The Hydrology and Water Quality Dynamics Associated with an Urban Beaver Pond Complex

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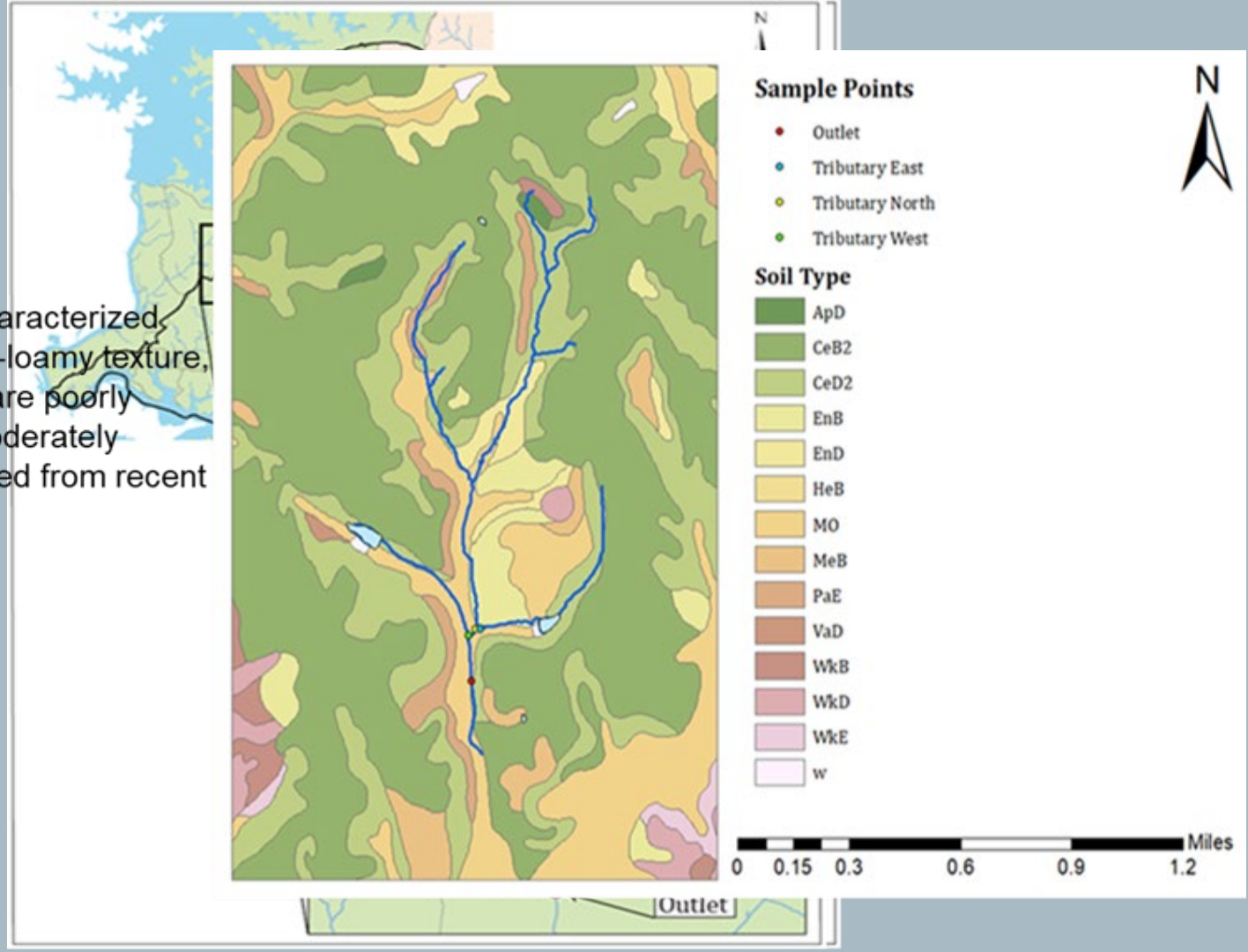
Outline

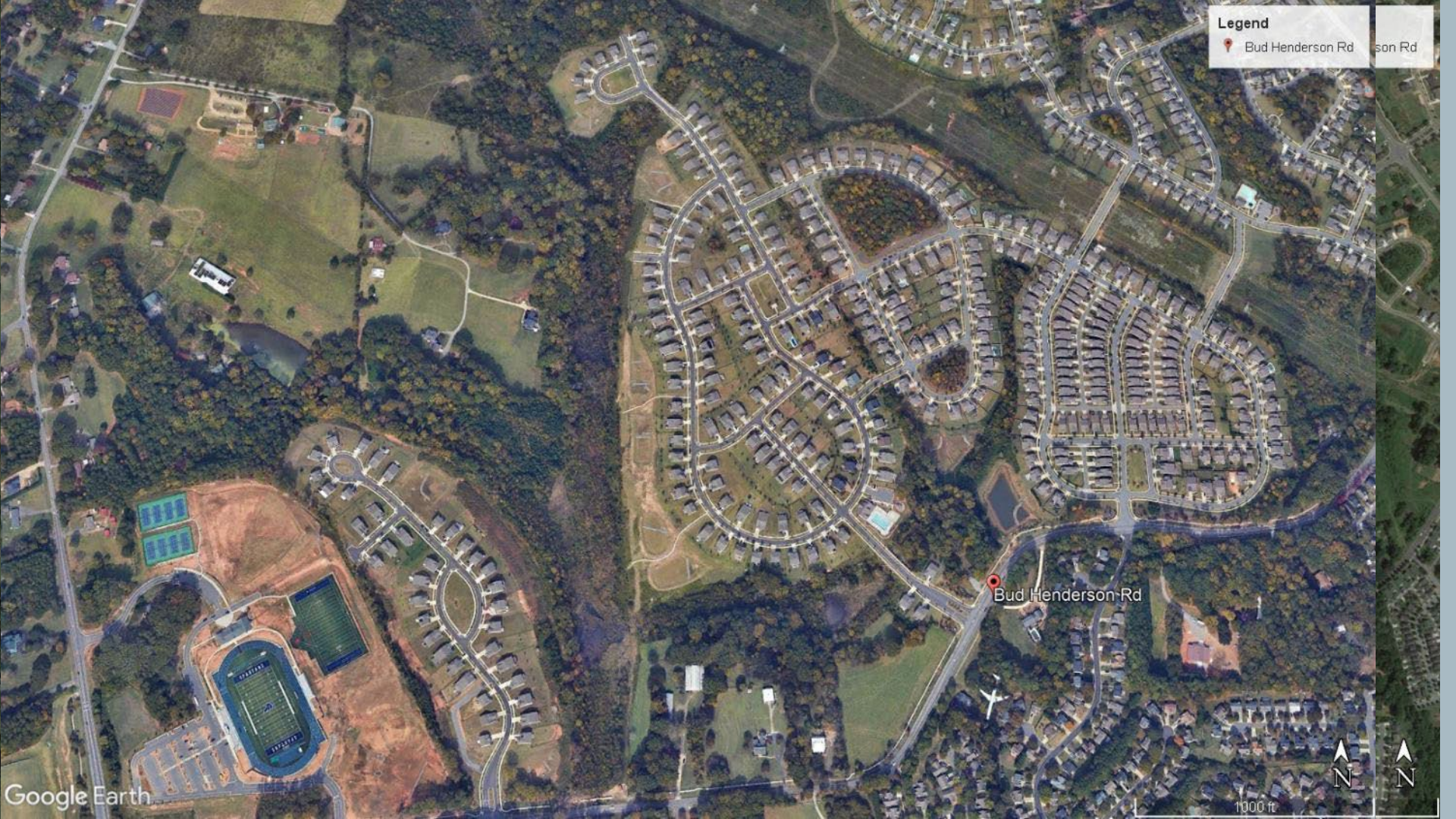
- Objectives
- Study site history McDowell Creek Tributary (MC5)
- Methods
  Hydrologic, Water quality
- Results
  Retention Time
  Mass Balance TSS, DOC, DTP, TDN, NO_3_N, NH_4_N
  DON.
- Initial Conclusions

Objectives of the Study

- Determine if beaver pond complexes have a significant impact on the hydrology and water quality of small urbanized watersheds in the SE Piedmont.
- How do ponds impact runoff residence time?
- Do ponds retain or are they sources of C, N, & P?
- What nutrient transformations might occur as water moves through the pond complex?

The soils are characterized as having a fine-loamy texture, mixed thermic, are poorly drained, and moderately permeable formed from recent alluvium

