

**Livingston County Water Quality Monitoring - 2021 Tributary
Program**

**Report Submitted to
The Livingston County Planning Department**

By

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Table of Contents

Summary	3
Recommendations	3
Background	4
Methods	5
Results and Discussion	
Graywood Gully	6
Sand Point Gully	7
Long Point Gully	8
Sutton Point Gully	9
Cottonwood Gully	10
Southwest Creek	11
North McMillan Creek	12
Hanna's Creek	12
No Name Creek	13
North Gully	14
Wilkins Creek	15
Additional Data	15
Conclusions	16
References	16
Tables	18
Figures	26
Appendices	55

Summary

- Eleven streams were sampled for water quality in 2021 from March - November. Former USDA study tributaries were monitored to continue long-term monitoring efforts in the best management practice (BMP) streams and a reference stream. Additional non-BMP streams were added for 2021 monitoring efforts.
- A dry spring time period was observed, before transitioning into a wet summer and fall with frequent and intense storm events.
- Graywood Gully and Southwest Creek continue to have some of the highest concentrations of phosphorus (dissolved and particulate) of all of the streams monitored. #
- Heavily agricultural watersheds continue to show greater nutrient concentrations than the reference stream, North McMillan Creek, and streams that have less agricultural activities occurring in their watersheds (e.g., North Gully and Wilkins Creek) during baseflow conditions. #
- Significant loading of nutrients and suspended solids occurred numerous times throughout the summer and fall during intense storm events in all tributaries, including North McMillan Creek and North Gully.#
- Nitrate/nitrite (NO_x) concentrations were very high during multiple summer storm events in Hanna's Creek, Graywood Gully, and Long Point Gully watersheds.#
- Compared to historical data, average loadings of nutrients and sediments were among the highest documented in several of the tributaries.

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.#
- 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. In 2021, we observed very heavy storm events during the summer and fall periods after a dry spring.#
- Current information on agricultural practices for the USDA tributaries and other subwatersheds is needed.#
- During heavy storm events, North McMillan Creek TSS concentrations and loadings are very high, as a result of streambank erosion and potentially changes in land use occurring in the watershed. Given the importance of North McMillan as a major tributary to Conesus Lake, and its historical use as a reference watershed, segment analysis in spring/summer 2022 is recommended on this stream to determine potential sources of high TSS concentrations observed during storm events. #
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Background

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 on 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 Irondequoit Bay and Lake Erie, 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 (NO_x) 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), NO_x, 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 NO_x 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 pristine 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 NO_x 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.

Methods

Eleven streams were sampled for water quality in 2021. Former USDA study tributaries were monitored to continue long-term monitoring efforts in the BMP streams and a reference stream (Tables 1 and 2; Appendix 1). Some additional non-BMP streams were added for 2021 monitoring efforts (Tables 1 and 2; Appendix 1). All tributary sites were monitored monthly for baseflow from 25 March to 9 November 2021, in addition to two storm events. A total of 11 sampling events were captured for selected tributaries. 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), nitrate/nitrite (NO_x), and orthophosphate (i.e., soluble reactive phosphorus, SRP); (2) stream discharge measurements; (3) *in-situ* water chemistry measurements, including temperature, dissolved

oxygen, pH, specific conductivity, and turbidity; and (4) 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 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 and NO_x were immediately filtered on site with 0.45- μ m syringe filters. One field duplicate and field 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. Stream discharge was estimated on select days, when possible, unless stream depth was too shallow, or too deep/fast. Stream staff gauges were used at each tributary site, and rating curves were developed (see appendix 3). Established rating curves were used to estimate discharge during selected sampling trips.

Concentration and loading data from 2021 were compared to past data collected by Makarewicz and Lewis (2010) in 2003-2010 from May through August, and Beers and Chislock (2021) in 2020 from May through August to assess if nutrients and TSS concentrations and loads from watersheds were improving, declining, or stable, relative to the historical data. In 2020 and 2021, TKN was calculated by subtracting NO_x concentration from TN concentration. It is important to note that sample frequency changed in 2020 and 2021; samples were collected weekly from 2003 to 2010, but monthly from May to August 2020 and 2021. Historical concentration and loading data from May through August are presented as averages by year on bar graphs with standard errors to compare the data. Loading data were compared using ANOVA and Tukey's post-hoc tests to determine if significant differences existed between 2021 and historical data. 2021 sampling concentration and loading data were also compared across sampling dates to examine water quality differences and if any temporal patterns exist on study tributaries. Lastly, we plotted water quality parameter vs discharge. 2003-2010 (or 2003-2009; some tributaries were not monitored in 2010) data were grouped together and a regression line was added to those data to observe the general trend in the concentrations as discharge increases. 2020 and 2021 data are also graphed but not grouped together. By comparing 2020 and 2021 data to historical data as a function of discharge, this provides further evidence to whether conditions are improving, declining, or are remaining the same over time and if any trends can be observed at various discharge points.

Results and Discussion

USDA BMP streams and other non-BMP stream monitoring activities

Graywood Gully (Tables 1 and 5, Figures 1 a-j, 2 a-e, and 20 a-g, appendix 2 and 3):

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 historical data, TP, SRP, NO_x, TKN, and TSS concentrations were higher in 2021 than in all prior sampling years (i.e., 2003-2010, 2020

in May through August) (Table 5, Figure 1 a, c, e, g, and i). In general, 2021 TP, SRP, TKN, and TSS loadings were higher than previous sampling years (Figure 1 b, d, h, and j). 2021 NO_x loading was greater than loadings observed from 2003, 2005 to 2009, and 2020 (Figure 1f). Based on statistical analyses, loadings for 2021 TP, NO_x, TKN, and SRP were significantly greater than 2008 and 2009 ($p < 0.05$). TSS loading in 2021 was significantly greater than 2006-2009 ($p < 0.05$).

For Graywood Gully, a positive relationship between discharge and analyte concentration was observed in the grouped 2003-2010 data (as discharge increased, so did concentration) for all analytes (Figure 2 a-e). For 2021, we observed concentrations of TP, SRP, NO_x and TSS above the 2003-2010 regression line, with some of the highest recorded concentrations (Figure 2 a-c, e). This likely indicates that conditions have been degrading over time for these parameters and previous BMPs may not be followed, or different land use practices have been occurring since the USDA study. 2021 TKN concentrations were mainly grouped with 2003-2010 data, except for one point during a very high discharge event, possibly indicating that TKN may be a problem during high discharge events but similar to concentrations seen in lower discharge (Figure 2d).

In 2021, we observed the highest TP, SRP, and TSS concentrations and loadings during the July 17th storm event. Concentrations and loads were also elevated on the June 21st storm event but not nearly as high. No seasonal patterns can be observed from baseflow concentration data in 2021 for all analytes. The stream was dry during the June and July baseflow sampling dates. The greatest NO_x concentration was observed on the June 21st storm event and the greatest TKN concentration was seen on the July 17th storm event. As with the other analytes, no seasonal differences in NO_x and TKN concentrations were observed in 2021 during baseflow. The greatest loading of NO_x and TKN occurred on July 17th followed by June 21st. The lowest nitrogen loading occurred during the fall period. The greatest discharge occurred on July 17th and during October baseflow sampling. The June 21st storm event had discharge that was comparable to baseflow discharge in the spring period (Figure 20 a-g).

Sand Point Gully (Tables 1 and 5, Figures 3 a-j, 4 a-f and 26 a-g, appendix 2 and 3):

Numerous BMPs were implemented in the Sand Point Gully watershed as a part of the USDA study, including rotational grazing, cattle fenced off from the stream, and crop rotation (Table 1). In 2021, we observed concentrations of TP, SRP, and TSS to be much higher than observed from 2003-2009, and 2020 from May through August (no monitoring program in 2010) (Table 5, Figure 3 a, c, and i). In contrast, NO_x concentrations were similar to 2009 and 2020 levels (which are greater than all other years) (Table 5, Figure 3 e). 2021 TKN concentration was the greatest of any other year (Table 5, Figure 3 g). In 2021, average loadings for all analytes were the highest observed (Figure 3 b, d, f, h, and j). Based on statistical analyses, 2021 loadings of TP, SRP, and TKN were significantly greater than May through August 2006-2009 ($P < 0.05$). 2021 NO_x loading was significantly greater than 2008 loading ($p < 0.05$). 2021 TSS loading was significantly greater than 2003, 2005-2009 ($p < 0.05$).

For Sand Point Gully, a positive relationship between discharge and analyte concentration was observed in the grouped 2003-2009 data (as discharge increased, so did concentration) for all analytes, except SRP, which was a slight decrease in concentration as discharge increased (Figure 4 a-f). For 2021, we observed concentrations of TP and SRP above the 2003-2009 regression line and some of the highest recorded (Figure 4 a-b). This likely indicates that conditions have been degrading over time for these parameters and that BMPs may not be followed anymore, or different land use practices have been occurring since the USDA study. 2021 NO_x, TKN, and TSS concentrations were mainly grouped with 2003-2010 data, except for one point during a very high discharge event for TSS, possibly indicating that these parameters have not degraded over time (Figure c-f).

In 2021 SRP and TP concentrations were the greatest during the July 17th storm event followed by June 21st. Spring baseflow concentrations of phosphorus were lower than summer and fall baseflow concentrations. Summer and fall concentrations of phosphorus during baseflow were very similar. The greatest loading of phosphorus occurred during the July storm event followed by the June storm event. The greatest discharge we observed occurred on July 17th. TSS concentrations were the greatest during storm events and during summer baseflow. Baseflow TSS concentrations during the spring and late fall were low. July 17th had the greatest suspended solid loading followed by June 21st. The greatest NO_x concentration was seen during the June 21st storm event and greatest TKN concentration was during the July 17th storm event. NO_x and TKN concentrations were lowest during spring baseflow while greater during fall baseflow. The greatest loading of NO_x and TKN occurred on July 17th and June 21st. Baseflow loading of these analytes were greater during the fall than spring and summer baseflow (Figure 26 a-g).

Long Point Gully (Tables 1 and 5, Figures 5 a-j, 6 a-e, and 22 a-g, appendix 2 and 3):

In Long Point Gully, BMPs were implemented in the watershed during the USDA study, and included a reduction in cropland, ceasing winter manure spreading, and injection of manure instead of spreading (Table 1). Compared to historical data, TP, SRP, NO_x, and TSS concentrations were highest in 2021 (Table 5, Figure 5 a-e and i). In contrast, 2021 TKN concentration was comparable to previous years (Table 5, Figure 4 g). 2021 TP, SRP, TSS, NO_x, and TKN loadings were higher than all previous years (Figure 4 b, d, f, h, and j). Based on statistical analyses, 2021 TP loading was significantly greater than loadings observed from 2006-2009 ($p < 0.05$). 2021 NO_x loading was nearly twenty times greater than 2008, but this difference was not statistically significant ($p = 0.051$). 2021 TSS loading was significantly greater than 2009 ($p < 0.05$). TKN and SRP loadings in 2021 were not significantly greater than historical loadings.

For Long Point Gully, a positive relationship between discharge and analyte concentration was observed in the grouped 2003-2009 data (as discharge increased, so did concentration) for all analytes (Figure 6 a-e). For 2021, we observed concentrations of TP, SRP, and TSS above the 2003-2009 regression line and some of the highest recorded for high discharge events (Figure 6 a, b, e). During lower discharge, TP, SRP, and TSS are similar to 2003-2010 data. This may indicate

that conditions have been degrading over time for these parameters and that BMPs may not be followed anymore, or different land use practices have been occurring since the USDA study and are having an impact during heavy discharge events. It is also possible that the BMPs installed in this watershed do not do as well in helping reduce nutrient runoff during heavy storm events. 2021 NO_x and TKN concentrations were mainly grouped with 2003-2010 data, possibly indicating that these parameters have not degraded over time or that BMPs continue to be maintained (Figure 6 c-d).

In 2021, the greatest TP, SRP, and TSS concentrations were observed in the summer storm events. Baseflow TP and SRP concentrations were greatest in the late summer and fall while lowest in the spring. The greatest phosphorus and TSS loading occurred during the July storm event. The creek was very low during baseflow in April, June and July and was impossible to estimate discharge at that low of a level, so no loading estimates exist for those dates. The greatest NO_x concentration was seen during the June 21st storm event and greatest TKN observed during July 17th event. NO_x and TKN concentrations were relatively similar across seasons during baseflow with the lowest concentrations occurring during the late summer period in September. The greatest loading of NO_x and TKN occurred during the storm event on July 17th followed by June 21st (Figure 22 a-g).

Sutton Point Gully (Tables 1 and 5, Figures 7 a-j, 8 a-f, and 28 a-g, appendix 2 and 3):

Sutton Point Gully had gully plugs installed and a 60% cropland conversion to alfalfa during the USDA study (Table 1). Compared to historical data, the greatest TP, SRP, TKN and TSS concentrations were seen in 2021 compared to previous years (Table 5, Figure 7 a, c, g and i). TSS concentrations in 2021 were especially higher than previous years, however is likely skewed by July 17th 2021 storm event. The greatest NO_x concentrations were also observed in 2021 than compared to 2003-2009 (no 2010 monitoring) but not higher than 2020 (Table 5, Figure 5 e). 2021 loading of TP, SRP, TKN, and TSS were the highest observed (Figure b, d, h, and j). NO_x loading was comparable to 2004, but greater than other monitoring years (Figure f). Based on statistical analyses, loading of TP, SRP, TKN and NO_x in 2021 were not significantly greater than historical loading ($p > 0.05$). TSS loading in 2021 was significantly greater than 2007 ($p < 0.05$).

