October 2025

NO3
N2
NO2
NH4

BASEFLOW NITROGEN CONCENTRATIONS IN HUNTING CREEK TRIBUTARIES, 2021-2025: MOSTLY GOOD NEWS!

By Ron Klauda (Friends of Hunting Creek) and Mary Hoover (American Chestnut Land Trust)

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In this document, we will examine five years of data on springtime baseflow dissolved nitrogen (as nitrite NO2+nitrate NO3) in non-tidal tributaries that drain the Hunting Creek watershed in central Calvert County, Maryland. By *springtime* and *baseflow,* we mean the stream levels occurring in early April, before leaf out, not influenced by rainfall/runoff during the previous 3-4 days, and therefore representative of mostly shallow/near surface groundwater.

To elaborate a bit—baseflow, the groundwater contribution to streamflow, sustains surface water courses between precipitation events and is an important indicator of groundwater availability (Schilling and Zhang 2004, Ayers et al. 2021). Ecological health depends upon baseflow discharge, not only because it maintains streamflow but also because it regulates water temperature and quality. Baseflow includes subsurface water from deep regional groundwater storage and shallow groundwater flow paths (Miller et al. 2014).

NO3 is the primary form of dissolved nitrogen in streams and groundwater (Munn et al. 2018). NO2 is generally unstable and contributes little to the total concentration of dissolved inorganic nitrogen in water.

Grab water samples were collected in tributary streams by the Friends of Hunting Creek (FOHC) volunteers, while participating in the annual Water Quality Blitz program sponsored by the American Chestnut Land Trust (ACLT) and led by Dr. Walter Boynton. Blitz samples were analyzed for NO2+NO3 by the Nutrient Analytical Services Laboratory at the University of Maryland's Chesapeake Biological Laboratory in Solomons, Maryland.

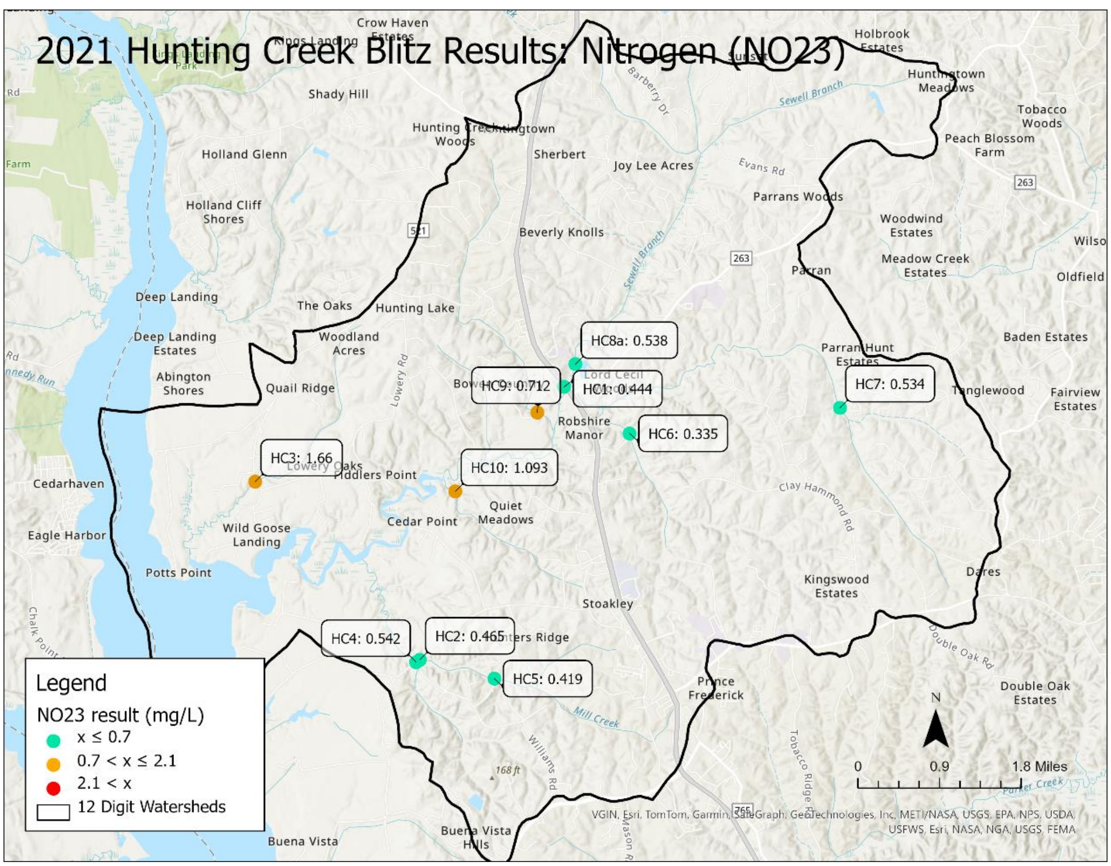
What Are the Five Years of Blitz Results Telling Us?

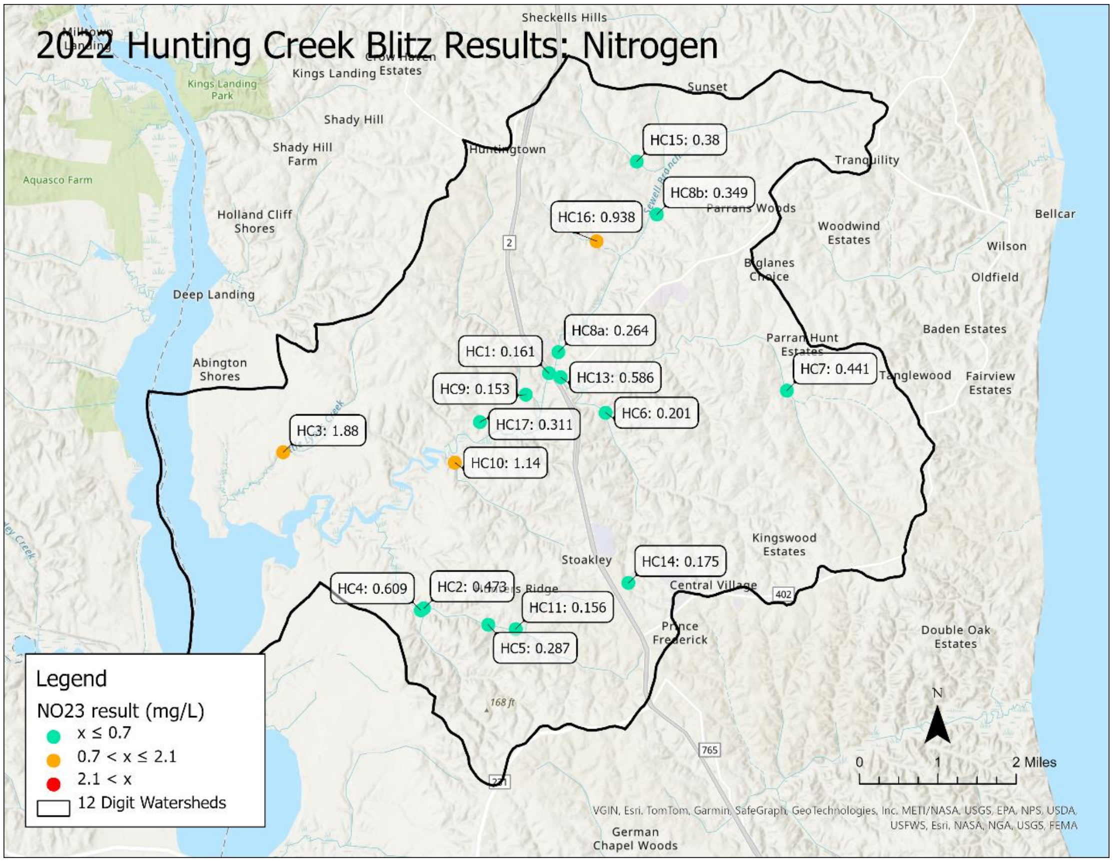
As our title says, mostly good news…so far. Five years of monitoring data is a good start toward building a robust data base. However, it's important to understand that five years of nitrogen data do not equal a time series appropriate for statistically-based trends analyses. To capture the full range of natural variability and have a reasonable chance of seeing a signal in the noise, conventional wisdom says we need at least 10 years of annual nitrogen measurements to create a useful time series.