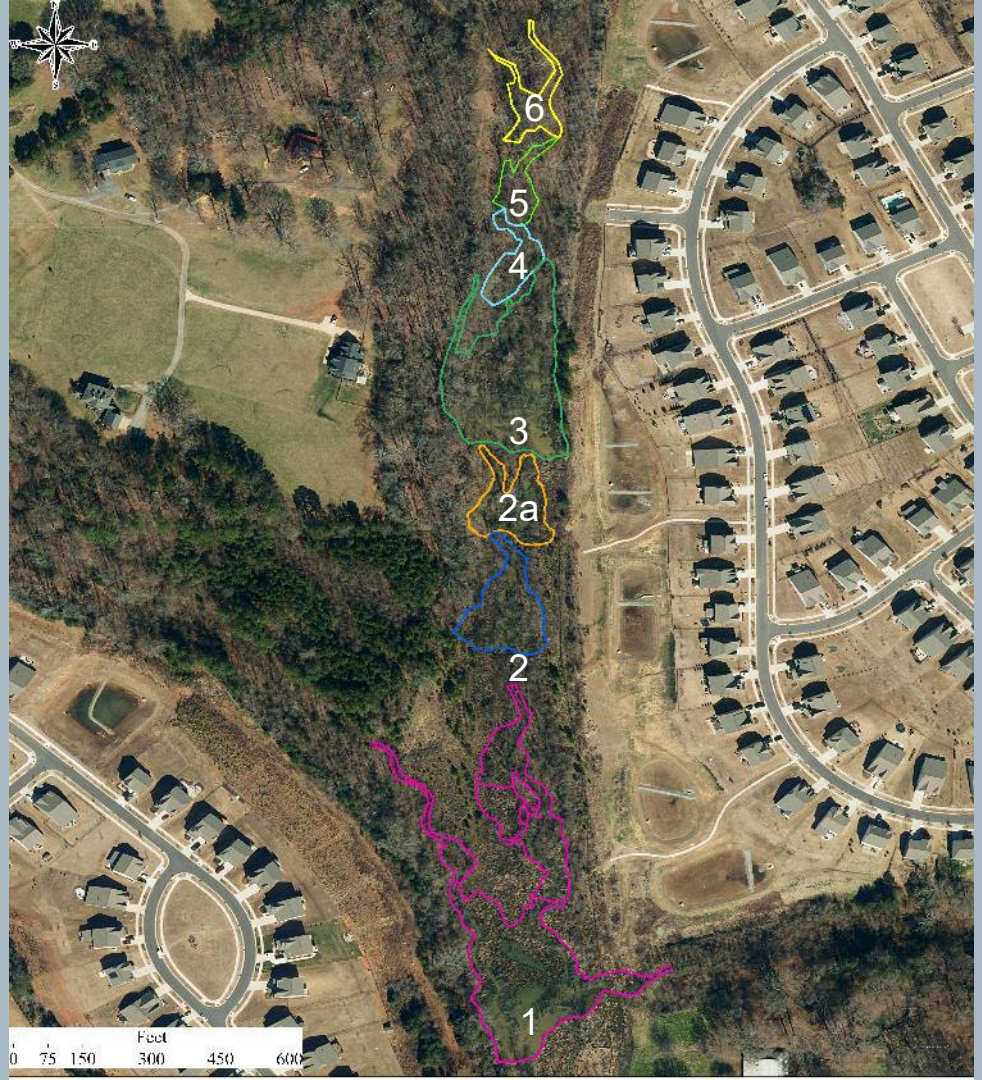



Legend
Bud Henderson Rd
Bud Henderson Rd
Google Earth
1000 ft
N
N

14 Dams
Total length 496.8 m

Max 82 m
Min 2.0 m

Maximum Height 2m



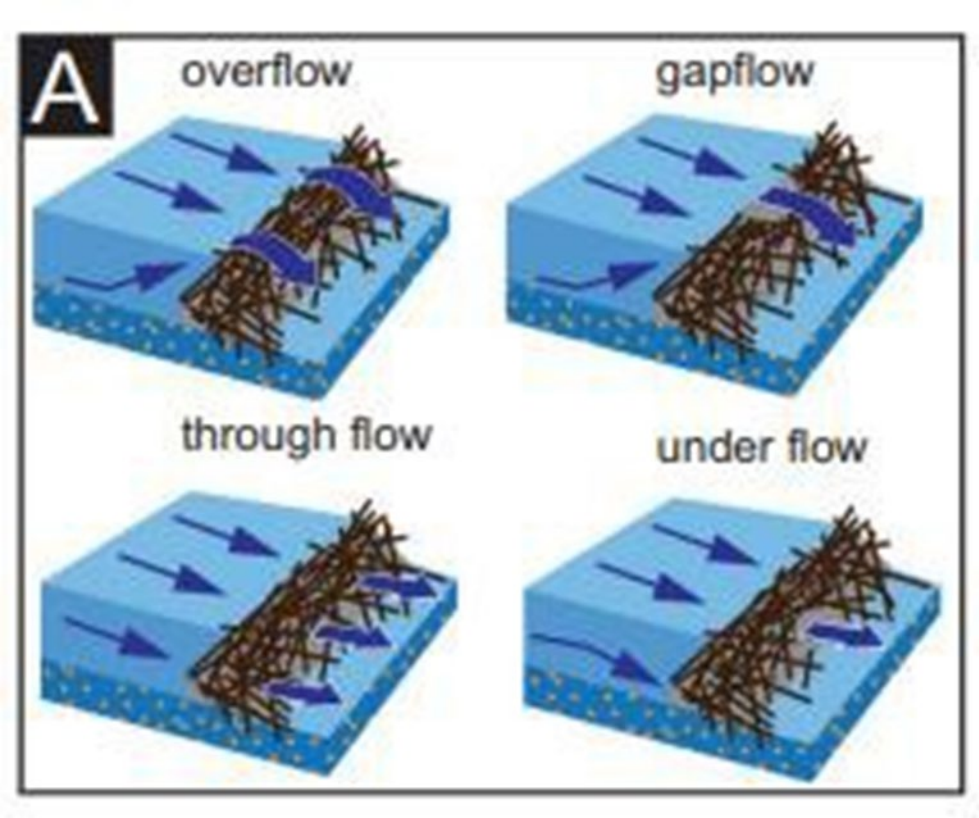
Ponds 5 and 6 2024

Pond 4 2022

Pond 3 2021

Ponds 2 + 2a 2020

Pond 1 2018



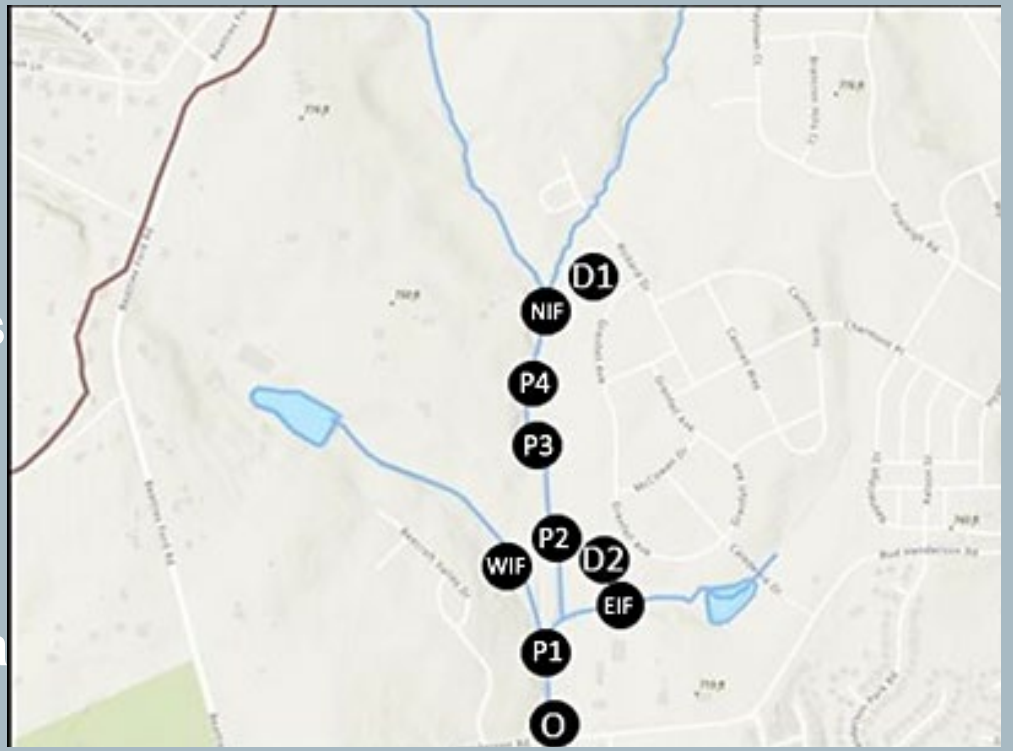
Beaverdam outflow types. After (Larsen et al., 2021)

Methods

Continuous Measurement of Pond and stream water levels and Precipitation.

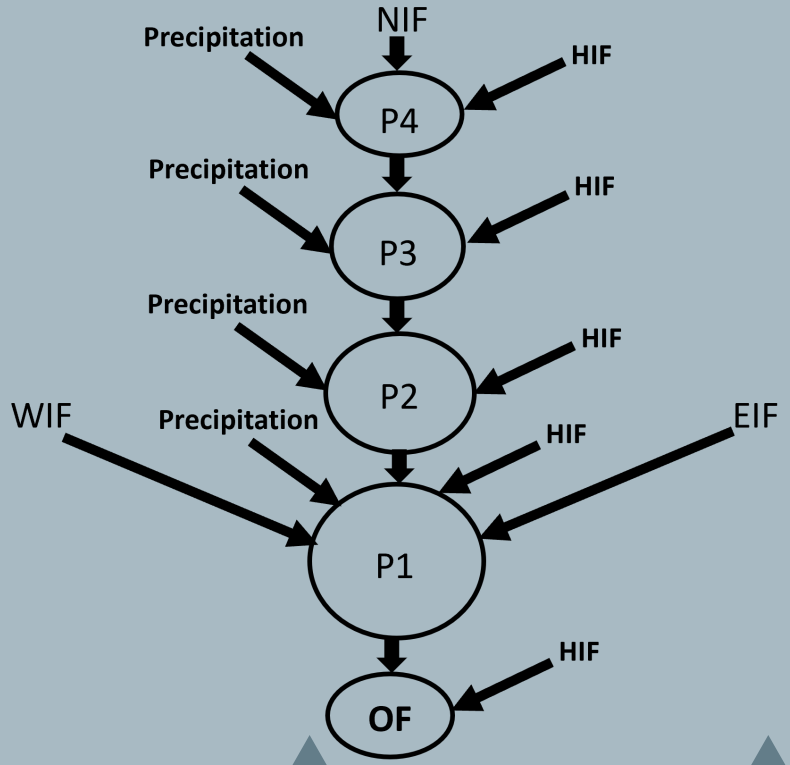
Weekly sampling of Ponds, Streams and Bulk Precipitation. In situ measurements of water temperature, DO, specific conductance, turbidity.

Major Ions via IC, DOC and DTN via Shimadzu TOC/TN Analyzer, Dissolved Total P- Ascorbic Acid Method, TSS via vacuum filtration.



Methodology: Pond and Stream water level measurements & establishment of stage-discharge relationships.

