EGU 2021

Estimating River Water-quality Trends under different Flow Conditions

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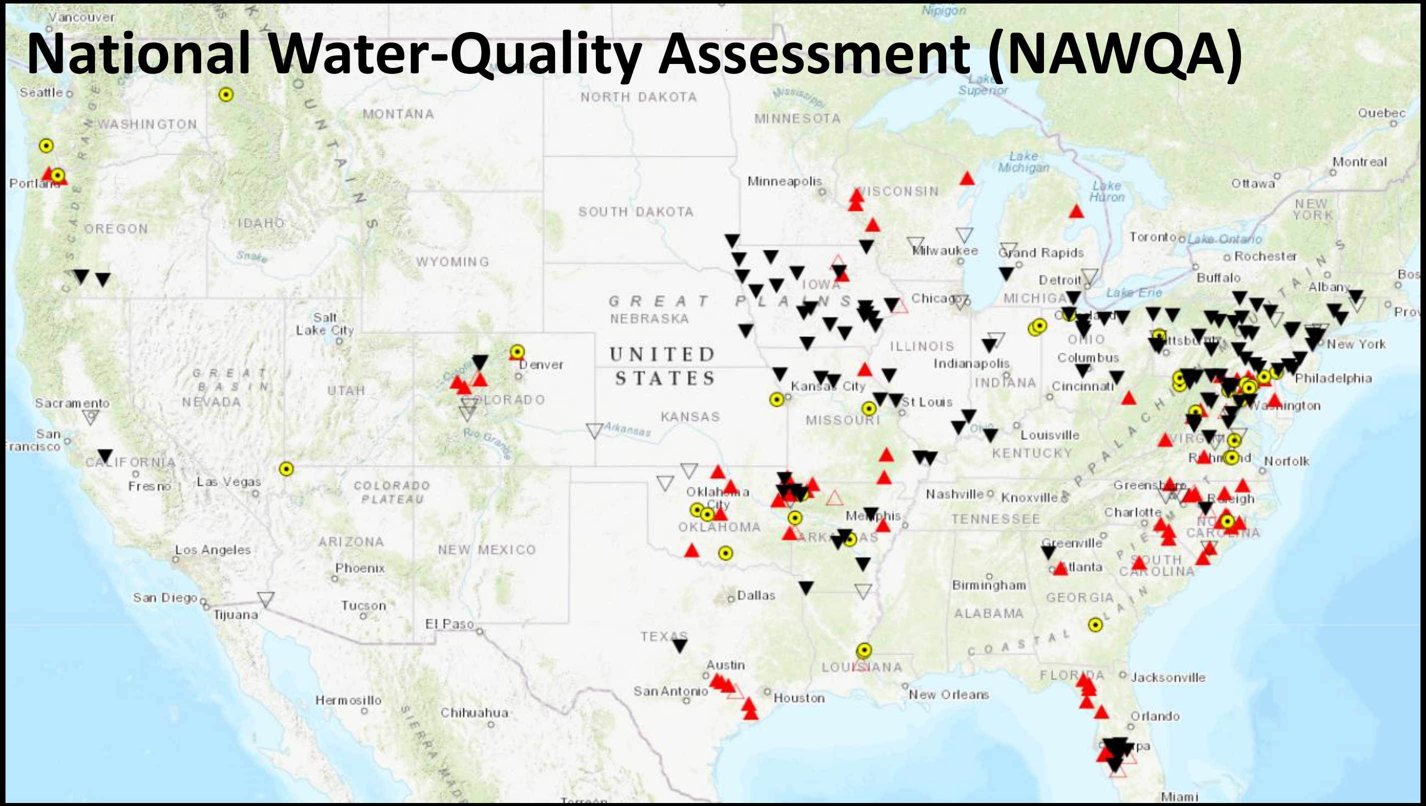
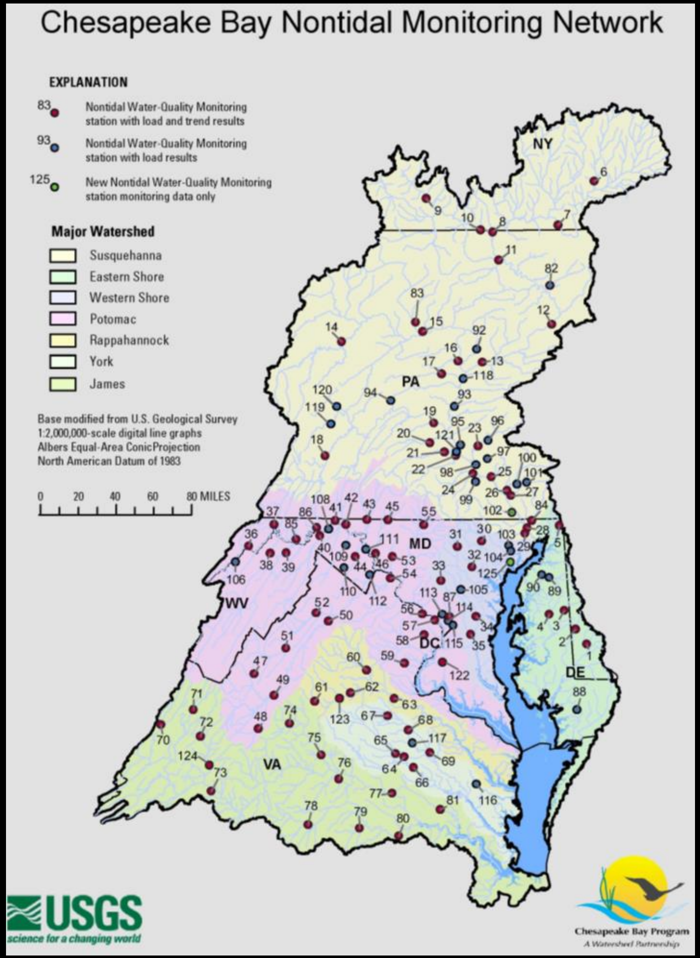
The main goal of this work was to propose an approach for quantifying river **water-quality trends** …