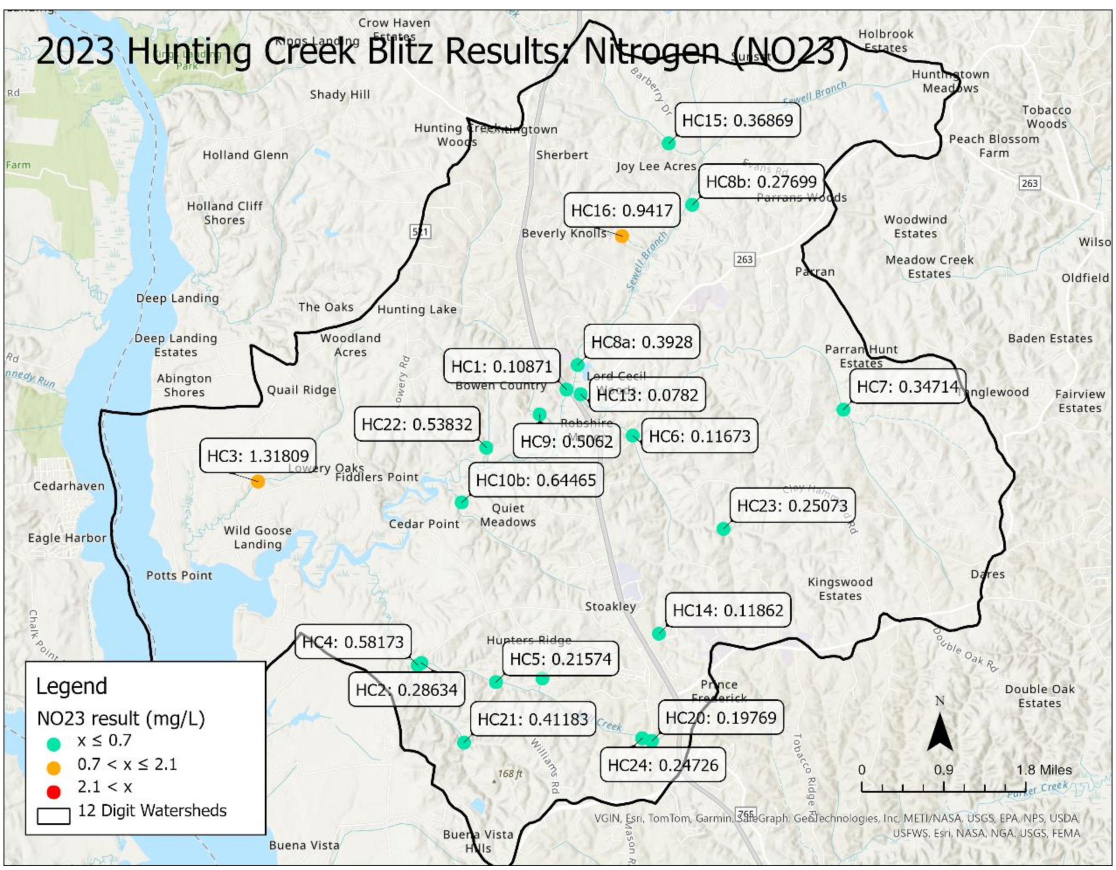
So, with only five years of Blitz sampling in Hunting Creek tributaries, it's premature to expect to detect definitive trends that tell us that baseflow nitrogen concentrations are increasing or decreasing or staying about the same. However, we can and will summarize the data in hand and offer several relevant observations. See the table in the Appendix for the NO23 data recorded during Blitz sampling by the Friends of Hunting Creek.