Methodology: Analytical Framework



P + HIF + CIF - OF = Net Flux

Where:

P = Precipitation (on Pond Surface)

HIF = Hillslope runoff

CIF = Channelized inflow

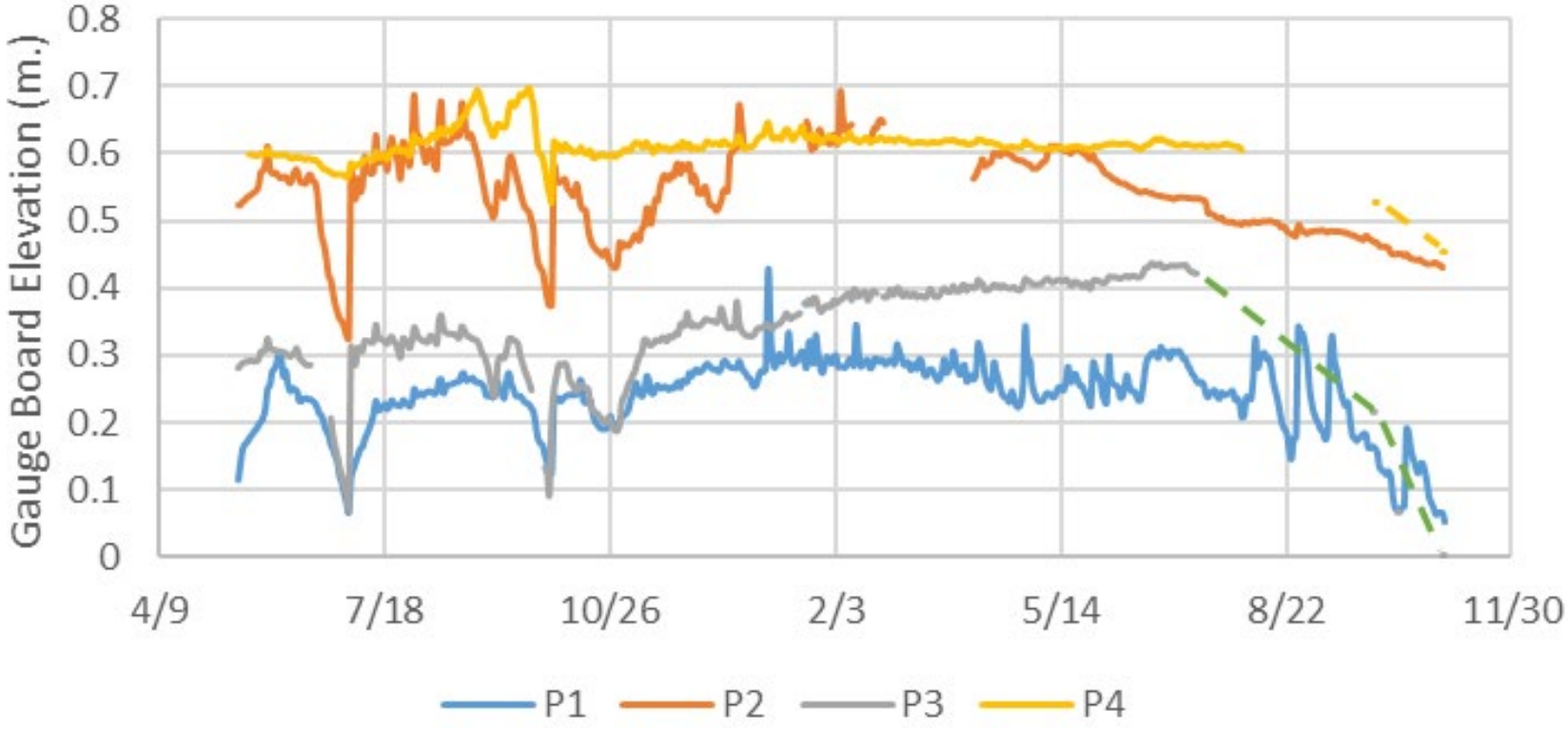
OF = Outflow

(-) Net Flux = Net Export

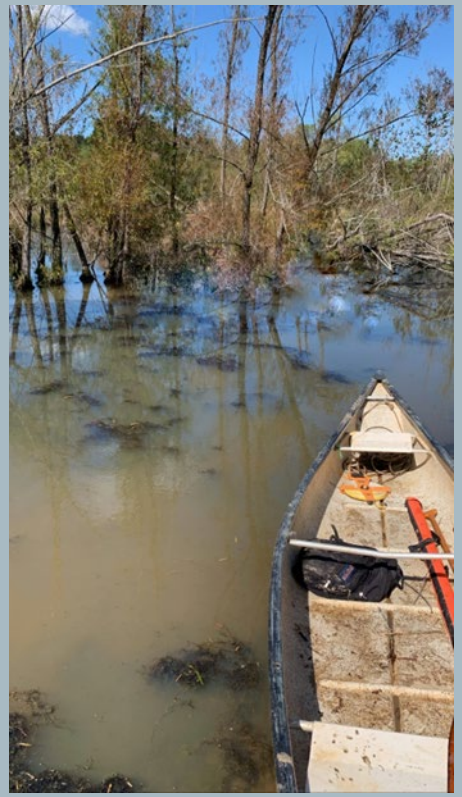
(+) Net Flux = Net Retention

Retention Time

MC5 Beaver Pond Water Levels 5/14/22 to 10/31/2023

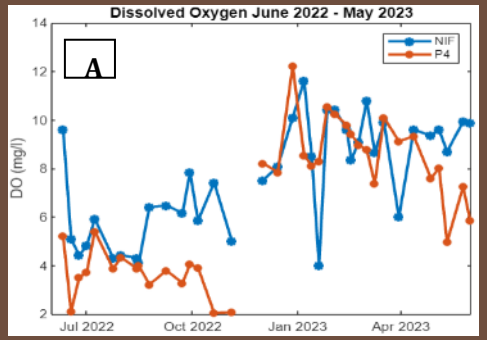


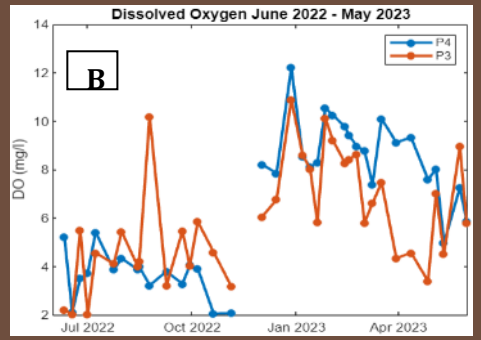
Pond Area, Mean Depth, Volume, Residence Time

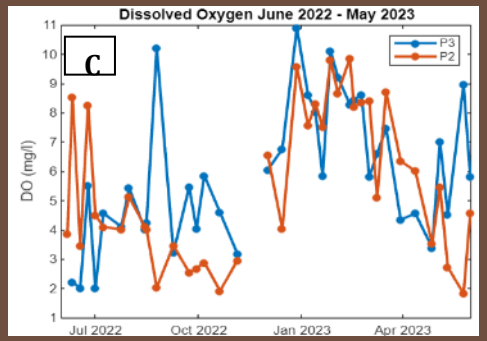


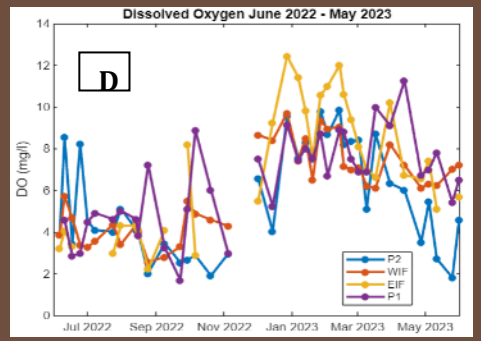
	Area (ha)	Mean Depth (m)	Volume (m^3)	Residence Time (days) Max	Min	Mean
BP1	0.89	0.81	7161	16.5	1.7	6.8
BP2 + 2A	0.37	0.64	2362	7.8	0.8	4.1
BP 3	0.54	1.20	4447	16.2	1.5	8.5
BP 4	0.09	0.30	275	1.1	0.1	0.6
BP 5	0.08	?	?	?	?	?
BP 6	0.09	?	?	?	?	?

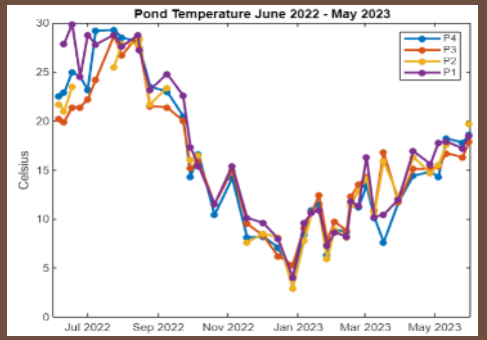
Water Quality

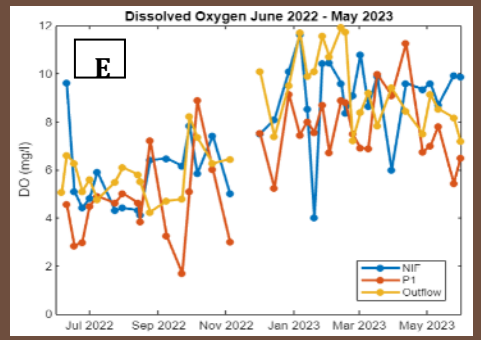












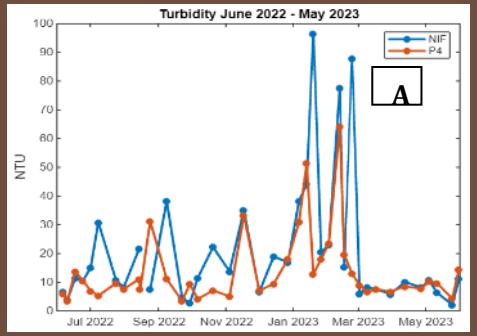
Dissolved Oxygen

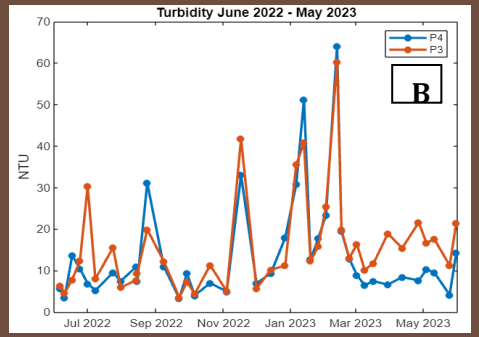
Concentrations remained >1.5mg/l and staying
mg/l threshold of anoxic conditions

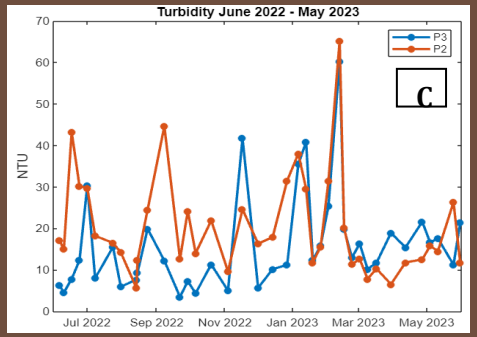
Variability in DO concentrations were slightly
within ponds (44.9) than tributaries (38.3)

