2023 Livingston County Water Quality Monitoring Program: Unassessed Waters, USDA, and Reference Streams

Report Submitted to the Livingston County Planning Department, Geneseo, NY

By

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Signature

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Table of Contents

Summary

- Ten streams were sampled for water quality in 2023. Select former USDA study tributaries were monitored to continue long-term monitoring efforts in the best management practice (BMP) streams, Unassessed and reference streams were also monitored.
- A dry summer and fall period was observed, causing many study streams to dry up, including all streams during our October and November baseflow sampling dates.
- For Graywood Gully, mean concentrations for all analytes in 2023 (except NOx) were greater than all BMP study years, had the greatest baseflow concentrations of all analytes compared to other study streams, and had the greatest total phosphorus (TP), soluble reactive phosphorus (SRP), nitrate + nitrite (NOx), and total Kjeldahl nitrogen (TKN) concentrations during storm events during the 2023 monitoring period.
- Sutton Point Gully had the greatest average SRP concentration compared to historic May-August data, with levels being comparable to 2021.
- Southwest Creek concentrations of SRP and TP continue to be greater than the BMP study years. Southwest Creek concentrations of SRP, NOx, and TN were the second greatest during storm events and TP was the third greatest during events when compared to other streams monitored during this period. Southwest Creek also had the second greatest concentrations of TP, SRP, and TKN during baseflow.
- North McMillan Creek continues to have issues of high TP and TSS during storm events.
- Northend Creek had the greatest average NH3 concentrations and third greatest SRP concentrations during events.
- South Gully had the third greatest TSS and fourth greatest TP concentrations during storm events.
- South McMillan Creek serves as a good reference during baseflow – it had the lowest average SRP and NOx concentrations.
- Creek 5574E had the greatest TSS and TP concentrations during events.
- Creek 6009W had the second greatest nitrogen concentrations during baseflow.

Recommendations

- Increased year-round tributary sampling frequency for former USDA tributaries and other major tributaries, as allowed by resources and funding - selected tributaries could potentially be sampled annually on a rotating basis.
- There are limited historical data for concentrations of dissolved forms of nitrogen (i.e., ammonia/ammonium) in USDA and reference subwatersheds (in addition to unassessed streams). Future monitoring efforts to determine ammonia concentrations as well as dissolved forms of phosphorus during spring runoff and seasonal storm events would be useful in assessing potential contributions to metaphyton growth and potential harmful algal blooms (HABs).

- Storm events should be sampled more frequently, as storm events have the potential to carry much greater concentrations and loads of nutrients into Conesus Lake than baseflow conditions. Heavy storm events are predicted to become more common in the future with climate change. BMP implementation and assessment of BMP effectiveness should be considered in the context of climate change.
- Current information on agricultural practices for the USDA tributaries and other subwatersheds is needed.
- Due to the abnormally dry conditions observed in the summer and fall, we recommend continued sampling of the unassessed subwatersheds in 2024 to capture the full range of conditions in these water bodies.

Introduction and Background

Nutrient and sediment pollution can have a myriad of impacts on aquatic ecosystem health and function. Nutrient and sediment pollution can also affect human use of water resources including drinking water, recreation, and aesthetics. Turbidity is a measure of water cloudiness and is often caused by soil runoff and is associated with total suspended solids (TSS) (USEPA 2022). There is no national standard for turbidity or TSS in streams; however, high turbidity and TSS can have negative impacts on aquatic ecosystem health. TSS can affect water clarity and light attenuation in the water column, which can have direct impacts on submerged aquatic vegetation and phytoplankton production. TSS can also affect the types of organisms that can survive in the system. Fine soil particles can clog gills in aquatic invertebrates and affect fish inhabitance. TSS includes inorganic soil particulates as well as organic particles including algae, leaves, and decomposing matter. TSS can be impacted by runoff, erosion, pollution, and disruptions of bottom sediment.

Phosphorus is a critical nutrient required for life and is often a limiting nutrient in aquatic ecosystems. Orthophosphate is a dissolved form of phosphorus and is readily available to plants and algae for uptake. Total phosphorus is the total of all dissolved and particulate forms of phosphorus. Excessive phosphorus can occur from poor agricultural practices, urban runoff, sewage treatment plant discharges, and from leaking septic systems (USEPA 2021B). Excessive phosphorus in aquatic ecosystems can cause increased algal and plant growth and can lead to decreased dissolved oxygen and eutrophication. Algal blooms caused by excessive nutrient inputs (both phosphorus and nitrogen) can produce toxins in water which are often harmful to aquatic and human health (USEPA 2021B). There is no national standard set by the EPA; however, in NYS, total phosphorus guidelines for most lakes and reservoirs is 20 µg/L (NYSDEC N.D.)

Nitrogen (dissolved and total) pollution is often caused by livestock manure runoff, human sewage, fertilizers, and can also occur from the erosion of natural deposits. The USEPA (2022) states the maximum contaminant level for nitrate is 10 mg/L in drinking water sources. If these levels are exceeded in drinking water resources, potential health effects, including blue baby syndrome (methemoglobinemia, a temporary blood disorder) in infants of less than six months old can occur (USEPA 2022). Ammonia is another form of nitrogen pollution originating from organic wastes, fertilizers, as well as from natural processes such as nitrogen fixation (USEPA 2021A). While no USEPA or World Health Organization (WHO) guidelines have been established, ammonia can be toxic for aquatic life, especially under conditions of elevated temperature and pH. Symptoms from ammonia pollution on aquatic life include toxic buildup of ammonia in internal tissue and blood, which can lead to death as the organisms are unable to excrete the toxicant efficiently (USEPA 2021A).

USDA Streams

In the early 2000s, several small tributary sub-watersheds of Conesus Lake were selected to evaluate if agricultural best management practices (BMPs) could reduce soil and nutrient runoff to the lake and whether impacts of reduced loadings on the lake ecosystem could be documented (Herendeen and Glazier 2009; Makarewicz et al. 2009). Monitoring began in September 2002 (Makarewicz et al. 2008). BMP implementation was voluntary for farms on selected tributaries (Herendeen and Glazier 2009). Watersheds were selected based on the type of agricultural activities occurring, whether the farmers wanted to voluntarily use BMPs, if there was previous knowledge of sediment and nutrient loss in the watershed, and if macrophytes and algal cover were present in stream mouths in the lake (Herendeen and Glazier 2009). Selected watersheds included Graywood Gully, Cottonwood Gully, Long Point Gully, Sand Point Gully, Sutton Point Gully, and North McMillan Creek. Watershed area, management practices implemented, and agricultural percentage in watersheds for selected tributaries are found in Table 1. Most selected BMP tributaries received a combination of cultural and structural BMPs (e.g., installation of grass filter strips and reduction in winter manure spreading in the watershed of Graywood Gully) (Table 1). All tributaries were sampled at the base of their watersheds during the entire study (Herendeen and Glazier 2009). A main goal of implementing BMPs was to reduce the abundance and biomass of algal cover and macrophytes in the lake by reducing nutrient loss in watersheds and nutrient input near stream mouths (Makarewicz et al. 2001; Makarewicz et al. 2009). However, it is realized that recovery is not instantaneous and other systems where BMPs were implemented, such as those in the Irondequoit Bay and Lake Erie watersheds, took as long as 20-25 years to improve water quality (Makarewicz et al. 2001).

Prior to BMP implementation, high concentrations of nutrients during storm events were measured in Graywood, Hanna's Creek, Sand Point, Long Point Gully, and North Gully (Makarewicz et al. 2001). High nitrate/nitrite (NOx) concentrations were documented in Long Point Gully, Cottonwood Gully, Sutton Point, Rivulet 5989 (also named Southwest Creek), Graywood Gully, and North Gully (Makarewicz et al. 2001). High concentrations of nutrients were measured during baseflow conditions in Graywood Gully as well, indicating water quality degradation (Makarewicz et al. 2001).

After BMPs were implemented, periodic monitoring continued on study tributaries (Makarewicz et al. 2009). Graywood Gully was found to have the greatest percent reduction in concentrations (55% lower) across the largest suite of analytes (e.g., total phosphorus, orthophosphate (i.e., soluble reactive phosphate, SRP), NOx, and total suspended solids) prior to 2009 (Makarewicz et al. 2009). With implementation of cultural and structural BMPs, major impacts on soil and nutrient losses were documented (Makarewicz et al. 2009). Significant reductions in concentrations of NOx during all flow regimes were observed when fields were planted with vegetative crops or left fallow, while reductions in total nutrients (total plus dissolved) were measured following structural BMP implementation (Makarewicz et al. 2009). While significant reductions of nutrients were observed after implementing BMPs in managed streams, ambient concentrations remained above those measured in reference streams (Makarewicz et al. 2009). In contrast, after 5 years of monitoring, suspended solids concentrations were not significantly different from the reference watershed (North McMillan) during non-event and event sampling after 5 years of monitoring (Makarewicz et al. 2009). It is possible that the full effect of BMPs on nutrients was still not realized after 5 years of post-monitoring.

In 2015, more than a decade after initial BMPs were introduced, monitoring of Long Point Gully, Graywood Gully, and Sutton Point Gully was performed after some additional BMPs were implemented (Lewis and Makarewicz 2015). Generally, decreases in total phosphorus (except Graywood Gully), total suspended solids, and NOx were observed with the addition of more BMPs (Lewis and Makarewicz 2015). It is likely that total phosphorus did not improve in Graywood Gully because BMP construction was occurring in the watershed during the study period (Lewis and Makarewicz 2015). However, SRP was elevated in all three watersheds compared to historical data (Lewis and Makarewicz 2015). It is unclear as to why SRP concentrations had increased in streams draining these watersheds. Installation of additional BMPs was recommended to help reduce soluble nutrient runoff.

In general, the implemented BMPs have demonstrated that water quality can be improved both within tributaries and in-lake near tributary mouths. Bacteria, macrophytes, and algae can be reduced from these practices (Makarewicz et al. 2008; Bosch et al. 2009; Makarewicz and Lewis 2009). Water quality should continue to be monitored in the USDA study streams to evaluate whether water quality conditions are improving in these watersheds and in the lake (Makarewicz et al. 2008; Makarewicz and Lewis 2009). Continued monitoring of these tributaries can also guide future BMP and management efforts designed to improve water quality and ecosystem health of Conesus Lake and its tributaries.