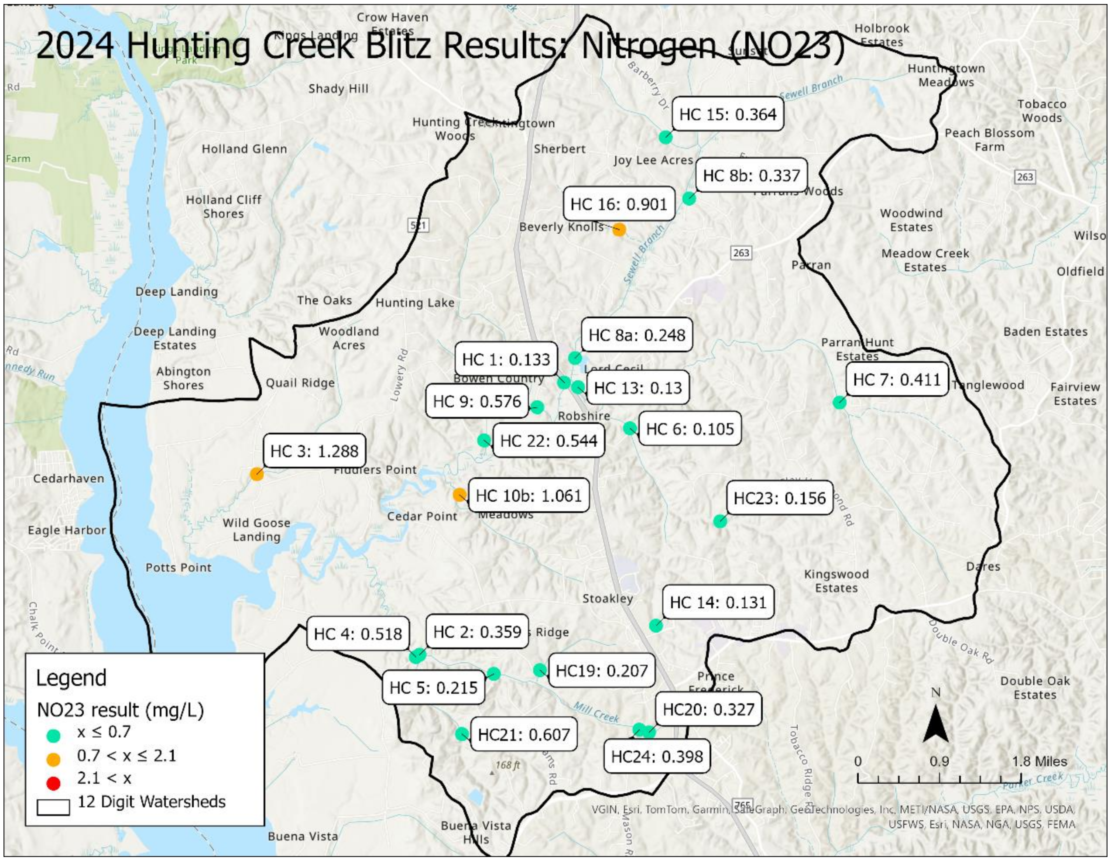
Some Maps to Peruse

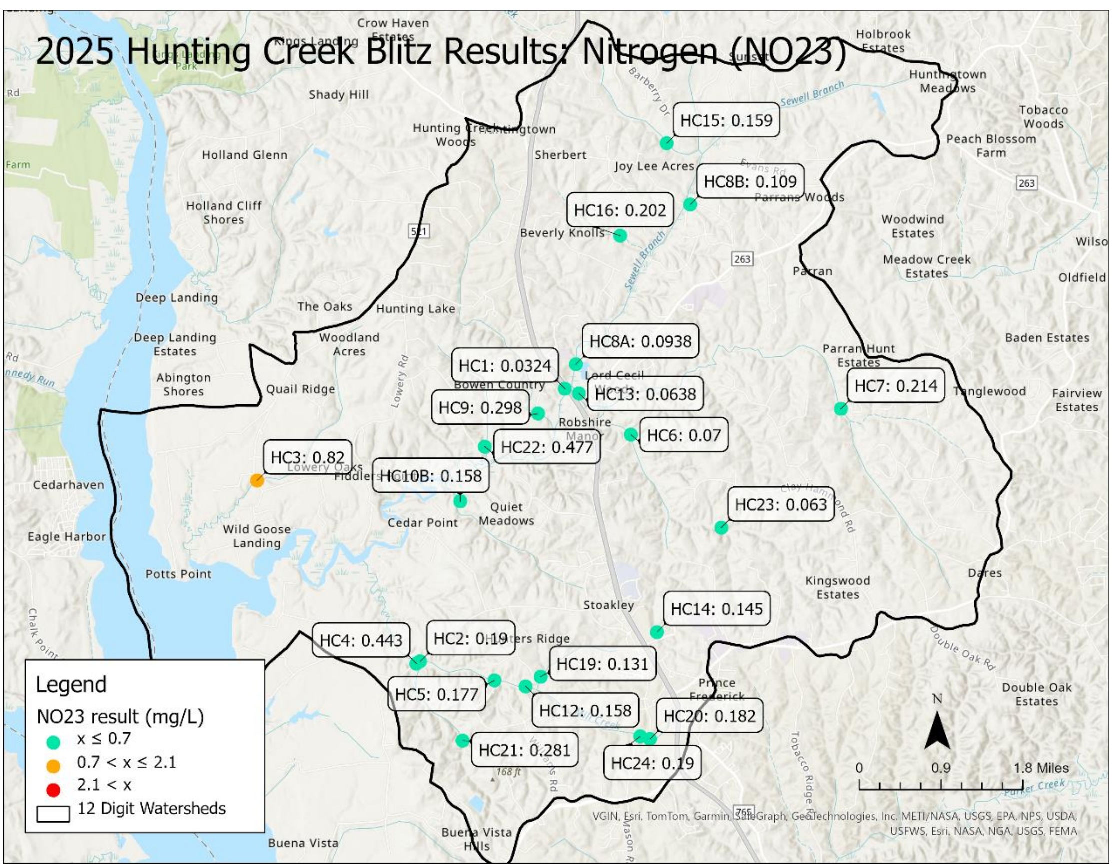
For starters, please examine the five maps below showing the Hunting Creek watershed boundary plus the locations of the FOHC's sampling sites from 2021 through 2025 and the nitrogen concentration at each site. The color of each dot represents a nitrogen condition category, associated with ecological stream health, that was suggested by ACLT's Science Committee (see the Parkers Creek Report Card [here](#)). Nutrients, including nitrogen, are essential for a healthy aquatic ecosystem. However, elevated nitrogen levels can cause harm to stream biota, shift aquatic food webs, deplete dissolved oxygen levels, reduce instream nutrient cycling, degrade instream habitat, and therefore diminish ecological health (Rabalais 2002, Camargo and Alonso 2006, Munn et al. 2018).




2022 Hunting Creek Blitz Results: Nitrogen
HC15: 0.38
HC8b: 0.349
HC16: 0.938
HC8a: 0.264
HC1: 0.161
HC13: 0.586
HC7: 0.441
HC9: 0.153
HC6: 0.201
HC17: 0.311
HC3: 1.88
HC10: 1.14
HC14: 0.175
HC4: 0.609
HC2: 0.473
HC11: 0.156
HC5: 0.287
Legend
NO23 result (mg/L)
x ≤ 0.7
0.7 < x ≤ 2.1
2.1 < x
12 Digit Watersheds
0
1
2 Miles
N
VGIN, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, USFWS, Esri, NASA, NGA, USGS, FEMA


2023 Hunting Creek Blitz Results: Nitrogen (NO23)
HC15: 0.36869
HC8b: 0.27699
HC16: 0.9417
HC8a: 0.3928
HC1: 0.10871
HC13: 0.0782
HC7: 0.34714
HC22: 0.53832
HC9: 0.5062
HC6: 0.11673
HC3: 1.31809
HC10b: 0.64465
HC23: 0.25073
HC14: 0.11862
HC4: 0.58173
HC5: 0.21574
HC2: 0.28634
HC21: 0.41183
HC20: 0.19769
HC24: 0.24726
Legend
NO23 result (mg/L)
x ≤ 0.7
0.7 < x ≤ 2.1
2.1 < x
12 Digit Watersheds
0
0.9
1.8 Miles
N
VGIN, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, USFWS, Esri, NASA, NGA, USGS, FEMA


2024 Hunting Creek Blitz Results: Nitrogen (NO23)
HC 15: 0.364
HC 8b: 0.337
HC 16: 0.901
HC 8a: 0.248
HC 1: 0.133
HC 13: 0.13
HC 9: 0.576
HC 7: 0.411
HC 6: 0.105
HC 22: 0.544
HC 3: 1.288
HC 10b: 1.061
HC23: 0.156
HC 14: 0.131
HC 4: 0.518
HC 2: 0.359
HC19: 0.207
HC 5: 0.215
HC20: 0.327
HC21: 0.607
HC24: 0.398
Legend
NO23 result (mg/L)
x ≤ 0.7
0.7 < x ≤ 2.1
2.1 < x
12 Digit Watersheds
N
0 0.9 1.8 Miles
VGIN, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, USFWS, Esri, NASA, NGA, USGS, FEMA