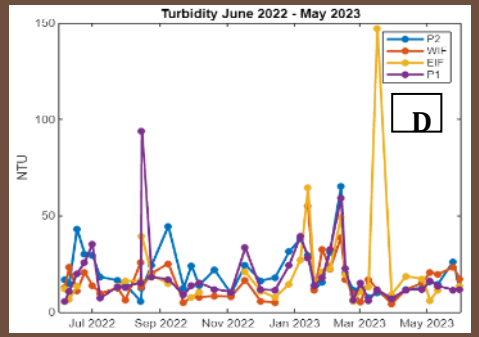
Pond DO decreased moving Downstream N
(40%)WIF and EIF reoxygenated the waters

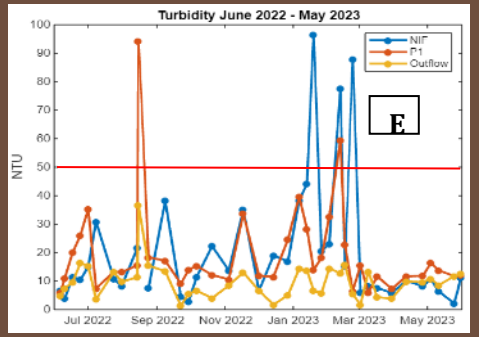
Turbidity







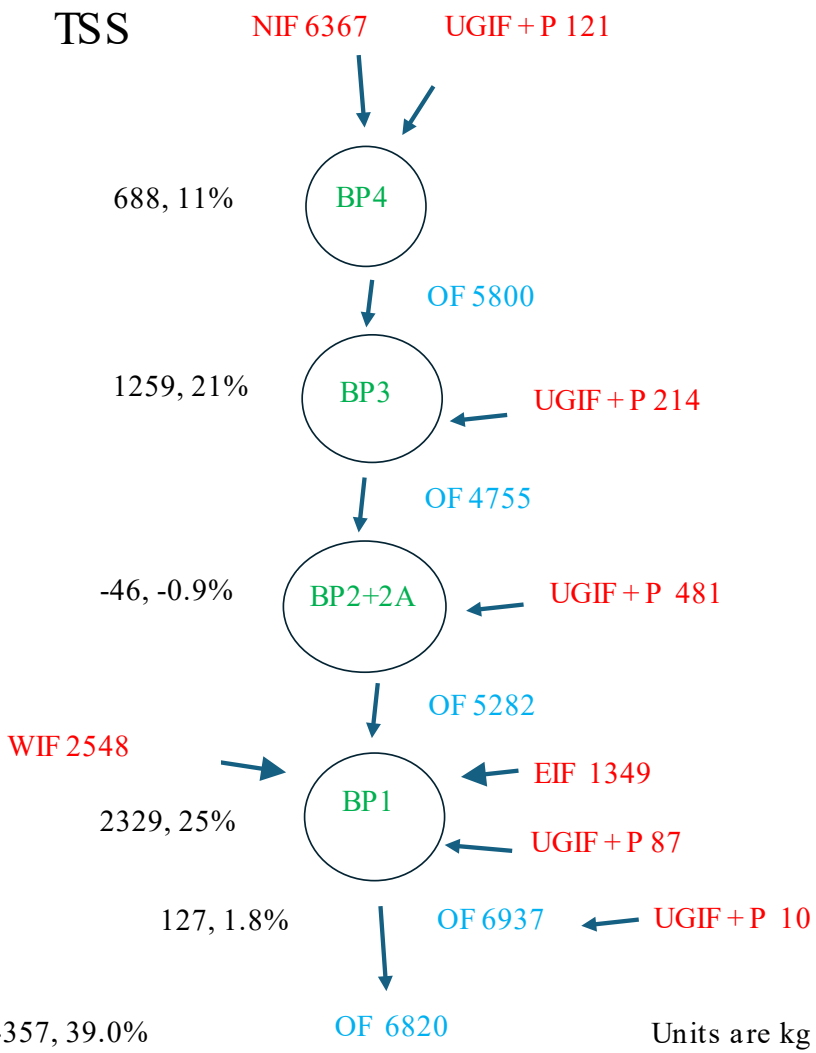




Outflow met the 50 NTU threshold required by N water quality standards for non-trout sustaining streams.

Recent land use changes increasing tributary variability (NIF & EIF).