The 2023 tributary monitoring program examined select BMP streams (as a continuation of our follow up study that began in April 2020), Reference streams, and unassessed streams (https://www.dec.ny.gov/chemical/36730.html) to evaluate the water quality conditions in these streams and continue to build long term datasets for those streams that have been monitored historically in the Conesus Lake watershed. The data presented here will continue to be used to examine long term trends in the USDA streams, and support long-term planning efforts to help facilitate best management practices (BMPs) and applied ecosystem management (AEM) in the Conesus Lake watershed.

Methods

Ten streams were sampled for water quality in 2023. Select former USDA study tributaries were monitored to continue long-term monitoring efforts in the BMP streams. Unassessed and reference streams were also monitored (Tables 1 and 2; Appendix 1). All tributary sites were monitored monthly for baseflow from 20 April 2023 to 9 November 2023, in addition to two storm events. A total of 10 sampling events were captured for selected tributaries (unless streams were dry). Sampling events were classified as baseflow or hydrometeorological event (>0.5 inches of precipitation in a 24h period) based on information from the Conesus Lake Association weather stations at the north end and south end of the lake (Table 4).

Each sampling event consisted of 1) collecting water samples for laboratory analyses, including total suspended solids (TSS), total phosphorus (TP), total nitrogen (TN), ammonia (NH_3) (during storm events only), nitrate/nitrite (NOx), and orthophosphate (i.e., soluble reactive phosphorus, SRP); (2) *in-situ* water chemistry measurements, including temperature, dissolved oxygen, pH, specific conductivity, and turbidity; and (3) field observations (Table 3). Water chemistry samples were collected from flowing water using a grab sampler and plastic bucket rinsed with deionized water and respective stream water at each site prior to sample collection. Water was not collected from streams that contained stagnant water, had insufficient sampling depth (less than 4 inches) or were dry. Samples were appropriately processed and placed into pre-cleaned and labeled bottles according to standard methods and stored on ice while in the field (Table 3). SRP, NH_3, and NOx were immediately filtered on site with 0.45-µm syringe filters. One field duplicate and equipment blank were collected during each sampling event. All water chemistry samples were analyzed by the SUNY-Brockport Limnology Laboratory (ELAP ID #12116) within standard hold times. *In-situ* measurements were obtained using a calibrated YSI multimeter probe.

Concentration data from 2023 in select USDA streams were compared to past data collected by Makarewicz and Lewis (2010) in 2003-2010, Beers and Chislock (2021) in 2020, and Beers and Chislock (2022) in 2021 from May through August to assess if nutrients and TSS concentrations from watersheds were improving, declining, or stable, relative to the historical data. In 2020-2021 and 2023, TKN was calculated by subtracting NOx concentration from TN concentration. Due to available budget, it is important to note that sample frequency changed in 2020-2021 and 2023; samples were collected weekly from 2003 to 2010, but monthly from May to August 2020-2021, and 2023. Historical concentration data from May through August are presented as averages by year on bar graphs with standard errors to compare the data. The 2023 sampling concentration data were also compared across sampling dates to examine water quality differences and if any temporal patterns exist on study tributaries.

Results and Discussion

USDA BMP streams and other non-BMP stream monitoring activities

Graywood Gully (Tables 1, 5, and 6, Figures 1 and 6 appendix 1):

In Graywood Gully, numerous BMPs were implemented in the watershed as part of the USDA study including reducing fertilizer, ceasing winter manure spreading, utilizing cover crops, and removing cattle from the stream (Table 1). Compared to historic May – August concentration data, TP, SRP, and TSS were comparable to concentrations we observed in 2020, but still greater than the USDA study period (2003-2010) (Table 5, Figure 1). NOx concentrations in 2023 were some of the lowest in recent memory and were comparable to levels seen when BMPs were implemented during the BMP study (Table 5, Figure 1). However, we are cautious to conclude that NOx concentrations are improving as this summer was very dry and little runoff was occurring – it is possible that with less runoff, vegetation was absorbing NOx in soils instead of it running off. TKN concentrations were also less than the elevated concentrations that we observed in 2021 but still greater than what was observed during the BMP study (Table 5, Figure 1).

In 2023, we observed the highest TP and SRP concentrations during May 20th storm event. No seasonal patterns can be observed from baseflow concentration data in 2023 for all analytes. The stream was dry most of the summer and fall during baseflow sampling dates. However, the greatest NOx concentrations were observed in the early spring prior to the major growing season (Figure 6). Compared to other study streams during this monitoring period, Graywood Gully had the greatest average TSS, TP, SRP, NOx, and TKN concentrations during baseflow sampling and the greatest concentrations of SRP, NOx, TN, and TKN during storm events. Graywood had the second greatest TP concentration during storm events and the third greatest ammonia concentrations (Figure 6, Table 6).

Sutton Point Gully (Tables 1, 5, and 6, Figures 2 and 7, appendix 1):

Sutton Point Gully had gully plugs installed and a 60% cropland conversion to alfalfa during the USDA study (Table 1). Compared to historical May – August data, TP is much lower than what was observed in 2021 (a very wet year with numerous heavy storm events). 2023 TP is, however, still slightly greater than most USDA study periods (Table 5, Figure 2). On the other hand, the average 2023 SRP concentration is the greatest observed of all years but comparable to 2021 (Table 5, Figure 2). Contrastingly, 2023 NOx concentrations were much lower than 2020-2021 and even lower than some of the concentrations observed during the USDA study years (Table 5, Figure 2). The same thing cannot be said for 2023 TKN concentrations, as even though they were lower than 2021 concentrations, they were still greater than many of the USDA BMP study years (Table 5, Figure 2). TSS was also lower in 2023 than the wet year of 2021 but still generally greater than the USDA study period (Table 5, Figure 2).

In 2023, TP was the greatest on the August baseflow sampling date. We observed a general increasing trend in TP, SRP, and TSS concentrations from spring to summer before the stream dried during much of the fall. We observed the greatest NOx concentration during July, then the lowest in August. TKN concentrations were the greatest during August and lowest during April baseflow. Figure 7). Compared to other study streams during this monitoring period, Sutton Point Gully had the second greatest average TSS concentration during baseflow sampling, but the lowest ammonia concentration during storm events (Table 6).

<u>Southwest Creek (Tables 1, 5, and 6, Figures 3 and 8, appendix 1)</u>

The Southwest Creek watershed had a manure pit installed as part of the USDA BMP study (Table 1). Compared to past data collected in May-August, TP and SRP concentrations in 2023 were lower than what we observed in 2020-2021, but greater than the USDA study period (Table 5, Figure 3). NOx and TKN concentrations in 2023 were also lower than what we observed in 2020-2021 and were generally comparable to the mid to late USDA BMP study years (Table 5, Figure 3). 2023 TSS concentrations were less than 2021 and comparable to 2020 and most USDA BMP years (Table 5, Figure 3).

In 2023, TP, TSS, and TKN concentrations were the greatest during the May 20th storm event. There was a slight seasonal increasing trend in SRP and TP concentrations from spring to summer, before drying for much of the fall. NOx concentrations were the greatest during storm events and during the spring baseflow periods before decreasing in the summer. TKN concentrations remained relatively stable during baseflow periods throughout the monitoring period (Figure 8). Compared to other study streams during this monitoring period, Southwest Creek had the second greatest average concentrations of TP, SRP, and TKN during baseflow, and the second greatest average storm event concentrations of SRP, NOx, and TN. Southwest Creek had the third greatest concentration of TP during storm events (Table 6).

<u>North McMillan Creek (Tables 1, 5, and 6, Figures 4 and 9, appendix 1)</u>

North McMillan Creek was the reference watershed during the USDA study due to its low agricultural land use and did not have any BMPs installed in the watershed during the BMP study (Table 1). In 2023, TP and TSS concentrations were lower than what were observed in 2021, but still some of the greatest concentrations observed compared to historic May-August concentration data (Table 5, Figure 4). The increasing trends of TP and TSS can likely be attributed to erosional issues found in the lower reaches of the stream and watershed. We documented this in a segment analysis of North McMillan Creek, see Beers and Chislock (2023) for more details and conclusions. TP and TSS concentrations during heavy storm events even exceed concentrations seen in some of the heavily agricultural tributaries. SRP in 2023 is elevated compared to USDA BMP study years but not the greatest observed in recent years (Table 5, Figure 4). 2023 NOx and TKN concentrations are comparable to recent years and still continue to be much lower than agricultural streams (Table 5, Figure 4).

In 2023, TP, TSS, and TKN concentrations were greatest during the May 20th storm event. During baseflow, all analytes were nearly stable during baseflow, and not many seasonal changes were observed in baseflow water quality before the stream dried for much of the fall period (Figure 9). Compared to other study streams during this monitoring period, North McMillan Creek had the lowest average concentrations of TSS, TP, TN, and TKN during baseflow, and lowest average concentrations of NOx and TN during storm events (Table 6).

Hanna's Creek (Tables 1, 5, and 6, Figures 5 and 10, appendix 1):

Hanna's Creek was not included in the USDA BMP study but monitored since 2020 for water quality (Table 1). 2023 data was compared to 2020-2021 data for Hanna's Creek. 2023 concentrations of TP, SRP, NOx, TKN, and TSS were comparable to 2020, but lower than what we observed during 2021 (a very wet year) (Table 5, Figure 5).

In 2023, we observed the greatest TSS, TP, TKN, and SRP concentrations during storm events. We were unable to observe seasonal trends as this stream was dry during much of the summer and fall during our baseflow sampling dates (Figure 10). Compared to other study streams monitored during this period, Hanna's Creek had the greatest average TKN concentrations during baseflow sampling, and the second greatest TSS concentration during storm events. However, Hanna's Creek also had the lowest average concentrations of TP, SRP, and TKN during storm events (Table 6).

Northend Creek (Tables 1 and 6, Figure 11, appendix 1)

Northend Creek is considered an "unassessed stream", so nutrients and water quality variables were monitored during 2023 for baseflow and storm events. We observed the greatest TP and SRP concentrations on the May 20th storm event. Compared to the spring monitoring period, TP and SRP concentrations were greater in the summer and early fall before the stream was too shallow to sample accurately. We observed an increasing trend of NOx concentrations through the summer, with the greatest NOx concentration being observed during September baseflow. TKN was greatest during storm events and mainly stable during baseflow throughout the monitoring period. TSS was greatest during summer baseflow compared to spring baseflow, and greatest on the May 20th storm event (Figure 11). Compared to other study steams during this monitoring period, Northend Creek had the greatest ammonia concentrations during storm events and had the third greatest average SRP and TKN concentrations during storm events (Table 6).

