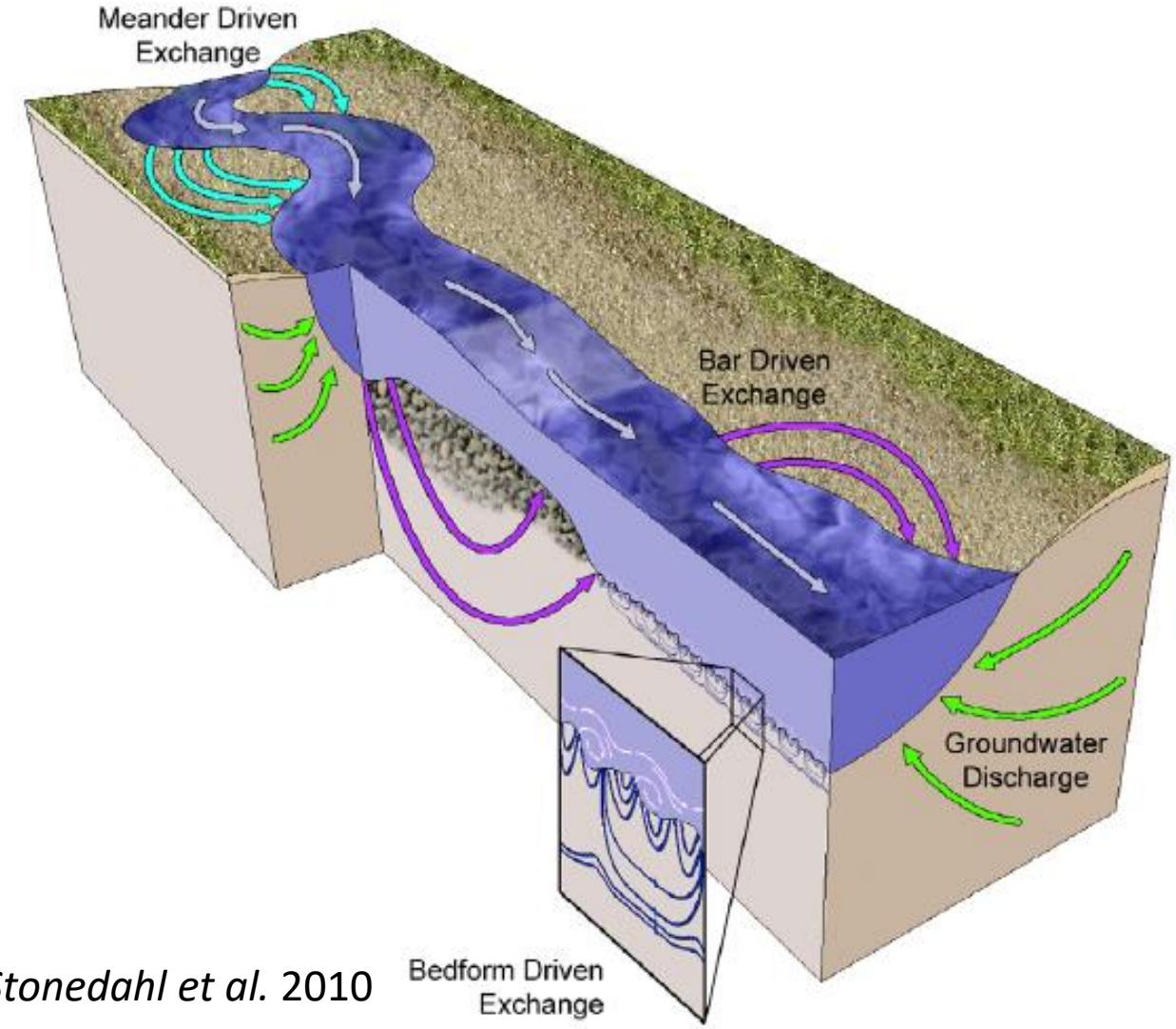


There are a wide range of processes that influence microplastic fate in streams

How does hyporheic exchange influence microplastic transport and persistence in streams?

Drummond et al., 2022 *Science Advances*

Hyporheic exchange is the transport of surface water through sediments in flow paths that return to surface water

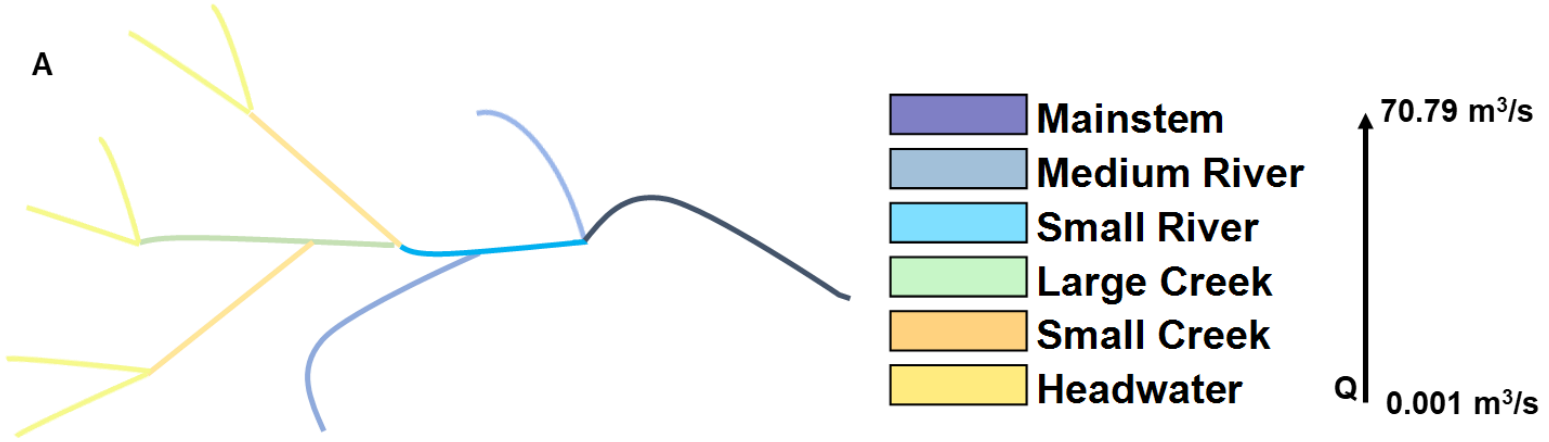


Stonedahl et al. 2010

- Hyporheic exchange influences downstream transmission of microplastics
- Gravitational settling (hours), hyporheic exchange (seconds)