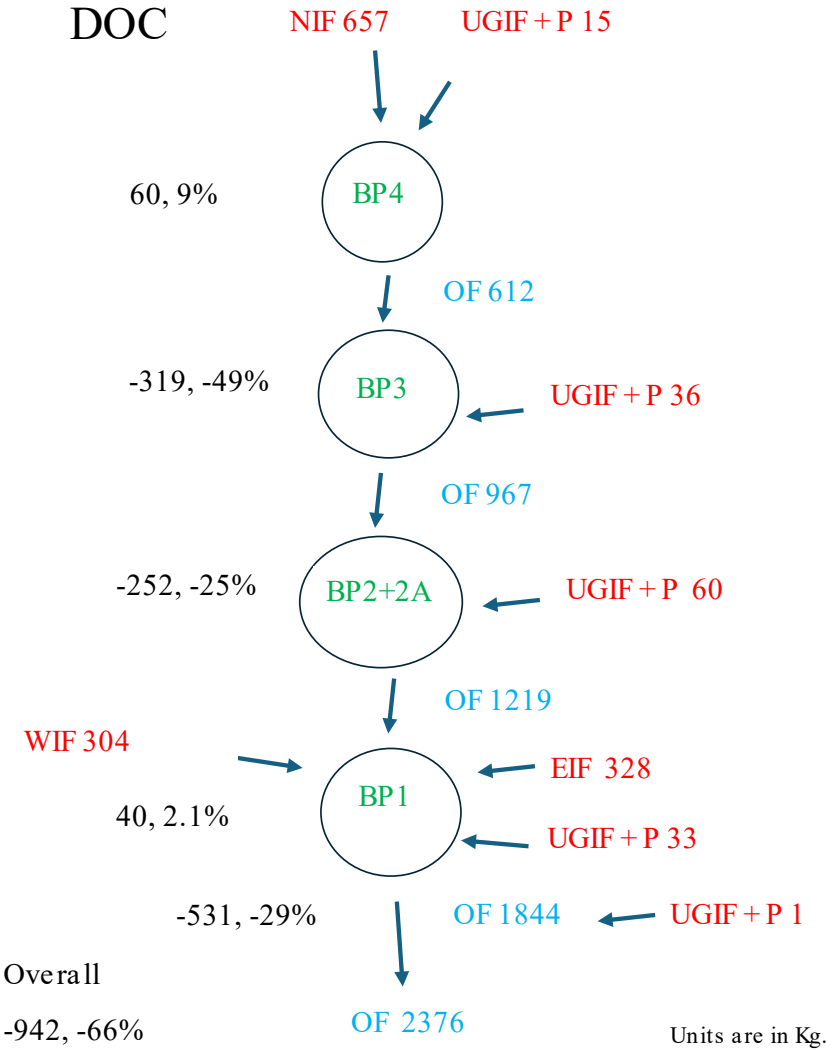
Inputs
Outputs
Retention



4,230 kg
38% Retention

127 kg
1.8% Retention

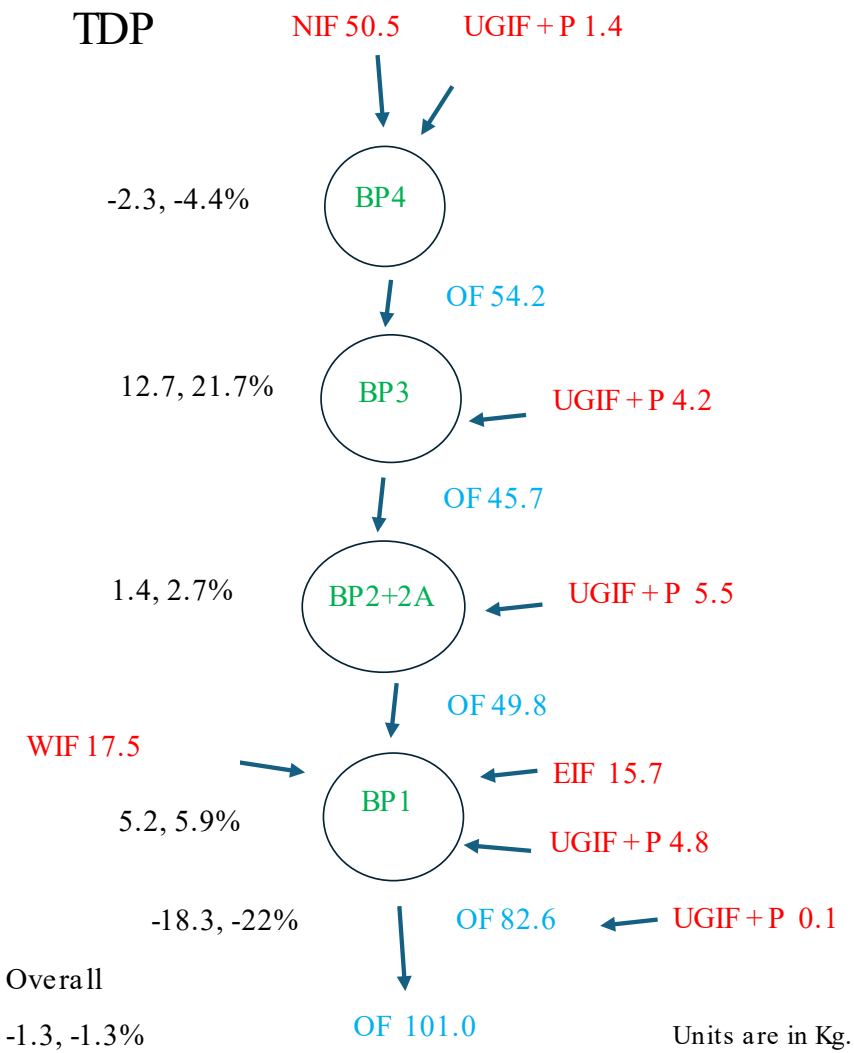
Inputs
Outputs
Retention



-411 kg
-29% Retention

-531 kg
-29% Retention

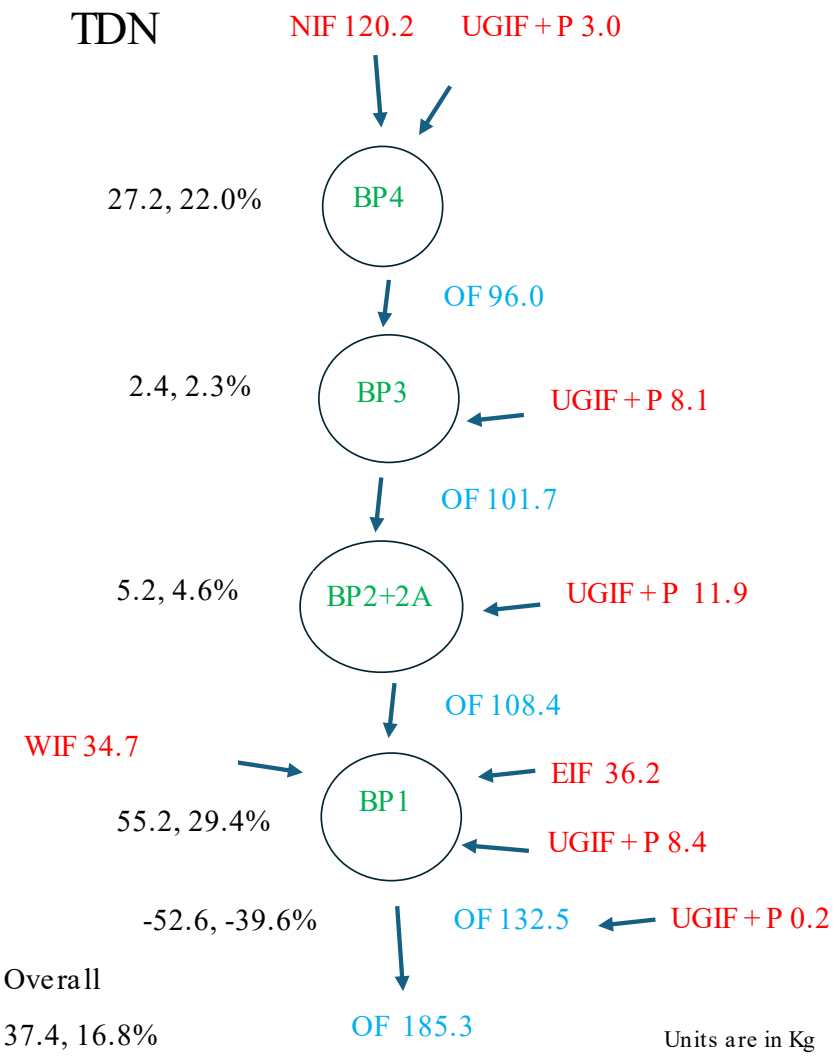
Inputs
Outputs
Retention



17.0 kg
17.1% Retention

-18.3 kg
-22% Retention

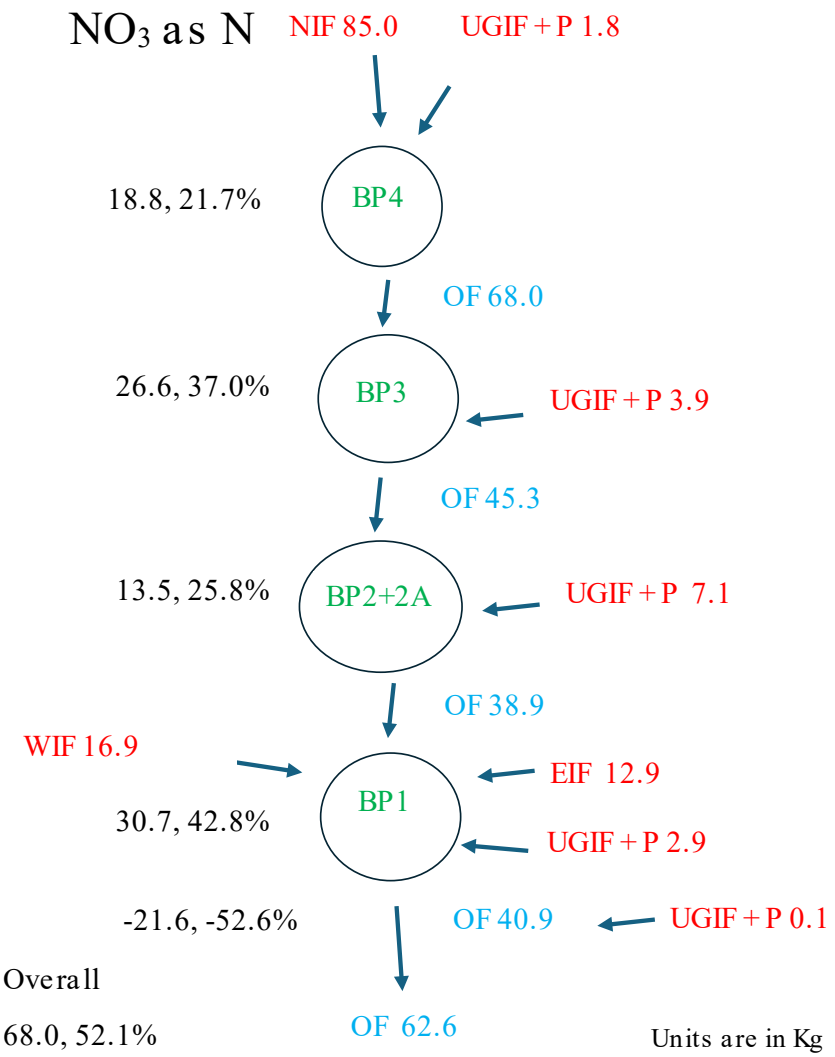
Inputs
Outputs
Retention



90.0 kg
40.4% Retention

-52.6 kg
-39.6% Retention

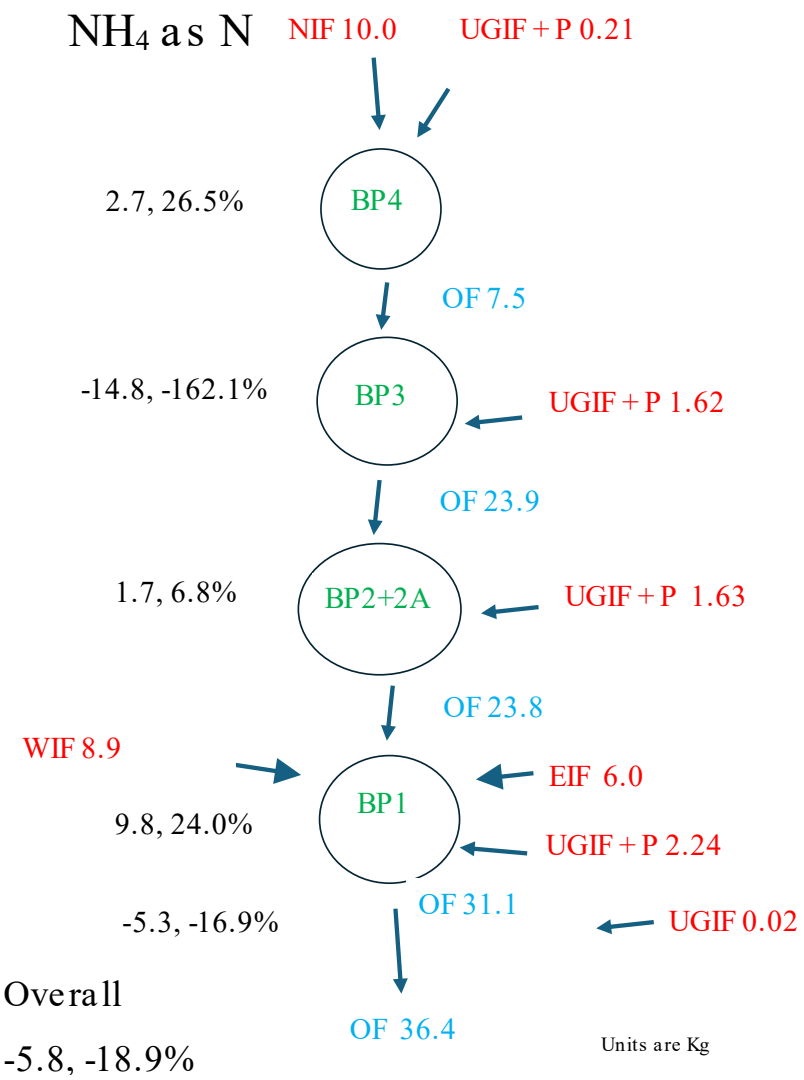
Inputs
Outputs
Retention



89.6 kg
68.7% Retention

-21.6 kg
-52.6% Retention

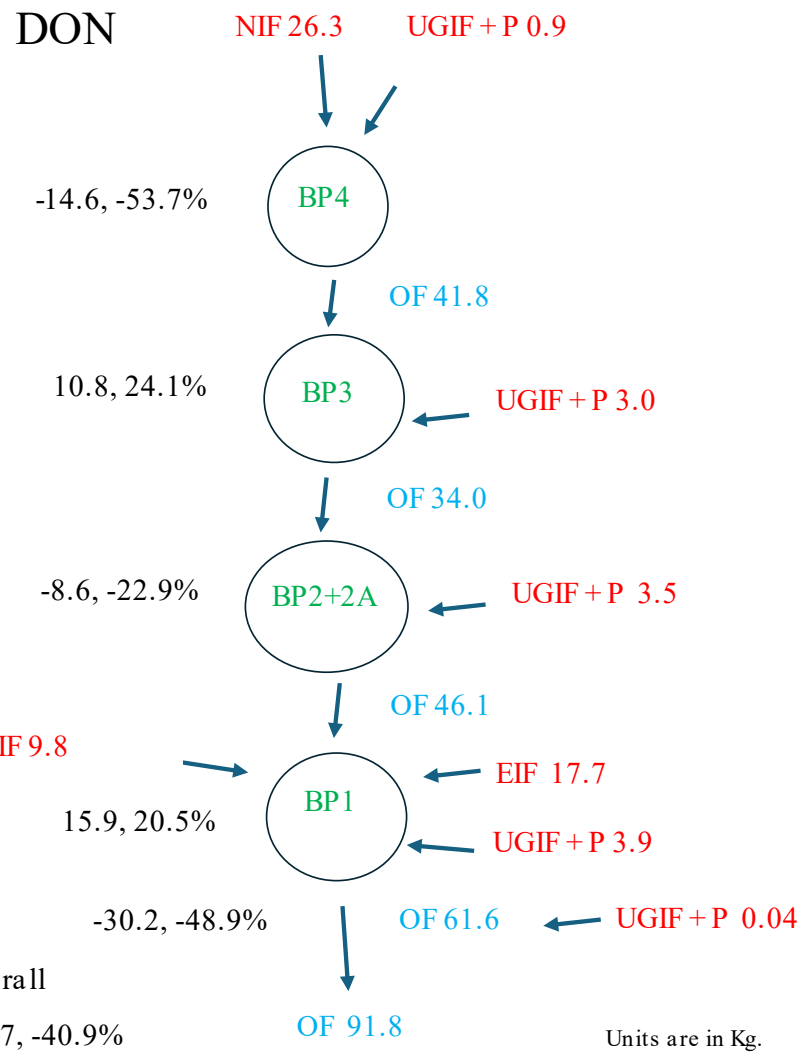
Inputs
Outputs
Retention



-0.5 kg
-1.6% Retention

-5.3 kg
-16.9% Retention

Inputs
Outputs
Retention



-3.5 kg
-5.4% Retention

-30.2 kg
-49.8% Retention

Summary

Retention Time

Post Impoundment retention time exceeded pre impoundment travel time of water by ≈ 26 times in the MC5 watershed.