South Gully (Tables 1 and 6, Figure 12, appendix 1)

South Gully is considered an "unassessed stream", so nutrients and water quality variables were monitored during 2023 for baseflow and storm events. TKN, TP, and SRP concentrations were greatest on the May 20th storm event. TP and SRP concentrations were greatest during the summer and lower during the spring. The stream was dry for much of the fall. NOx concentrations also generally increased from spring to summer and TKN was relatively stable between seasons during baseflow (Figure 12). Compared to other study streams in this monitoring period, South Gully had the third greatest average TSS concentration and fourth greatest TP concentrations during storm events (Table 1).

South McMillan Creek (Tables 1 and 6, Figure 13, appendix 1)

South McMillan Creek is considered an additional “reference stream” in addition to North McMillan Creek, so nutrients and water quality variables were monitored during 2023. Due to the high TP and TSS concentrations observed recently during storm events in North McMillan Creek, South McMillan Creek was added to serve as an additional reference tributary. Like many of the other streams, we observed the greatest TP and TSS concentrations on the May 20th storm event. TP and SRP were nearly stable during spring baseflow, but the stream dried for much of the summer and fall during our sampling dates, TKN and NOx concentrations were greater during storm events than baseflow (Figure 13). Compared to other study streams during this monitoring period, South McMillan Creek had the lowest average baseflow concentrations of SRP and NOx (Table 6).

5574 East Lake (Tables 1 and 6, Figure 14, appendix 1 and 2)

The creek located at 5574 East Lake Road is considered an “unassessed stream”, so nutrients and water quality variables were monitored during 2023. Personal observations from Beers and Chislock indicated very turbid and sediment laden runoff entering Conesus Lake from this tributary during past storm events across multiple monitoring years (see photos in appendix 2). We observed the greatest concentrations of all analytes measured during the May 20th storm event. Unfortunately, we were unable to observe seasonal changes during baseflow conditions in this tributary as it dried up for the entire summer and fall during our sampling dates (Figure 14). Land use and watershed size of this watershed also need to be confirmed to understand what is causing the highly sediment laden runoff. Whether this is due to stream bank erosion, land use activities, or both, it is important to determine an accurate watershed size and land use estimate. Compared to other study streams monitored during this monitoring period, Creek 5574E had the greatest average TSS and TP concentrations during storm events, the second greatest average TKN and NH3 concentrations during storm events and the fourth greatest SRP concentrations during storm events (Table 6).

6009 West Lake (Tables 1 and 6, Figure 15, appendix 1)

The creek located at 6009 West Lake Road is considered an “unassessed stream”, so nutrients and water quality variables were monitored during 2023. We observed the greatest TP, TKN, and TSS concentrations during the May 20th storm event. SRP and TP concentrations during baseflow increased from spring to summer. The creek dried for most of the fall period. We observed a decreasing trend of NOx during baseflow from spring to summer. We did not observe any seasonal trends in TSS or TKN during baseflow during the monitoring period (Figure 15).

Compared to other study streams monitored during this monitoring period, Creek 6009W had the second greatest average NOx and TN concentrations during baseflow sampling. The creek had the lowest TSS concentrations of all study streams during storm events but the third greatest average concentrations of NOx and TN during storm events (Table 6).

Conclusions

Ten streams were monitored for water quality in 2023, including select USDA streams, reference streams and unassessed streams. For streams where historic data is available, we compared 2023 data to prior years' data to see if there are increasing or decreasing trends over time. For Graywood Gully, all analytes in 2023 (except NOx) were greater than all BMP study years, had the greatest baseflow concentrations of all analytes compared to other study streams, and the greatest TP, SRP, NOx, and TKN during storm events during this monitoring period. Sutton Point Gully had the greatest average SRP concentration compared to historic May-August data. Southwest Creek concentrations of SRP and TP continue to be greater than the BMP study years. Southwest Creek concentrations of SRP, NOx, and TN were the second greatest during storm events and TP was the third greatest during events when compared to other streams monitored during this period. Southwest Creek also had the second greatest concentrations of TP, SRP, and TKN during baseflow compared to other streams monitored during this period. North McMillan Creek continues to have issues of high TP and TSS during storm events. Hanna's Creek also has high TSS during storm events. North End Creek had the greatest average NH3 concentrations and third greatest SRP concentrations during events compared to all other streams monitored for this period. South Gully had the third greatest TSS and fourth greatest TP concentrations during storm events. South McMillan Creek serves as a good reference during baseflow – it had the lowest average SRP and NOx concentrations during baseflow. Creek 5574E had the greatest TSS and TP concentrations during storm events. Whether this is from stream bank erosion or land use practices, the concentrations of these analytes during storm events are very concerning. Lastly, Creek 6009W had the second greatest nitrogen concentrations during baseflow conditions. This monitoring period of 2023 was characterized by very dry weather conditions and low precipitation, especially in the summer and fall when many streams dried up. Due to the overly dry conditions, we recommend following up on these same streams to determine their water quality during a normal precipitation year. We also recommend verifying current land use practices in all study tributaries so we can have an accurate representation on what is going on in these watersheds.

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Tables and Figures:

Table 1. Selected subwatersheds of Conesus Lake. Watershed area, percentage of agriculture in watershed and implemented management plans are listed (Herendeen and Glazier 2009; Makarewicz *et al.* 2009; Bida *et al.* 2015; Model my Watershed 2017). * Indicates that land use needs to be verified.

Tributary	Watershed area (ha)	Agricultural activity (% of watershed)	Implemented Management Practices
Graywood Gully	38.1	74	Winter manure spreading ceased, fertilizer reduced, drain tiles, grass filter strips, contour tillage, cover crops, cattle removed from stream.
Northend Creek	179.28	62	Unassessed Stream
South Gully	269.15	49	Unassessed Stream
South McMillan Creek	2821	24	Reference Watershed
Sutton Point Gully	67.5	76	Gully plugs, and 60% of cropland to alfalfa
Southwest Creek	176.4	72	Manure pit installed
North McMillan Creek	1778.2	12	Reference watershed
Hanna’s Creek	760	68	Agricultural non-BMP
Creek 5574E	52.74	43*	Unassessed Stream
Creek 6009W	145.1	68	Unassessed Stream

Table 2. Sampling Locations, Justifications, and Data Collection

Site Code	Sampling Location	GPS Coordinates		Sample Justification	Field Measurements[1]	Water Chemistry[2]
		North	West			
GRAY	Graywood Gully	42.810421	-77.716416	Prior implementation of BMPs, including winter manure spreading ceased, fertilizer reduced, drain tiles, grass filter strips, contour tillage, cover crops, cattle removed from stream	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), ammonia, total suspended sediments
HANN	Hanna's Creek	42.833364	-77.707621	Agricultural non-BMP	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), ammonia, total suspended sediments
NEND	North End Creek	42.833584	-77.696457	Unassessed stream	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), ammonia, total suspended sediments
NMDN	Downstream-North McMillan	42.725611	-77.707056	Remediated site for Erosion Control and Streambank Remediation Study; historical reference stream	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), ammonia, total suspended sediments
SGUL	South Gully	42.772123	-77.712049	Unassessed stream	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), ammonia, total suspended sediments

SMCM	South McMillan	42.719152	-77.705499	Reference stream	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), ammonia, total suspended sediments
SUTT	Sutton Point Gully	42.741986	-77.727513	Prior implementation of BMPs, including Gully plugs, and 60% of cropland to alfalfa	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), ammonia, total suspended sediments
SWCK	Southwest Creek	42.73532	-77.72480	Prior implementation of BMPs, including Manure pit installed	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), ammonia, total suspended sediments
5574E	Unnamed tributary at 5574 E Lake	42.750459	-77.712519	Unassessed stream	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), ammonia, total suspended sediments
6009W	Unnamed tributary at 6009 W Lake	42.727483	-77.720087	Unassessed stream	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), ammonia, total suspended sediments

[1]Water temperature (°C), specific conductivity (µS/cm), pH, dissolved oxygen (LDO - %, mg/L), turbidity (NTUs).

[2]Total phosphorus (µg/L), total nitrogen (mg/L), orthophosphate (µg/L), nitrate + nitrite (NO_x) (mg/L), Ammonia (mg/L), and total suspended solids (TSS) (mg/L).

Table 3: Parameters, analytical specifications, and QA/QC requirements.

Lab Measurements Analyte	Method	Minimum Volume/ Container	Preservative	QC Sample	Frequency	QC Acceptance Limits	Corrective Action	Holding Time	Method Detection Limit	Report Limit
Ammonia	SM 4500-NH3 H-2011	60 ml plastic	H2SO4 to pH<2,cool; 4°C	Method Blank	10%	< 0.002 mg/l	Reanalyze or Qualify data	28 days	0.002 mg/l	0.010 mg/l
				ICC/LCS	10%	% Recovery between 90% to 110%	Reanalyze or Qualify data			
				Lab Duplicate	10%	RPD within ± 10%	Reanalyze or Qualify data			
				Matrix spike duplicate set	10%	Between 90% to 110%	Qualify data Reanalyze or Qualify data			
Total nitrogen	SM 4500-N C-2011	125 ml plastic	Cool; -20°C	Method Blank	10%	< 0.024 mg/L	Reanalyze or Qualify data	28 days	0.024 mg/l	0.100 mg/l
				ICC/LCS	10%	% Recovery between 90% to 110%	Reanalyze or Qualify data			
				Lab Duplicate	10%	RPD within ± 10%	Reanalyze or Qualify data			
				Matrix spike duplicate set	10%	Between 90% to 110%	Qualify data Reanalyze or Qualify data			
Nitrate + Nitrite	EPA 353.2, Rev. 2.0 (1993)	125 ml plastic	Filter 0.45µm, cool; 4°C	Method Blank	10%	< 0.003 mg/L	Reanalyze or Qualify data	2 days	0.003 mg/l	0.010 mg/l
				ICC/LCS	10%	% Recovery between 90% to 110%	Reanalyze or Qualify data			
				Lab Duplicate	10%	RPD within ± 10%	Reanalyze or Qualify data			
				Matrix spike duplicate set	10%	Between 90% to 110%	Qualify data Reanalyze or Qualify data			
Orthophosphate	SM 4500-P G-2011	125 ml plastic	Filter 0.45µm, cool; 4°C	Method Blank	10%	< 0.0006 mg/L	Reanalyze or Qualify data	2 days	0.0006 mg/l	0.001 mg/l
				ICC/LCS	10%	% Recovery between 90% to 110%	Reanalyze or Qualify data			
				Lab Duplicate	10%	RPD within ± 10%	Reanalyze or Qualify data			
				Matrix spike duplicate set	10%	Between 90% to 110%	Qualify data Reanalyze or Qualify data			
Total phosphorus	SM 4500-P H-2011	125 ml plastic	H2SO4 to pH<2, cool; 4°C	Method Blank	10%	< 0.002 mg/L	Reanalyze or Qualify data	28 days	0.002 mg/l	0.003 mg/l
				ICC/LCS	10%	% Recovery between 90% to 110%	Reanalyze or Qualify data			
				Lab Duplicate	10%	RPD within ± 10%	Reanalyze or Qualify data			
				Matrix spike duplicate set	10%	Between 90% to 110%	Qualify data Reanalyze or Qualify data			
Total suspended solids	SM 2540 D-2011	1000 ml plastic	Cool; 4°C	Method Blank	10%	< 0.3 mg/L	Reanalyze or Qualify data	7 days	*0.3 mg/l *For 1000 ml sample	*0.3 mg/l *For 1000 ml sample
				ICC/LCS	10%	% Recovery between 90% to 110%	Reanalyze or Qualify data			
				Lab Duplicate	10%	RPD within ± 10%, ±50% for values < 5 mg/L	Reanalyze or Qualify data			
				Matrix spike duplicate set	NA	NA	NA			

Table 3 cont.: Parameters, analytical specifications, and QA/QC requirements.