… **under different flow conditions** …

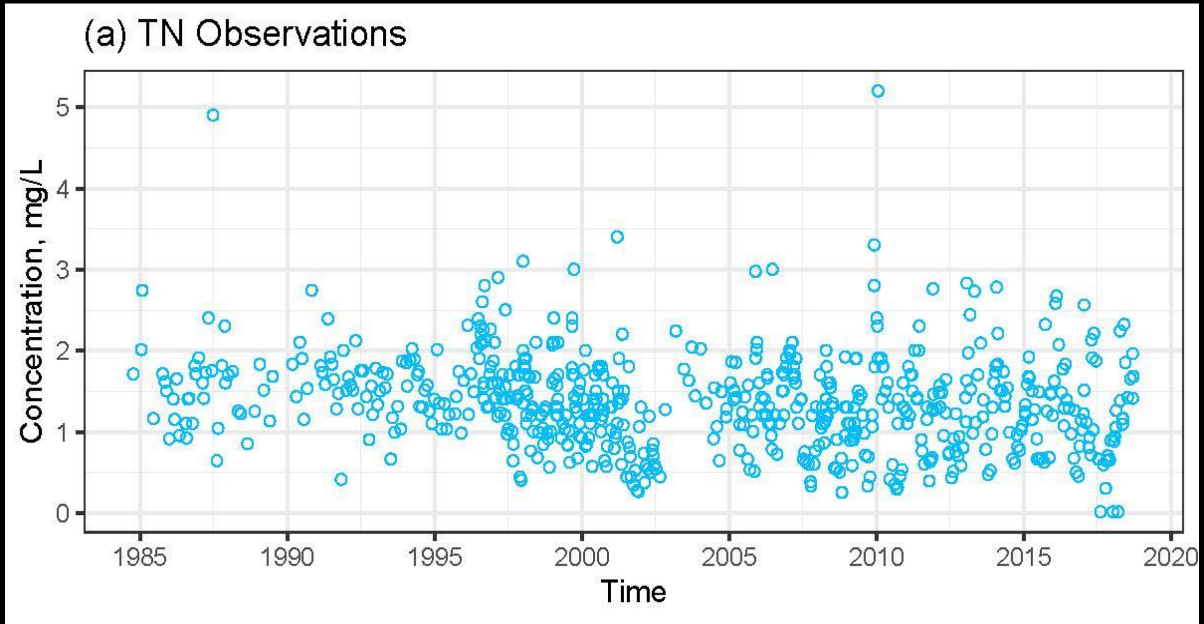
…by adding a **simple extension** to the widely used **WRTDS** method.

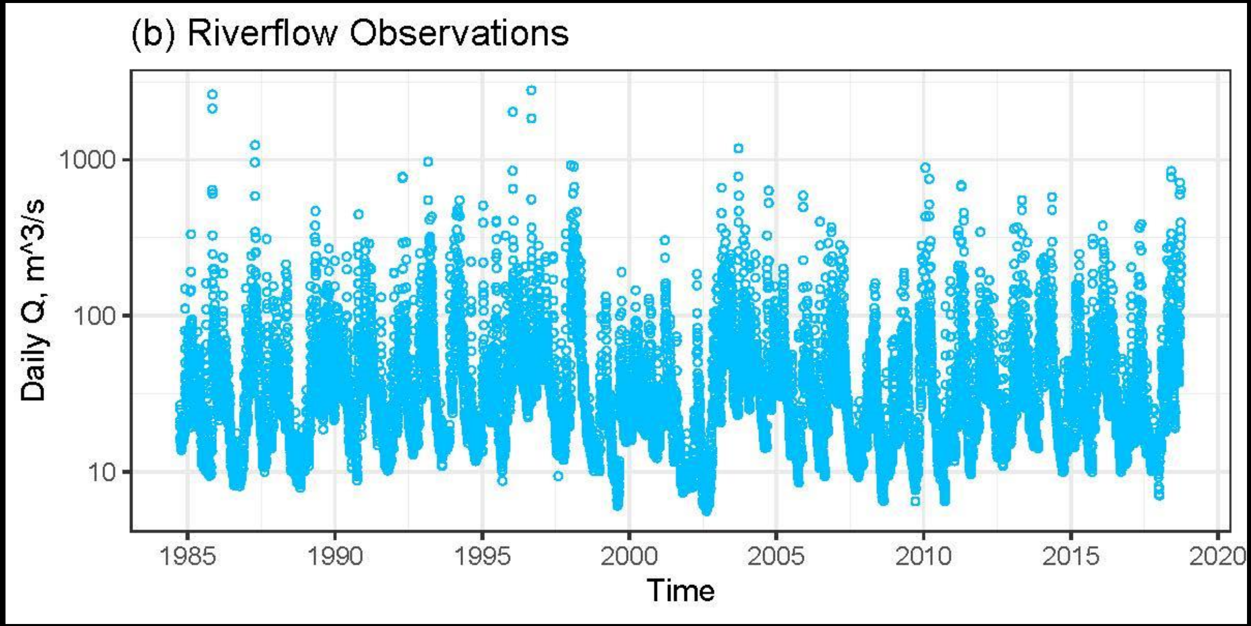
Trend analysis methods can extract essential information from river WQ monitoring data.





