Understanding Distribution of Nutrients in Karst Systems Using Biogeochemical Methods

University of Kentucky

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Introduction:

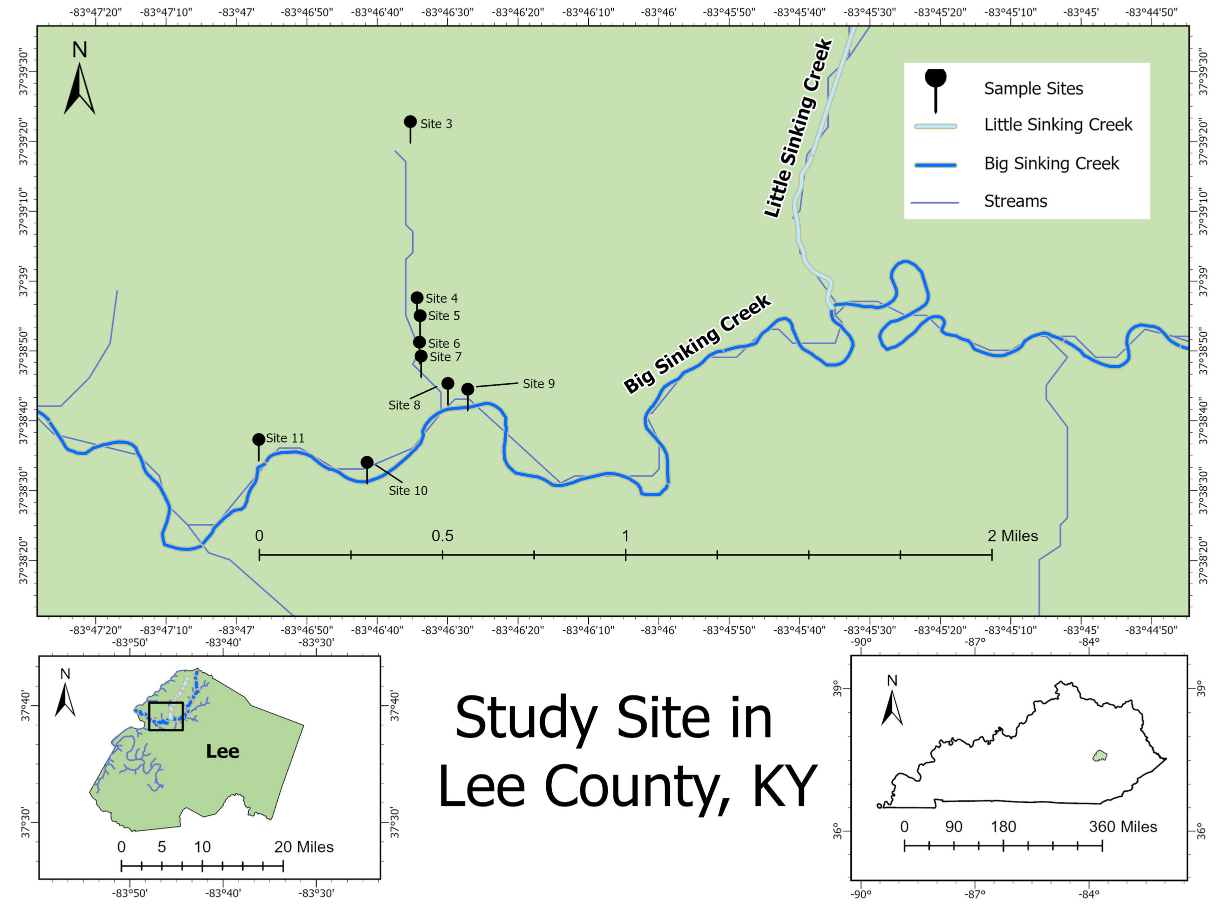


Figure 1: Map of all study sites within Lee County, KY.