For Sutton Point Gully, a slight positive relationship between discharge and analyte concentration was observed in the grouped 2003-2009 data (as discharge increased, so did concentration) for all analytes, except SRP and TP, which declined slightly as discharge increased (Figure 8 a-f). For 2021, we observed concentrations of soluble nutrients (SRP and NO_x) above the 2003-2009 regression line and some of the highest recorded for high discharge events for SRP (Figure b, c). This indicates that soluble nutrients may be becoming a problem in this watershed compared to the USDA study period. During lower discharge, TP, TKN, and TSS are similar to 2003-2009 data, but higher during high discharge events (Figure 8 a, d, e-f). This may indicate that the BMPs installed in this watershed do not do as well in helping reduce nutrient and sediment runoff during heavy storm events.

In 2021, the greatest baseflow TP and SRP concentrations occurred during the late spring through the fall and the greatest storm event concentrations occurred on July 17th (Figure 28 a). Loading was greatest during the July storm event and lowest in the spring when we saw the lowest measured discharge (Figure 28 b, g). NOx concentrations were the greatest during the spring and fall baseflow, and lowest during the late summer baseflow (Figure 28 c). NOx concentrations were lowest during storm events. TKN concentrations were relatively consistent throughout the sampling period, except during the July storm event when the greatest concentration was observed (Figure 28 c). The greatest baseflow NOx loading occurred during the fall, while TKN loading remained relatively consistent through the sampling period (Figure 28 d). The greatest loading of NOx and TKN occurred on July 17th. TSS concentrations were greatest during the storm events and lowest during fall baseflow (Figure 28 e). TSS loading was relatively consistent during the sampling period, except for the storm events, when loading was high (Figure 28 f).

Cottonwood Gully (Tables 1 and 5, Figures 9 a-j, 10 a-e, and 19 a-g, appendix 2 and 3):

Numerous BMPs were implemented in the Cottonwood Gully watershed during the USDA study including cover crops, reducing cropland area, installing gully plugs and ceasing fall tillage activities (Table 1). Compared to historical data, SRP, TP, and TKN concentrations were the highest in 2021 (Table 5, Figure 9 a, c, and g). TSS concentrations in 2021 were the greatest since 2004/2005 (Table 5, Figure 9 i). NOx concentrations were lower in 2021 than numerous past years (Table 5, Figure 9 e). 2021 TP, SRP, TKN, and TSS loading was greater than historic loading, except in 2004 (Figure 9 b, d, h, j). Based on statistical analyses, TP, TKN, and TSS loadings in 2021 were not significantly greater than previous years. SRP 2021 loading was significantly greater than 2006 loading ($p=0.048$). NOx loading in 2021 was not significantly greater than previous years (Figure 9 f).

For Cottonwood Gully, a positive relationship between discharge and analyte concentration was observed in the grouped 2003-2010 data (as discharge increased, so did concentration) for all analytes (Figure 10 a-e). For 2021, we observed concentrations of SRP close to the higher points recorded during the 2003-2010 sampling (Figure 10 b). This indicates that SRP may be becoming a problem in this watershed compared to the USDA study period. 2021 TP, NOx, TKN, and TSS are similar to 2003-2010 data, but greater during high discharge events for TKN (Figure 10 a, c-e).

In 2021, baseflow TP and SRP concentrations were generally the lowest during the spring sampling period and higher in the summer and fall. The greatest TP concentration was on July 17th. While TP concentration was high, SRP was lower than summer baseflow concentrations on July 17th. The June 21st storm event had similar phosphorus concentrations to baseflow concentrations. Phosphorus loading was the greatest on July 17th and loading from the June storm event was similar to late summer and fall loading. The lowest loading occurred in the spring monitoring period (Figure 19 a and b). Baseflow NOx concentrations were the lowest during the summer and highest during the spring and fall (Figure 19 c). NOx concentrations during the storm

events were similar to baseflow concentrations in the spring period. NO_x loading was greatest on July 17th during the greatest observed discharge, followed by October baseflow loading (Figure 19 c, g). TKN concentration was relatively consistent through the sampling period and lowest loading occurred during the spring (Figure 19 c). The greatest TKN concentration and loading occurred on July 17th (Figure 19 c, and d). The greatest 2021 TSS concentrations were observed during the storm events and during late summer and early fall (Figure 19 e). TSS loading was greatest during the July 17th storm event (Figure 19 f).

Southwest Creek (Tables 1 and 5, Figures 11 a-j, 12 a-e, and 27 a-g, appendix 2 and 3)

The Southwest Creek watershed had a manure pit installed as part of the USDA BMP study (Table 1). Compared to 2003-2009 historical data (no data collected in 2010), 2021 had the greatest TP, SRP, and TSS concentrations recorded (Table 5, Figure 11 a, c, i). TP, SRP, and TSS loading in 2021 were also the highest recorded (Figure 11 b, d, j). 2021 TKN concentrations were relatively consistent to concentrations observed in 2004-2009 and 2020 (Table 5, Figure 11 g). Nitrate concentrations in 2021 were observed to be the highest since 2003 (Table 5, Figure 11 e). TKN loading in 2021 was the greatest than all previous years. NO_x loading in 2021 was the greatest observed since 2003 (Figure 11 f and h). Based on statistical analyses, TP loading in 2021 was significantly greater than loadings observed in 2005-2007 ($p < 0.05$). SRP loading in 2021 was significantly greater than loadings observed in 2003-2008 ($p < 0.05$). NO_x loading in 2021 was significantly greater than loadings observed in 2005-2006 ($p < 0.05$). Although average loading of TSS and TKN in 2021 was greater than previous years, they were not significantly greater than historic loading.

For Southwest Creek, a positive relationship between discharge and analyte concentration was observed in the grouped 2003-2009 data (as discharge increased, so did concentration) for all analytes (Figure 12 a-e). For 2021, we observed concentrations of TP and SRP above the 2003-2009 regression line and some of the highest recorded for high discharge events (Figure 12 a-b). This indicates that these analytes may be becoming a problem in this watershed compared to the USDA study period. NO_x concentrations in 2021 were greater than the regression line, but not the highest recorded (Figure 12 c). During lower discharge, TKN, and TSS were similar to 2003-2009 data, but higher during high discharge events (Figure 12 d-e). This may indicate that the BMPs installed in this watershed do not do as well in helping reduce nutrient and sediment runoff during heavy storm events for these analytes.

In 2021, TP and SRP concentrations remained consistently high throughout the sample period with a slight increase during the summer and major increase in TP during the July storm event (Figure 27 a). The greatest baseflow loading of TP and SRP occurred in the summer and fall and lowest in the spring (Figure 27 b). The greatest NO_x concentrations occurred in the spring, decreased in the summer, then increased in the fall for baseflow (Figure 27 c). TKN concentrations during baseflow were relatively consistent throughout the sampling period (Figure 27 c). The lowest NO_x concentration occurred during the storm event in July while the greatest TKN

concentration occurred during the July storm event. Baseflow NO_x and TKN loading were the greatest during the summer and fall period in 2021, while the greatest storm event loading occurred during the July storm event, when we saw the greatest discharge (Figure 27 d). TSS concentrations were greatest during the July 17th storm event (Figure 27 e). Loading of TSS was greatest during the July 17th storm event but relatively consistent during other sample dates (Figure 27 f). We observed a significant growth of algae in Southwest Creek during the late spring and early summer with the high nutrient availability in the stream water.

North McMillan Creek (Tables 1 and 5, Figures 13 a-j, 14 a-f, and 25 a-g, appendix 2 and 3)

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 2021, average TP and TSS concentrations were much higher than observed historically (Figure 13 a, i). SRP concentration was greater than all years except 2010 (Table 5, Figure 13 c). NO_x and TKN concentrations remained relatively stable in 2021 compared to historic data, however both were greater than 2020 concentrations (Table 5, Figure 13 e and g). Average loading of TP, SRP, TSS, NO_x, and TKN in 2021 were the greatest observed in all previous years. (Figure 13 b, d, f, h, and j). Based on statistical analyses, TP loading in 2021 was significantly greater than 2005-2006 loading ($p < 0.05$). SRP loading in 2021 was significantly greater than 2008 and 2020 loading ($p < 0.05$). NO_x, TKN, and TSS loadings in 2021 were significantly greater than 2006 loadings ($p < 0.05$).

For North McMillan Creek, a positive relationship between discharge and analyte concentration was observed in the grouped 2003-2010 data (as discharge increased, so did concentration) for all analytes (Figure 14 a-f). For 2021, we observed concentrations of TP and TSS above the 2003-2010 regression line during high discharge events, but similar to concentrations observed in 2003-2010 for lower discharge (Figure 14 a, e-f). This may indicate erosion occurring in the watershed during high discharge events. 2021 SRP, NO_x, and TKN were similar to 2003-2010 data (Figure 14 b-d). This may indicate that water quality has not degraded for these analytes since the USDA study period data for the late spring and summer period.

In 2021, TP and SRP concentrations were greatest during the fall and during the storm events in June and July, and greatest loading occurred during the July 17th storm event (Figure 25 a and b). TP and SRP loading were lowest during the spring and early summer months (Figure 25 b). NO_x and TKN concentrations and loading remained relatively stable throughout the sampling period and the greatest concentration and loading occurred during the July storm event (Figure 25 c and d). TSS concentrations and loadings were greatest during the storm events and relatively stable during baseflow throughout the sampling period (Figure 25 e and f). Discharge was relatively consistent throughout the sampling period except on July 17th, where discharge was much greater than baseflow (Figure 25 g).

Hanna's Creek (Table 1, Figure 15 a-j, 21 a-g, appendix 2 and 3):

Hanna's Creek was not included in the USDA BMP study, but monitored in 2021 for water quality (Table 1). 2021 data was compared to 2020 data for Hanna's Creek. 2021 concentrations of TP, SRP, NO_x, and TSS were greater than 2020 (Figure 15 a, c, e, g). Average TKN concentrations in 2021 were comparable to 2020 (Figure 15 g). While the loadings in 2021 were greater than 2020, they were not significantly greater for all analytes measured ($p>0.05$) (Figure 15 b, d, f, h, and J).

In 2021, we observed high total phosphorus concentrations during the summer storm events, especially on July 17th (Figure 21 a). SRP and TP concentrations were the greatest during the fall and lowest in the spring during baseflow conditions. The stream was dry in July and August during baseflow (Figure 21 a). Loading for TP and SRP was greatest on July 17th when we observed the greatest discharge (Figure 21 b). NO_x and TKN concentrations were relatively similar throughout the sampling period during baseflow, while the greatest NO_x concentration occurred on July 17th (Figure 21 c). NO_x and TKN loading were greatest during the July storm event and relatively similar during baseflow throughout the sampling period (Figure 21 d). The greatest TSS concentrations and loading occurred during the summer storm events (Figure 21 e and f).

Compared to BMP tributaries, Hanna's Creek had greater average TP concentrations than Cottonwood, Sand Point, Southwest Creek, and Sutton Point. SRP was greater in Hanna's Creek than Sutton Point, and much greater than North McMillan Creek. Hanna's Creek also had greater NO_x and TKN concentrations than Sand Point, Sutton Point, Cottonwood, Southwest Creek, and North McMillan Creek. TKN in Hanna's Creek was higher than Long Point in 2021. Hanna's Creek had greater TSS concentrations than Cottonwood, Sutton Point, and Southwest Creek. Loading for nutrients is also greater than numerous BMP tributaries as Hanna's Creek generally had greater discharge.

No Name Creek (Table 1, Figure 16 a-j, 23 a-g, appendix 2 and 3):

No Name Creek was not included in the USDA BMP study, but monitored in 2021 for water quality (Table 1). 2021 data was compared to 2020 data for No Name Creek. In 2021, TP, SRP, TSS, and NO_x concentrations were all greater than concentrations observed in 2020 (Figure 16 a, c, e, and i). TKN concentrations in 2021 were lower than what we observed in 2020 (Figure 16 g). Average loading of TP, SRP, TSS, and TKN in 2021 were greater than average loads seen in 2020, but not significantly greater ($p>0.05$) (Figure 16 b, d, h, and j). NO_x loading in 2021 was lower than 2020, but not significantly lower (Figure 16 f).

No Name Creek was dry during July baseflow. TP and SRP concentrations were the greatest during the July 17th storm event and were lowest during spring baseflow before gradually increasing during the summer and fall baseflow periods (Figure 23 a). The greatest loading of TP and SRP occurred during the July 17th storm event and was much lower during the other sampling

dates (Figure 23 b). NO_x concentrations were greatest during the late spring and fall baseflow periods and lowest during the early spring and in September. (Figure 23 c). NO_x loading was greatest during the July 17th storm event (Figure 23 d). TKN concentrations were relatively similar during baseflow and greatest during the July 17th storm event. Loading of TKN was greatest on July 17th when we observed the greatest discharge (Figure 23 d and g). TSS concentrations and loading were the greatest during storm events (Figure 23 e and f). Significant stream bank erosion is occurring at this sampling site near the bridge of NYS RT 256 (See site pictures in Appendix 4- Figure 1A).

Compared to BMP tributaries, No Name Creek had greater TP concentrations than Cottonwood and greater SRP concentrations than Long Point, Sand Point, Sutton Point, Cottonwood, and the reference stream, North McMillan Creek. No Name Creek also had greater NO_x concentrations than Sand Point, Sutton Point, Cottonwood, and North McMillan Creek and greater TKN concentrations than Long Point, Sutton Point, and North McMillan Creek. TSS concentrations in 2021 were greater than TSS in Southwest Creek. Loading was also greater than numerous BMP tributaries that had less stream discharge.