Field Measurements **Parameter**	**Method**	**Calibration/ Verification**	**Precision**	**Range**	**QC Sample**	**QC Acceptance Limits**
Temperature	YSI, *in situ*	Factory set annual check with NIST-reference thermometer	±0.20 C	-5 to 70°C	Field Duplicate	RPD within +/- 20% or ±0.20 C for low numeric values
Luminescent Dissolved oxygen	YSI, *in situ*	Daily	±0.1 mg/L or 1%	0 to 50 mg/L	Field Duplicate	RPD within +/- 20% or ±0.1 mg/L for low numeric values
pH	YSI, *in situ*	Daily	±0.2	0 to 14	Field Duplicate	RPD within +/- 20% or ±0.2 for low numeric values
Specific Conductivity	YSI, *in situ*	Daily	±0.001 mS/cm or 0.5%	0 to 200 mS/cm	Field Duplicate	RPD within +/- 20% or ±0.001 mS/cm for low numeric values

Table 4: Tributary sampling dates, previous 24-hour weather conditions, and event classification

Date	Previous 24-hour Weather:	Event?
4/20/2023	Light Rain	No
5/11/2023	Partly Cloudy	No
5/20/2023	Rain	Yes; 1 -1.33” in 12 hrs.
6/13/2023	Rain	Yes; 0.66- 1” in 12 hrs.
6/20/2023	Partly Cloudy	No
7/13/2023	Partly Cloudy	No
8/10/2023	Drizzle	No
9/12/2023	Partly Cloudy	No
10/10/2023	Partly Cloudy	No
11/7/2023	Mostly Cloudy	No

Table 5: Average summer stream nutrient and TSS concentration (May through August) for Graywood, Sand Point, Long Point, Sutton Point, Cottonwood, Southwest Creek, North McMillan and North Gully. Data from 2003 to 2010 are adapted from Makarewicz and Lewis (2010), data from 2020 are from Beers and Chislock (2021), and data from 2021 are from Beers and Chislock (2022).

		TP (µg/L)		NOx (mg/L)		TSS (mg/L)		TKN (µg/L)		SRP (µg/L)	
	Year	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean
Graywood	2003	248	72	8.09	1.21	8.8	1.4	539	42	116.6	15.4
	2004	242	25	8.14	1.20	14.8	2.7	558	35	120.8	13.1
	2005	163	11	3.63	0.40	9.1	2.4	555	54	104.7	8.9
	2006	174	20	1.87	0.19	7.1	1.5	384	52	105.5	13.5
	2007	96	21	2.22	0.31	5.3	1.2	376	77	59.2	13.3
	2008	124	20	1.21	0.31	5.4	1.0	303	44	99.1	16.2
	2009	237	43	3.79	1.26	19.4	4.6	768	135	171.5	36.0
	2010	206	33	4.52	1.17	18.4	6.8	546	64	159.5	27.0
	2020	456	101	5.22	0.46	99.6	36.2	675	222	270.1	36.2
	2021	989	591	11.80	3.86	301.2	253.4	1159	772	445.9	147.0
	2023	438	142	3.01	1.43	82.0	32.5	820	338	267.0	77.3
Sutton Point	2003	46	5	1.93	0.36	11.6	3.2	415	50	28.4	2.6
	2004	217	161	1.15	0.10	13.7	7.3	413	56	26.5	3.7
	2005	47	5	1.28	0.26	4.2	0.7	318	38	30.9	3.9
	2006	49	3	0.98	0.09	2.8	0.9	352	86	28.9	2.9
	2007	38	3	1.57	0.21	1.0	0.1	305	83	25.0	4.1
	2008	47	2	1.32	0.28	3.7	1.1	221	36	31.2	3.0
	2009	47	3	1.09	0.10	5.3	2.1	483	85	35.9	2.2
	2010					NO DATA					
	2020	68	16	3.29	1.29	16.4	8.0	252	33	42.2	8.9
	2021	251	192	2.96	0.59	126.5	121.5	609	477	53.7	5.9
	2023	88	14	0.94	0.23	19.4	7.0	494	161	55.1	5.6
Southwest	2003	83	5	3.54	0.74	5.7	1.5	1054	527	63.1	7.2
	2004	179	48	1.63	0.24	46.2	34.6	796	204	78.1	10.2
	2005	124	8	1.28	0.39	10.8	3.5	486	61	69.1	7.7
	2006	98	6	1.03	0.17	4.6	1.7	456	63	61.8	4.9
	2007	116	10	1.09	0.11	7.1	3.6	469	100	76.4	5.0
	2008	100	4	1.17	0.14	3.0	0.8	297	33	69.5	5.3
	2009	128	9	1.17	0.10	8.9	4.3	633	76	100.5	7.5
	2010					NO DATA					
	2020	232	35	1.58	0.50	6.43	2.5	563	205	192.5	19.4
	2021	361	154	2.61	0.38	62.4	59.7	736	325	217.6	21.6
	2023	223	29	1.35	0.27	8.9	6.1	495	135	174.6	15.5

Table 5 Continued		TP (µg/L)		NOx (mg/L)		TSS (mg/L)		TKN (µg/L)		SRP (µg/L)	
	Year	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean
North McMillan	2003	11	2	0.26	0.05	2.7	1.3	265	41	4.4	0.6
	2004	40	27	0.14	0.02	33.3	30.0	365	85	5.1	1.4
	2005	11	2	0.24	0.03	3.5	0.8	276	39	4.8	0.6
	2006	11	2	0.13	0.03	1.7	0.5	229	30	3.7	0.9
	2007	8	1	0.14	0.02	2.0	0.5	246	64	2.5	0.3
	2008	14	7	0.11	0.02	2.3	0.4	220	34	2.9	0.5
	2009	27	9	0.13	0.01	70.3	67.1	455	96	9.1	4.3
	2010	14	4	0.19	0.04	1.8	0.2	559	66	59.7	1.9
	2020	17	3	0.15	0.03	3.7	1.9	157	20	5.3	0.8
	2021	352	335	0.23	0.06	316.4	313.0	646	234	13.2	5.3
	2023	49	41	0.15	0.03	31.0	30.2	257	135	8.3	0.9
Hanna's Creek	2020	151.43	39.32	0.53	0.17	24.14	12.13	860.28	185.22	52.42	10.67
	2021	488.6	322.1	4.194	3.353	242.1	196.5	943	174	65.91	29.28
	2023	134.47	65.58	0.67	0.16	19.94	17.167	854	160	54.27	21.52

Table 6: 2023 averages for each analyte for each stream monitored. Baseflow and event sampling averages are distinguished from each other. * NH3 data collected during event sampling only. * NC indicates not collected.

	TSS	*TP*	*SRP*	*NOx*	*TN*	*TKN*	NH3
5574E							
Nonevent average	2.42	28	25.3	0.22	0.4	161	NC
event average	534.6	760	60.5	0.27	1.8	1424	.057
6009W							
Nonevent average	4.4	55	47.0	1.97	2.2	215	NC
event average	7.8	77.65	43.1	1.92	2.5	533	.023
Graywood							
Nonevent average	57.4	283	186.7	3.96	4.2	247	NC
event average	98.9	685	413.0	3.15	4.6	1490	.056
Hanna's Creek							
Nonevent average	2.5	25	10.4	0.70	1.2	470	NC
event average	187.0	75	0.5	1.52	1.0	54	.054
North End							
Nonevent average	11.1	53	29.5	1.26	1.5	291	NC
event average	71.3	243	62.2	0.67	1.6	898	.073
North McMillan							
Nonevent average	0.9	8	7.8	0.12	0.3	127	NC
event average	91.3	131	8.1	0.18	0.7	525	.023
South Gully							
Nonevent average	7.2	34	24.0	0.94	1.1	199	NC
event average	131.8	265	31.7	0.68	1.5	779	.030
South McMillan							
Nonevent average	2.3	15	6.7	0.10	0.4	256	NC
event average	82.1	134	12.7	0.38	0.9	499	.030
Southwest							
Nonevent average	2.4	186	162.4	1.12	1.5	329	NC
event average	21.8	267	172.8	1.95	2.7	763	.049
Sutton							
Nonevent average	20.2	77	52.0	0.92	1.3	414	NC
event average	8.9	89	48.4	1.06	1.5	480	.017