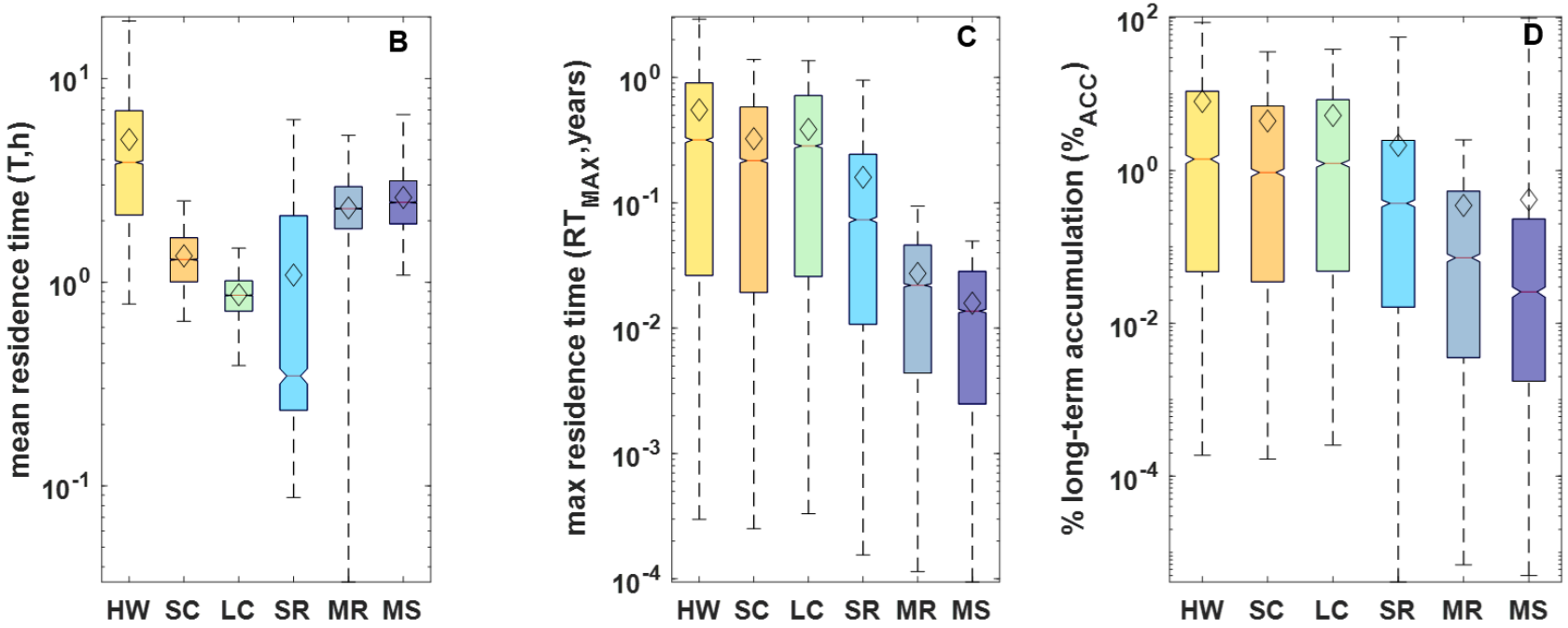
Rivers accumulate large amounts of microplastics

- ~ 5% of microplastic inputs per river km accumulate long term (> 300 years)



- Headwaters → residence times ~5 h/ km but up to 7 years/km during low flow

How does microplastic fate change under dynamic flow conditions?