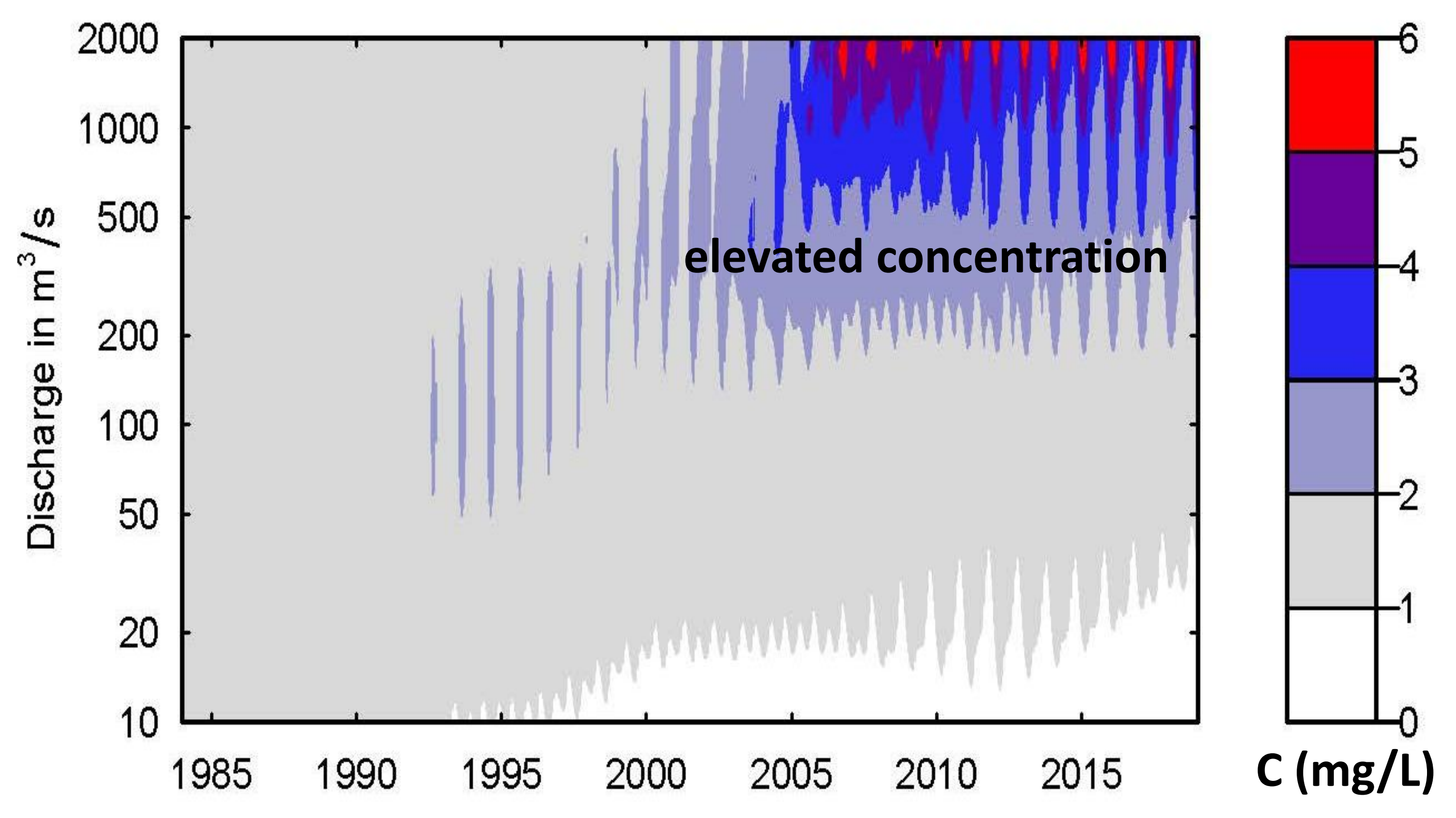
Trend analysis approaches need effectively filter out the trend signal in the data from the variability related to time, season, and discharge.





South Fork Shenandoah River at Front Royal, Virginia (USGS ID 01631000)

One recent approach designed to achieve that is WRTDS, or Weighted Regressions on Time, Discharge, and Season (*Hirsch et al., 2010*).