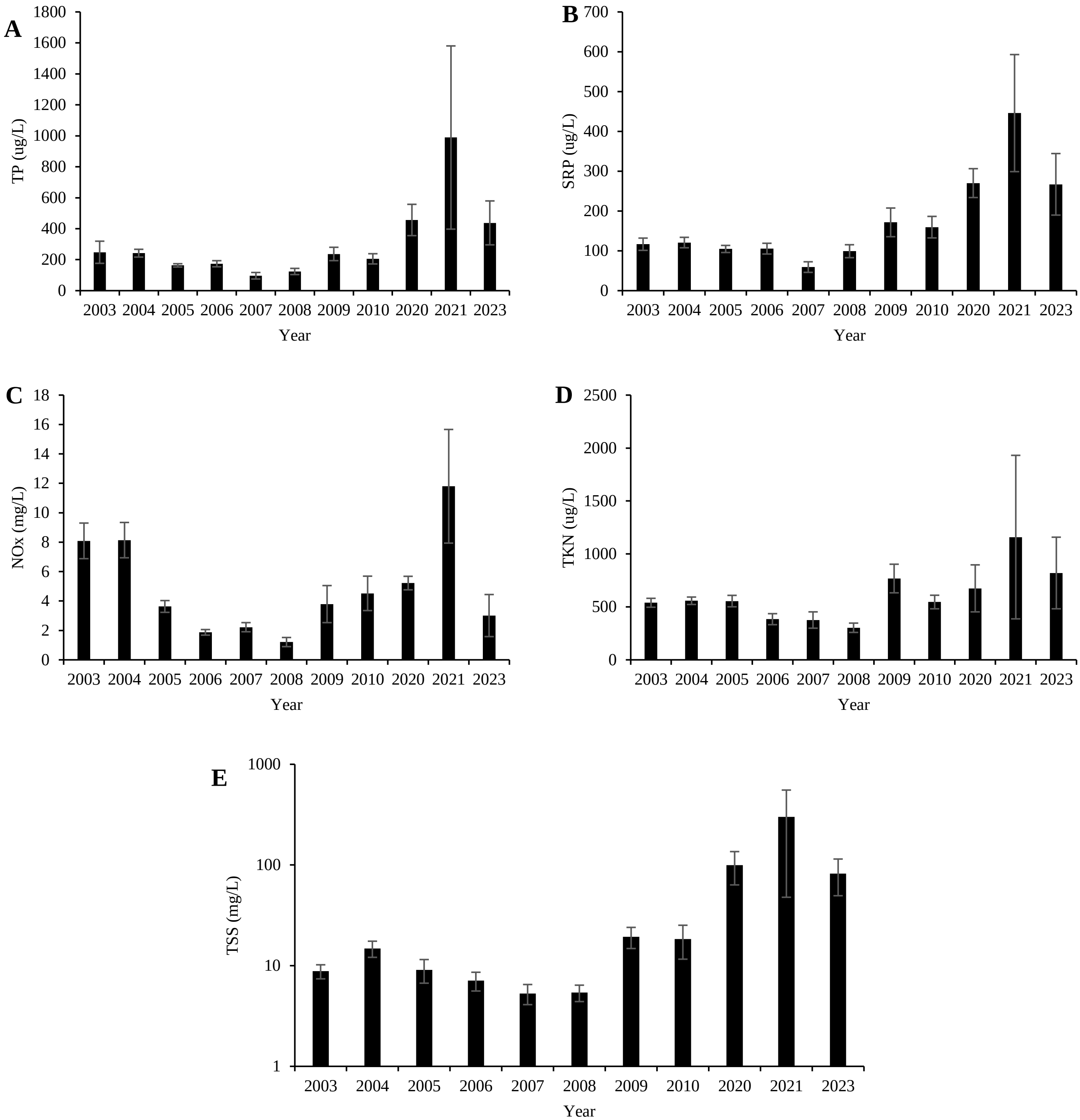


Figure 1: Average (+/- SE) concentrations (May through August) of total phosphorus (TP) (A), soluble reactive phosphorus (SRP) (B), NOx (C), total Kjeldahl nitrogen (TKN) (D), and total suspended solids (TSS) (E) in Graywood Gully from 2003 to 2010, 2020-2021, and 2023. S.E.=standard error. Some graphs have log transformed Y axes.

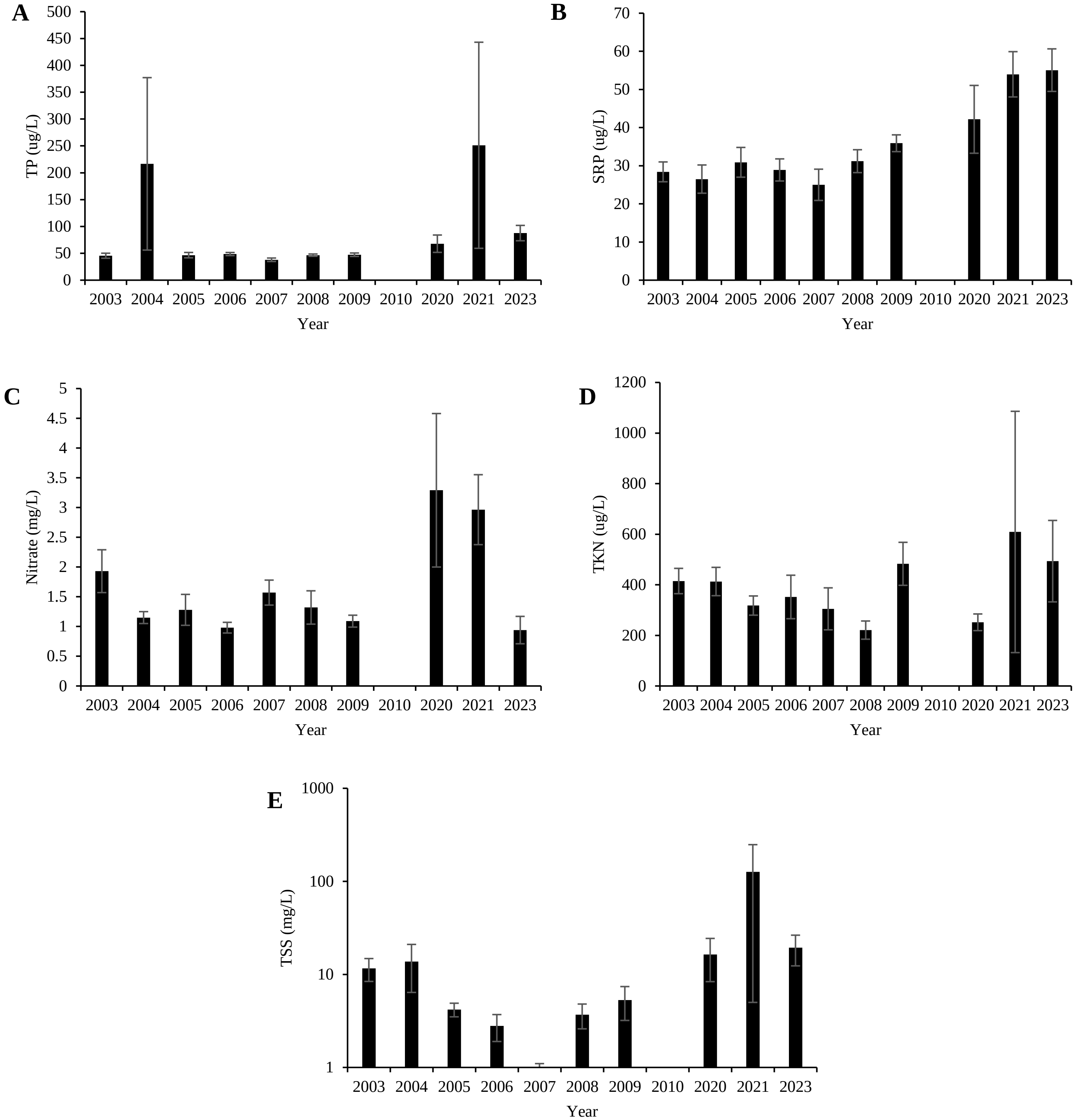


Figure 2: Average (+/- SE) concentrations (May through August) of total phosphorus (TP) (A), soluble reactive phosphorus (SRP) (B), NOx (C), total Kjeldahl nitrogen (TKN) (D), and total suspended solids (TSS) (E) in Sutton Point Gully from 2003 to 2009 (no data in 2010), 2020-2021, and 2023. S.E.=standard error. Some graphs have log transformed Y axes.

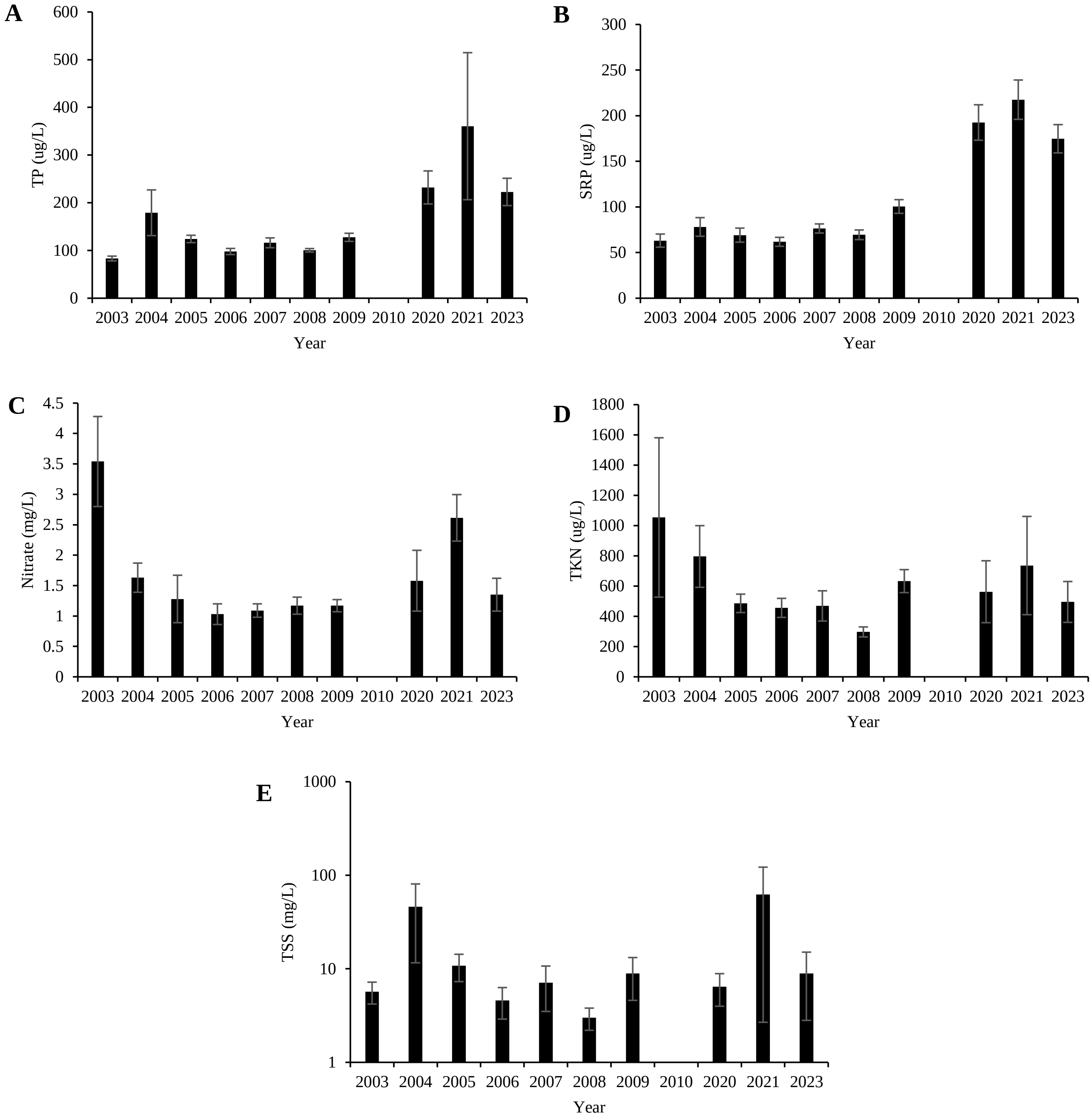


Figure 3: Average (+/- SE) concentrations (May through August) of total phosphorus (TP) (A), soluble reactive phosphorus (SRP) (B), NOx (C), total Kjeldahl nitrogen (TKN) (D), and total suspended solids (TSS) (E) in Southwest Creek from 2003 to 2009 (no data in 2010), 2020-2021, and 2023. S.E.=standard error. Some graphs have log transformed Y axes.