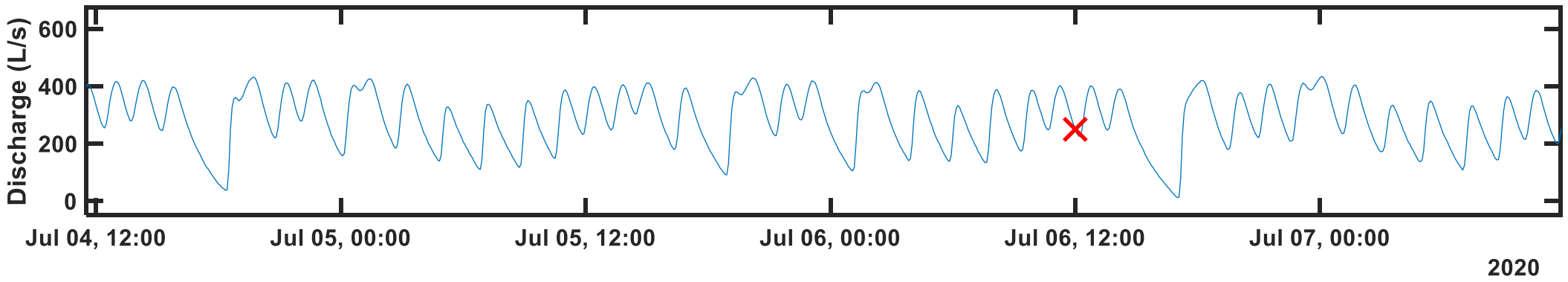


Drummond et al., 2022 Science Advances

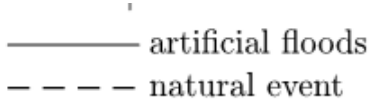
MAIN OBJECTIVES

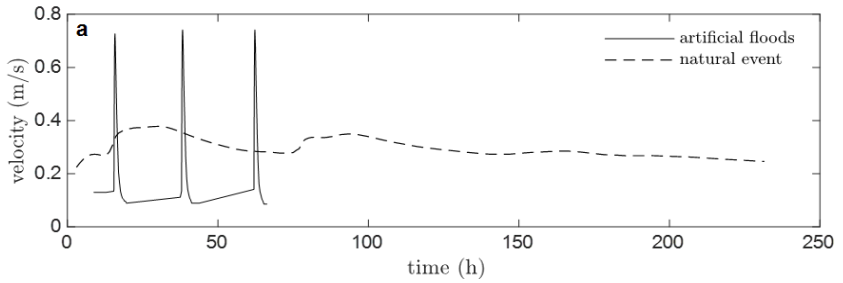
1) Measure microplastic persistence downstream of a wastewater treatment plant

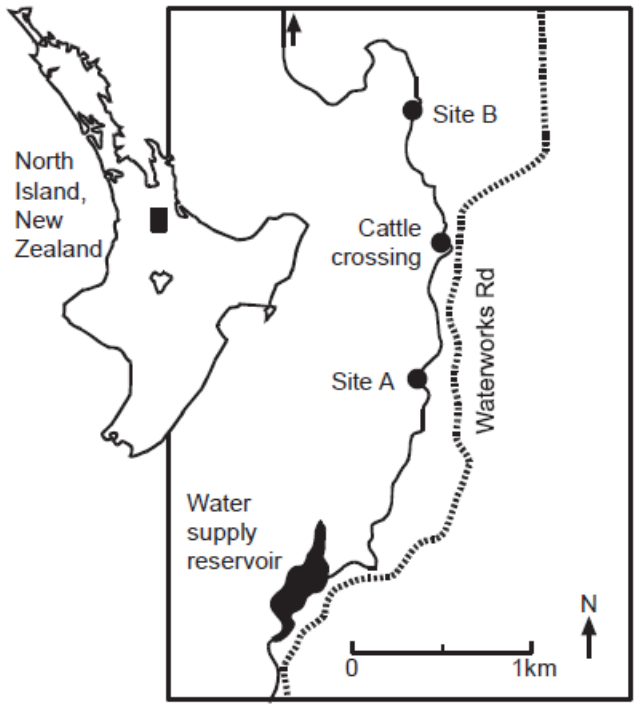
2) Simulate microplastic transport (deposition, resuspension) during **dynamic** flow conditions to predict microplastic presence continuously in surface water, hyporheic sediments, and deeper sediments

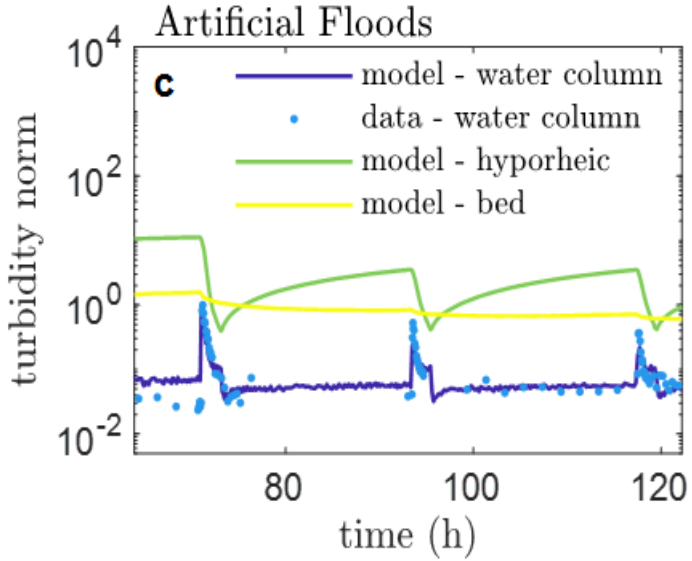


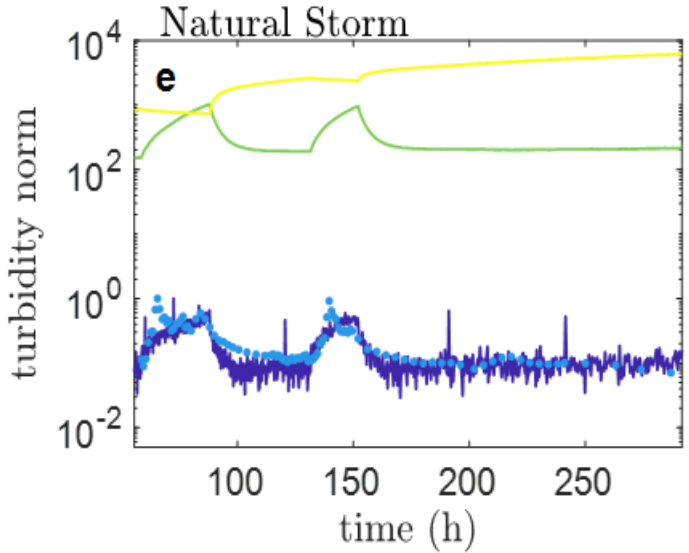
Validated particle tracking mobile-immobile model with artificial floods and natural storm events measuring *E. coli* and turbidity (fine sediments)