Nine total study sites were located along the streams, springs, and caves within the karst lithology of Lee County, KY. The samples were taken from Stillhouse Cave (SHC) [Site 3], Cave Hollow Cave (CHC) [Sites 4-6], Cave Hollow Spring [Site 7-8], and along the Big Sinking Creek (BSC) [Sites 9-11]. SHC and CHC both have a known colony of bats, so water testing was conducted in these locations in hopes of visualizing possible interactions between bats and nutrients in the water system.

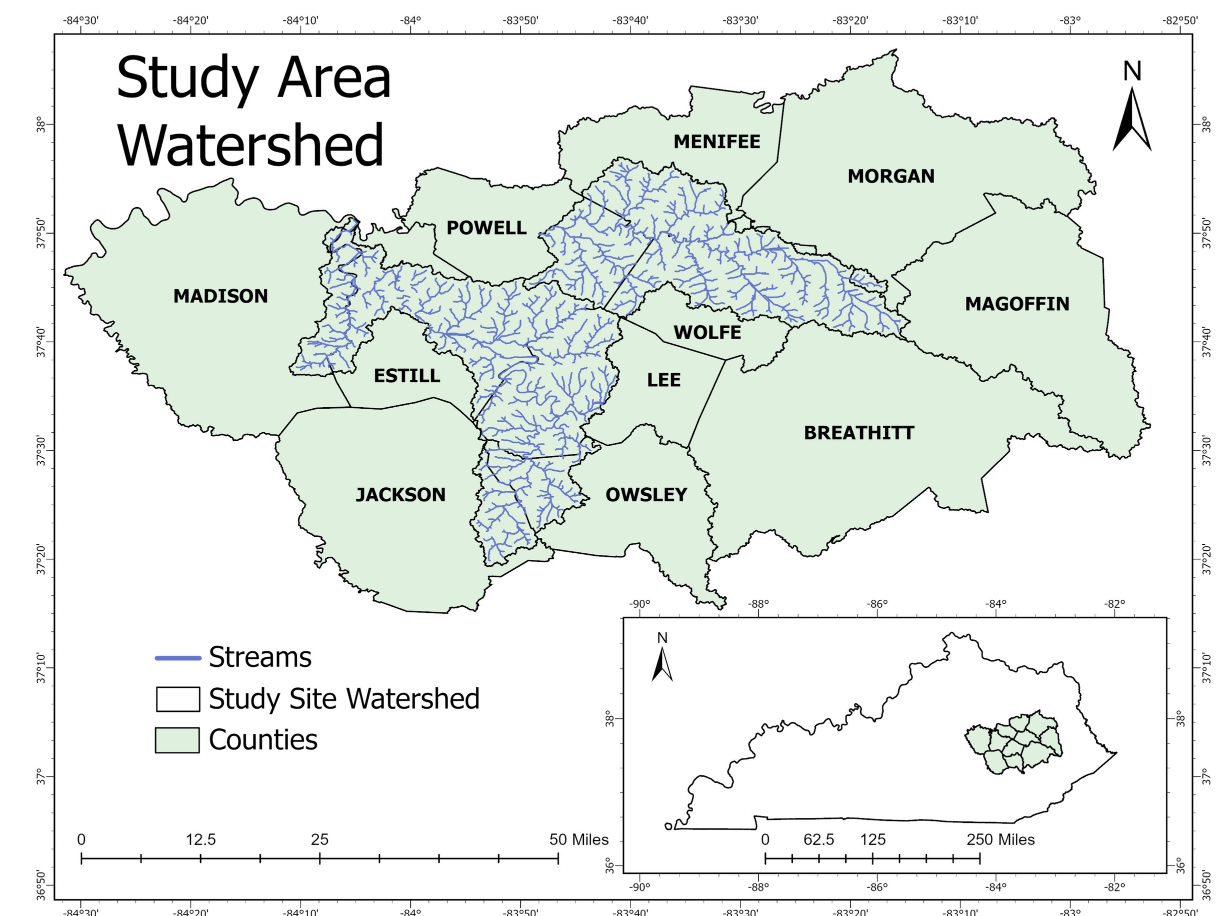


Figure 2: Map of the complete watershed of the study area and all the counties it resides in.