2025 Hunting Creek Blitz Results: Nitrogen (NO23)
HC15: 0.159
HC8B: 0.109
HC16: 0.202
HC8A: 0.0938
HC1: 0.0324
HC13: 0.0638
HC9: 0.298
HC7: 0.214
HC6: 0.07
HC22: 0.477
HC3: 0.82
HC10B: 0.158
HC23: 0.063
HC14: 0.145
HC4: 0.443
HC2: 0.19
HC19: 0.131
HC5: 0.177
HC12: 0.158
HC20: 0.182
HC21: 0.281
HC24: 0.19
Legend
NO23 result (mg/L)
x ≤ 0.7
0.7 < x ≤ 2.1
2.1 < x
12 Digit Watersheds
N
0 0.9 1.8 Miles
VGIN, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, USFWS, Esri, NASA, NGA, USGS, FEMA

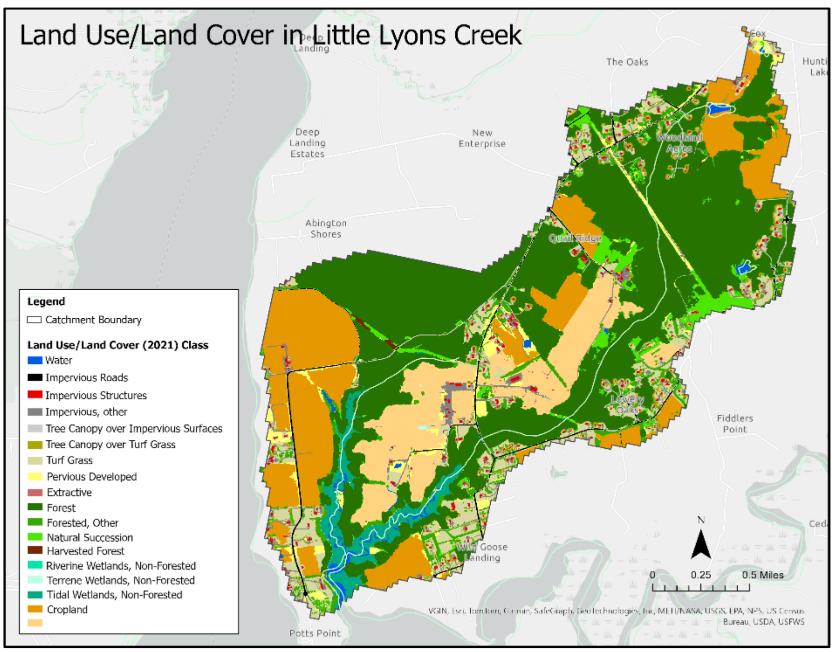
The first encouraging result clearly shown in these maps is that none of the non-tidal tributaries sampled during the five Blitz years had baseflow nitrogen levels high enough to receive a red dot and a POOR condition rating. Most sites instead had low nitrogen concentrations, receiving green dots and GOOD condition ratings for ecological health—all good news.

The not-so-good news is that four sites received yellow dots for baseflow nitrogen and were placed in the FAIR condition category for ecological health. Site HC3 in Little Lyons Creek scored a FAIR rating in all five years. Sites HC10/HC10b in Fox Point Creek and site HC16 in Quail Ridge Run scored a FAIR rating in three years. Site HC9 in Reits Branch scored a FAIR rating in only one year: 2021.

Do we have any clues for what may be contributing to the slightly elevated nitrogen concentrations measured during baseflow conditions at HC3, HC10/10b, and HC16? As a matter of fact, we do.

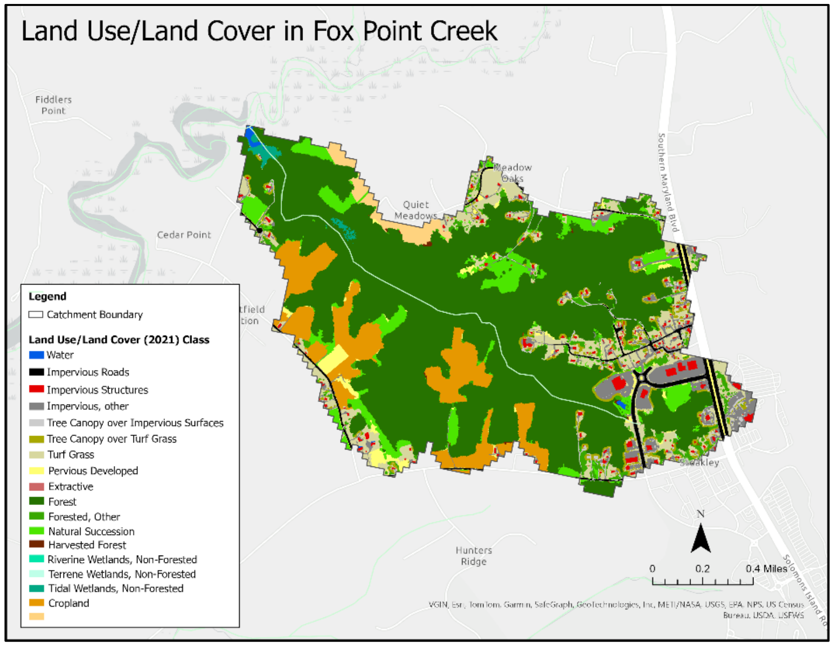
Land use/land cover in the catchments where these three sampling sites are located is at the top of our list of plausible explanations. Gburek and Folmar (1999) developed a simple model that predicted baseflow NO3 concentrations at the subwatershed (catchment) scale of east Mahantango Creek in Pennsylvania based on major land use categories. They reported that tributaries draining agricultural areas had higher concentrations of NO3 than tributaries draining a forested ridge. Munn et al. (2018) published study results that reached similar conclusions.