North Gully (Tables 1 and 5, Figure 17 a-j, 24 a-f, appendix 2 and 3):

North Gully was not included in the USDA BMP study, but monitored in 2021 for water quality (Table 1). 2021 loading data was compared to 2020 loading data for North Gully. May through August 2021 concentration data was compared to 2004-2007, 2009, and 2020. While historic concentration data is available for comparison, there was no loading data from the same period. Average 2021 concentrations of TP, SRP and TSS were the greatest seen of all previous years (Table 5, Figure 17 a, c, and i). NO_x concentrations in 2021 were comparable to 2020 but greater than concentrations in 2004, 2006-2007, and 2009 (Figure 17 e). Average TKN concentrations in 2021 were greater than 2020 but relatively similar to historic data (Figure 17 g). While 2021 average loading was greater than 2020 for all analytes, the increases were not significant ($p>0.05$).

In 2021, we saw the greatest SRP and TP concentrations in the summer and fall and lowest in the spring during baseflow conditions (Figure 24 a). The greatest overall TP concentrations occurred during the storm events, especially on July 17th. Loading for TP and SRP was the greatest during the July 17th storm event where we observed the greatest discharge (Figure 24 b, g). NO_x concentrations were the lowest during spring baseflow, greater during the summer and fall baseflow, and greatest during the July storm event. (Figure 24 c). TKN concentrations were relatively similar during the study period while the greatest was observed during the July storm event (Figure 24 c). The greatest NO_x and TKN loading occurred on July 17th storm event and during the late summer and fall for baseflow (Figure 24 d). Lowest nitrogen loading occurred in the spring. Highest TSS concentrations and loadings occurred during storm events, especially on July 17th (Figure 24 e and f).

Compared to BMP tributaries, North Gully had greater average TP and TSS concentrations than Sand Point, Sutton Point, Cottonwood, and Southwest Creek in 2021. North Gully also had greater SRP, NO_x and TKN than North McMillan Creek. While concentrations of most analytes were lower than BMP tributaries, loading from North Gully was greater than numerous BMP tributaries due to greater stream discharge into Conesus Lake.

Wilkins Creek (Table 1, Figure 18 a-j, 29 a-f, appendix 2 and 3):

Wilkins Creek was not included in the USDA BMP study, but monitored in 2021 for water quality (Table 1). 2021 data was compared to 2020 data for Wilkins Creek. Average 2021 concentrations for all analytes were greater than average concentrations observed in 2020 (Figure 18 a, c, e, g, and i). 2021 TP, SRP, NO_x, TKN, and TSS, loadings were significantly greater than 2020 loadings from May through August ($p < 0.05$) (Figure 18 b, d, f, h, and j).

In 2021, TP and SRP concentrations were the greatest during the summer and early fall baseflow sampling dates and greatest during the July 17th storm event (Figure 29 a). TP and SRP loadings were greatest during storm events, especially July 17th where we saw the greatest discharge (Figure 29 b). NO_x concentrations were greatest during summer and fall during baseflow and lowest during the spring baseflow period (Figure 29 c). NO_x was greatest during the June storm event followed by the July storm event. TKN concentrations were relatively similar throughout the sampling period during baseflow and was greatest on July 17th. NO_x and TKN loadings were greatest during the fall baseflow sampling dates with greater discharge than during the spring and summer (Figure 29 d). NO_x and TKN loading were greatest during the storm events, especially on July 17th. TSS concentrations in Wilkins Creek were highest during storm events and relatively consistent during baseflow (Figure 29 e). TSS loading was the greatest during the July 17th storm event (Figure 29 f).

Compared to BMP tributaries, Wilkins Creek generally had lower concentrations of the analytes measured in 2021. Wilkins Creek had greater concentrations of SRP, NO_x, and TKN than North McMillan Creek. Loading of some analytes were greater than some BMP tributaries, likely due to greater stream discharge in Wilkins Creek.

Additional Data (appendix 5):

Brockport graduate student, Dan Beers, thesis focuses on the same streams analyzed in this report, but with a greater attention to storm event response sampling. The work has shown that storm events in 2021 transport very high concentrations of nutrients and sediment into Conesus Lake (Appendix 5). Storm events in summer and fall 2021 have been very intense at times and caused significant rises among study tributaries, especially evident in North McMillan, North Gully, Long Point, Hanna's Creek and No Name Creek. While these data were not analyzed with the data included in this report, it is still important to show the massive amounts of nutrients and sediment being transported into Conesus Lake. Southwest Creek and Graywood Gully have been observed to have very high total phosphorus and SRP concentrations during these storm events.

North McMillan and North Gully have extremely high TP and TSS concentrations and loading during these very intense storm events, possibly indicative of erosion occurring in these watersheds, or changes in land use. Segment analysis is recommended in the future to determine where the source of high TSS and TP concentrations within the North McMillan sub-watershed. During several summer and fall storm event samples, the smell of chicken manure was present in the stream water in Southwest Creek, Sutton Point Gully, and No Name Creek. We also observed very high NO_x concentrations during storm events in Hanna's Creek, Graywood Gully and Long Point Gully during summer 2021 storm events. Climate change in the Finger Lakes and Great Lakes region is expected to increase the intensity and frequency of storm events into the future (USGCRP 2017), and it is important to document the outcome of greater frequency storm events on Conesus Lake tributary water quality and the water quality of the lake.

Conclusions

Graywood Gully and Southwest Creek continue to have some of the highest concentrations of phosphorus (dissolved and particulate) of all of the streams monitored during baseflow and storm event sampling. Changes in land use activities may be occurring in these watersheds. Highly agricultural watersheds continue to show greater nutrient concentrations than the reference stream, North McMillan Creek, and streams that have less agricultural activities occurring in their watersheds, such as North Gully and Wilkins Creek during baseflow. During storm events in 2021, we observed significant loading of TP and TSS from North Gully and North McMillan, in addition to high agricultural streams. It is important to note that sampling frequency in 2021 is much less than sampling frequency of 2003-2010, where samples were taken weekly. 2021 also had a very wet summer. Different results may have been seen if 2021 had been a drier summer. Storm events should also be sampled more frequently in future years, especially in the summer and fall (as allowable), as storm events have the potential to carry much greater concentrations and loads of nutrients into Conesus Lake than baseflow conditions. We also observed open fields during the late summer and early fall, when numerous heavy storm events occurred. Very high TP and TSS concentrations were seen in streams after these very heavy rain events (see appendix for pictures of sediment laden runoff and pictures of open fields (Figure A2 and A3)). These heavy storm events caused very high discharge readings and very high loading of nutrients and sediment into Conesus Lake numerous times during the summer and fall seasons.

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Tables:

Table 1. Selected subwatersheds of Conesus Lake from past studies. 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).

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
Cottonwood Gully	98.8	75	Cover crops, fall tillage ceased, 28% reduction in cropland, and gully plugs
Long Point Gully	587.9	86	37% reduction in cropland, cow removal, winter manure spreading ceased, inject manure instead of spreading
Sand Point Gully	188.0	83	9.5% area transformed to rotational grazing, cattle fenced from stream, crop rotation, soybean plants increased by 50%, gully plugs and tile drains
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
Wilkins Creek	630	50	Agricultural non-BMP
North Gully	700	48	Agricultural non-BMP
No Name Creek	355	68.2	Agricultural non-BMP

Table 2. Sampling Locations, Justifications, and Data Collection

Site Code	Sampling Location	GPS Coordinates		Sample Justification	Field Measurements ¹	Water Chemistry ²
		North	West			
SAND	Sand Point Gully	42.786988	-77.722795	Prior implementation of BMPs, including: 9.5% area transformed to rotational grazing, cattle fenced from stream, crop rotation, soybean plants increased by 50%, gully plugs and tile drains	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO _x), 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), total suspended sediments
LONG	Long Point Gully	42.780157	-77.722837	Prior implementation of BMPs, including: 37% reduction in cropland, cow removal, winter manure spreading ceased, inject manure instead of spreading	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO _x), total suspended sediments
COTT	Cottonwood Gully	42.757887	-77.727248	Prior implementation of BMPs, including: Cover crops, fall tillage ceased, 28% reduction in cropland, and gully plugs	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO _x), total suspended sediments
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), 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), total suspended sediments
HANN	Hanna's Creek	42.833364	-77.707621	Agricultural non-BMP	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite

						(NO _x), total suspended sediments
NNAM	No Name Creek	42.748912	-77.727358	Agricultural non-BMP	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO _x), total suspended sediments
WCDN	Downstream-Wilkins Creek	42.823167	-77.686028	Remediated site for Erosion Control and Streambank Remediation Study	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO _x), total suspended sediments
NGDN	Downstream-North Gully	42.7785	-77.71025	Remediated site for Erosion Control and Streambank Remediation Study	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO _x), total suspended sediments
NMDN	Downstream-North McMillan	42.725611	-77.707056	Remediated site for Erosion Control and Streambank Remediation Study	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO _x), total suspended sediments

¹Water temperature (°C), specific conductivity (µS/cm), pH, dissolved oxygen (LDO - %, mg/L), turbidity (NTUs), Discharge (ft³/s, cfs).

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

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

<i>Lab Measurements</i> Analyte	Method	Minimum Volume/ Container	Preservative	QC Sample	Frequency	QC Acceptance Limits	Corrective Action	Holding Time	Method Detection Limit	Report Limit
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
				ICCLCS	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
				ICCLCS	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
				ICCLCS	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
				ICCLCS	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
				ICCLCS	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			

<i>Field Measurements</i> Parameter	Method	Calibration/ Verification	Precision	Range
Temperature	YSI, <i>in situ</i>	Factory set annual check with NIST-reference thermometer	±0.20 C	-5 to 70°C
Luminescent Dissolved oxygen	YSI, <i>in situ</i>	Daily	±0.1 mg/L or 1%	0 to 50 mg/L
pH	YSI, <i>in situ</i>	Daily	±0.2	0 to 14
Specific Conductivity	YSI, <i>in situ</i>	Daily	±0.001 mS/cm or 0.5%	0 to 200 mS/cm
Turbidity	YSI, <i>in situ</i>	Daily	±0.3 FNU or 2%	0-4000 FNU
Velocity (wadable)	Marsh McMirney Flo-Mate Model 2000 Portable Flowmeter, <i>in situ</i>	Factory set, annual self-test diagnostics	±2% + 0.05 ft/sec	-0.5-19.99 Ft/s

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

Date	Previous 24-hour Weather:	Event?
3/25/2021	Light Rain	No ~0.35 inches
4/8/2021	Sunny	No
5/13/2021	Sunny	No
6/4/2021	Sunny	No
6/21/2021	Rain/Thunder	Yes, 0.97 inches north basin, 0.57 inches south basin
7/7/2021	Sunny	No
7/17/2021	Heavy Rain	Yes, 1.75 inches south basin, 2.92 inches north basin
8/2/2021	Light Rain	No 0.28 inches
9/14/2021	Light Rain	No ~0.25 inches
10/12/2021	Sunny	No
11/9/2021	Sunny	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).

	Year	TP (µg/L)		NOx (mg/L)		TSS (mg/L)		TKN (µg/L)		SRP (µg/L)	
		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
Sand Point	2003	60	4	2.00	0.50	5.5	1.3	569	75	39.2	5.0
	2004	111	44	0.97	0.13	46.8	41.1	719	217	37.0	9.1
	2005	76	9	1.65	0.36	5.0	1.6	466	76	50.3	6.8
	2006	87	14	1.17	0.14	3.8	0.6	539	104	43.5	4.5
	2007	70	8	1.57	0.66	2.5	0.3	477	59	48.5	8.0
	2008	80	4	0.66	0.04	4.5	1.1	505	40	54.3	4.0
	2009	80	8	2.44	0.80	15.8	90.9	654	90	50.3	4.3
	2010					NO DATA					
	2020	75	15	2.55	0.62	9.5	4.1	379	77	49.4	13.8
	2021	345	202	2.55	1.27	159.0	135.5	867	318	103.4	25.6
Long Point	2003	102	23	4.99	0.97	10.6	4.4	775	116	39.7	7.1
	2004	219	129	4.41	1.11	132.6	124.0	832	199	40.4	7.7
	2005	70	18	2.58	0.58	8.7	4.2	568	54	34.4	8.5
	2006	61	15	2.23	0.55	8.1	3.8	552	95	29.5	7.7
	2007	41	15	2.40	0.96	3.4	0.7	515	90	14.8	8.3
	2008	76	16	1.97	0.31	16.5	13.1	771	265	44.8	7.9
	2009	50	10	3.85	0.98	4.8	3.5	489	78	33.2	5.6
	2010	60	4	5.09	1.32	3.5	0.9	544	50	43.1	4.9
	2020	98	78	2.36	0.89	18.8	17.2	677	267	34.1	24.9
	2021	572	454	5.49	2.82	391.3	369.4	509	332	79.6	26.0