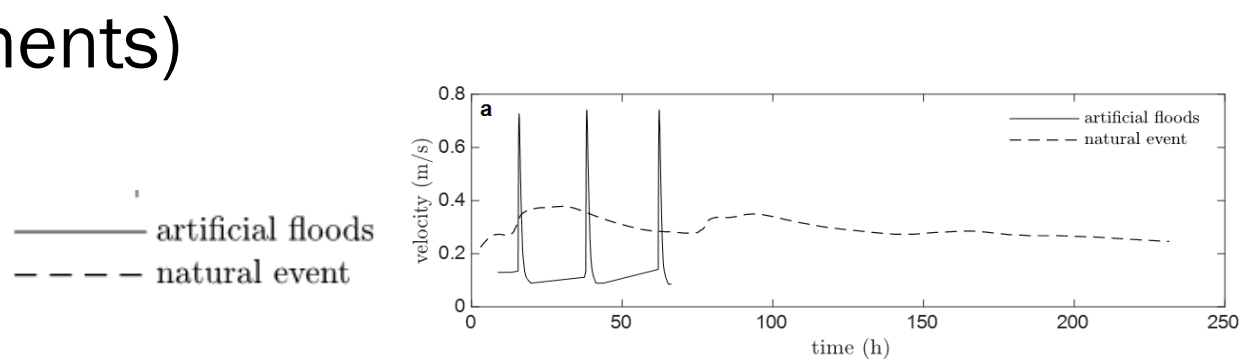


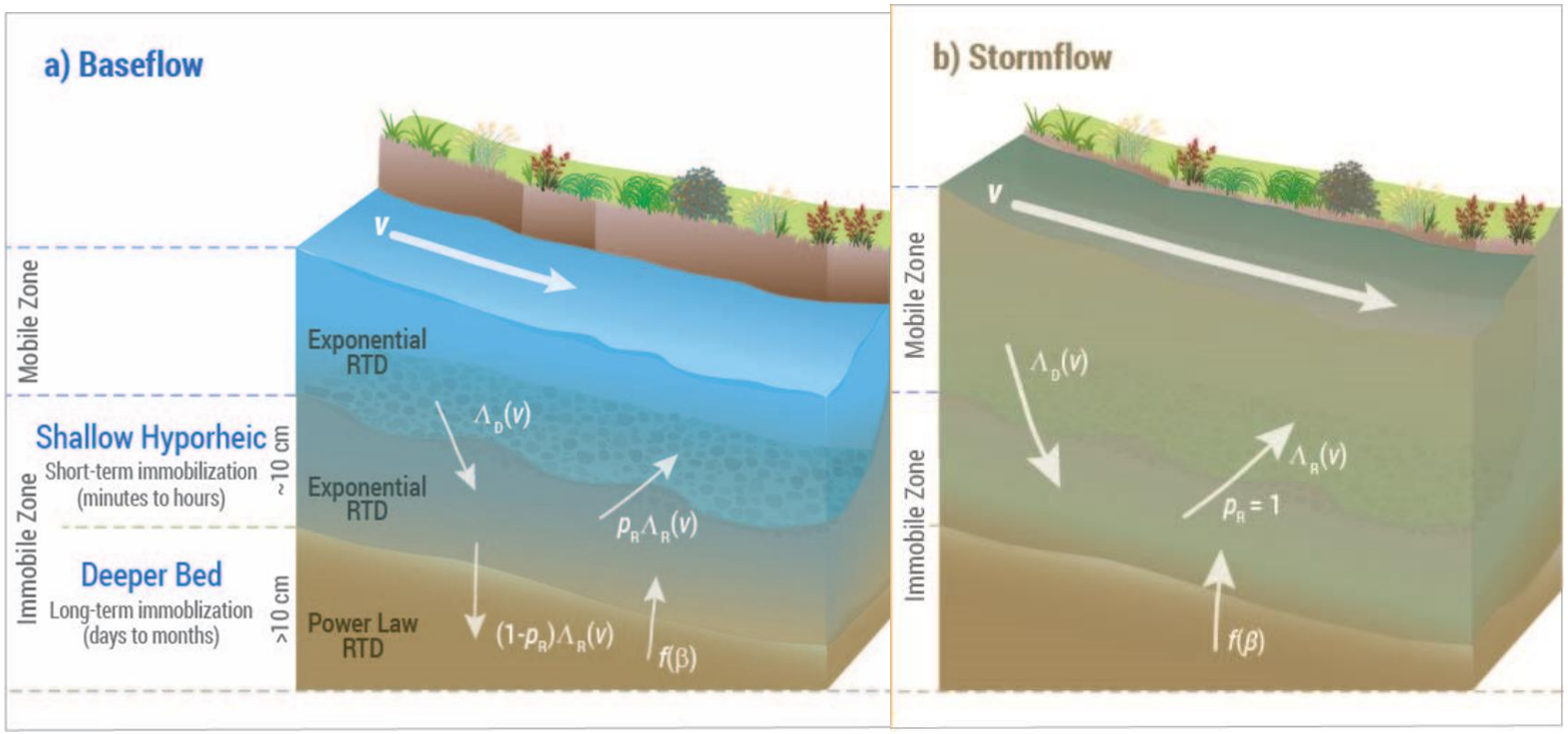


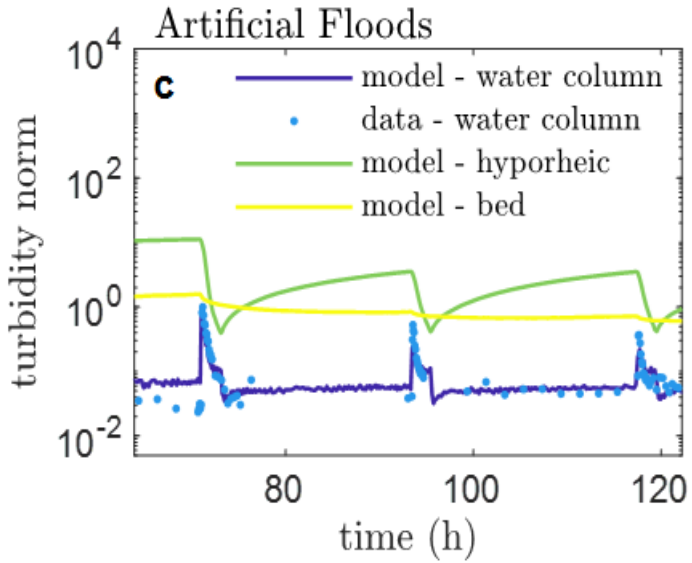


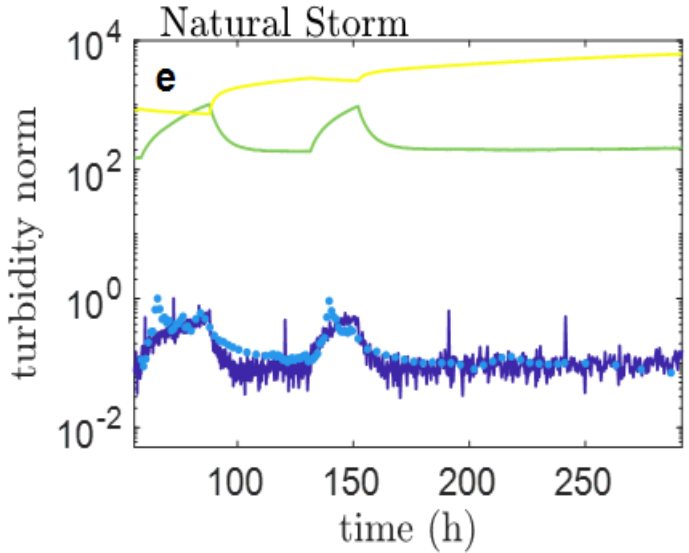
Drummond et al. 2022 GRL
Muirhead et al. 2001

Validated particle tracking mobile-immobile model with artificial floods and natural storm events measuring *E. coli* and turbidity (fine sediments)