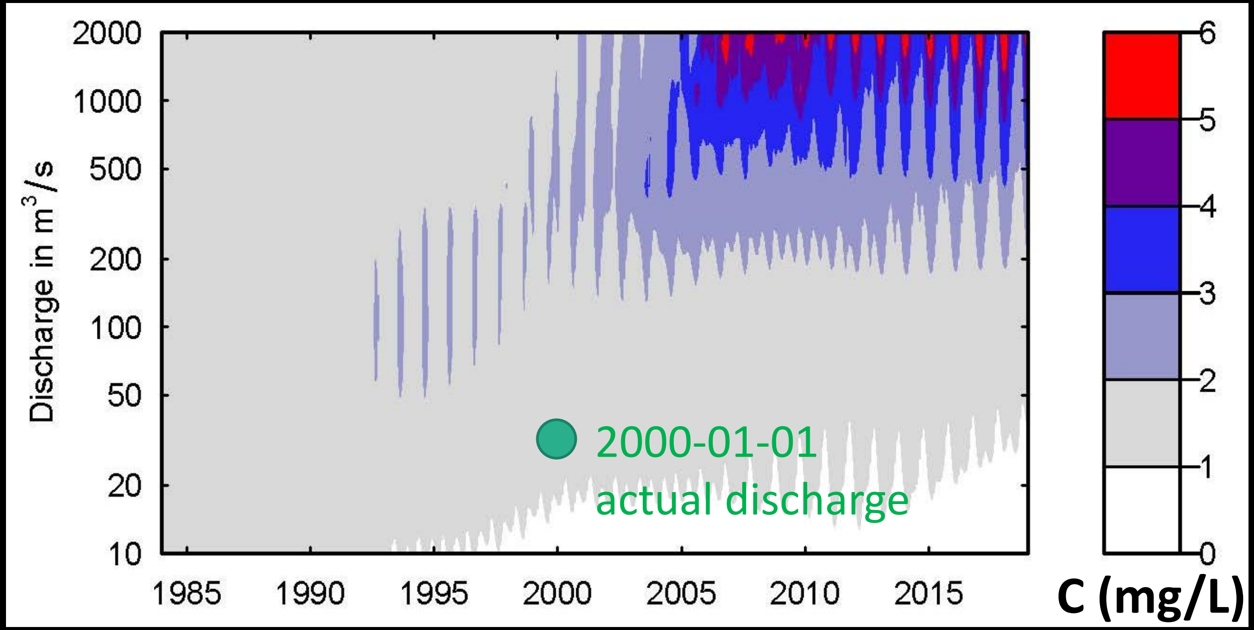
List of WRTDS Resources

WRTDS Method
Hirsch et al., 2010 (JAWRA)

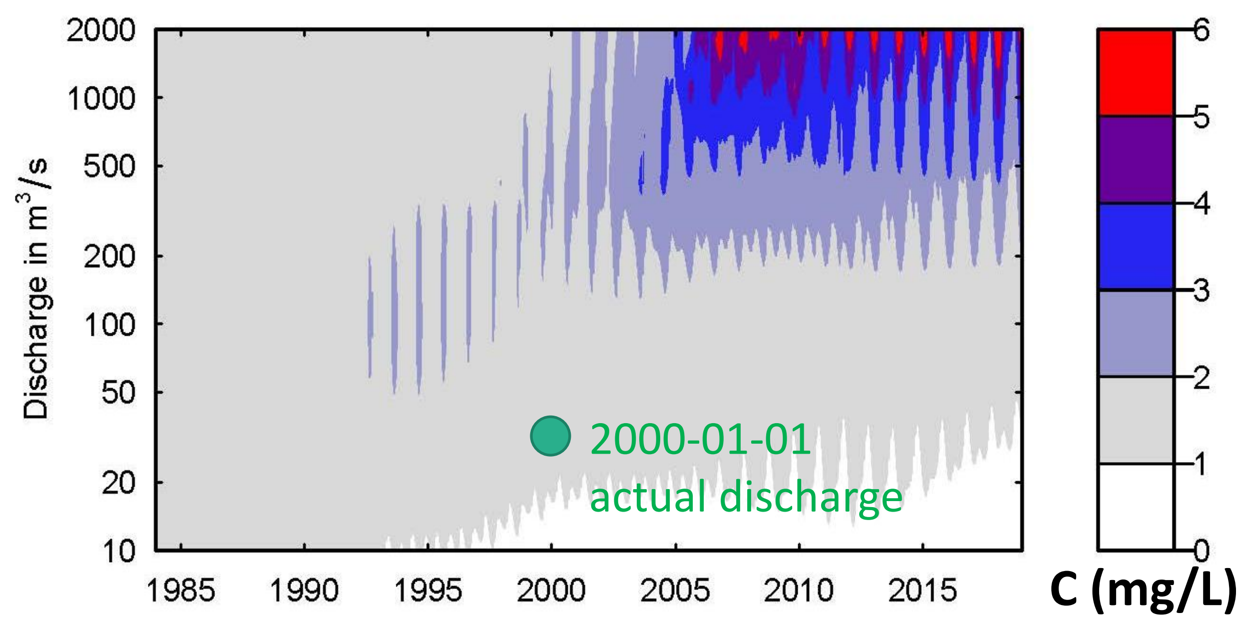
WRTDS Software
Hirsch & De Cicco, 2015 (USGS)
EGRET and **EGRETci** R packages

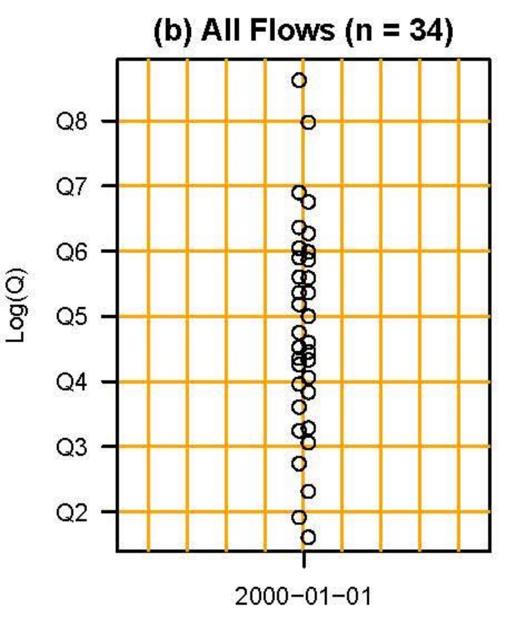
WRTDS Studies
http://usgs-r.github.io/EGRET/articles/References_WRTDS.html

WRTDS can use the regression surface to provide true-condition (actual) concentration and flux estimates for each day in the record.