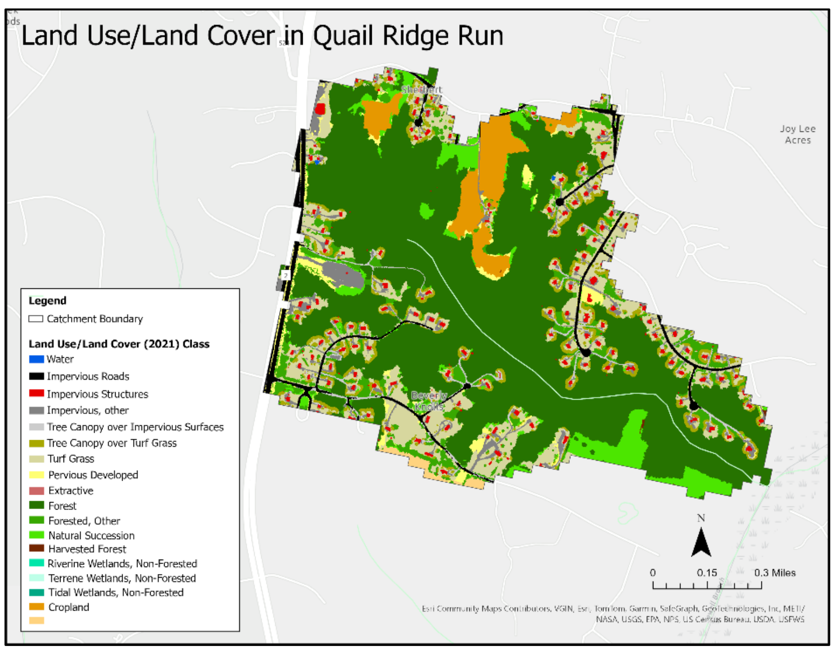
We examined 2017/2018 land use/land cover data available from the Chesapeake Conservancy and learned that almost one third (31.3%) of the Little Lyons Creek catchment (total area of 1577 acres) in the Hunting Creek watershed was classified as agricultural land use (farm fields and pastures). That is the highest percentage of agricultural land use of the 13 catchments that comprise the watershed. So, it seems reasonable to conclude that nitrogen fertilizers and livestock manure are the most likely sources of the



baseflow nitrogen measured at HC3 in 2021-2025.

Sites HC10/HC10b are in Fox Point Creek, a 711-acre catchment that drains the north-central portion of the Prince Frederick Town Center. Land use/land cover in this catchment in 2017/2018 was 28.3% developed, with 9.4% impervious surfaces, and 13.4% agriculture. Site HC16 is in Quail Ridge Run, a 732-acre catchment that is 44.7% developed (mostly large-lot residential), with 12.0% impervious surfaces, and only 5.4% agriculture. The relatively high percentages of developed land use and impervious surfaces in the Quail Ridge Run catchment are primarily associated with the Marley Run community of about 250 single-family homes on larger lots. So, urban and suburban development, not agriculture, are presumably the major sources of the slightly elevated concentrations of baseflow nitrogen at sites HC10/HC10b and HC16.





A Few Stats to Study

Table 1 presents some simple statistics associated with the spring baseflow nitrogen results in the Hunting Creek watershed. The highest nitrogen concentration measured during the five years of Blitz sampling was 1.880 mg/L at HC3, Little Lyons Creek, in 2022. The lowest nitrogen concentration of 0.032 mg/L was measured at HC1, in the mainstem of Hunting Creek at the Rts. 2/4 bridge, not far upstream from the head-of-tide, in 2025.

Blitz Date	No. of Sample Sites	Baseflow Nitrogen (NO23) Concentration (mg/L)			
		Highest	Lowest	Mean (Average)	Median
4/3/21	10	1.7	0.34	0.67	0.54
4/2/22	17	1.9	0.15	0.50	0.35
4/1/23	21	1.3	0.11	0.40	0.29
4/6/24	21	1.3	0.11	0.43	0.36
7/5/25	22	0.8	0.03	0.22	0.17

Table 1

Mean (average) nitrogen concentrations, across all sampled sites, ranged from 0.217 mg/L in 2025 to 0.674 mg/L in 2021. So, it's clear that, on average, spring baseflow nitrogen levels were below 0.7 mg/L and therefore in the GOOD condition category… more encouraging news. Median nitrogen concentrations showed a similar picture to what the mean concentrations showed. The highest overall nitrogen concentrations across all five years of Blitz sampling occurred in 2021, with the lowest nitrogen concentrations in 2025.

How About Four Graphs to Ponder?

We've included some graphs of the stats that communicate more observations extracted from our Blitz results. In the two histograms below (Figs.1 and 2), the solid bars are representations of the annual mean and median nitrogen concentrations in each of the five years that we presented in Table 1 above. The cross-hatched bars also show mean and median nitrogen concentrations from each Blitz year, but only for the nine sites that were sampled in all five years. These sites are: HC1, HC2, HC3, HC4, HC4, HC6, HC7, HC8a, and HC9.