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Table 5 Continued	Year	TP (µg/L)		NOx (mg/L)		TSS (mg/L)		TKN (µg/L)		SRP (µg/L)	
		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
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
Cottonwood	2003	68	6	2.83	0.48	3.6	1.1	468	65	51.1	5.7
	2004	143	66	2.35	0.60	69.4	58.3	568	86	53.0	6.6
	2005	97	23	2.30	0.44	10.5	4.5	424	38	57.5	6.0
	2006	69	6	1.64	0.17	1.0	0.3	393	37	43.4	3.9
	2007	64	4	1.48	0.13	2.5	0.8	433	76	45.8	3.7
	2008	85	10	1.12	0.13	2.6	0.8	381	46	57.7	3.9
	2009	73	4	2.79	0.28	3.9	1.2	518	82	58.8	3.2
	2010	74	6	3.86	0.72	6.6	2.2	559	66	59.7	1.9
	2020	117	12	1.62	0.58	9.7	4.3	421	95	80.8	13.5
	2021	188	86	1.67	0.37	53.1	50.1	745	259	88.0	11.3
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

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Table 5 Continued	Year	TP (µg/L)		NOx (mg/L)		TSS (mg/L)		TKN (µg/L)		SRP (µg/L)	
		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
North Gully	2003	NO DATA									
	2004	33	17	0.41	0.15	5.1	6.3	413	203	15.7	14.3
	2005	35	26	0.71	0.90	4.8	5.2	312	212	17	14.7
	2006	28	18	0.31	0.17	5.0	15.7	366	153	13.5	9.5
	2007	29	15	0.20	0.15	5.7	7.4	273	171	15.2	8.7
	2008	NO DATA									
	2009	40	11	0.33	0.07	15.1	6.5	370	54	18.2	4.4
	2010	NO DATA									
	2020	34	12	0.61	0.12	12.6	8.9	273	37	13.9	3.5
	2021	376	298	0.62	0.13	314.6	298.0	442	163	34.9	14.1

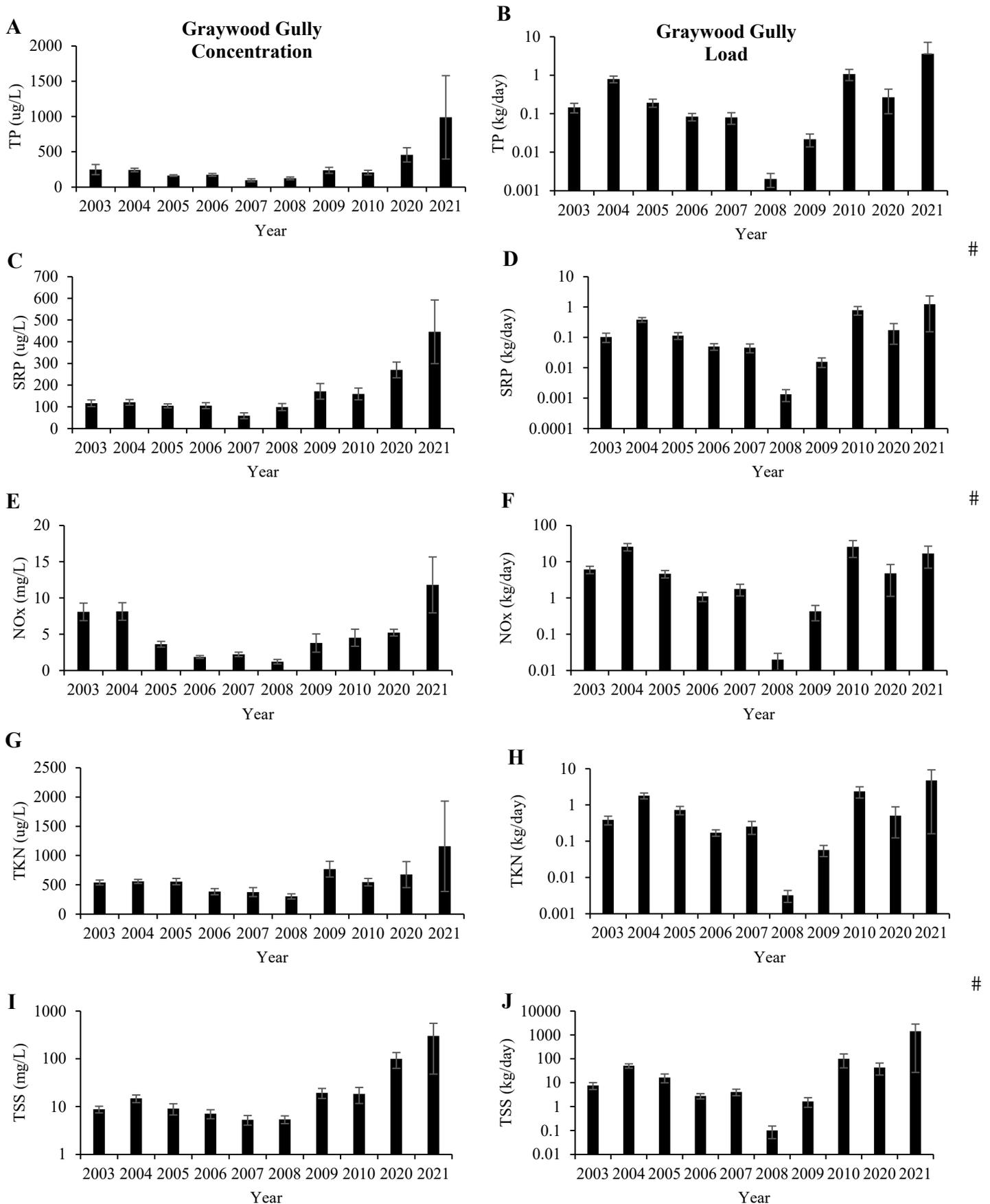
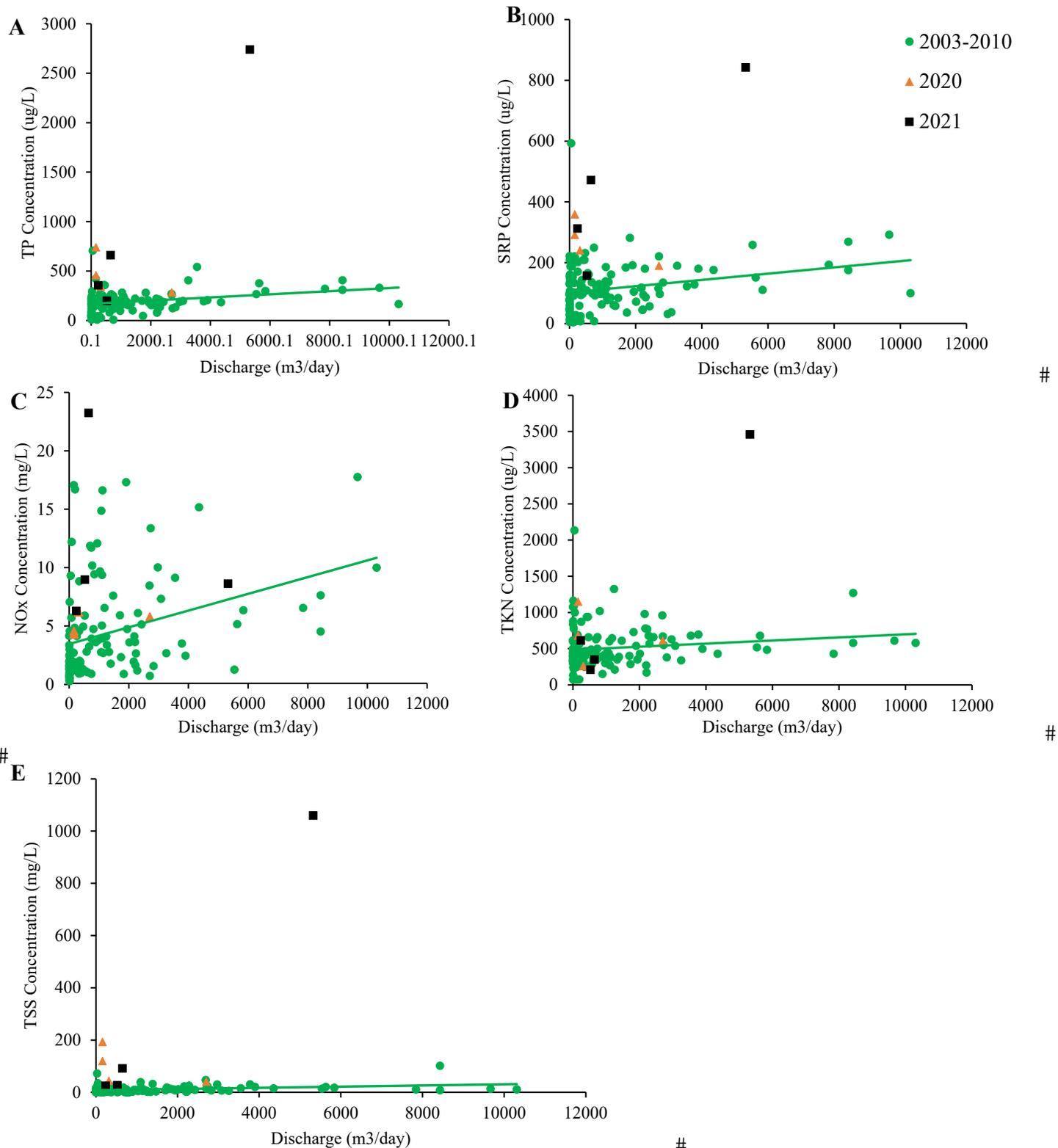


Figure 1: Average (+/- SE) concentrations and average nutrient load (May through August) of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (C and D), NOx (E and F), total Kjeldahl nitrogen (TKN) (G and H), and total suspended solids (TSS) (I and J) in Graywood Gully from 2003 to 2010, and 2020-2021. S.E.=standard error. Some graphs have log transformed Y axes. # 26#



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Figure 2: Graywood Gully May through August discharge versus analyte concentration of TP (A), SRP (B), NOx (C), TKN (D), and TSS (E). 2003-2010 data is grouped together with linear regression line. 2020 data and 2021 data are also plotted.