There are many streams throughout the large watershed of the study area. Little Sinking Creek (LSC) is located upstream from the sample sites and flows into BSC directly.

Methods:

- An fDOM (fluorescent dissolved organic material) spectroscopic analysis of water samples was completed following standard operating procedures (Wilson et al, 2022).
- Using the data collected from the fDOM analysis, a PARAFAC analysis of EEM (excitation-emission matrix) was conducted to separate DOM components within Rstudio using the staRdom (spectroscopic analysis of dissolved organic matter) package.
- A general water quality analysis was completed for water samples taken from all sites on 6/4/2024. Bicarbonate and carbonate were not measured during this test, so an approximation was modeled as "alkalinity" and used in their place when modeling for *Figures 3* and *4* using GeoChemist Workbench.
- Total CNP (organic carbon, nitrogen, and phosphorous) analysis was done for all water samples on 6/4/24 and 6/25/24 using Hach testing kits and a Teledyne Tekmar TOC (Total Organic Carbon) for combustion analysis of carbon.
- Bio inventory of CHC was catalogued by a unique zoning technique (see posters of Grzynkowicz and Gribbins).

Results:

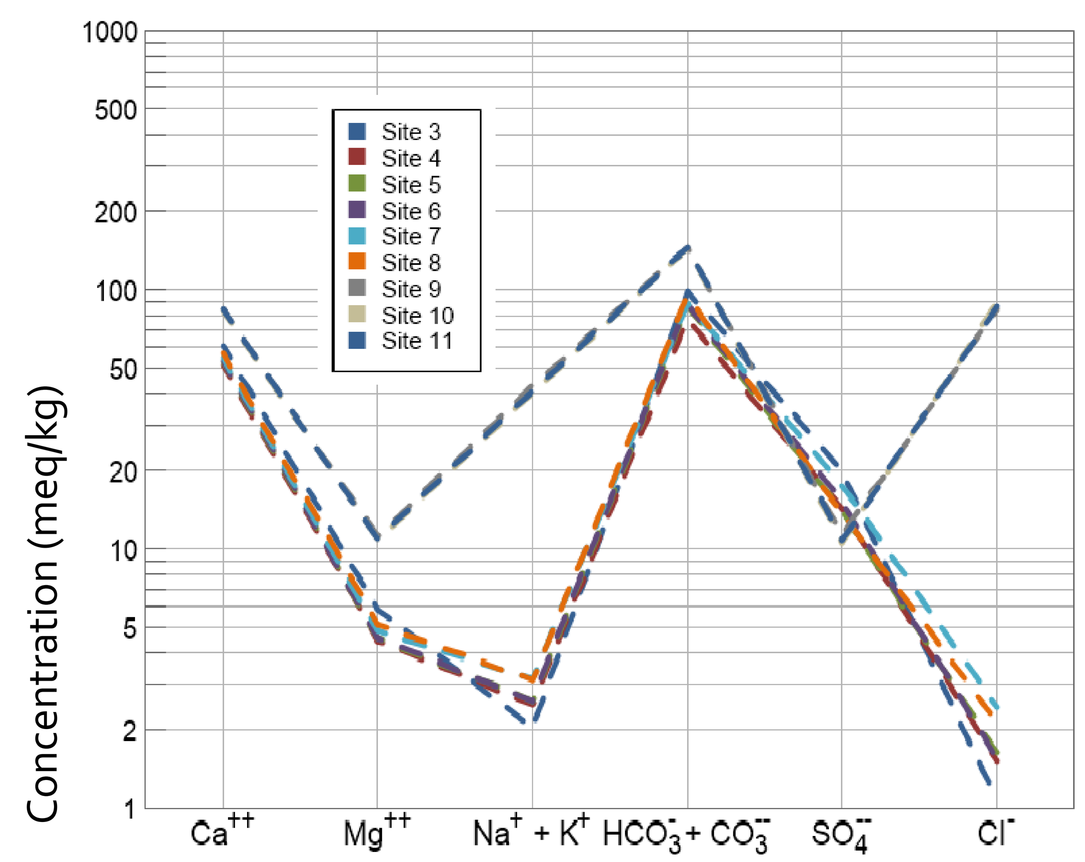


Figure 3: Logarithmic Schoeller diagram of the main water component concentrations. There is a higher trend at Sites 9, 10, and 11.