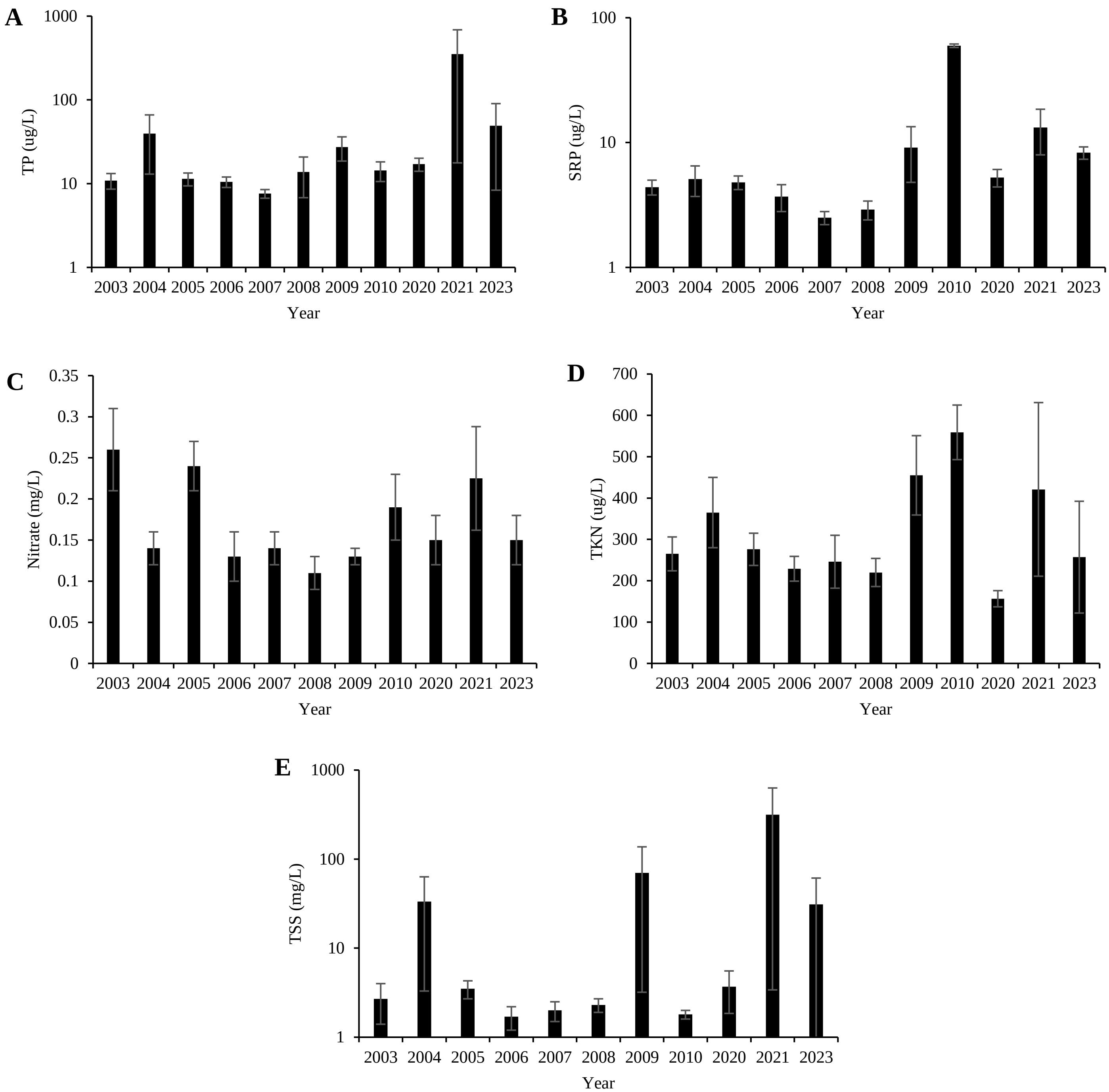


Figure 4: Average (+/- SE) concentrations (May through August) of total phosphorus (TP) (A), soluble reactive phosphorus (SRP) (B), NOx (C), total Kjeldahl nitrogen (TKN) (D), and total suspended solids (TSS) (E) in North McMillan Creek from 2003 to 2010, 2020-2021, and 2023. S.E.=standard error. Some graphs have log transformed Y axes.

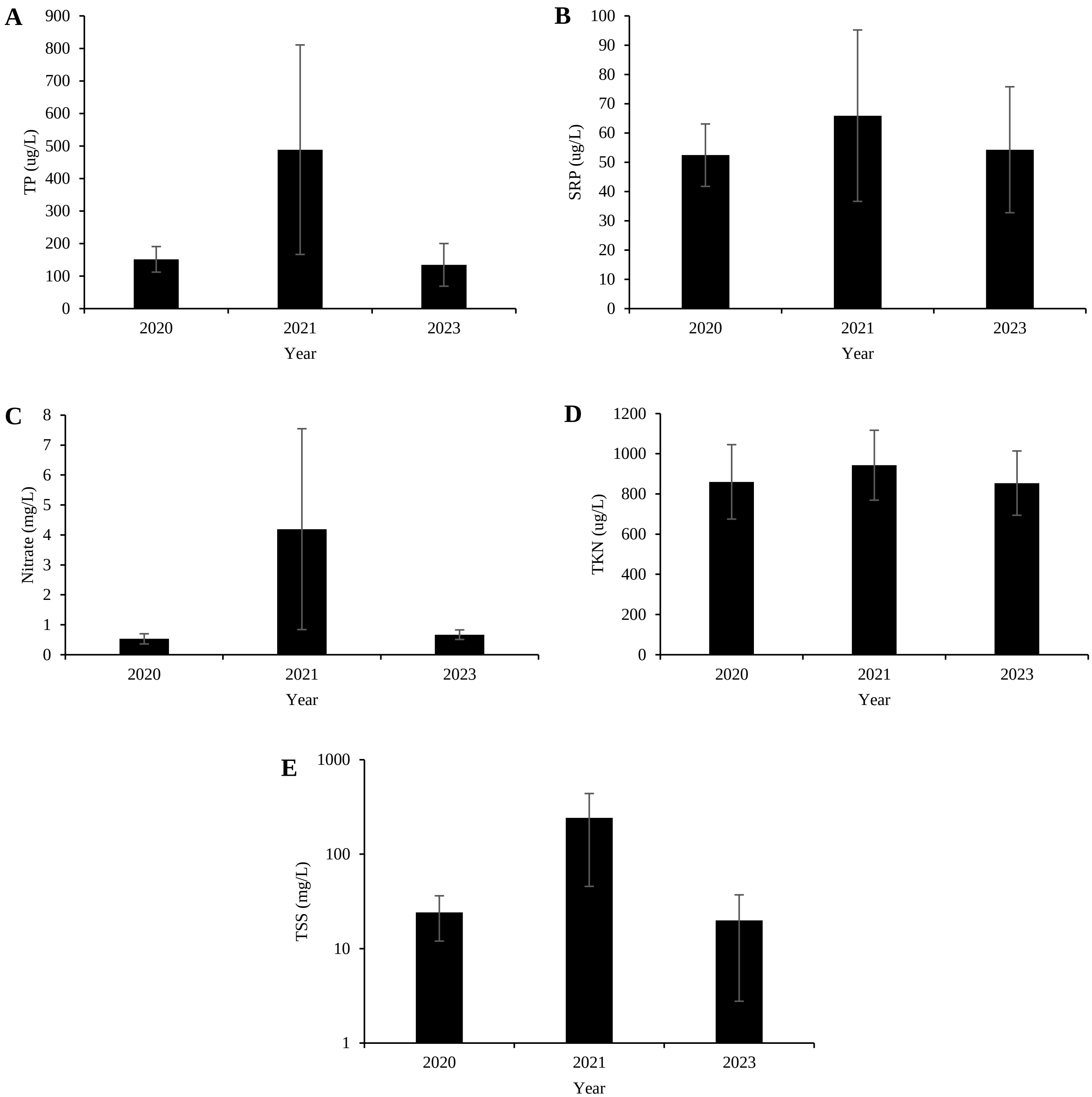


Figure 5: Average (+/- SE) concentrations (May through August) of total phosphorus (TP) (A), soluble reactive phosphorus (SRP) (B), NOx (C), total Kjeldahl nitrogen (TKN) (D), and total suspended solids (TSS) (E) in Hanna's Creek from 2020-2021, and 2023. S.E.=standard error. Some graphs have log transformed Y axes.