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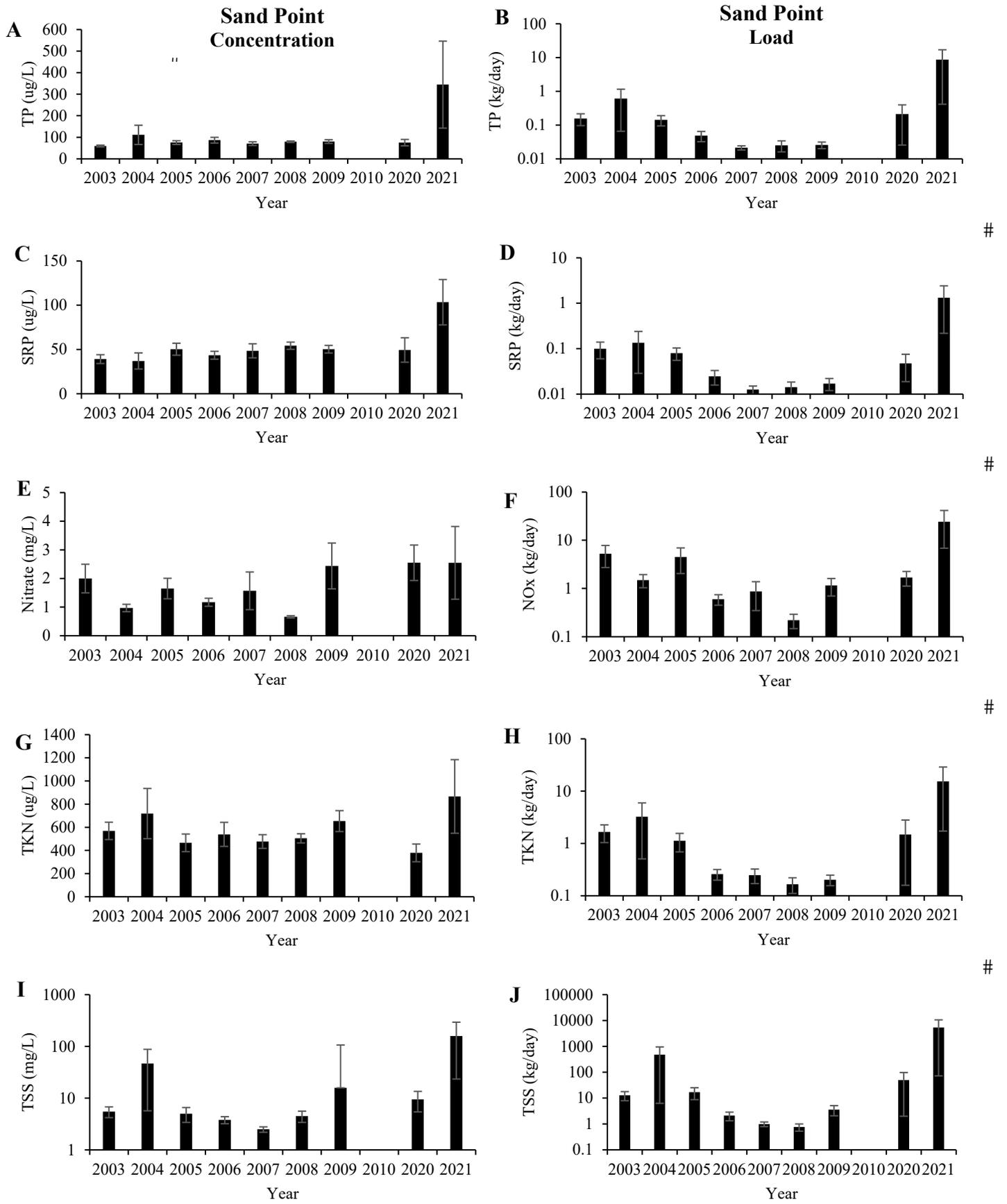
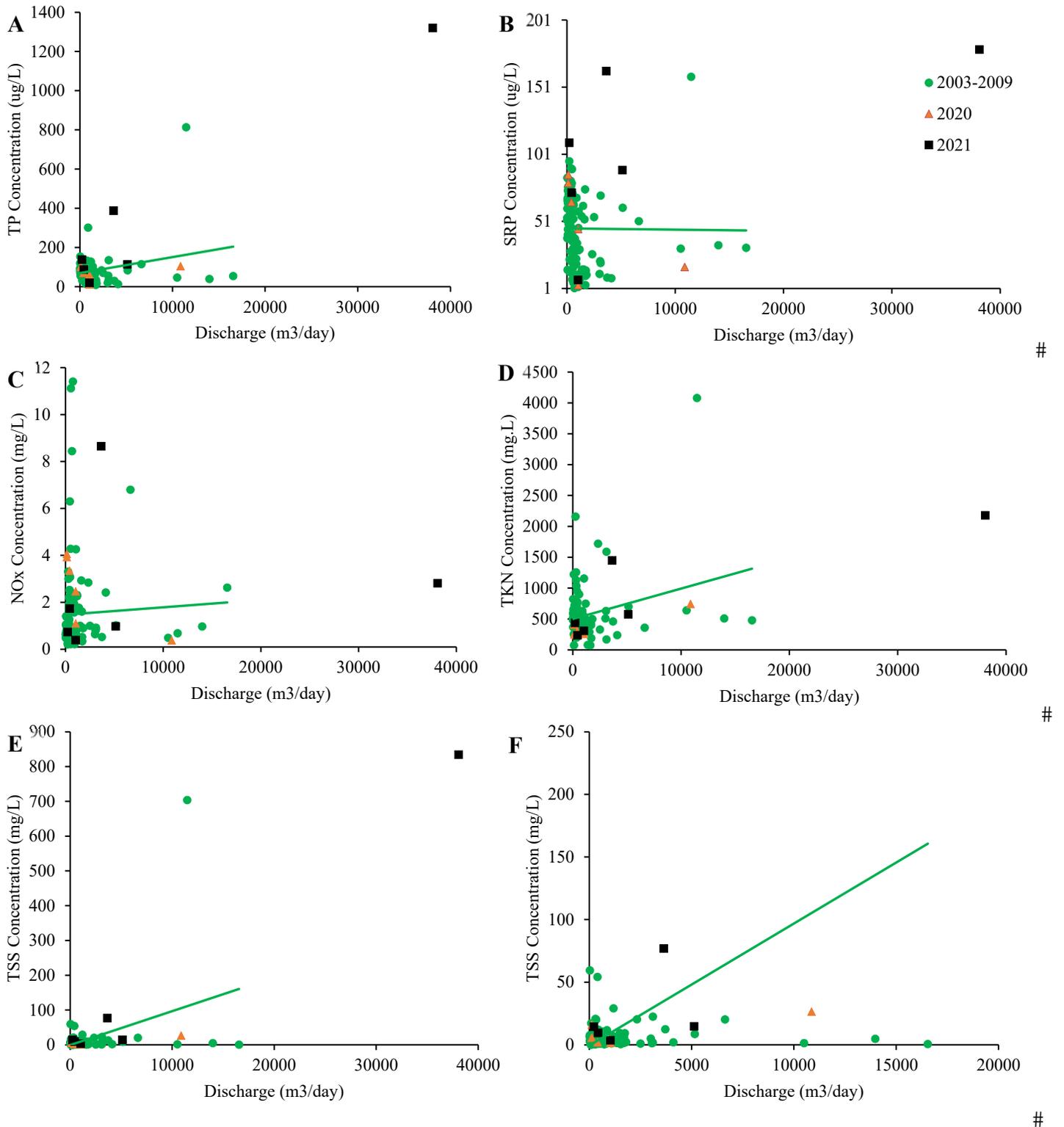


Figure 3: Average (+/- SE) concentrations and average nutrient load (May through August) of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (C and D), NOx (E and F), total Kjeldahl nitrogen (TKN) (G and H), and total suspended solids (TSS) (I and J) in Sand Point Gully from 2003 to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



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Figure 4: Sand Point Gully May through August discharge versus analyte concentration of TP (A), SRP (B), NOx (C), TKN (D), and TSS (E and F (zoomed in)). 2003-2009 data is grouped together with linear regression line. 2020 data and 2021 data are also plotted.

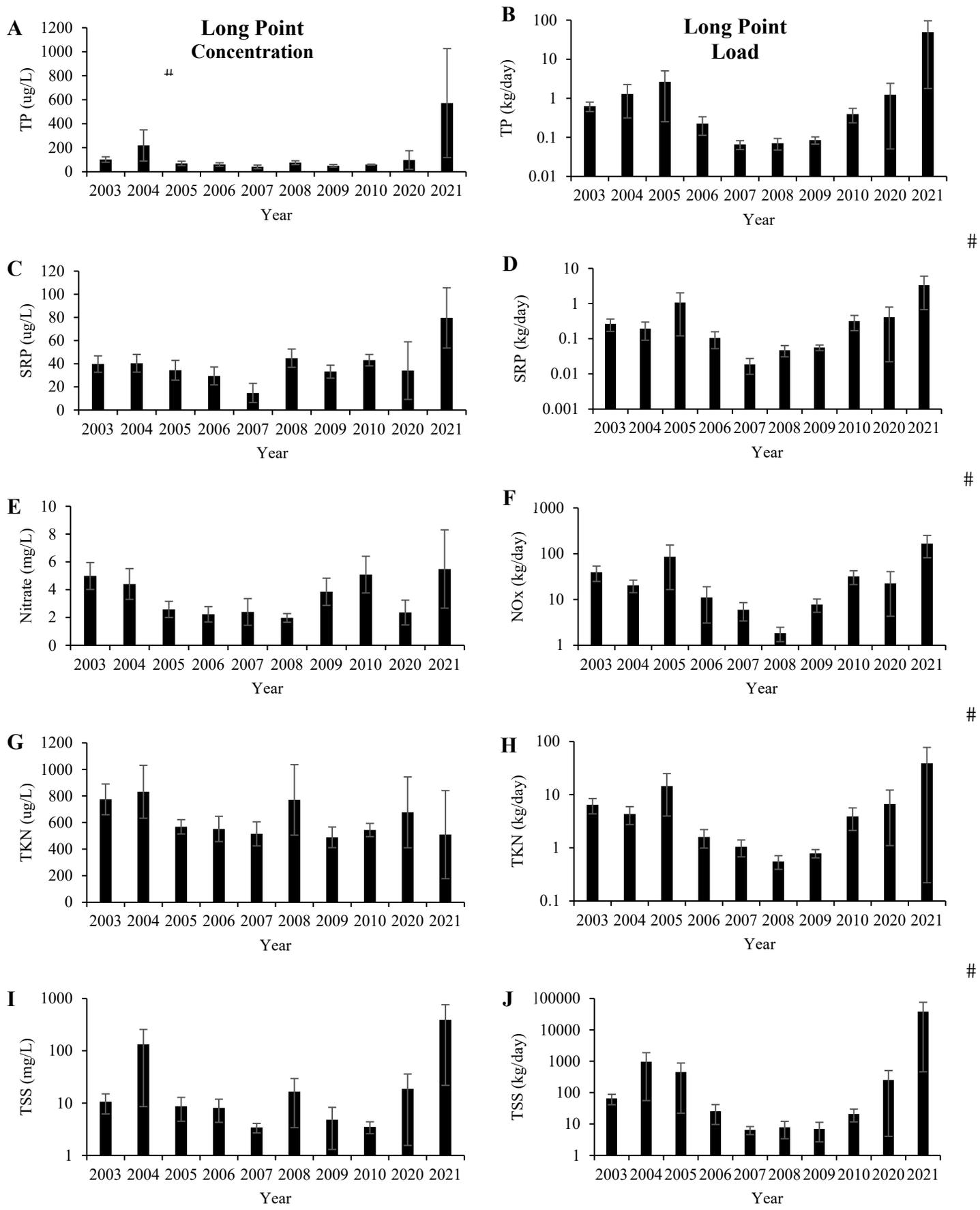


Figure 5: Average (+/- SE) concentrations and average nutrient load (May through August) of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (C and D), NO_x (E and F), total Kjeldahl nitrogen (TKN) (G and H), and total suspended solids (TSS) (I and J) in Long Point Gully from 2003 to 2010, 2020, and 2021. S.E.=standard error. Some graphs have log transformed Y axes.

30#

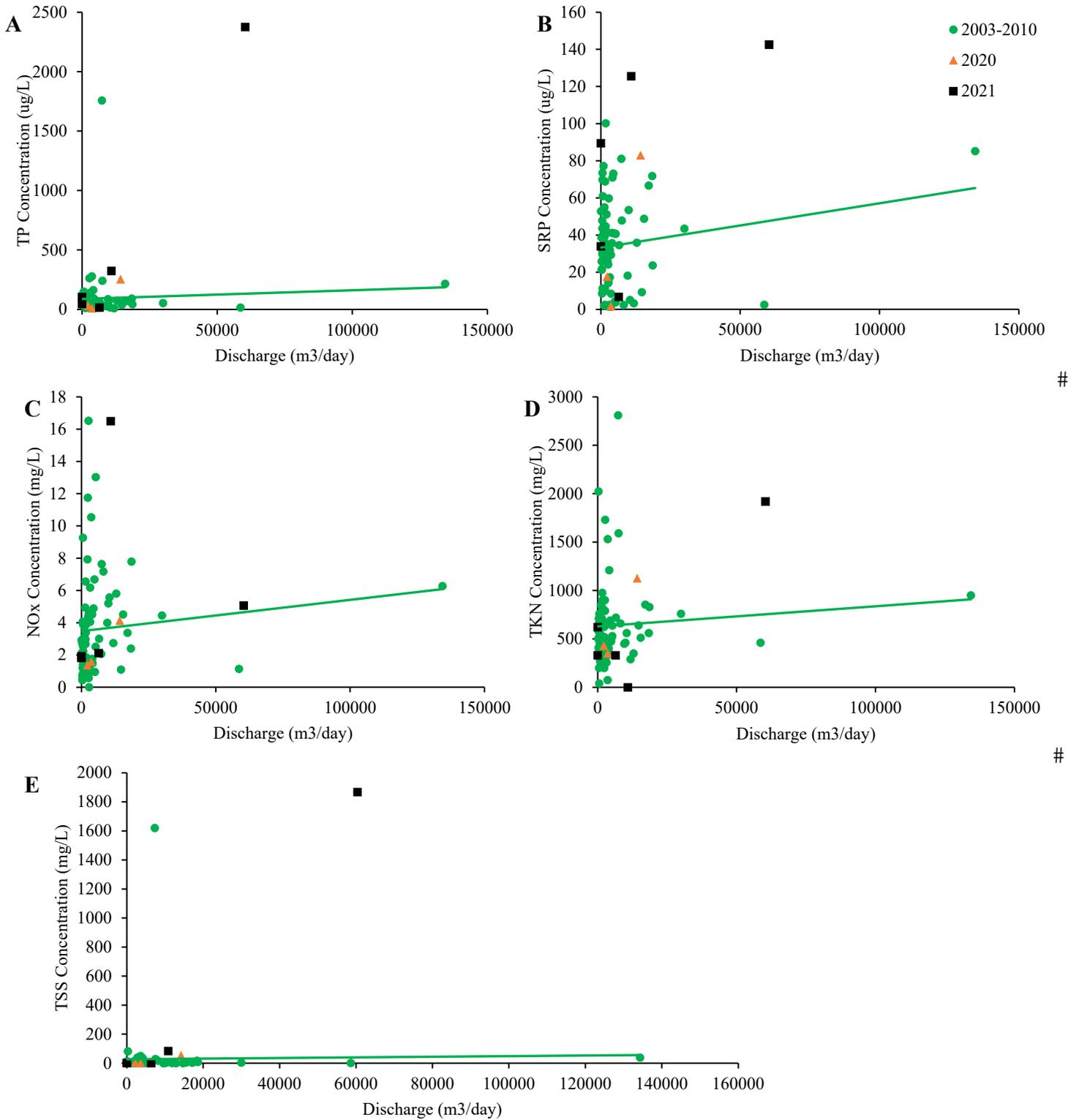


Figure 6: Long Point Gully May through August discharge versus analyte concentration of TP (A), SRP (B), NOx (C), TKN (D), and TSS (E). 2003-2010 data is grouped together with linear regression line. 2020 data and 2021 data are also plotted.