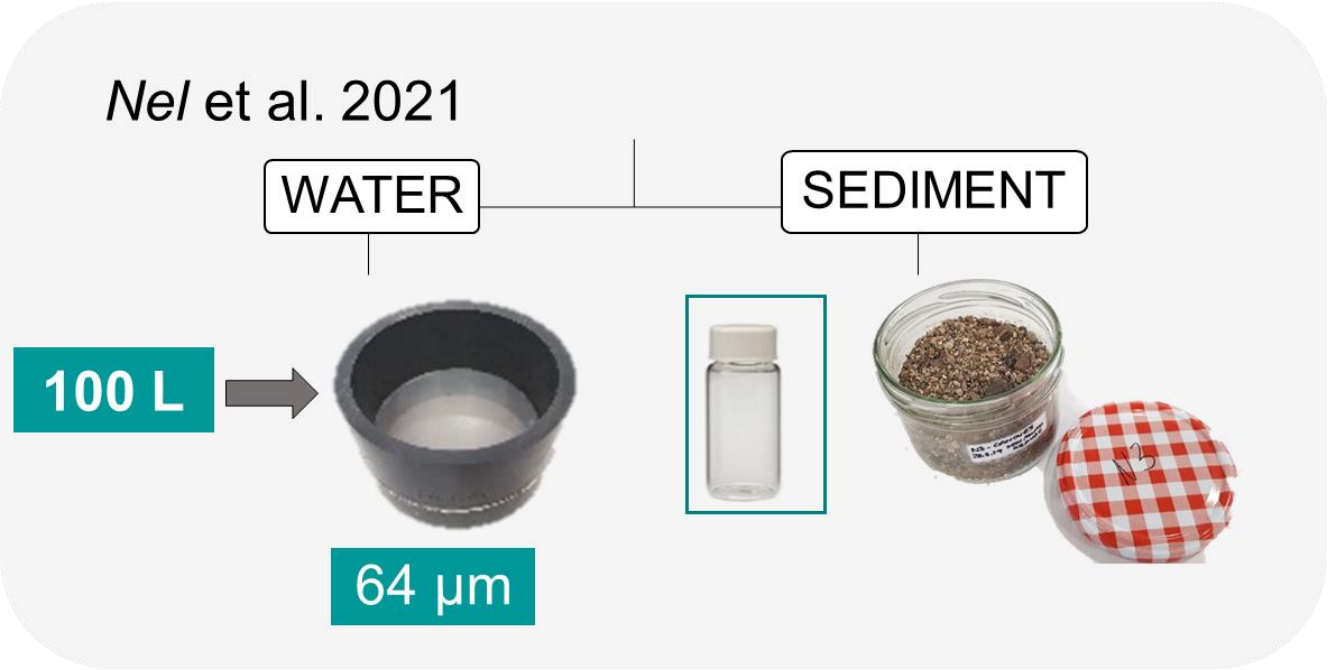






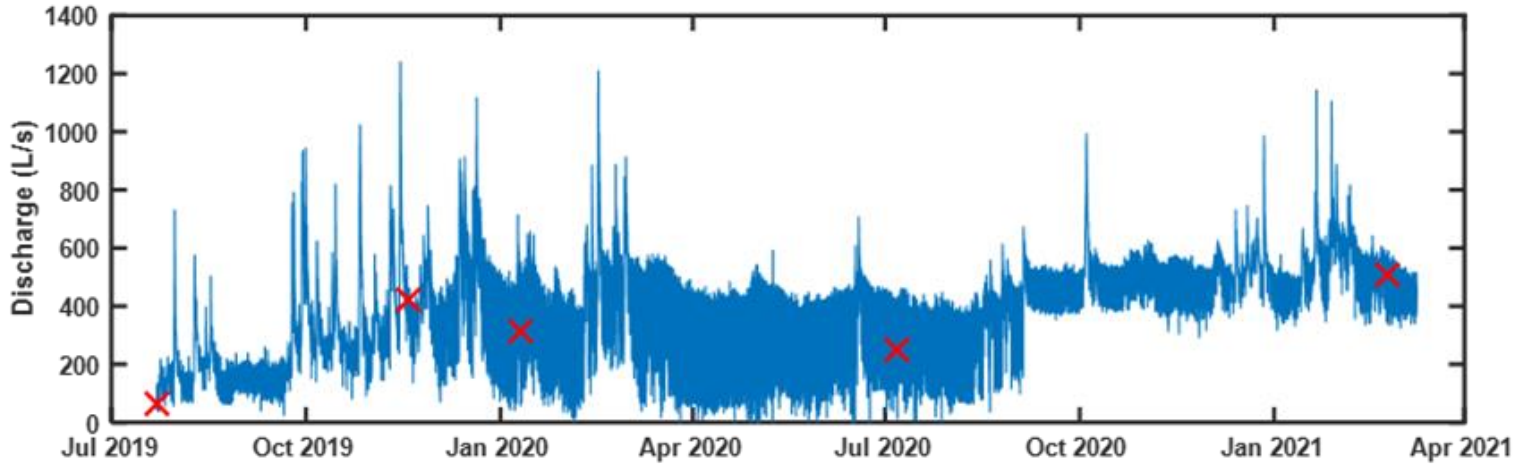
Drummond et al. 2022 GRL
Muirhead et al. 2001

Field sampling & Methods



- From 2019-2021, water and sediment samples were collected ~1 km below the WWTP point source.

- Semi-continuous measurements of flow and electrical conductivity characterized the stream hydrologic conditions



Lab methods

Extraction