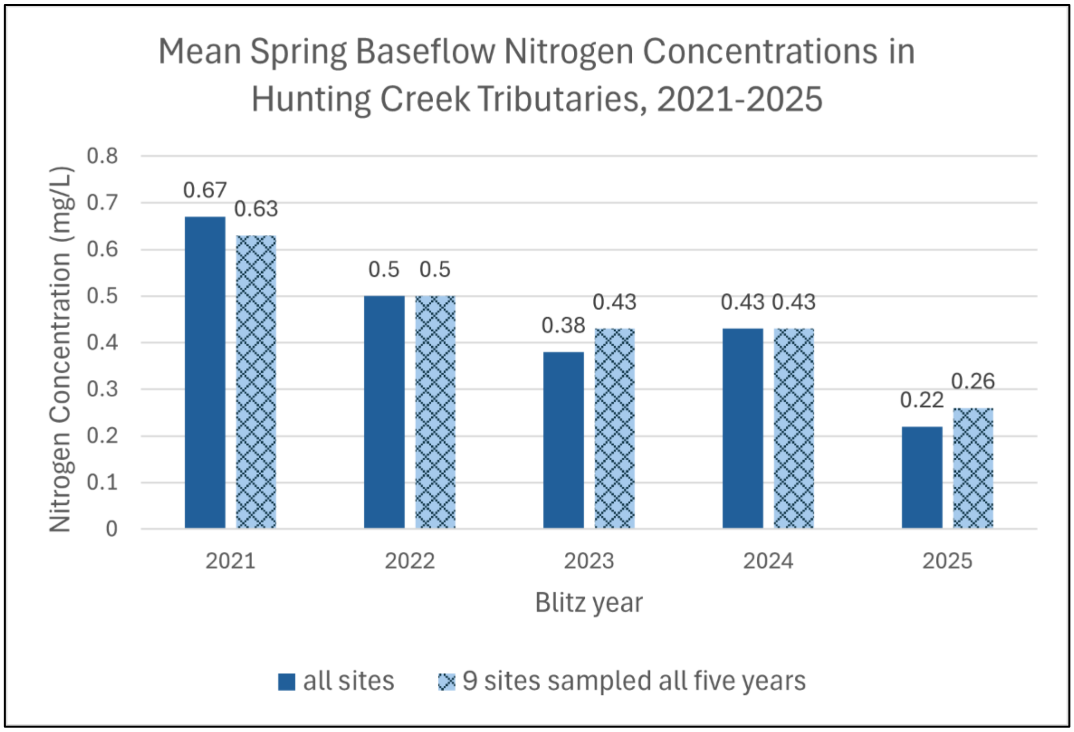


Figure 1

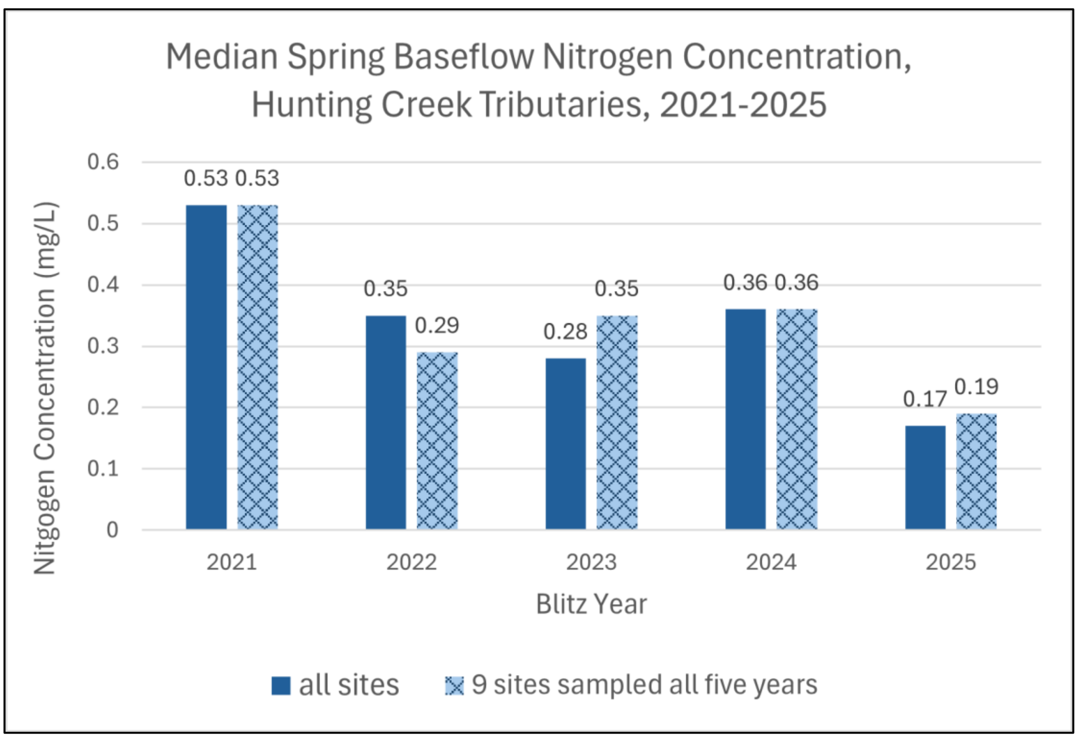


Figure 2

Visual inspection of Figs. 1 and 2 reveals us that the two sets of mean and median nitrogen concentrations—namely all sites vs. only the nine sites sampled in all five years—lead to the same conclusions: (a) baseflow nitrogen levels in the Hunting Creek watershed were highest in 2021, (b) nitrogen levels were lowest in 2025, and (c) nitrogen levels were intermediate and about the same in 2022, 2023, and 2024. These are observations of annual difference across the five years, but not necessarily indicative of a long-term trend.

However, with regards to short-term trends, we have some results to report. At the request of Dr. Boynton, Amir Azarnivand, a doctoral student at the Chesapeake Bay Laboratory, conducted trends analyses on the entire Water Quality Blitz data set. In the Hunting Creek watershed, his analyses revealed a statistically-significant ($p<0.05$) and decreasing trend in baseflow nitrogen concentration at four sites (Figure 3). HC3 in Little Lyons Creek showed the largest decrease, but the baseflow nitrogen level there in 2025 was still in the FAIR condition range. Being able to detect these statistically-significant decreases in baseflow nitrogen in Little Lyons Creek, middle Mill Creek, Fox Run, and upper Hunting Creek, after only five years of Blitz sampling, is more good news.

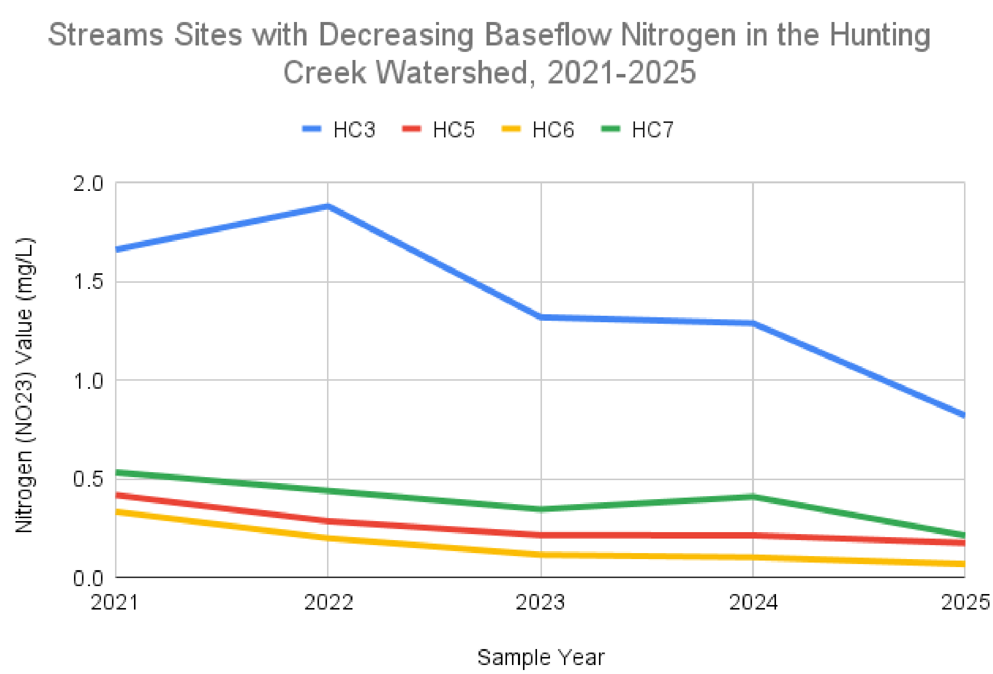


Figure 3

For a different look at the five years of spring baseflow nitrogen results, we give you Figure 4. These histograms show the percentages of the nine stream sites sampled in all five years that had nitrogen concentrations in the green (Good) and yellow (FAIR) condition categories for ecological health. As mentioned above, none of the water samples collected by the FOHC during the annual Blitzes had nitrogen concentrations above 2.1 mg/L, in the POOR condition range. Figure 4 summarizes the results shown in the five Hunting Creek watershed maps: most (77.8% to 88.9%) of the nine sites had low baseflow nitrogen concentration in 2021-2025. That is more good news.