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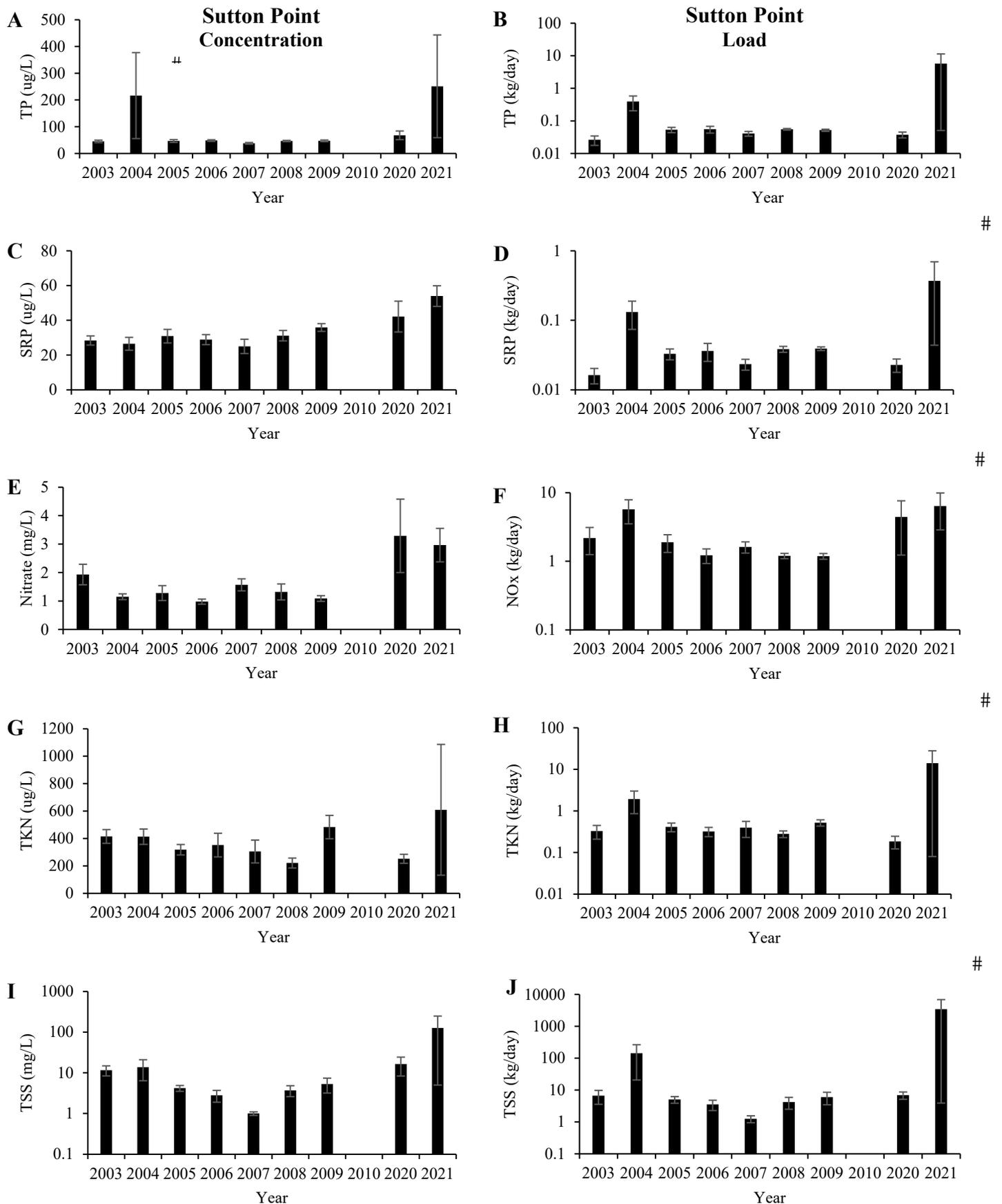


Figure 7: Average (+/- SE) concentrations and average nutrient load (May through August) of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (C and D), NO_x (E and F), total Kjeldahl nitrogen (TKN) (G and H), and total suspended solids (TSS) (I and J) in Sutton Point Gully from 2003 to 2009 (no data in 2010), 2020 and 2021. S.E.=standard error. Some graphs have log transformed Y axes. #

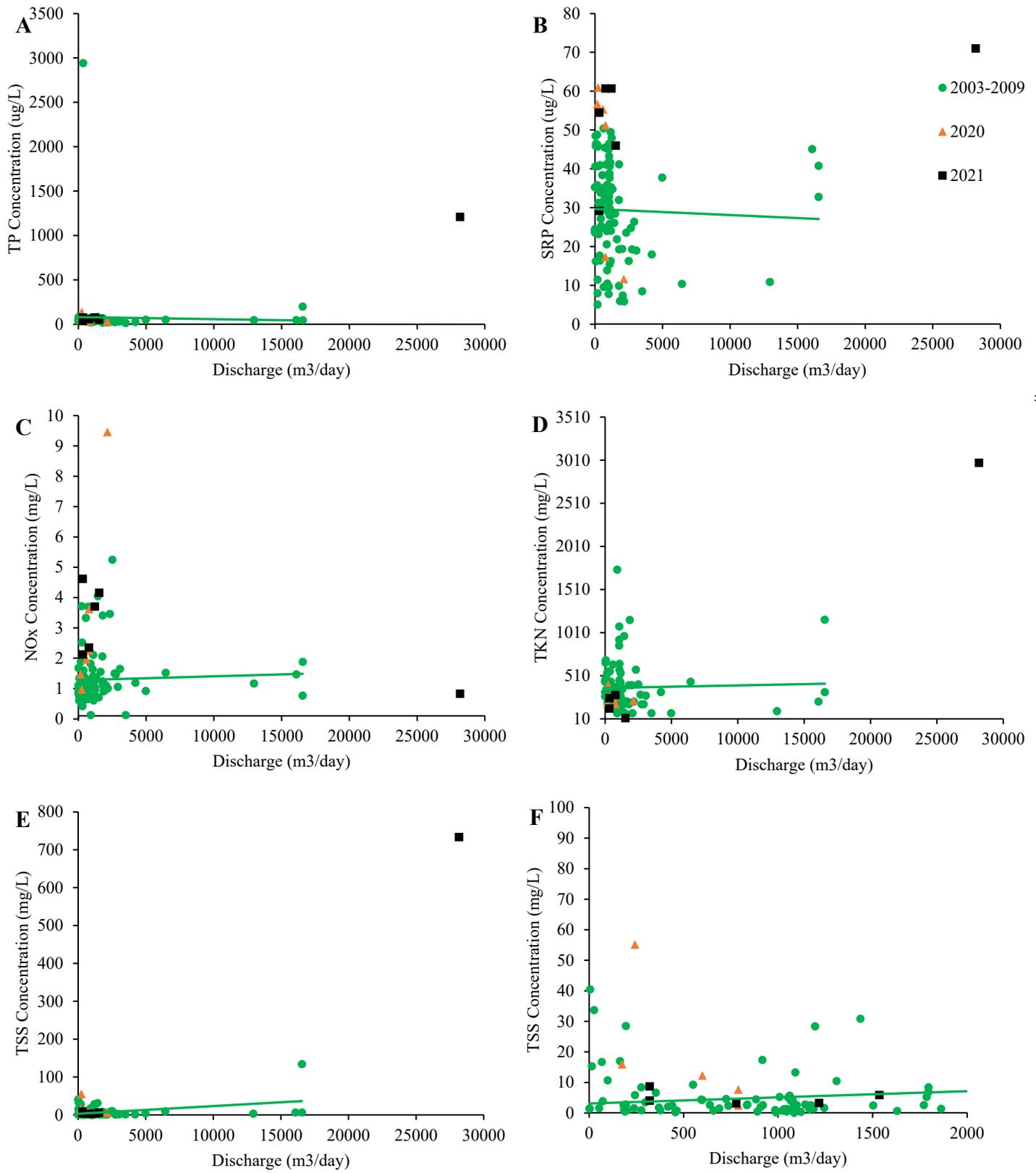


Figure 8: Sutton Point Gully May through August discharge versus analyte concentration of TP (A), SRP (B), NOx (C), TKN (D), and TSS (E and F (zoomed in)). 2003-2009 data is grouped together with linear regression line. 2020 data and 2021 data are also plotted.

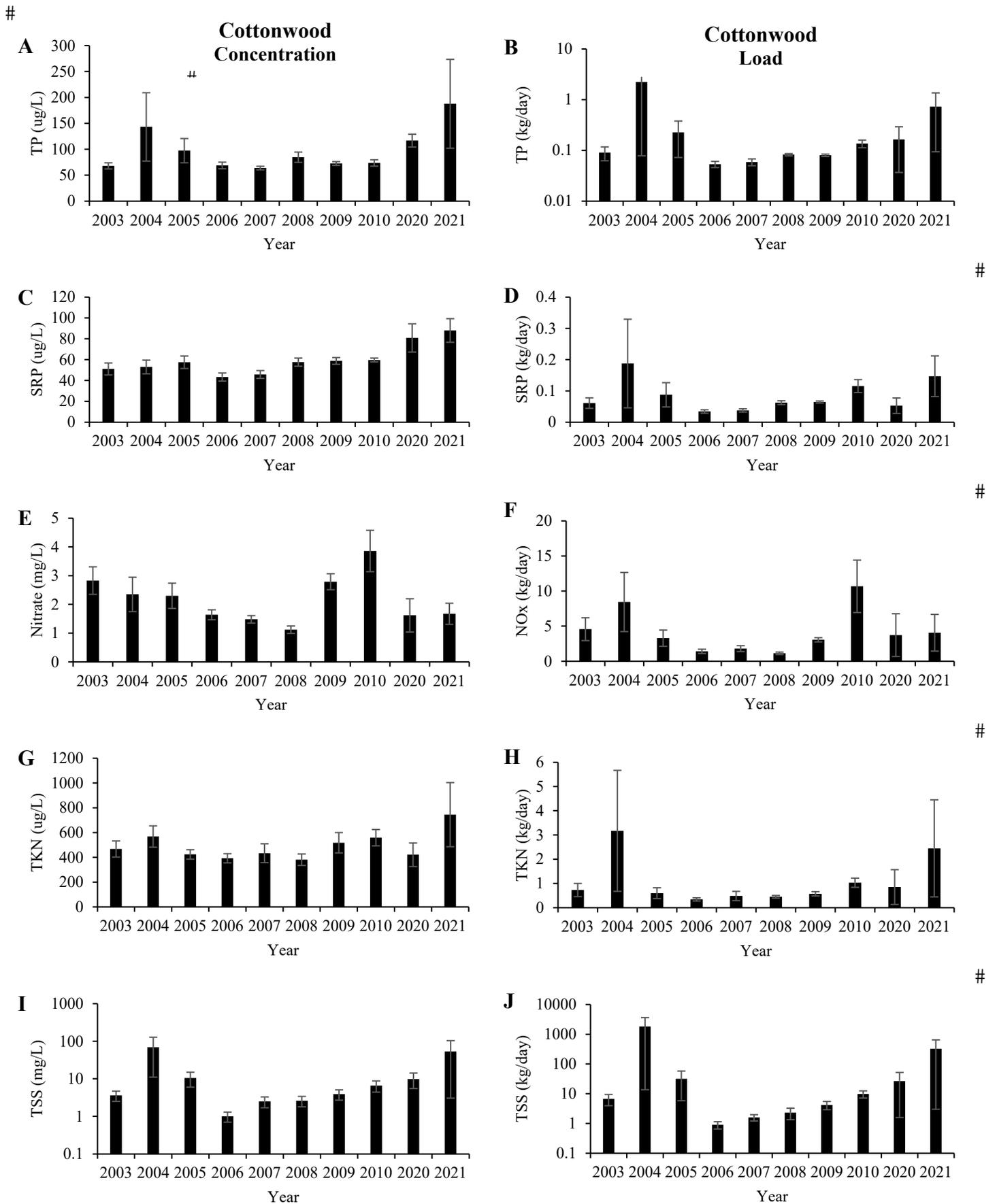


Figure 9: Average (+/- SE) concentrations and average nutrient load (May through August) of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (C and D), NOx (E and F), total Kjeldahl nitrogen (TKN) (G and H), and total suspended solids (TSS) (I and J) in Cottonwood Gully from 2003 to 2010, 2020 and 2021. S.E.=standard error. Some graphs have log transformed Y axes.