Pond storage capacity and inflow volume determined individual ponds retetnion time. Two of the four beaver ponds exceeded EPA wet detention standard of 24 to 48 hours retention (USEPA 2021).

Retention of Nutrients & TSS

TSS, TDN, and NO_3 had statistacally signifigant retention attributed to the MC5 beaver pond impoundment.

The impoundments were a significant source of DOC

The actively eroding wet meadow below the pond complex was a significant source of DOC, TDP, TDN, NO_3 and DON.

Nutrient Transformations

Components of TDN Inputs
Ammoium 13%
Nitrate 60%
Organic N 27%

Components of TDN Exports
Ammoium 19%
Nitrate 33%
Organic N 48%

Components of DTP Inputs
Organic P≈ 100%

Components of DTP Exports
Organic P ≈ 100%

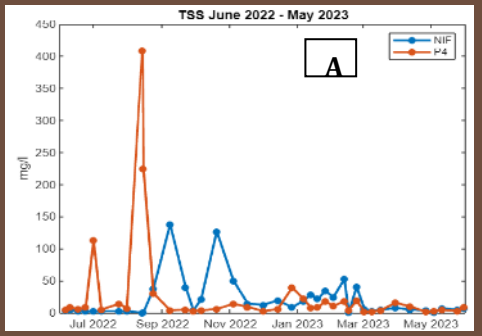
References

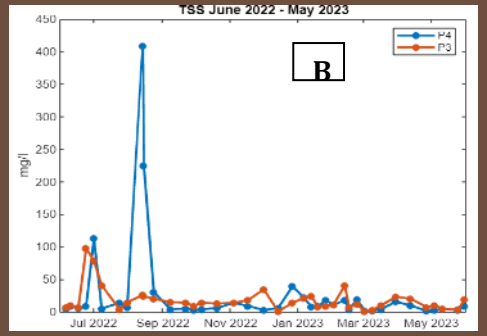
Larsen, Annegret, et al. “Dam Builders and Their Works: Beaver Influences on the Structure and Function of River Corridor Hydrology, Geomorphology, Biogeochemistry and Ecosystems.” Earth-Science Reviews, Elsevier, 5 May 2021, https://www.sciencedirect.com/science/article/pii/S0012825221001239.

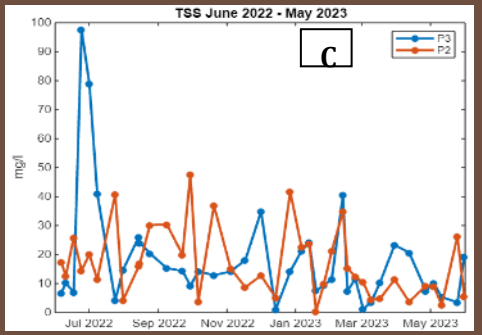
Grabus, C.; Allan, C. Analysis of Hydrological and Water Quality Alterations in a Suburbanizing Piedmont Watershed. thesis, 2009.

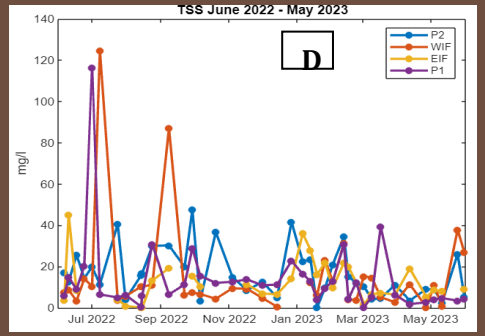
U.S.E.P.A. 2021. Stormwater Best Management Practice Wet Ponds. EPA-832-F-21-031BB. 7 p.

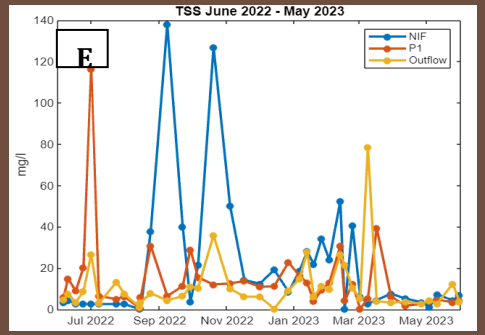
Thank You, Questions?











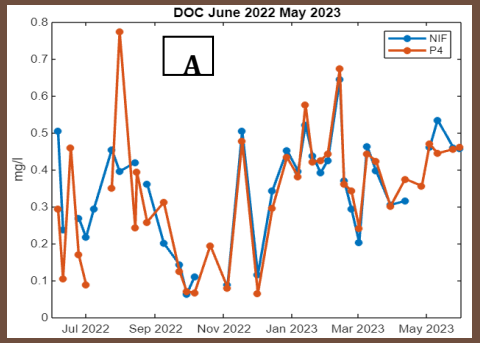
TSS Annual Trends

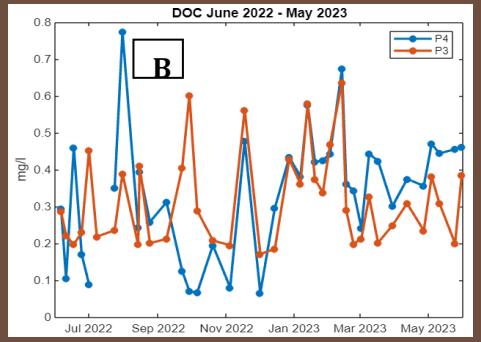
Low TSS compared to Piedmont surface waters, +100 mg/L on 3 occasions in tributary streams and once in Pond 4.

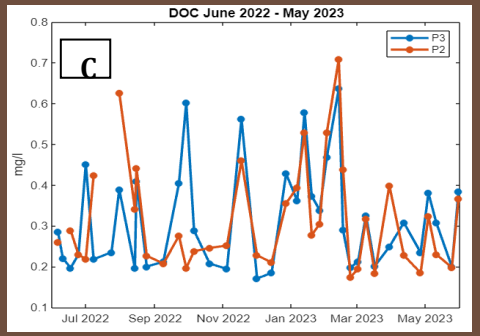
Median TSS increases 52% moving downstream NIF to P2 decreases following P1.

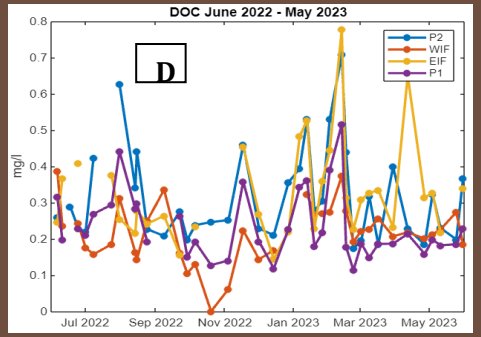
Variability in concentrations decreased 52% moving downstream decreases from the NIF to the outflow.

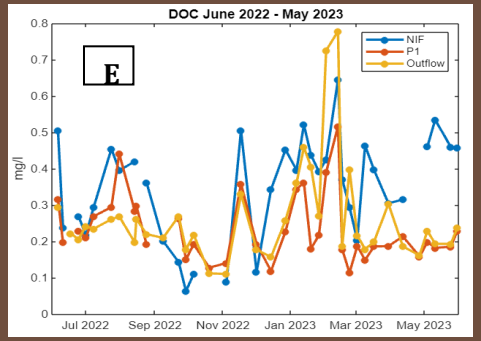
DOC Annual Trends







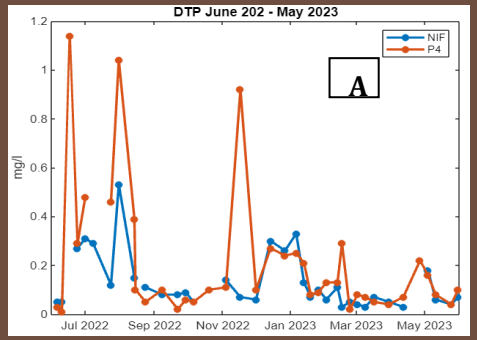


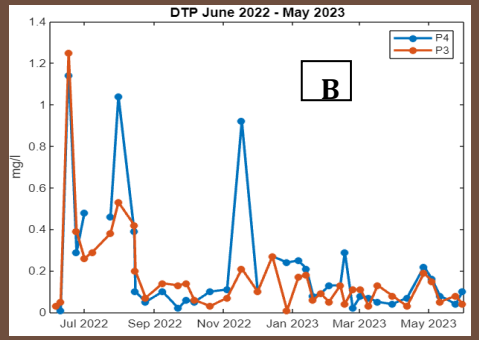


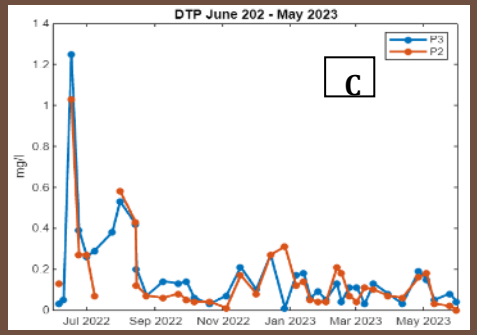
DOC concentrations increase 80% moving do NIF to the outflow.