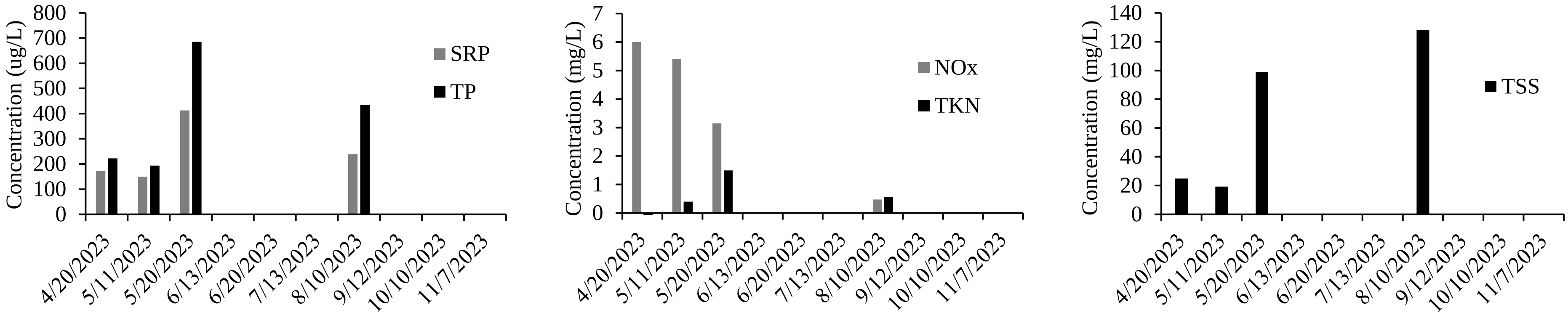


Figure 6: Concentrations of water quality parameters collected in Graywood Gully from 2023 sampling dates.

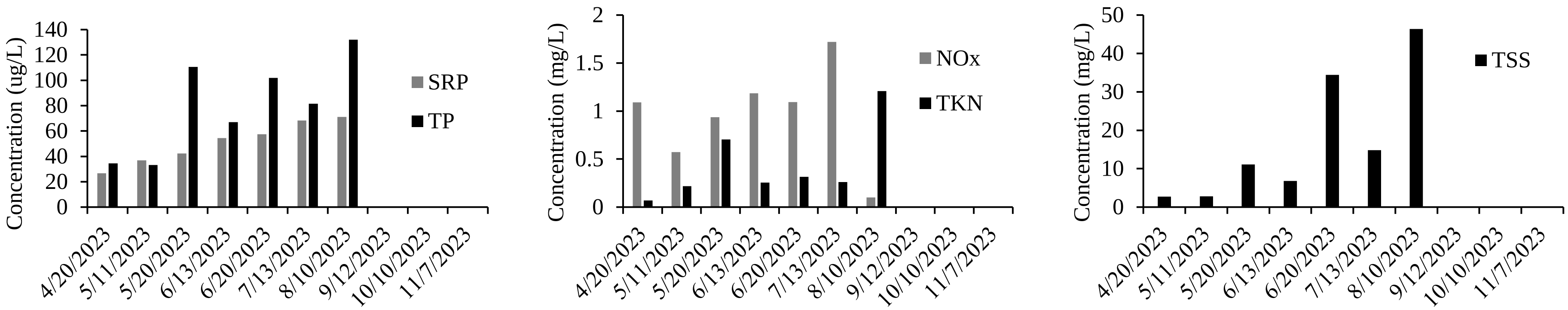


Figure 7: Concentrations of water quality parameters collected in Sutton Point Gully from 2023 sampling dates.

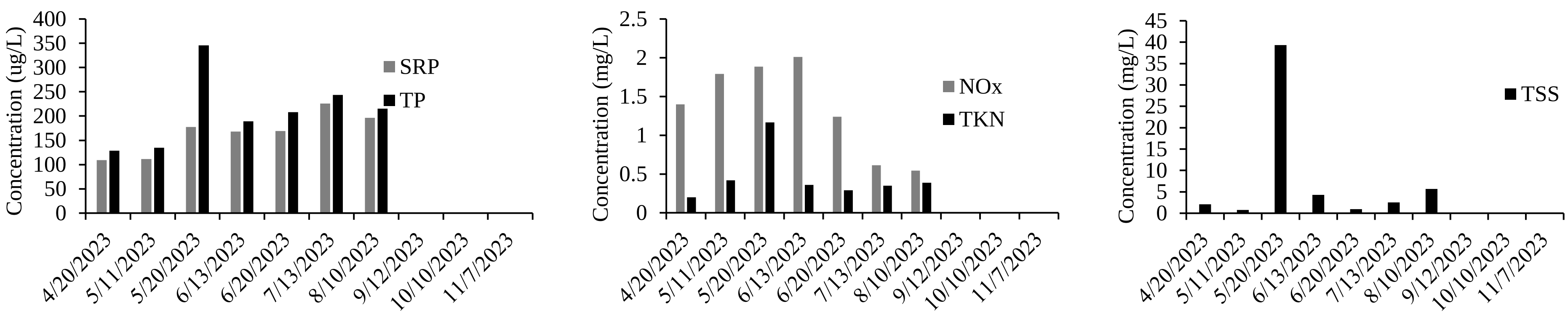


Figure 8: Concentrations of water quality parameters collected in Southwest Creek from 2023 sampling dates.

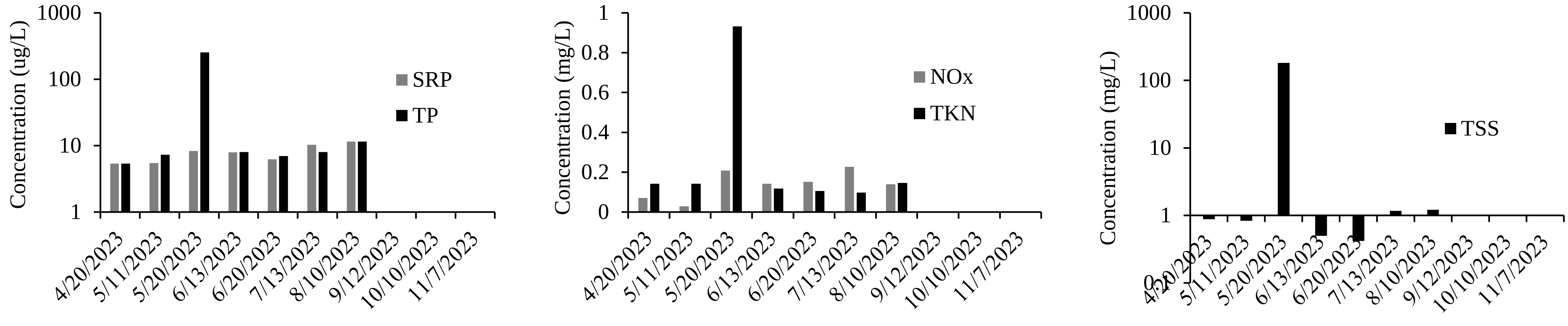


Figure 9: Concentrations of water quality parameters collected in North McMillan Creek from 2023 sampling dates.

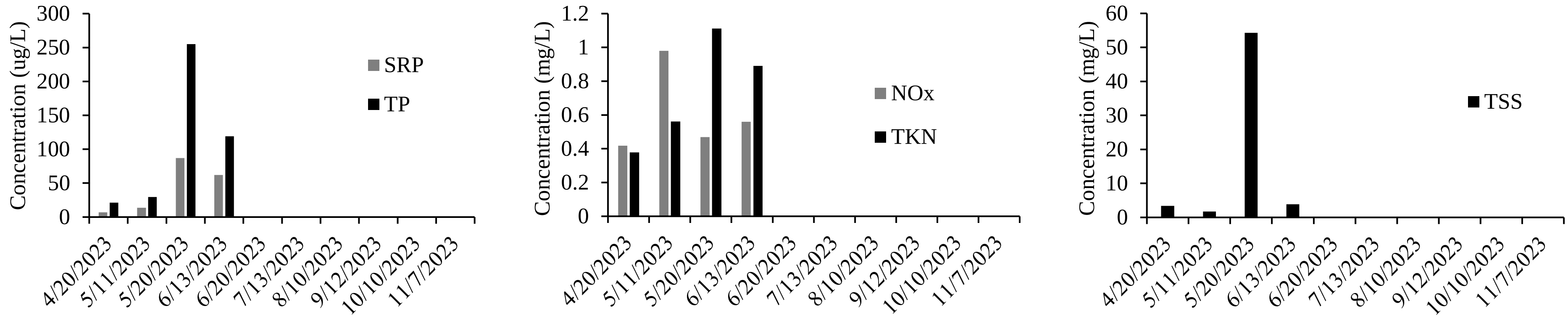


Figure 10: Concentrations of water quality parameters collected in Hanna's Creek from 2023 sampling dates.

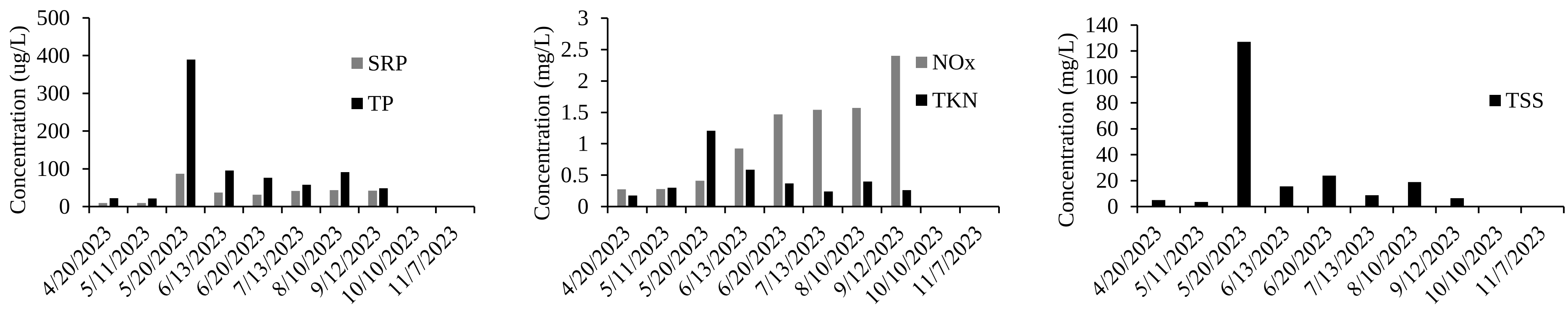


Figure 11: Concentrations of water quality parameters collected in North End Creek from 2023 sampling dates.