To remove effects of inter-annual riverflow variability, WRTDS has a procedure that provides flow-normalized (FN) estimates for each day.

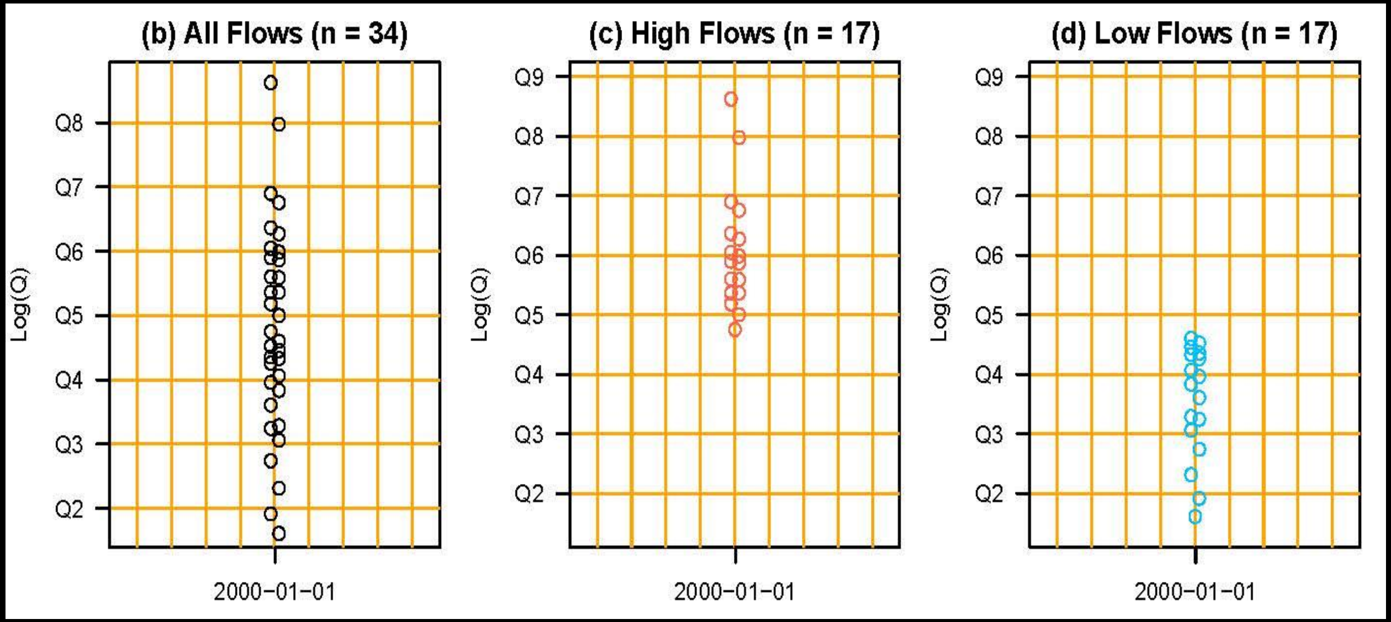




Each point Represents the January 1st of a year between 1985 and 2014.

$$F_{FN} = \frac{1}{34}\sum_{j=1}^{34} C_j Q_j$$

The proposed FN_{2Q} approach is a simple extension of WRTDS FN. It considers the lower and upper 50% of the flow distribution, respectively.



$$F_{FN\_HIGH} = \left(\frac{1}{17}\sum_{k=1}^{17} C_k Q_k\right) * \left(\frac{17}{34}\right)$$