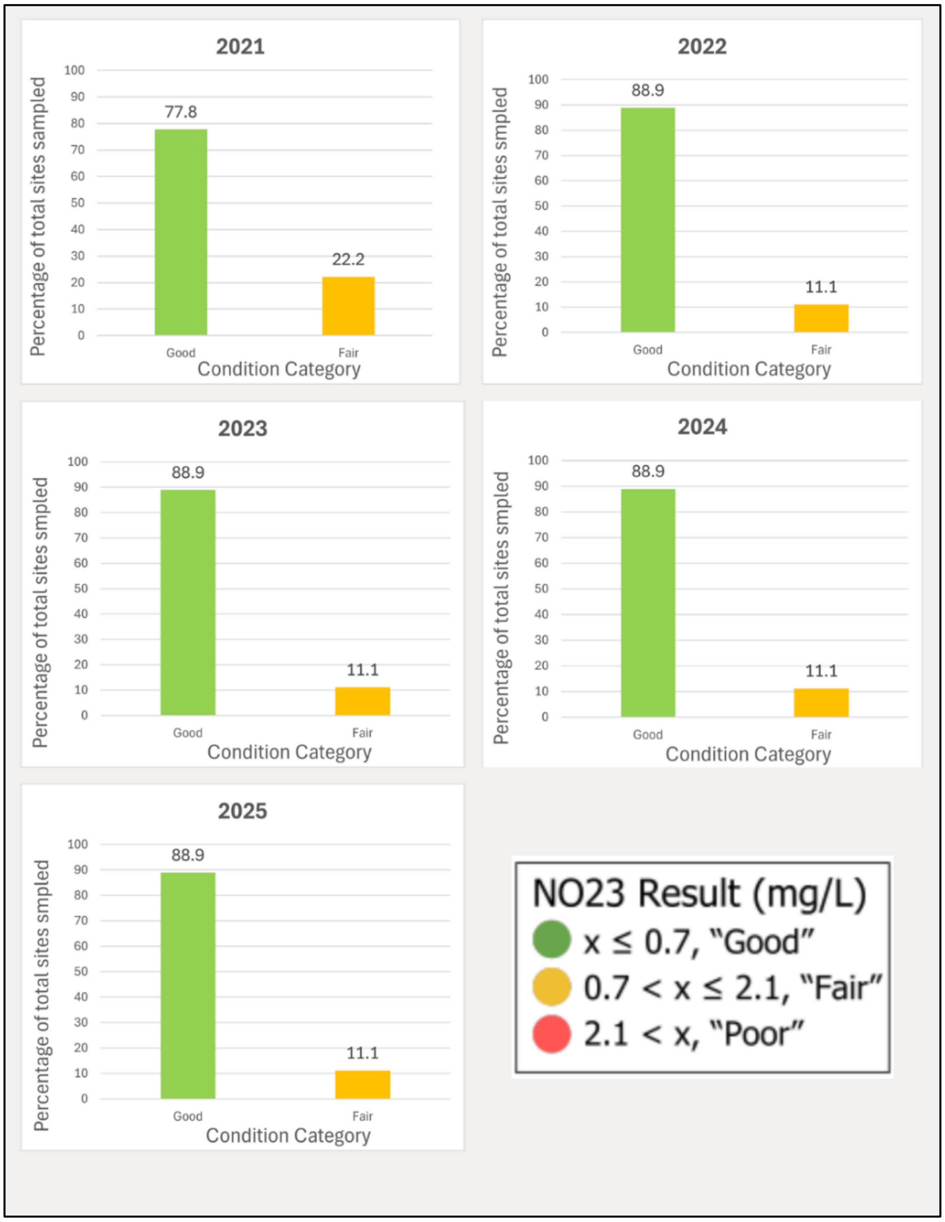


Figure 4

The final graph (Fig. 5) is our attempt to dig deeper into the annual differences in median baseflow nitrogen concentrations shown in Table 1 and Fig.2. To see if annual variations in precipitation could be involved, we used rainfall data obtained from daily records measured by CoCoRahs program volunteer, Kathryn Klauda, at her site MD-CV-7 near Prince Frederick, Maryland (-76.6159, 38.5517). These rainfall data can be accessed at this link (dex.cocorahs.org/stations/MD-DV-7/).

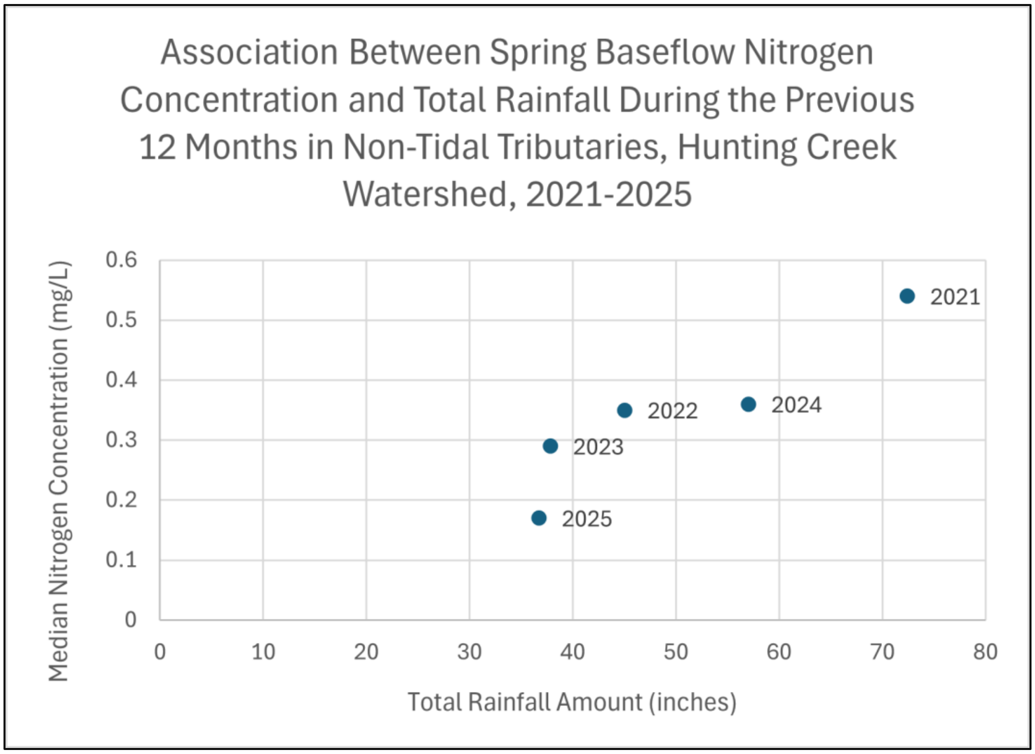


Figure 5

In Figure 5, we plotted the total rainfall measured at MD-CV-7 that fell during the 12 months preceding Blitz sampling against median baseflow nitrogen concentrations in each of the five years. A positive association was revealed. The largest median nitrogen concentration (0.536 mg/L) was measured in 2021, the year with the most rainfall (72.4 inches) during the 12 months preceding the 2021 Blitz. Conversely, the lowest median nitrogen concentration (0.168 mg/L) was measured in 2025, the year with the least rainfall (36.7 inches) during the 12 preceding months.