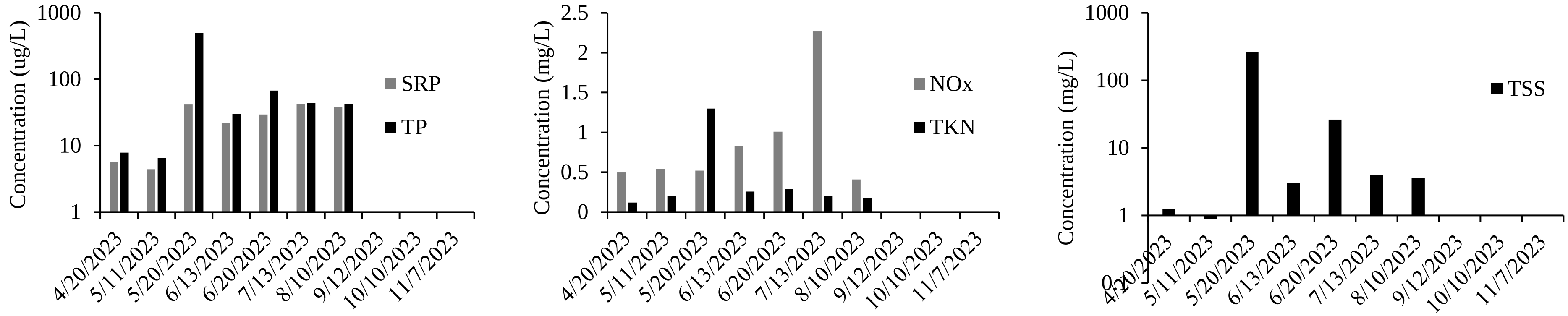


Figure 12: Concentrations of water quality parameters collected in South Gully from 2023 sampling dates.

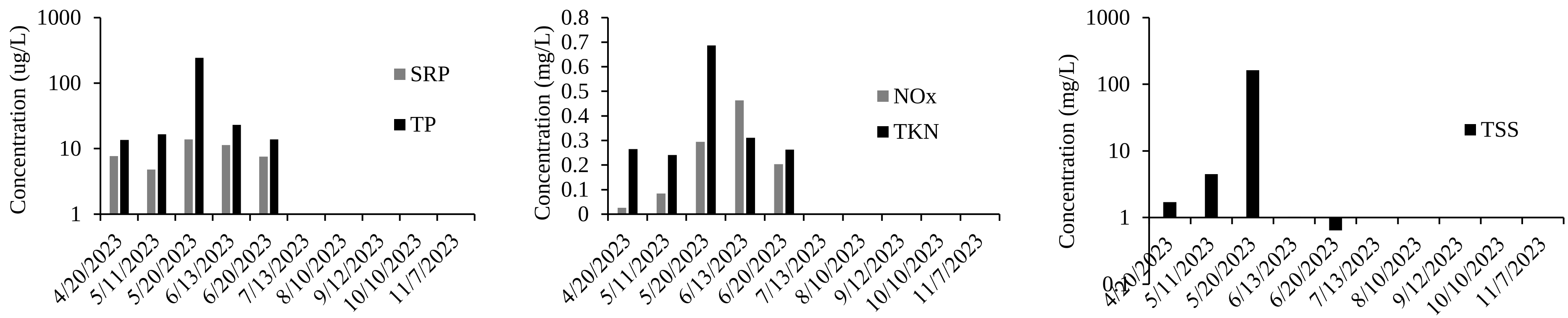


Figure 13: Concentrations of water quality parameters collected in South McMillan Creek from 2023 sampling dates.

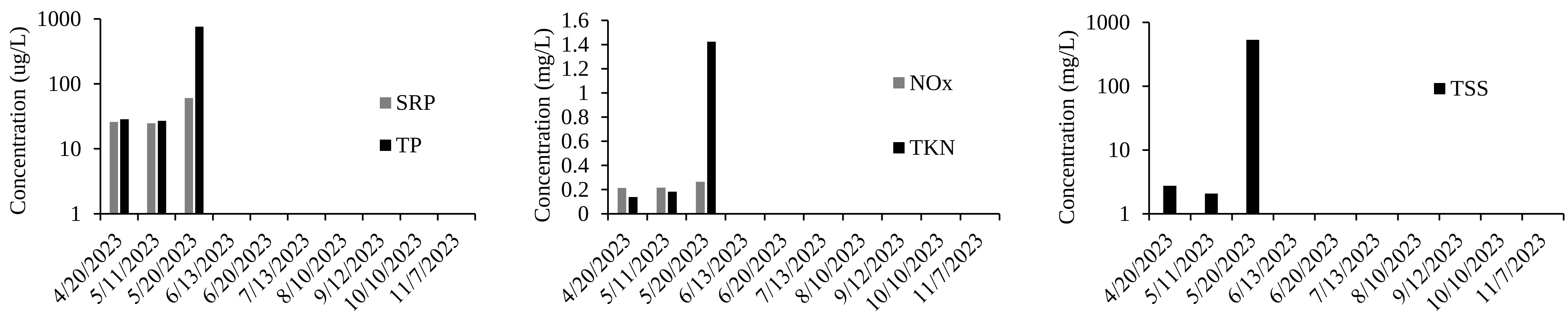


Figure 14: Concentrations of water quality parameters collected in Creek 5574E from 2023 sampling dates.

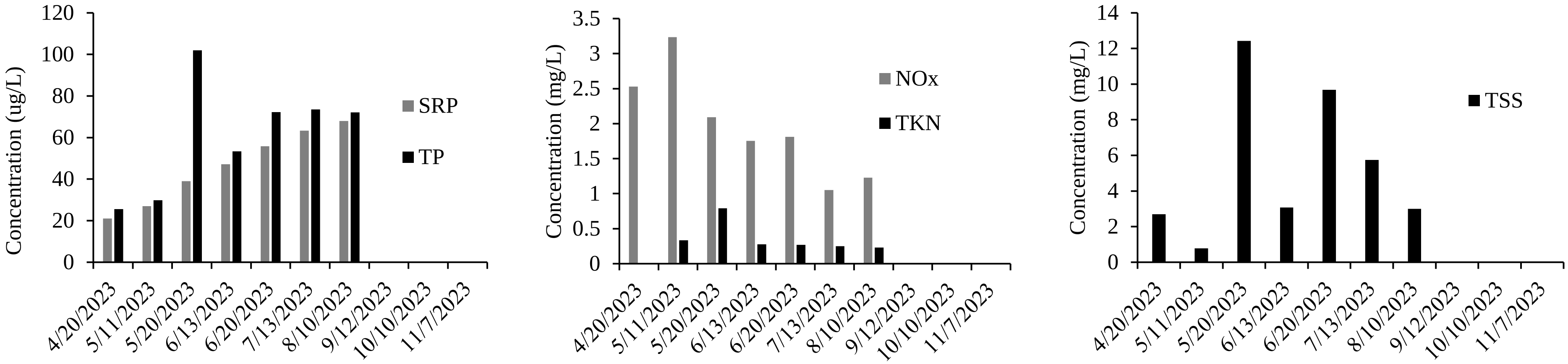
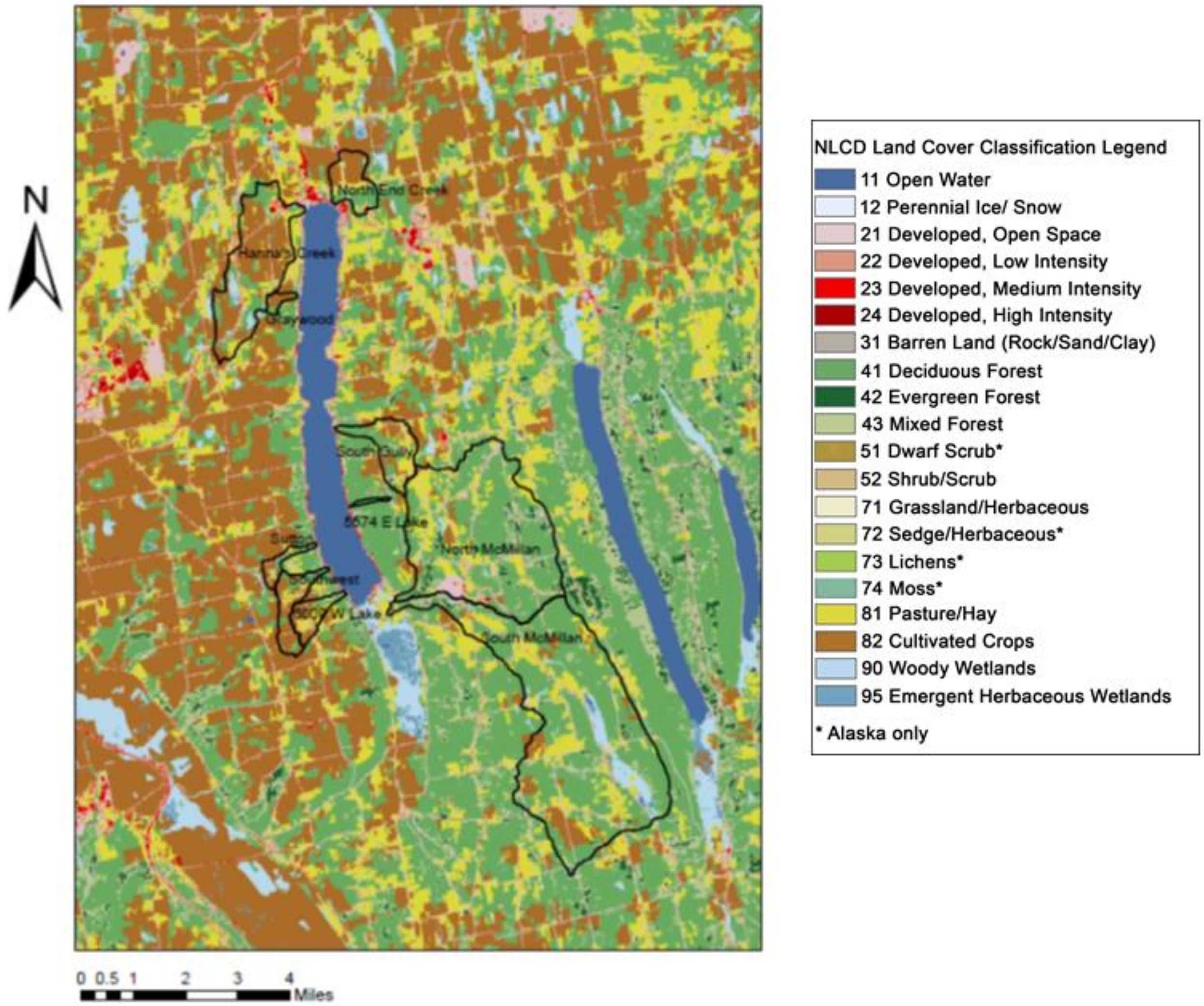


Figure 15: Concentrations of water quality parameters collected in Creek 6009W from 2023 sampling dates.

Appendices:



Appendix 1. Map of study watersheds with associated land use from the 2019 National Land Cover Database. GPS coordinates for sampling site locations are in Table 1.

Appendix 2: Photos of storm event runoff at Creek 5574E showing highly sediment laden water.