Sediment Microplastic Isolation (SMI) Unit, 30 g sediment + $ZnCl_2$

Coppock et al. 2017

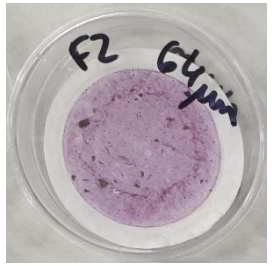
64 µm

Digestion

H_2O_2 30% + Fe^{2+} (0’05M)

NOAA, 2015

Staining and Counting

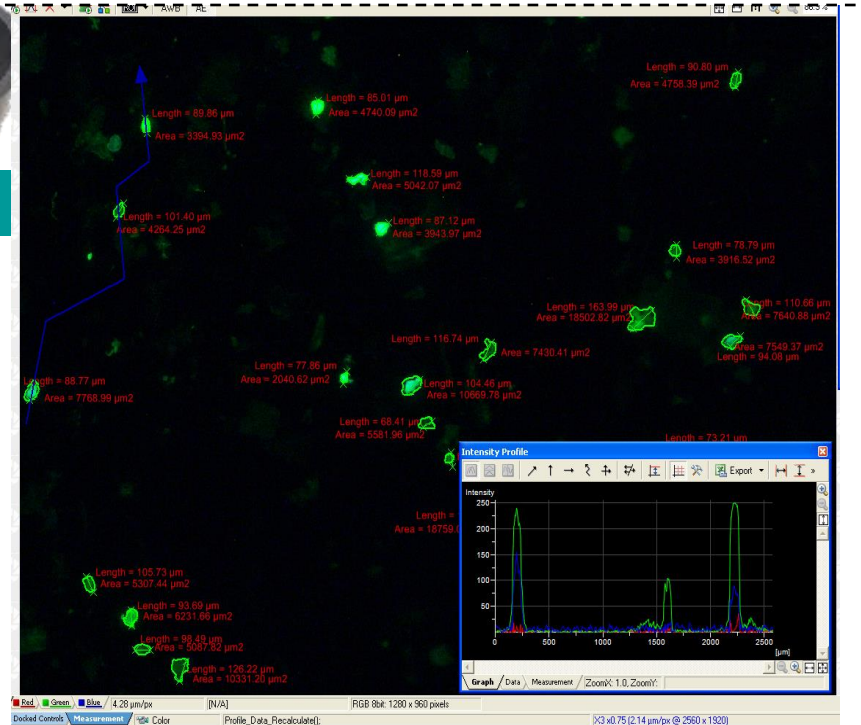


Nel et al., 2021; Maes et al., 2017

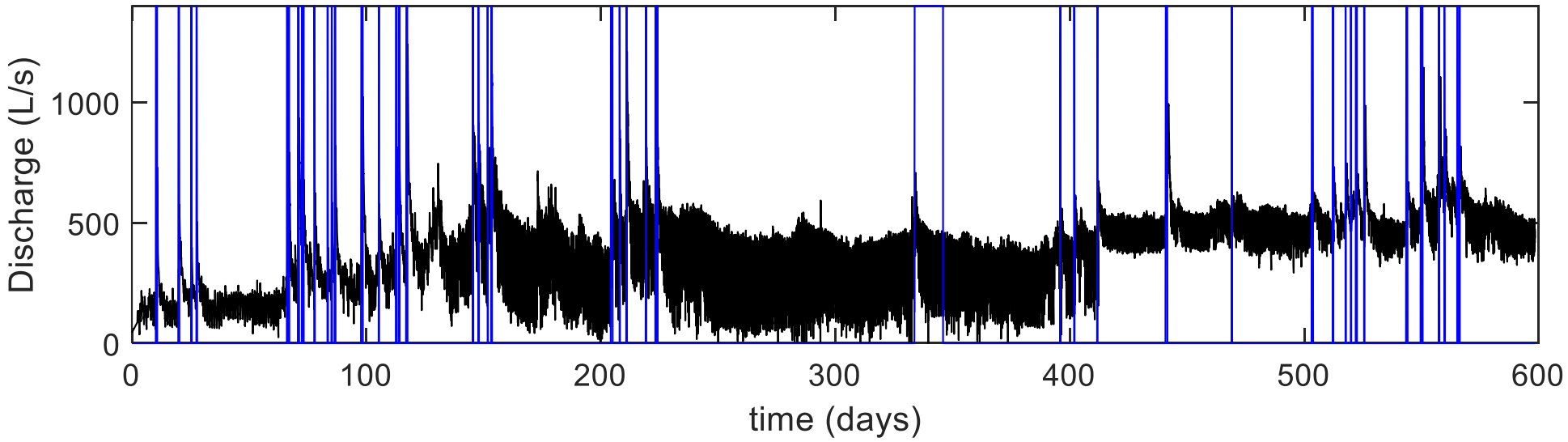
Nile Red Solution

NIS-Elements Microscope Imaging (Nikon)