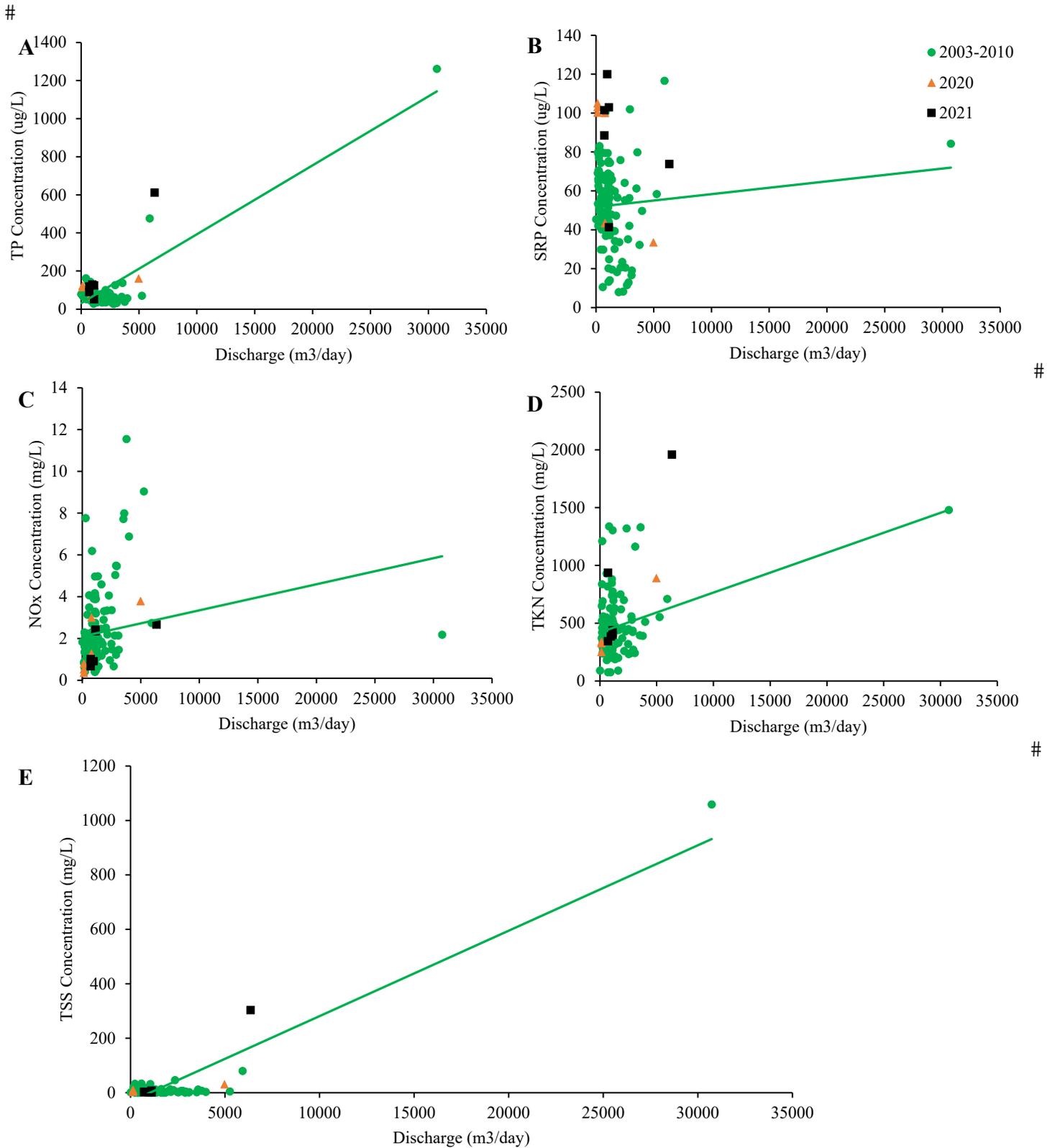


Figure 10: Cottonwood Gully May through August discharge versus analyte concentration of TP (A), SRP (B), NOx (C), TKN (D), and TSS (E). 2003-2010 data is grouped together with linear regression line. 2020 data and 2021 data are also plotted.

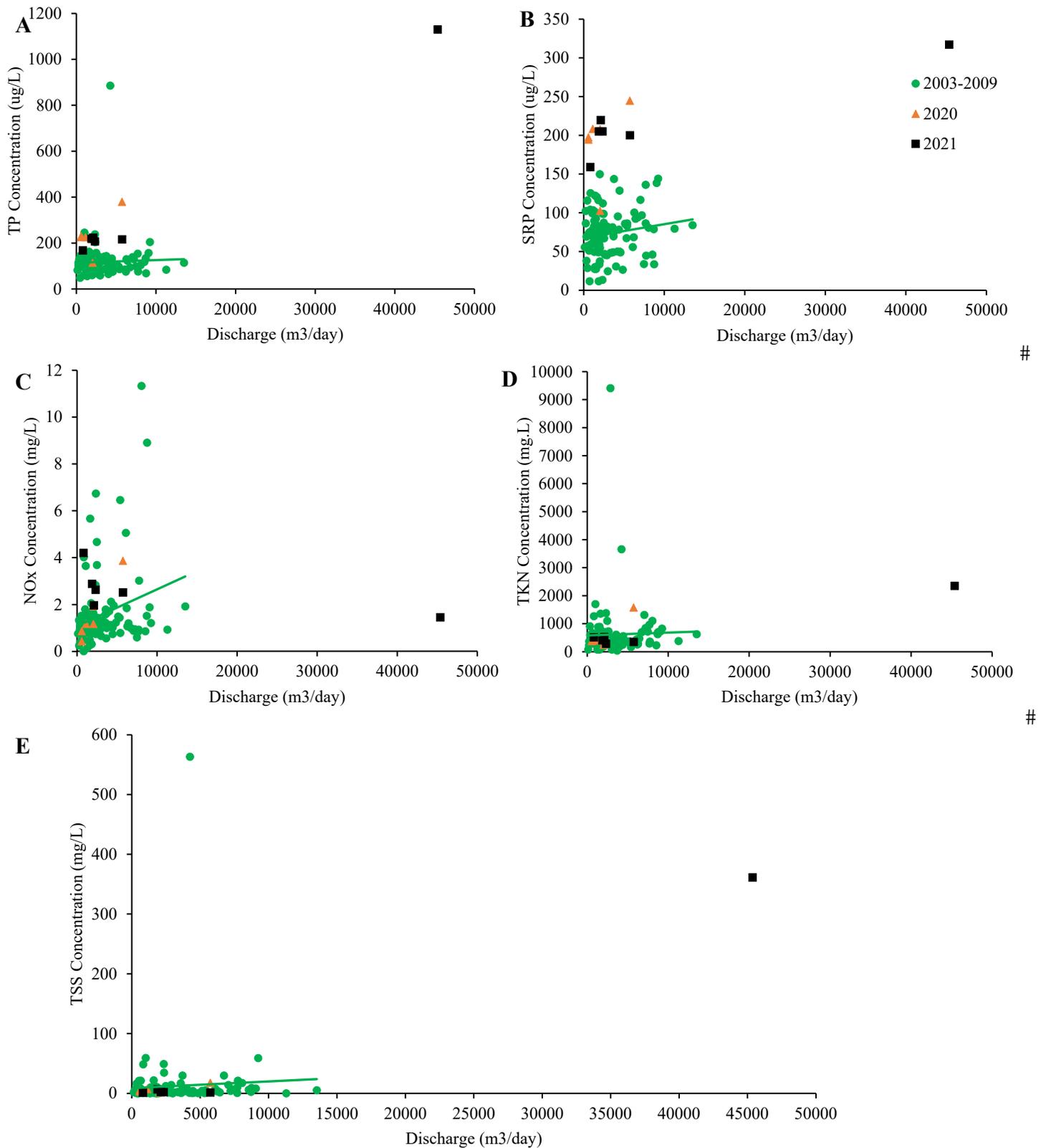


Figure 12: Southwest Creek May through August discharge versus analyte concentration of TP (A), SRP (B), NOx (C), TKN (D), and TSS (E). 2003-2009 data is grouped together with linear regression line. 2020 data and 2021 data are also plotted.

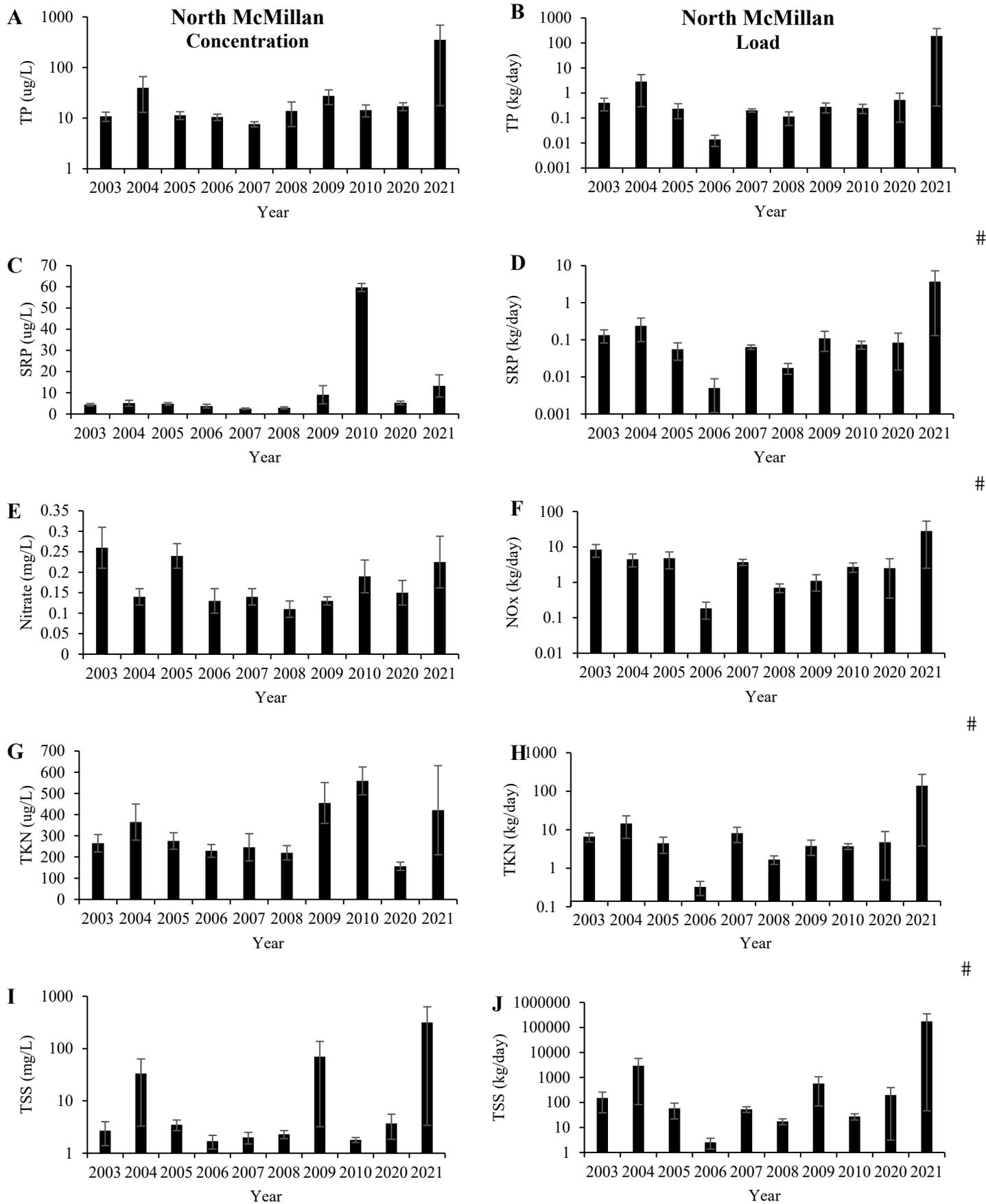


Figure 13: Average (+/- SE) concentrations and average nutrient load (May through August) of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (C and D), NOx (E and F), total Kjeldahl nitrogen (TKN) (G and H), and total suspended solids (TSS) (I and J) in North McMillan Creek from 2003 to 2010, 2020, and 2021. S.E.=standard error. Some graphs have log transformed Y axes. # 38#

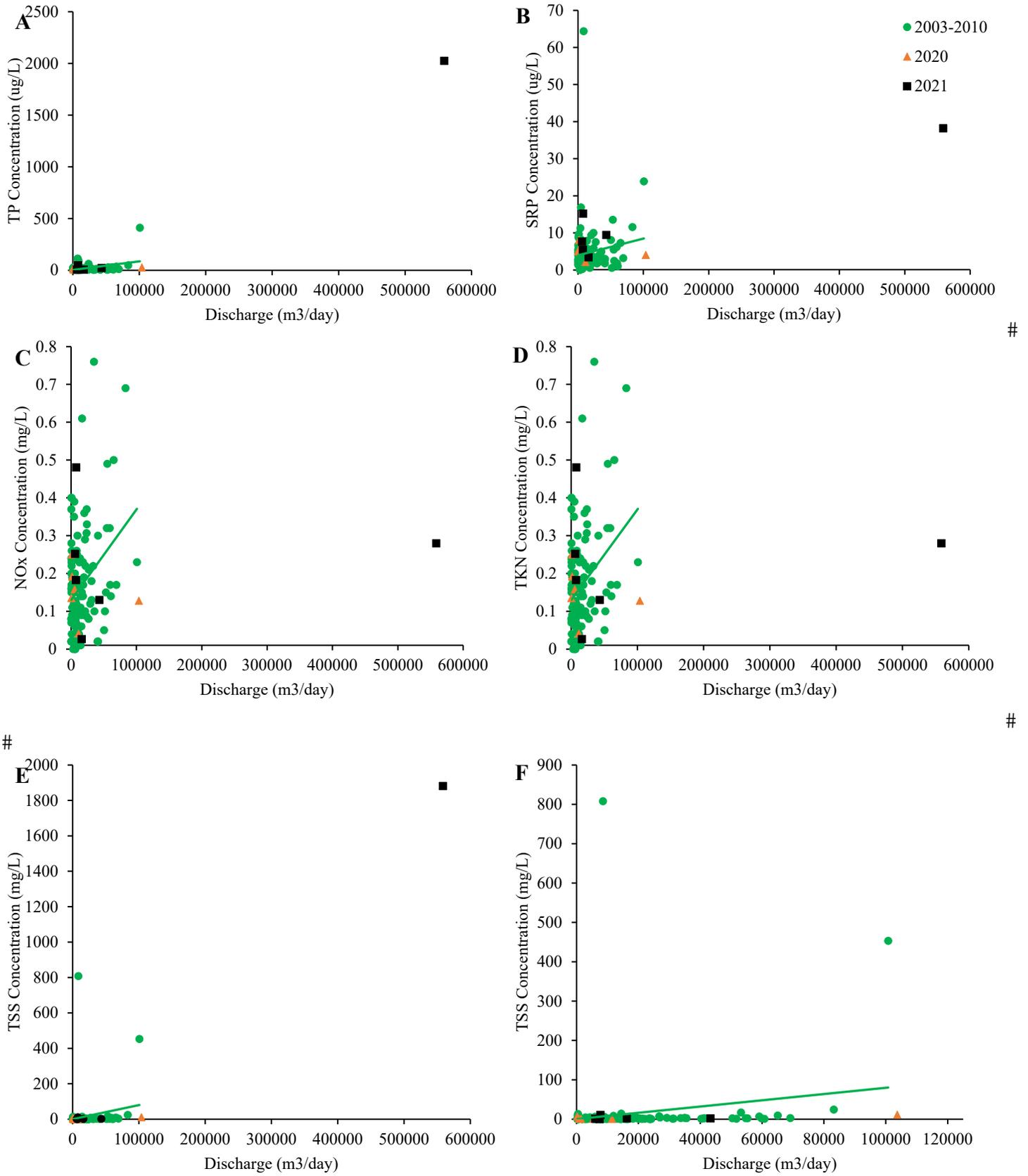


Figure 14: North McMillan Creek May through August discharge versus analyte concentration of TP (A), SRP (B), NO_x (C), TKN (D), and TSS (E). 2003-2010 data is grouped together with linear regression line. 2020 data and 2021 data are also plotted.