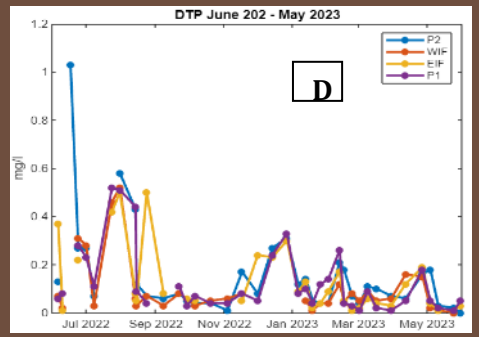
Variability in concentrations decreases 77% moving downstream NIF to the outflow.

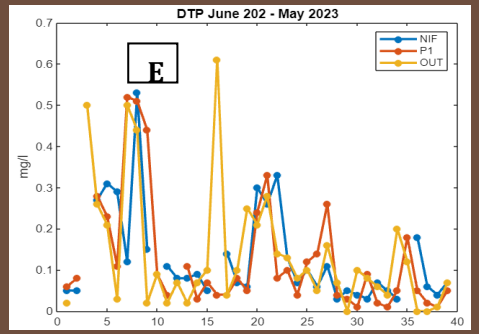
Outflow DOC yield (per Ha) was 61% higher than averages for the 2016-2018 (12.6 kg/ha)









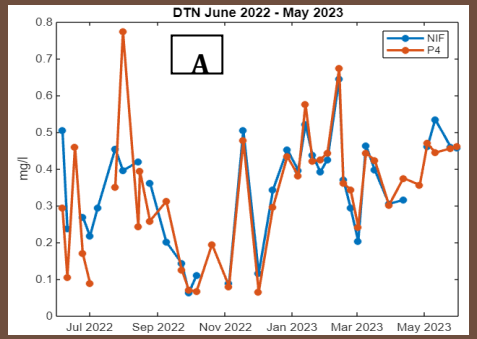


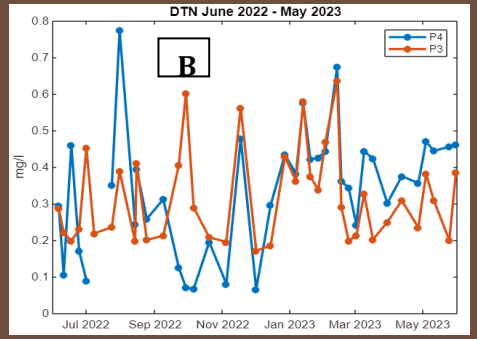
DTP Annual Trends

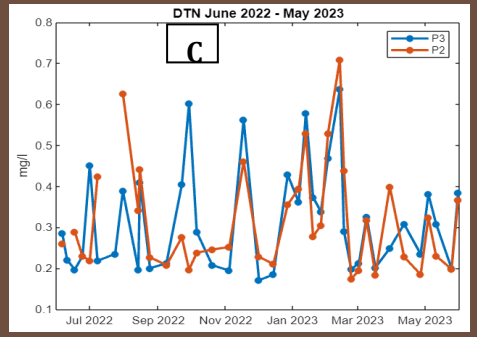
DTP concentrantions generally decreased m downstream 50% P4 to outflow.

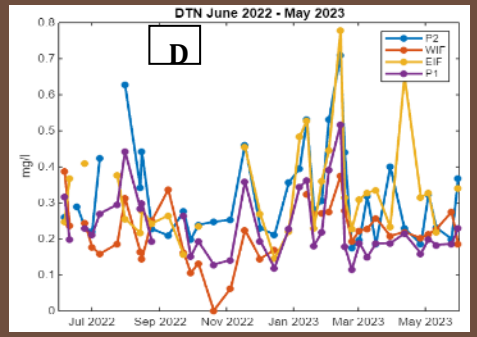
DTP concentration varience decreased with pond size 227.1 in P4, 179.7 in P1.

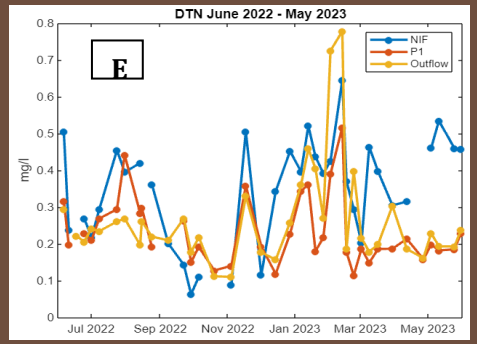
Outflow DTP yield (per Ha) was 69% higher than the TP yield average yield for 2016-2018 (0.4 kg/ha) .











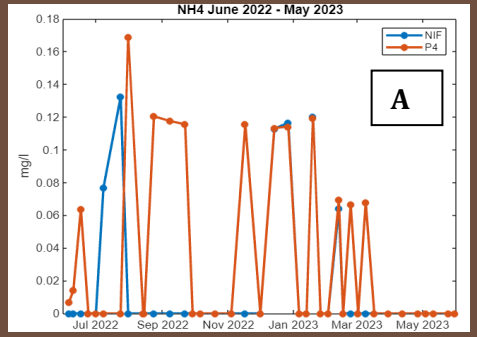
DTN Annual Trends

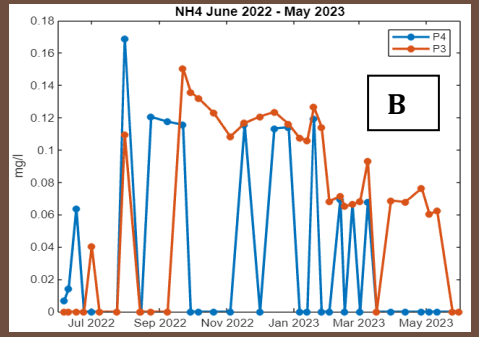
Concentrations are consistent moving downstr

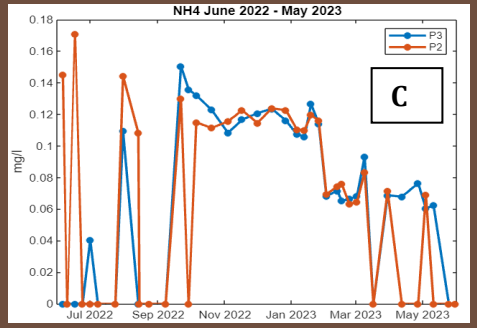
small decreases NIF – outflow(0.3-0.2mg/l)

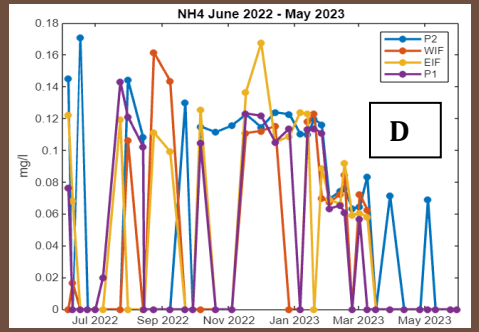
Variatoin in pond concentrations decreases 29% moving downstream

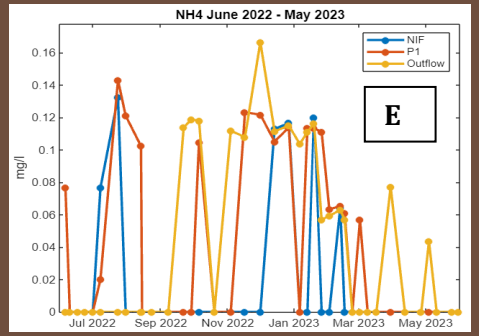
Outflow DIN yield increased by approximately 56% in comparison to the 2016-2018 averages (1.13 kg/ha).











NH_4 Annual Trends

Concentrations of ammonium slightly decrea

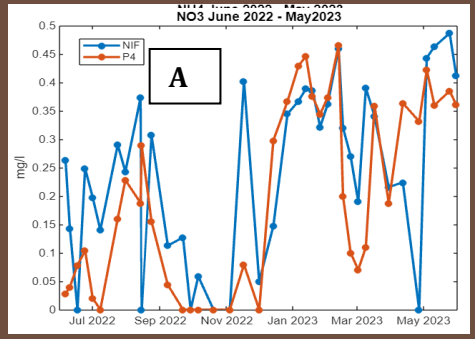
moving downstream NIF (0.10) - outflow (0.9).

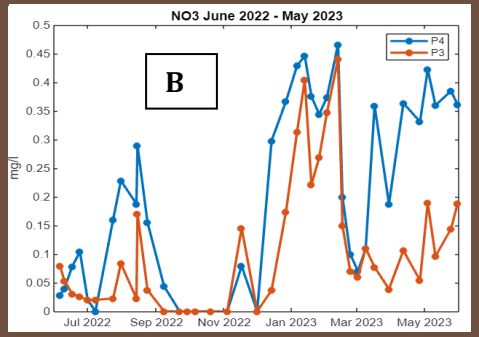
Concentration variance decreases in ponds 41%

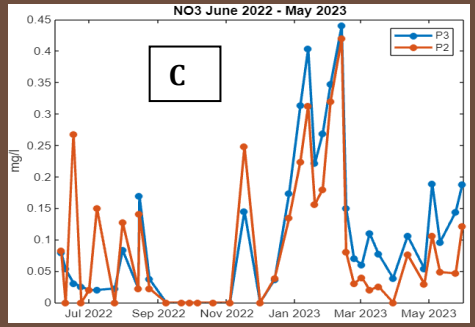
moving downstream

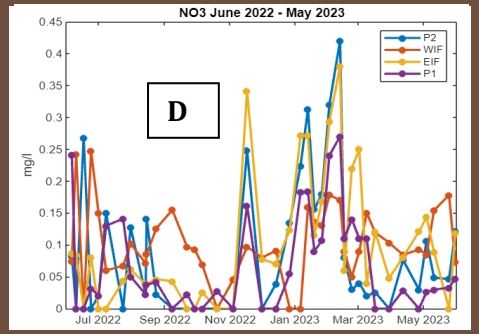
Outflow NH_4 yield (per Ha) was 50% lower than the

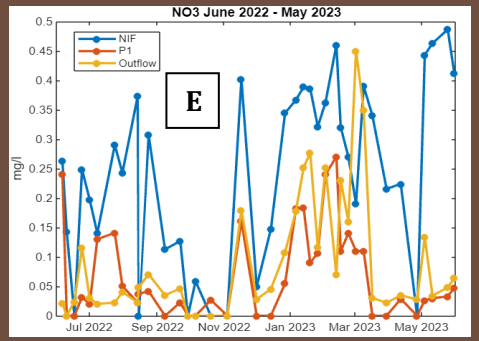
yield average yield for 2016-2018 (1.13 kg/ha).