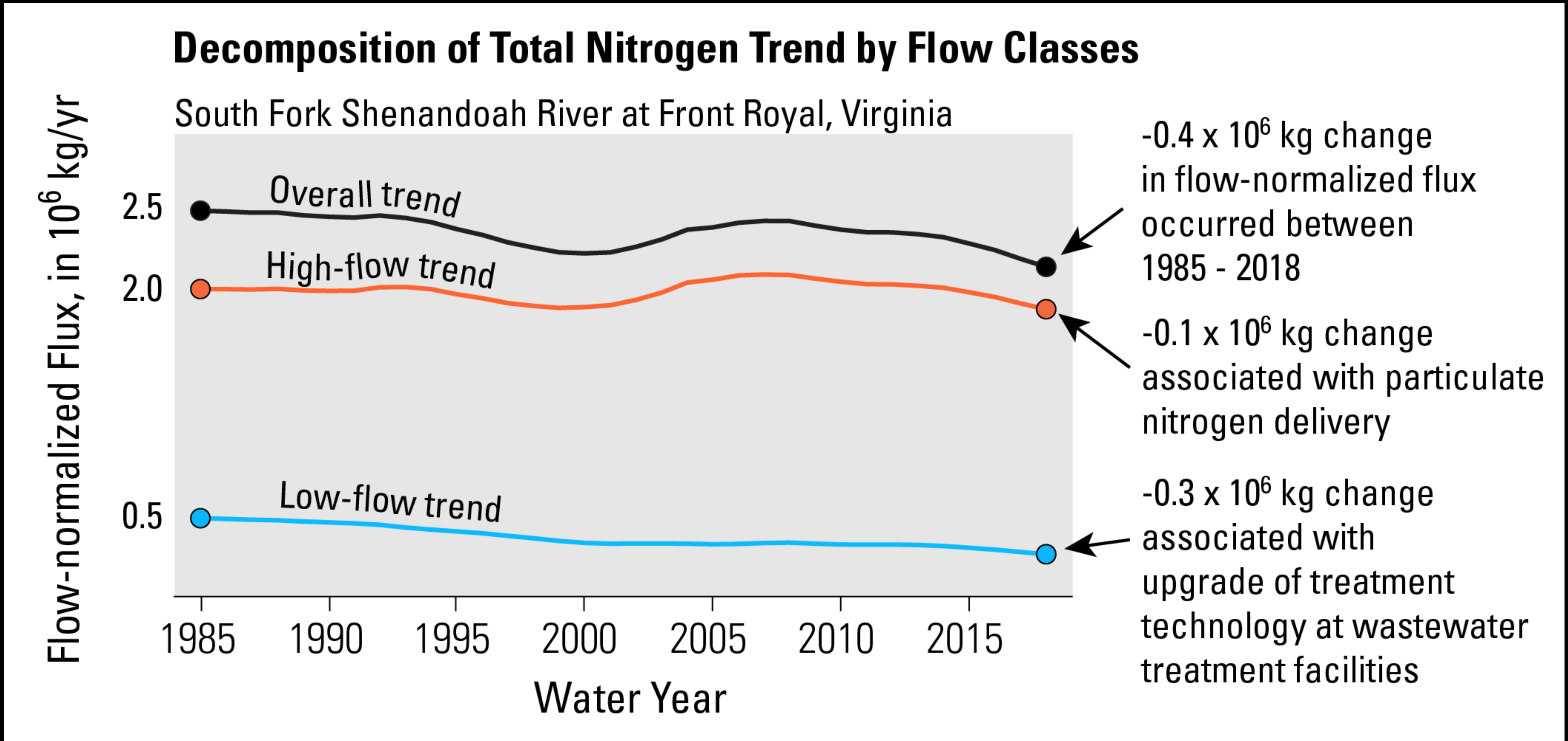
$$F_{FN\_LOW} = \left(\frac{1}{17}\sum_{k=18}^{34} C_k Q_k\right) * \left(\frac{17}{34}\right)$$

$$F_{FN\_TOTAL} = F_{FN\_HIGH} + F_{FN\_LOW}$$

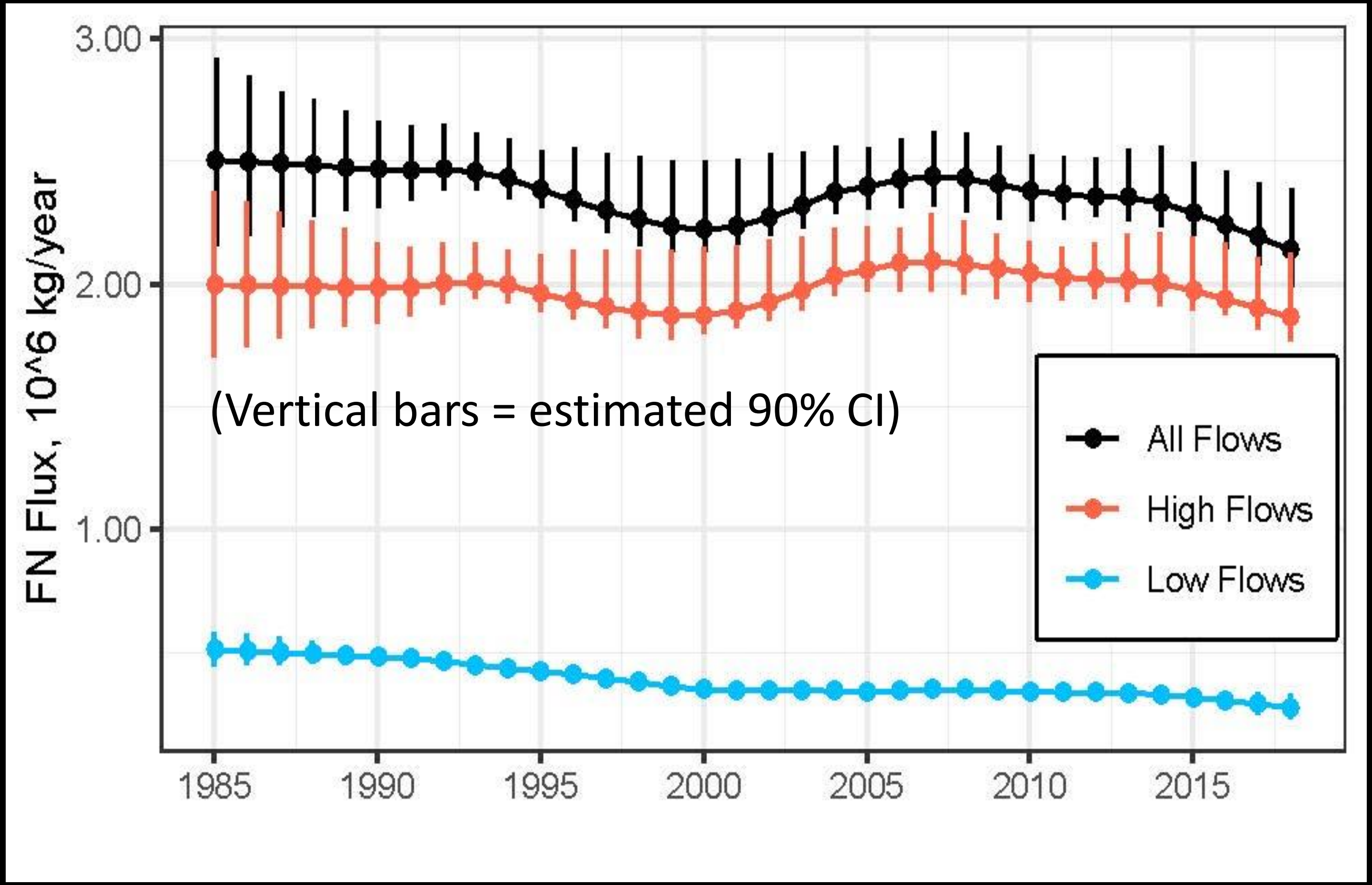
Why WRTDS?