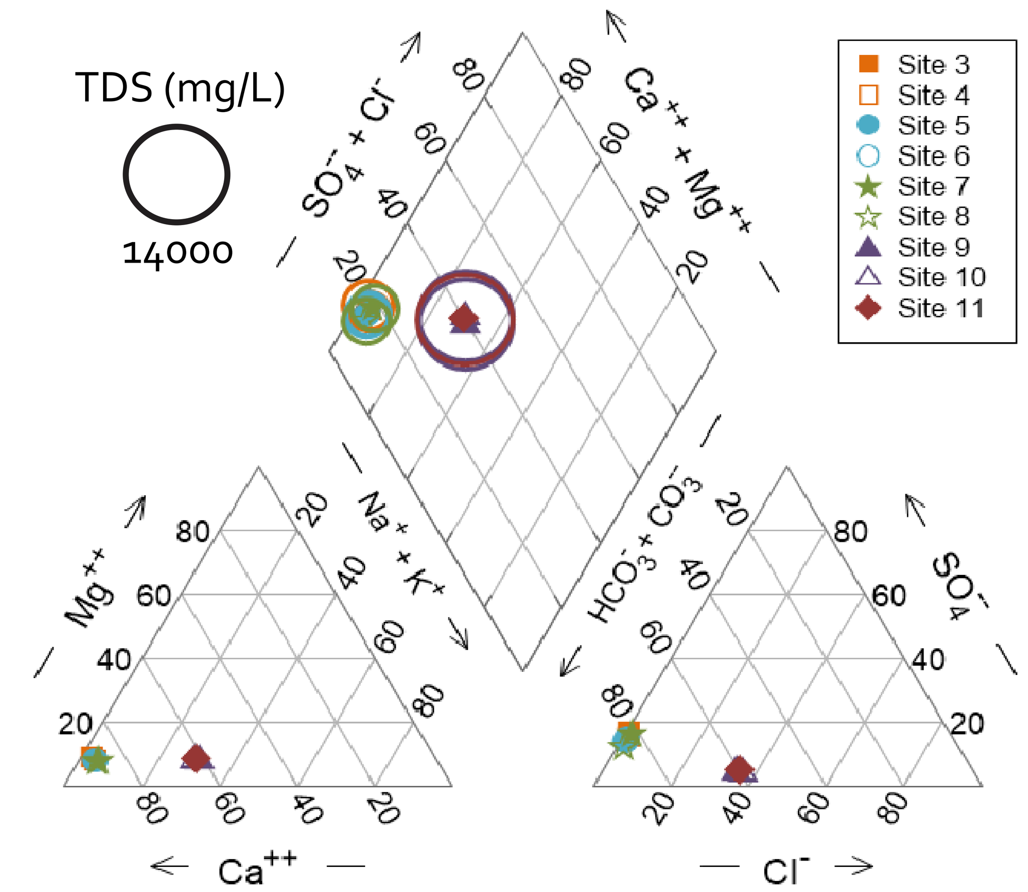
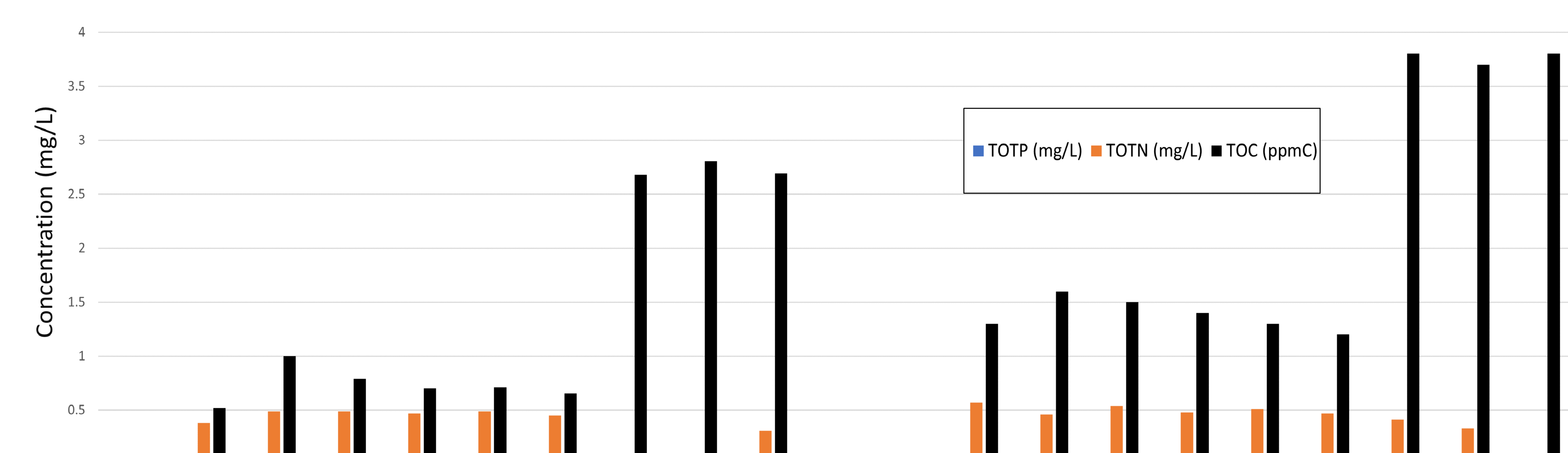