64 µm

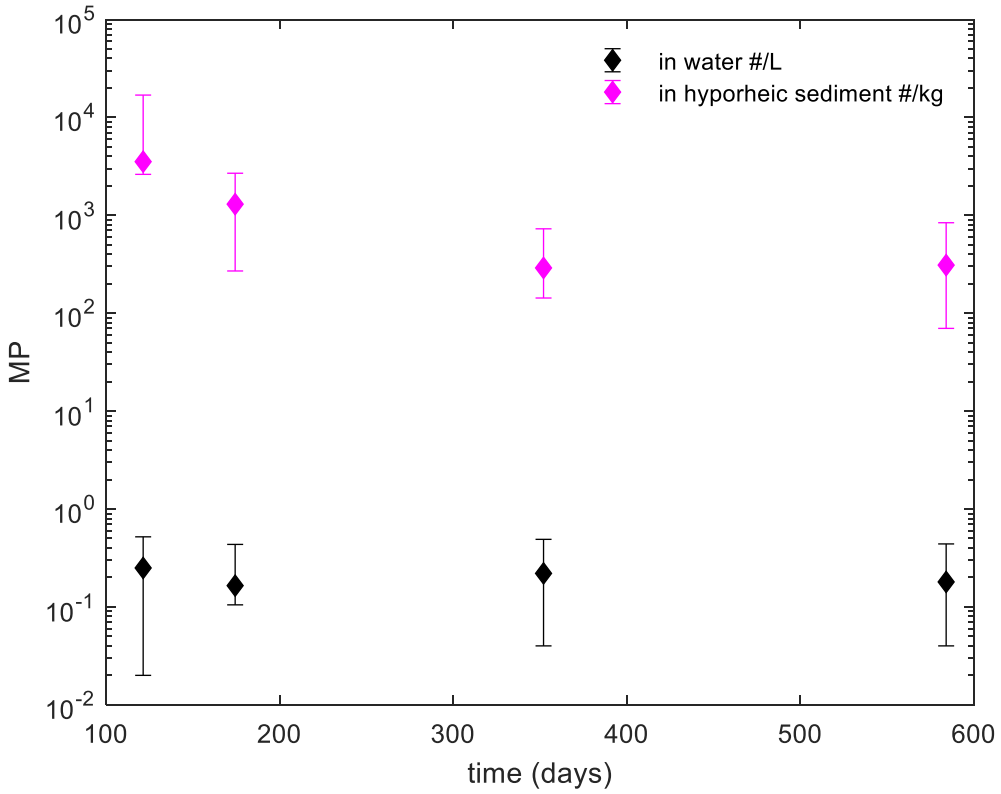


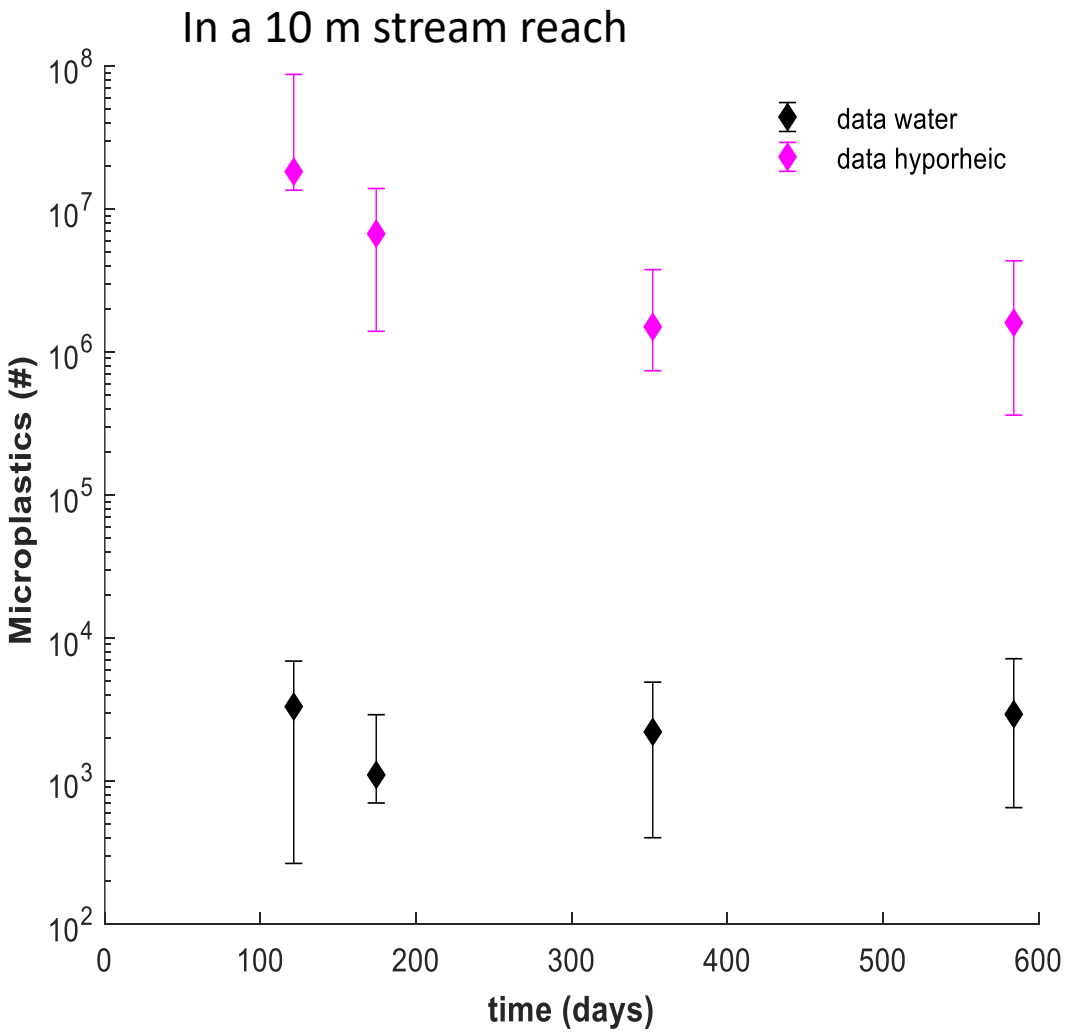
Stormflow defined with blue vertical lines