- WRTDS can systematically estimate, store, and visualize water-quality patterns for different times and discharges.
- WRTDS generally can offer improved estimates than prior approaches, because it does not assume homoscedasticity of model errors or a fixed C-Q relationship.
- WRTDS has already been widely used in national and regional assessments of water-quality changes and trends.
- WRTDS FN_{2Q} provides internally consistent trend estimates with WRTDS FN, adding a natural extension to these studies toward understanding river water-quality dynamics.

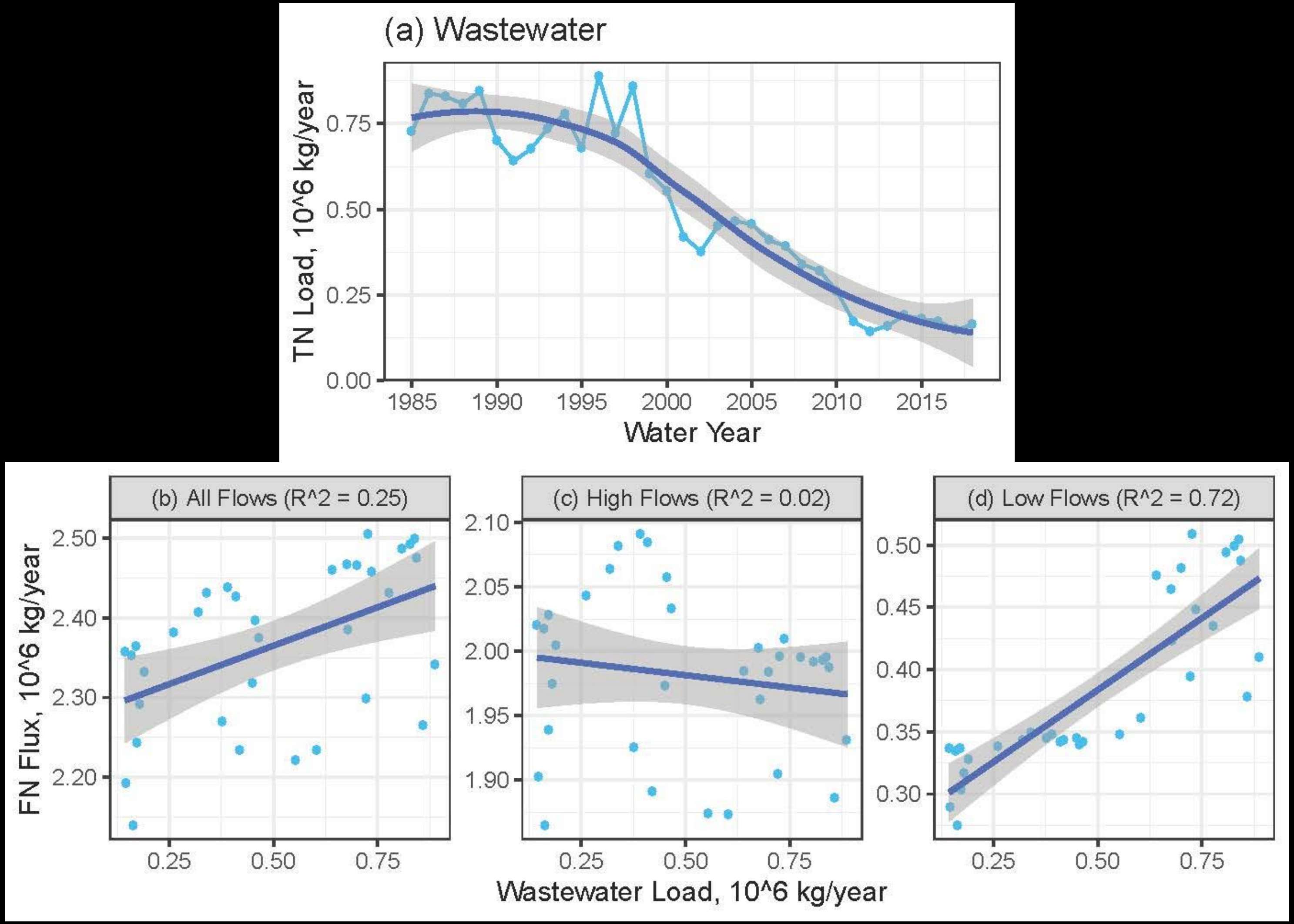
FN_{2Q} is not only useful for characterizing river water-quality trends under different flows, but also guiding the direction of additional analysis for capturing the underlying drivers.