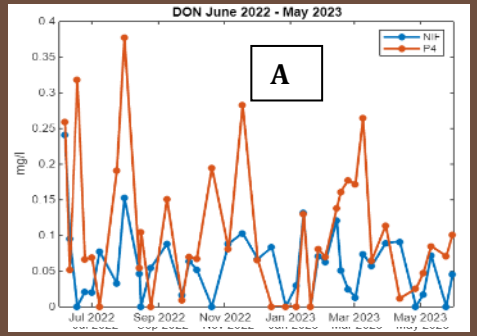


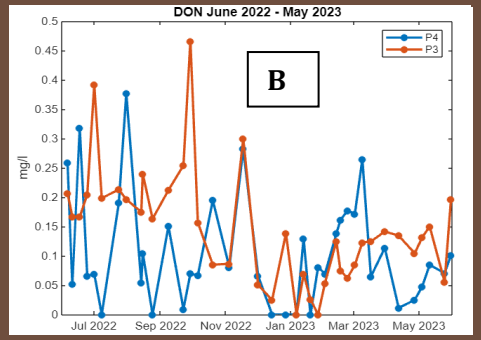
NO_3 Annual Trends

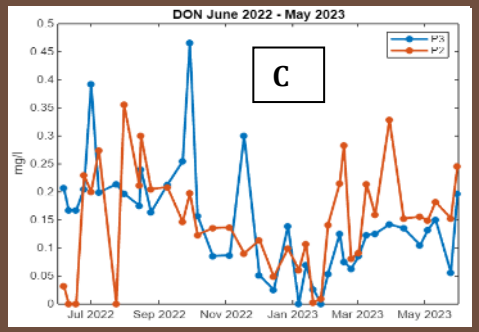
Nitrate concentrations decreased 88% NIF to

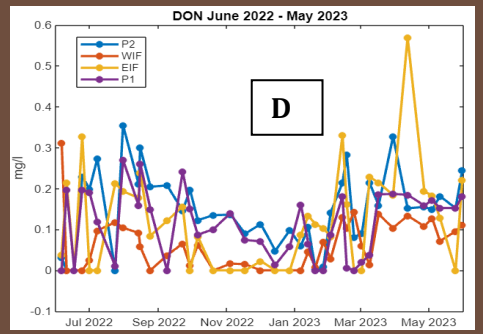
Higher concentration variation in ponds (103.7) than tributaries (72.4).

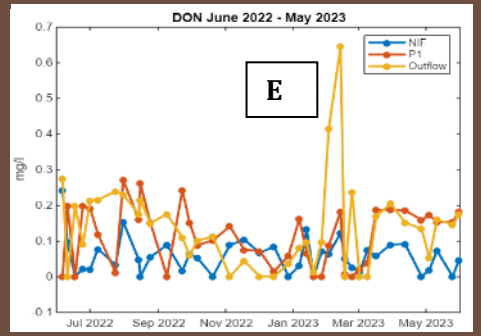
Outflow Nitrate yield (per Ha) was 43% lower than the yield average yield for 2016-2018 (0.6 kg/ha)











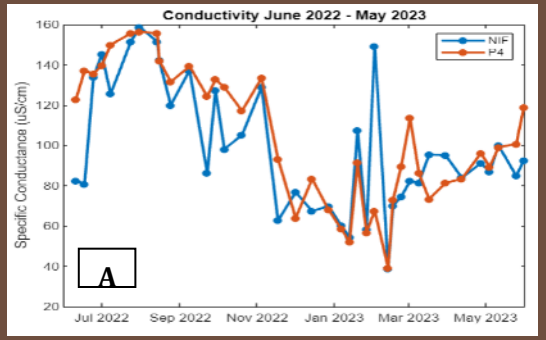
DON Annual Trends

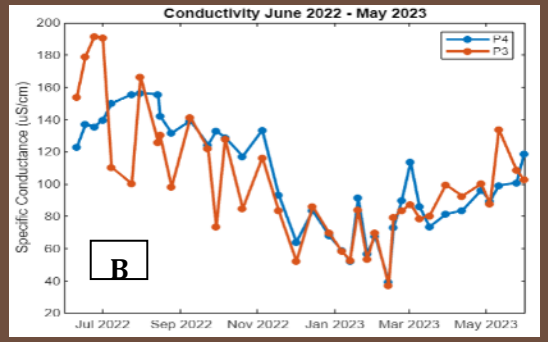
DON higher in ponds increasing with volur 0.7-0.14 mg/l.

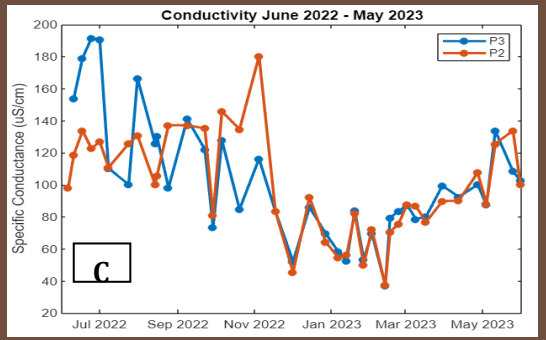
Concentration varience decreases with increased pond volume 88.9-71.6.

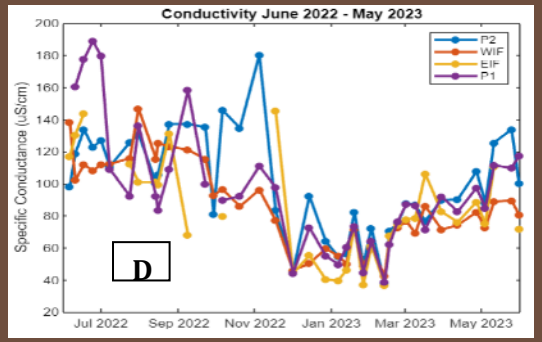
Outflow DON yield (per Ha) was 80% higher than the yield in 2018 (0.5 kg/ha).

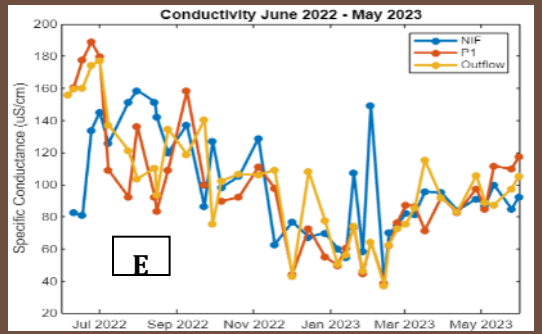
Conductivity

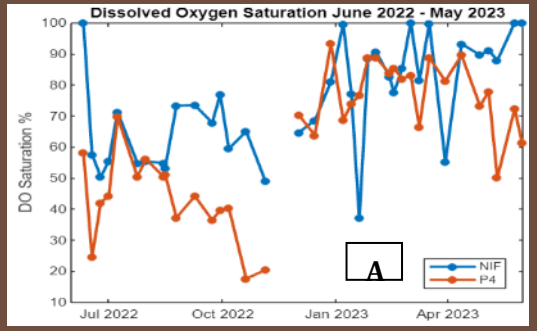


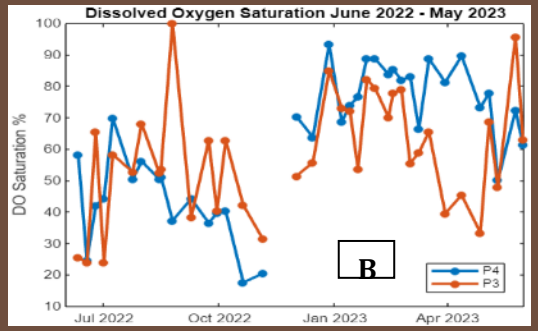


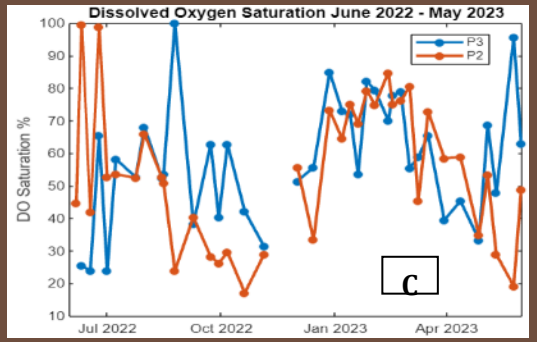


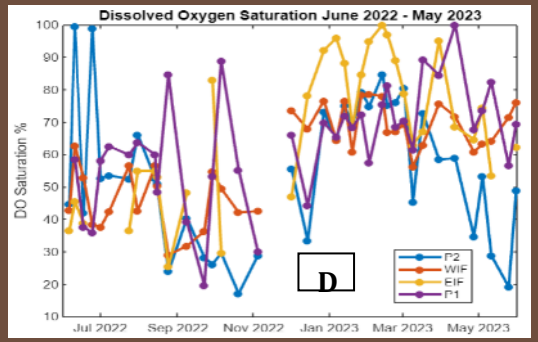


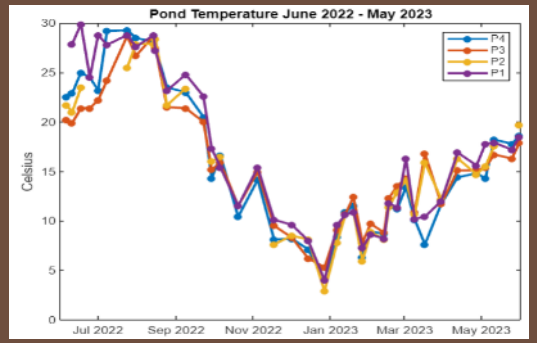


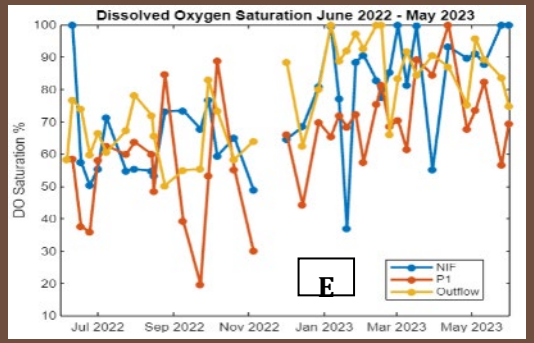












DO Saturation %

Lowest DO Saturation found in Ponds

As low as ≈ 17%

DO Saturation is Consistently higher in late Dormant season for all locations