Rainfall amount prior to Blitz sampling offers at least one plausible explanation for annual differences in baseflow nitrogen concentrations in Hunting Creek tributaries in 2021-2025. A positive association between rainfall amount and baseflow nitrogen has been reported in other studies. Nitrogen loads and yields from watersheds in these studies also tended to be higher in wet years vs. dry years (Vanni et al. 2001, Howarth et al. 2006, Davis et al. 2014, Outram et al. 2016, Baeumler and Gupta 2019, Wolf et al. 2020). Increased connectivity between riparian areas and stream channels during wet periods can increase the mobilization and transport of nitrogen from the soil and shallow groundwater to stream channels at baseflow conditions. Additional years of Blitz sampling in the Hunting Creek watershed should give us an opportunity to more rigorously test the hypothesis that wetter conditions during the preceding 12 months increase spring baseflow nitrogen concentrations.

Let's Sum Up

The Friends of Hunting Creek (FOHC) participated in annual Water Quality Blitzes focused on spring baseflow measurements of dissolved nitrogen (as NO2+NO3) in 2021 through 2025.

The FOHC sampled 10 tributary stream sites in 2021, 17 sites in 2022, 21 sites in 2023 and 2024, and 22 sites in 2025.

No sites had measured nitrogen concentrations in the POOR condition category (>2.1 mg/L).

Only four sites had slightly elevated nitrogen concentrations in the FAIR condition category.

Site HC3 in Little Lyons Creek had the highest nitrogen concentrations measured at any site in all five years (a range of 0.820 to 1.880 mg/L).

Of the 13 catchments (sub-watersheds) that comprise the Hunting Creek watershed, Little Lyons Creek has the highest percentage of agricultural land use at 31.3%--the most likely nitrogen source.

Mean (average) nitrogen concentration, across all sampled sites, ranged from a low of 0.217 mg/L in 2025 to a high of 0.674 mg/L in 2021, but below 0.7 mg/L and in the GOOD condition category.

Overall, baseflow nitrogen concentrations in Hunting Creek tributaries were highest in 2021, lowest in 2025, and intermediate/about the same in 2022, 2023, and 2024.

A trends analysis revealed that Blitz sites in Little Lyons Creek, middle Mill Creek, Fox Run, and upper Hunting Creek showed declines in baseflow nitrogen from 2021 to 2025.

A positive association was observed between median spring baseflow nitrogen concentrations and total rainfall during the 12 months preceding Blitz sampling.

The FOHC's goal is to continue our participation in the annual Water Quality Blitz program and transform our 5-year data base on baseflow nitrogen measurements into a robust time series.

Acknowledgements

We are grateful to those willing and able folks who volunteered to participate in one or more of the five Water Quality Blitzes talked about in this document. They stepped up and helped collect the grab water samples that were analyzed for baseflow nitrogen. They are: Alyssa Matanin and her middle school students at Calverton, Becky Hunter, Bob Estes, Danielle Reader-Jolley, Eric Thompson, Erin McPhillips, Evan Klauda, Frank McPhillips, Kathryn Klauda, Kyle Greene, Michele Lyons, Mike Zeruto, Ray Malmrose, and Seth Herritt. Our thanks to Frank McPhillips for his helpful editorial comments on the draft document.

References

Ayers, J.R., et al. 2021. On the statistical attribution of changes in monthly baseflow across the U.S. Midwest. Journal of Hydrology 592 (125551):1-28.

Baeumler, N.W. and S.C. Gupta. 2018. Precipitation as the primary driver of variability in river nitrogen loads in the midwest United States. Journal of the American Water Resources Association 56(1):113-135.

Camargo, S.A. and A. Alonso. 2006. Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment. Environment International 32(6):831-849.

Davis, C.A., et al. 2014. Antecedent moisture controls on stream nitrate flux in an agricultural watershed. Journal of Environmental Quality 43(4):1494-1503.

Gburek, W.J. and G.J. Folmar. 1999. Flow and chemical contributions to stream flow in an upland watershed: a baseflow survey. Journal of Hydrology 212 (1-2):1-18.

Howarth, R.W., et al. 2006. The influence of climate on average nitrogen export from larger watersheds in the northeastern United States. Biogeochemistry 79:163-186.

Miller, J.D., et al. 2014. Assessing the impact of urbanization on storm runoff in a peri-urban catchment using historical change in impervious cover. Journal of Hydrology 515:59-70.

Munn, M.D. et al. 2016. Understanding the influence of nutrients on stream ecosystems in agricultural landscapes. U.S. Geological Survey Circular 1437, 80 p.

Outram, F.N., et al. 2016. Antecedent conditions, hydrological connectivity and anthropogenic inputs: factors affecting nitrate and phosphorus transfers to agricultural headwater streams. Science of the Total Environment 545-546:184-199.

Rabalais, N.N. 2002. Nitrogen in aquatic ecosystems. AMBIO: A Journal of the Human Environment 31(2):102-112.

Schilling, K. and Y-K Zhang. 2004. Baseflow contribution to nitrate-nitrogen export from a large agricultural watershed, USA. Journal of Hydrology 295 (1-4):305-316.

Wolf, K.A., et al. 2020. Precipitation drives nitrogen load variability in three Iowa rivers. Journal of Hydrology: Regional Studies 30(100705):1-15.

Vanni, M.J., et al. 2001. Dissolved and particulate nutrient flux from three adjacent agricultural watersheds: a five-year study. Biogeochemistry 56:85-114.

Appendix A

Nitrate + Nitrite (NO23) values in mg/L for all Hunting Creek Stations sampled from 2021-2025

STATION ID	2021 NO23	2022 NO23	2023 NO23	2024 NO23	2025 NO23
HC1	0.44	0.16	0.11	0.13	0.03
HC2	0.47	0.47	0.29	0.36	0.19
HC3	1.66	1.88	1.32	1.29	0.82
HC4	0.54	0.61	0.58	0.52	0.44
HC5	0.42	0.29	0.22	0.22	0.18
HC6	0.34	0.20	0.12	0.10	0.07
HC7	0.53	0.44	0.35	0.41	0.21
HC8a	0.54	0.26	0.39	0.25	0.09
HC8b	ns	0.35	0.28	0.34	0.11
HC9	0.71	0.15	0.51	0.58	0.30
HC10	1.09	1.14	ns	ns	ns
HC10b	ns	ns	0.64	1.06	0.16
HC11	ns	0.16	ns	ns	ns
HC12	ns	ns	ns	ns	0.16
HC13	ns	0.59	0.08	0.13	0.06
HC14	ns	0.18	0.12	0.13	0.15
HC15	ns	0.38	0.37	0.36	0.16
HC16	ns	0.94	0.94	0.90	0.20
HC17	ns	0.31	ns	ns	ns
HC19	ns	ns	0.04	0.21	0.13
HC20	ns	ns	0.20	0.33	0.18
HC21	ns	ns	0.41	0.61	0.28
HC22	ns	ns	0.54	0.54	0.48
HC23	ns	ns	0.25	0.16	0.06
HC24	ns	ns	0.25	0.40	0.19

*ns = not sampled