Precipitation events used to identify potential stormflow (Daily Total Rainfall >4.9 mm, Met Office)

Overview – microplastic counts in water and hyporheic sediments → convert to model output results

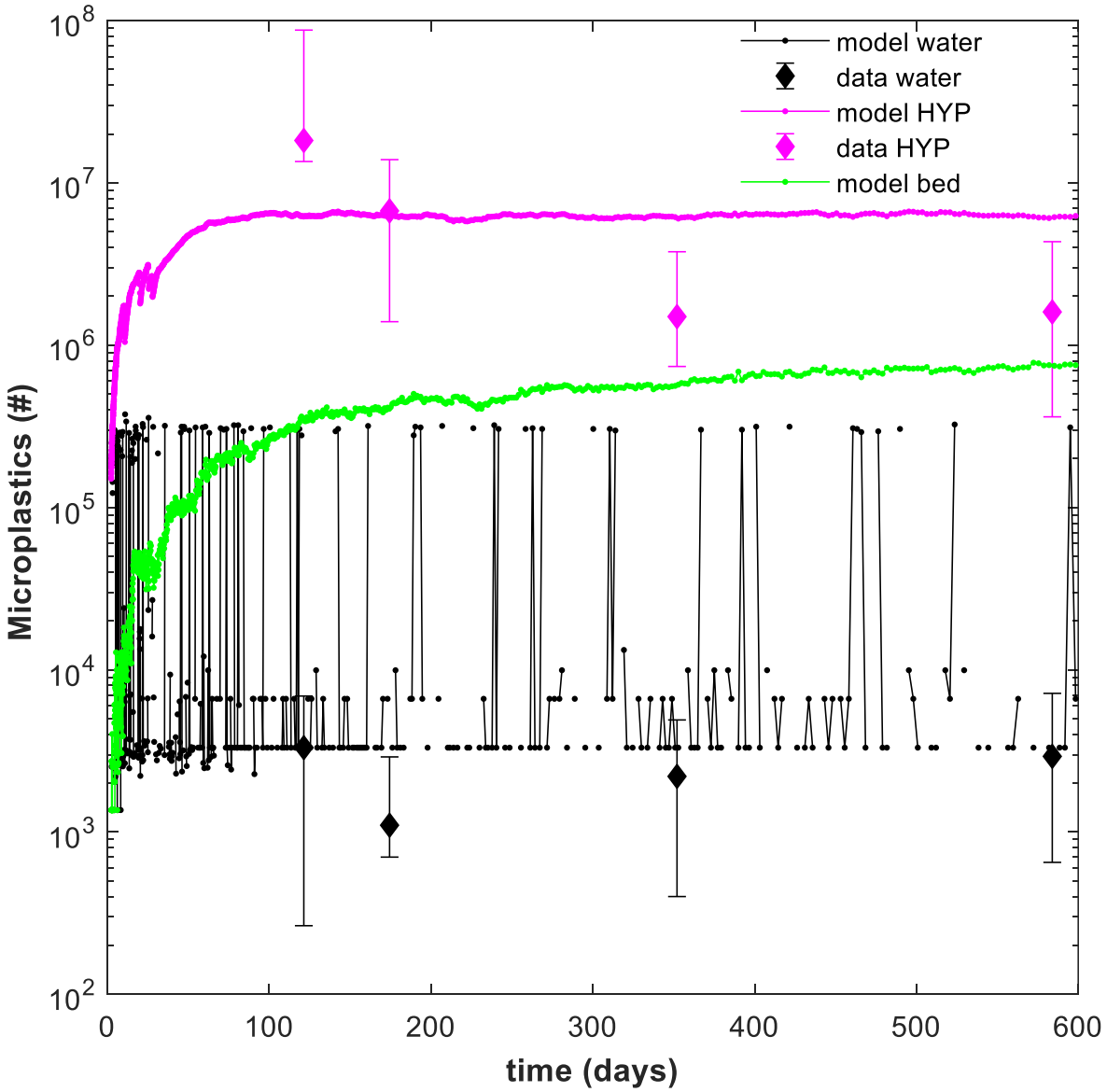




Overview – model results show spatial and temporal variation in microplastics in all 3 zones

- First test with a continuous input
- Variation in water column (sometimes below detection limit)

In a 10 m stream reach



Conclusions

- Longitudinal transport of microplastics can be represented by a mobile-immobile particle tracking model

- Next steps – try varying the microplastic input function, also model organic matter data

- Dynamic transport into and out of the hyporheic zone to regulate the presence of microplastics in the stream
  → important to consider both baseflow and dynamic flow conditions when studying microplastics persistence in streams

Thank you!

@jddrummo
j.Drummond@bham.ac.uk
UNIVERSITY OF BIRMINGHAM
MARIE CURIE ACTIONS