Figure 4: Piper diagram showing the major ion composition of water samples.



	6/4/2024	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11
TOTP (mg/L)				0.009	0.007	0.009	0.007			
TOTN (mg/L)		0.38	0.49	0.49	0.47	0.49	0.45			0.31
TOC (ppmC)		0.52	1.00	0.79	0.70	0.71	0.66	2.68	2.81	2.69

		6/25/2024	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11
TOTP (mg/L)											
TOTN (mg/L)			0.57	0.46	0.54	0.48	0.51	0.47	0.41	0.33	
TOC (ppmC)			1.30	1.60	1.50	1.40	1.30	1.20	3.80	3.70	3.80

Figure 5: Total CNP bar graph covering two separate sampling dates. Sites 9, 10, and 11 have noticably higher CNP concentrations than the other site locations across both testing days.

Interpretation of Results:

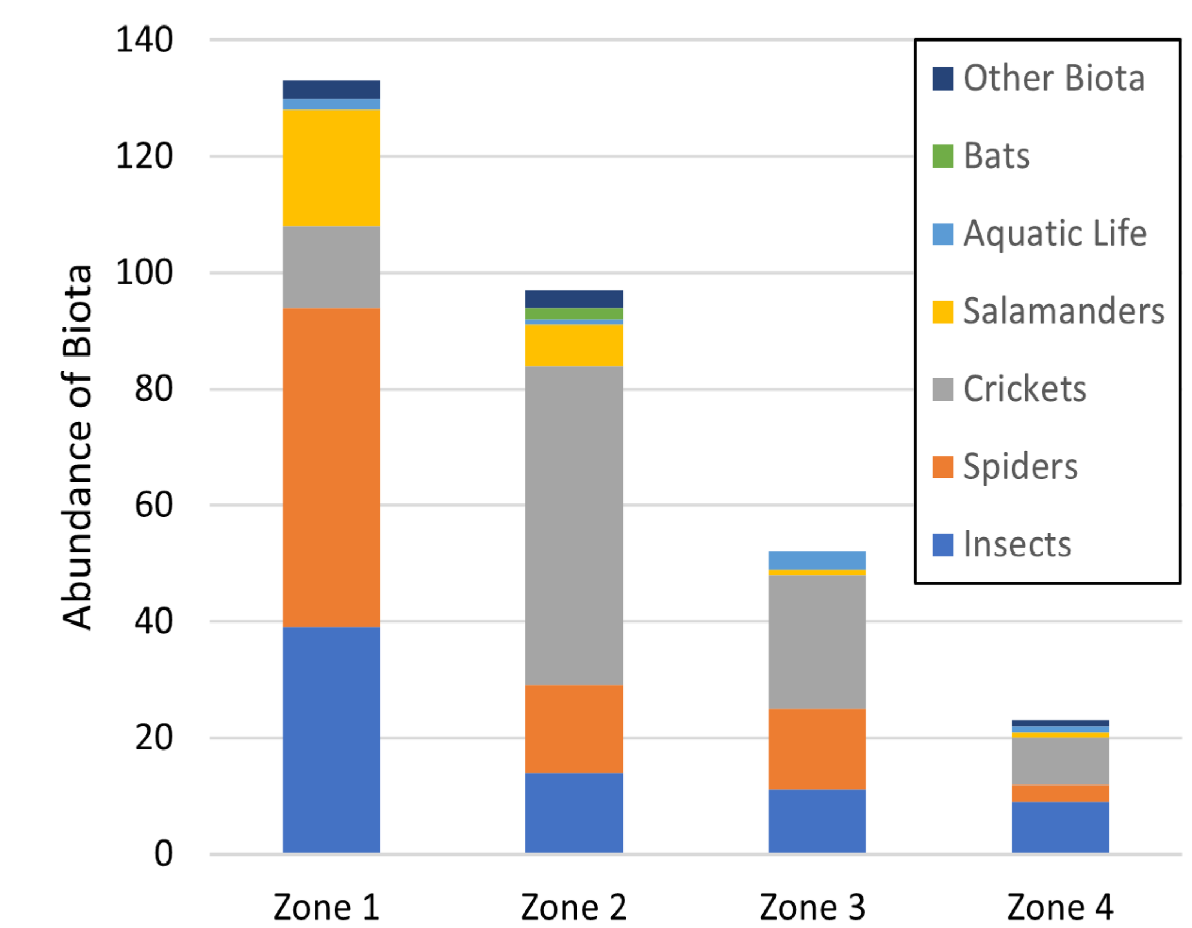


Figure 6: Graph of bio inventory results per zone in Cave Hollow Cave.

My initial hypothesis was that study sites within the caves would have a high nitrogen count, as denitrification and degradation of bat guano affects nitrogen, sulphate, and phosphate levels (Lundberg et al, 2022). Additionally, guano has been shown to be a vital nutrient source in other researched caves (Fenolio et al, 2014). However, those caves are much larger than either SHC or CHC. *Figure 6* shows a pattern of lessening biota as the distance increases from the cave entrance, which has been studied further in other works (Tobin et al, 2013). The nitrogen levels shown in *Figure 5* are not significant enough to conclude that the bats are a vital nitrogen sink within the study sites. Despite this, an interesting finding was discovered by analyzing the chemistry in *Figures 3* and *4*, as it shows two different water systems throughout the study area. Since the highest concentrations were recorded at Sites 9, 10, and 11, this could suggest that nutrients are washing from upstream BSC or LSC.

Future Work:

Based off this study, future research should be conducted over a longer time frame to further our understanding of the annual nutrient flux in caves. Additionally, it could be beneficial to expand the study area to include more locations upstream to better locate specific point sources of nutrients. Monthly or bi-monthly water quality tests would provide a more precise comparison of data between sites and, consequently, would greatly improve statistical analysis quality. Furthermore, important factors to consider are stormwater drainage and water movement from frequent flooding events, as these factors can vastly impact data variability when performing water testing.

Acknowledgements:

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