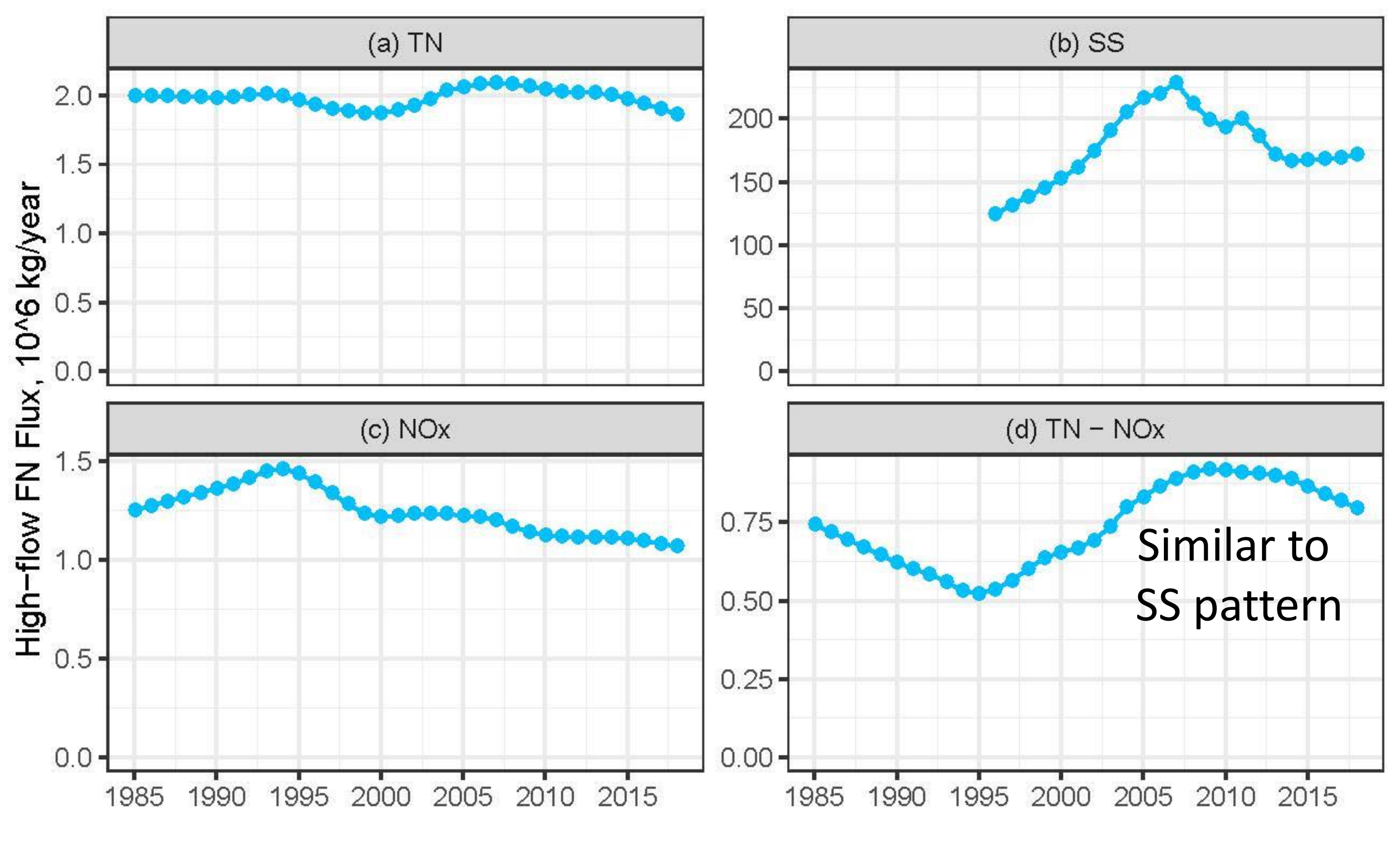
#1: F_{FN_TOTAL} of TN is mostly contributed by F_{FN_HIGH} in terms of mass; however, the decline in F_{FN_TOTAL} in 1985-2018 is mostly caused by the decline in F_{FN_LOW}.



#2: The decline in F_{FN_LOW} was highly correlated with WWTP effluent loads, indicating that WWTP upgrades have likely led to the improvement of water quality under low flows.



#3: F_{FN_HIGH} showed a spike around 2007, which was likely caused by increased delivery of particulate nitrogen associated with sediment transport.



FN_{2Q} can easily be applied to water-quality records elsewhere to quantify trends under different flows. Our publication and R code are freely available.

Applicability:

- Common WQ constituents.
- Flow classes can be re-defined.
- Seasonal trends can be computed.
- Record with left-censored values.
- Record of 20+ years with 200+ samples.
- Riverflow is stationary.
- Not appropriate for flashy rivers.

Publication:

Zhang, Q., J. S. Webber, D. L. Moyer, and J. G. Chanat, 2020. "An approach for decomposing river water-quality trends into different flow classes", *Science of the Total Environment*, 143562, doi: 10.1016/j.scitotenv.2020.143562.

R Code and Application:

Webber, J.S, and Zhang, Q., 2020, Chesapeake Bay Nontidal Network 1985 – 2018: Daily High-Flow and Low-Flow Concentration and Load Estimates, *U.S. Geological Survey data release*, https://doi.org/10.5066/P9LBJEY1.