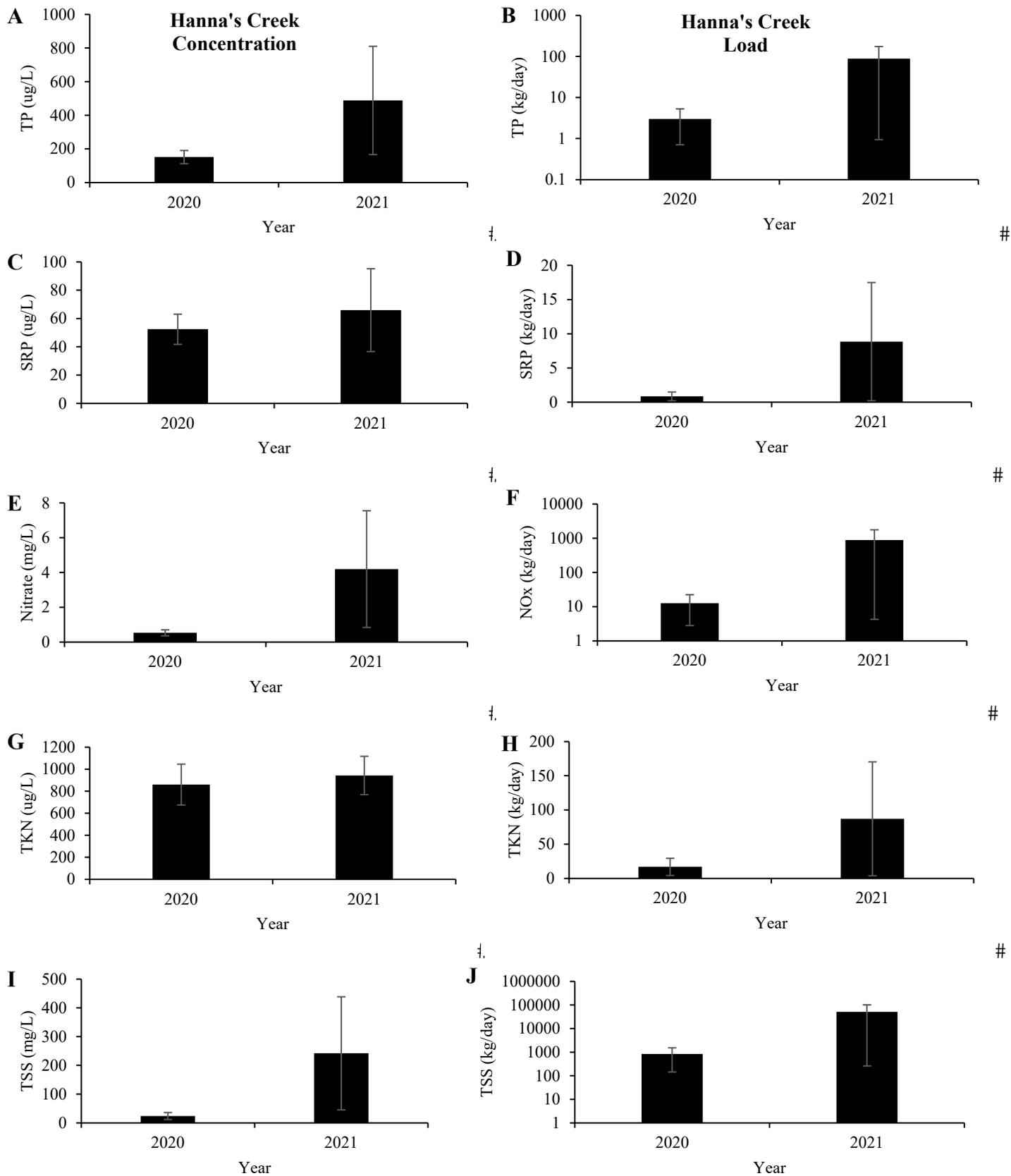


Figure 15: Average (+/- SE) concentrations and average nutrient load (May through August) of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (C and D), NOx (E and F), total Kjeldahl nitrogen (TKN) (G and H), and total suspended solids (TSS) (I and J) in Hanna's Creek from 2020-2021. S.E.=standard error. Some graphs have log transformed Y axes.

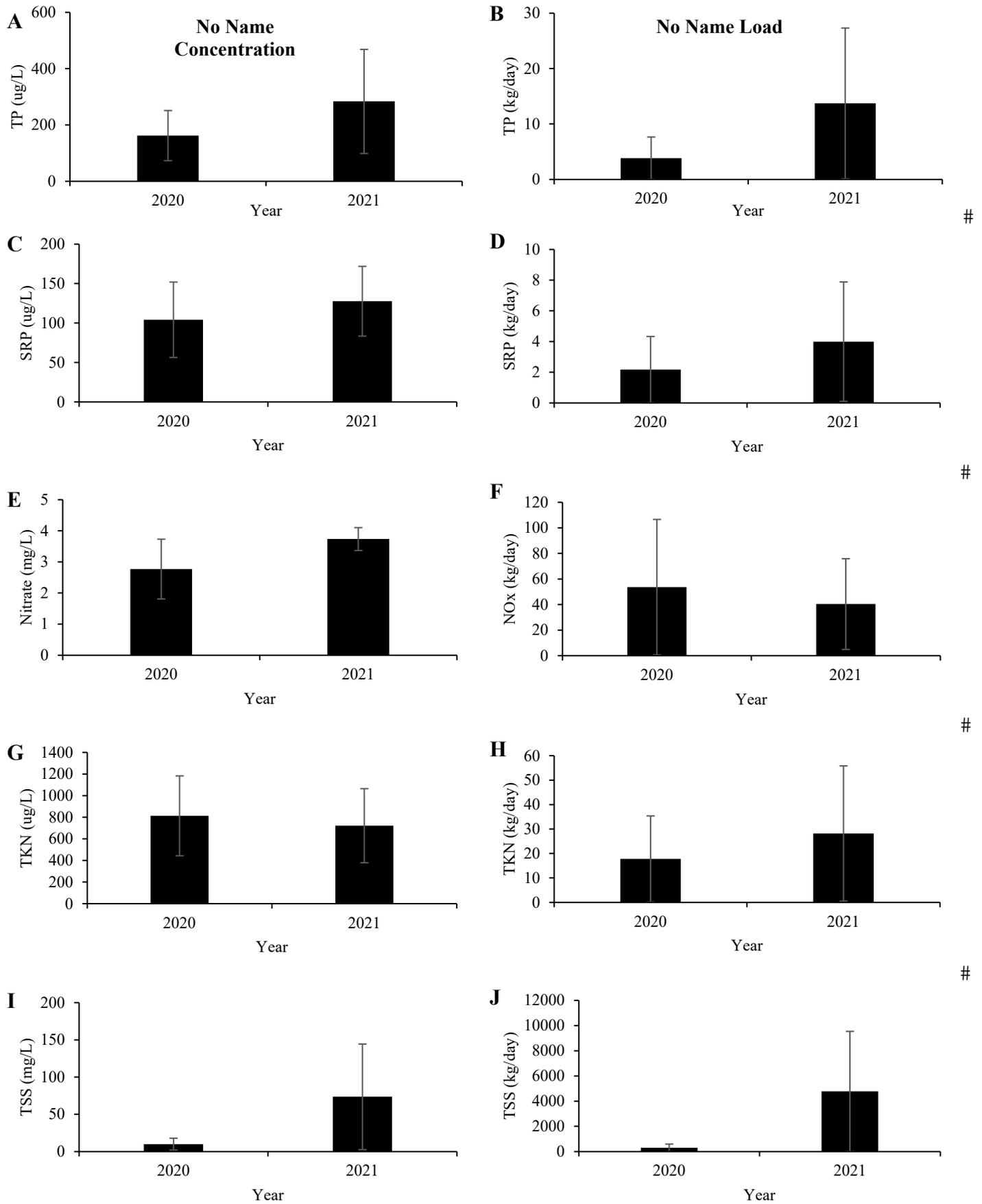


Figure 16: Average (+/- SE) concentrations and average nutrient load (May through August) of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (C and D), NO_x (E and F), total Kjeldahl nitrogen (TKN) (G and H), and total suspended solids (TSS) (I and J) in No Name Creek from 2020-2021. S.E.=standard error. Some graphs have log transformed Y axes.

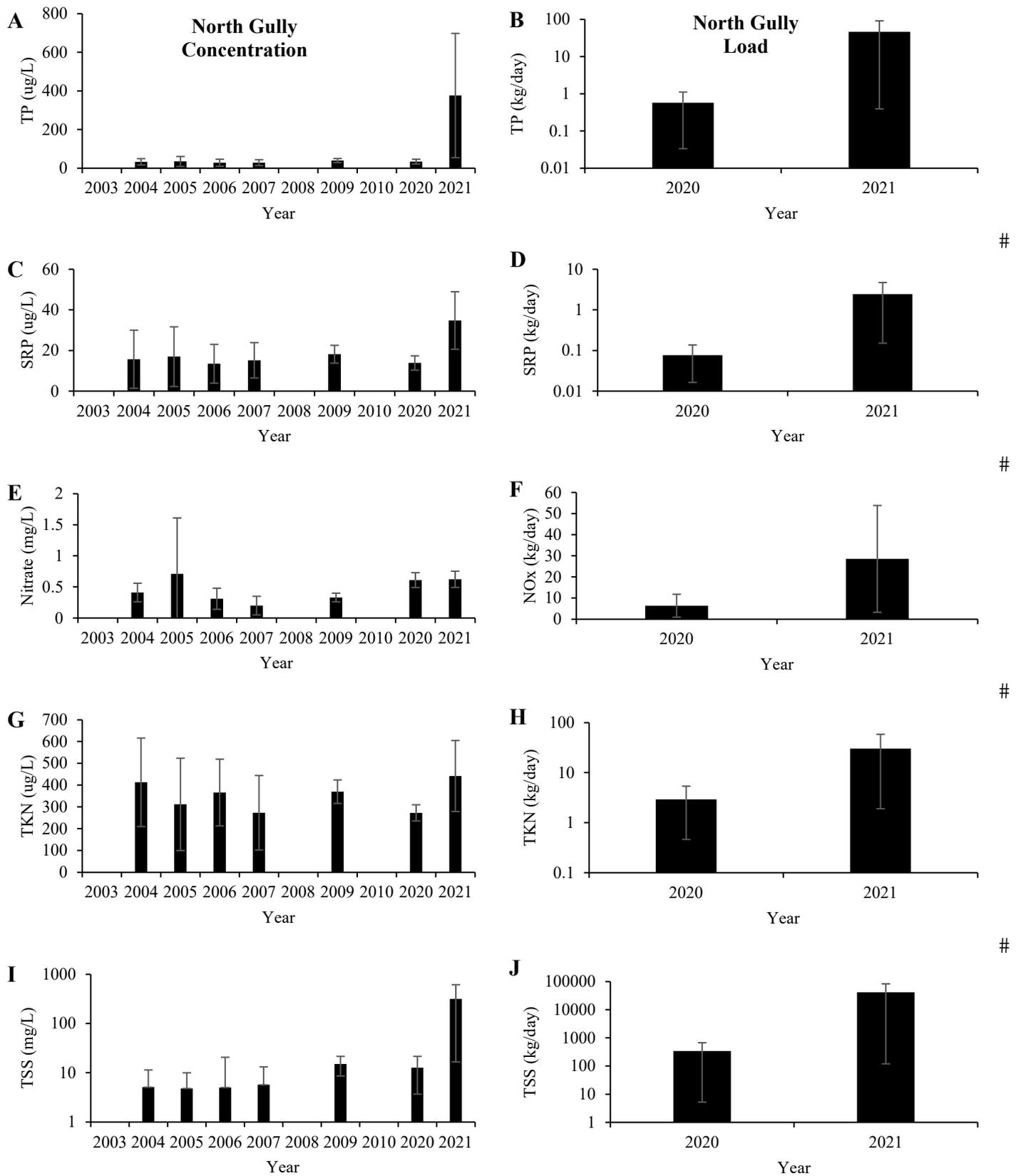


Figure 17: Average (+/- SE) concentrations and average nutrient load (May through August) of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (C and D), NO_x (E and F), total Kjeldahl nitrogen (TKN) (G and H), and total suspended solids (TSS) (I and J) in North Gully from 2020-2021. S.E.=standard error. Some graphs have log transformed Y axes.

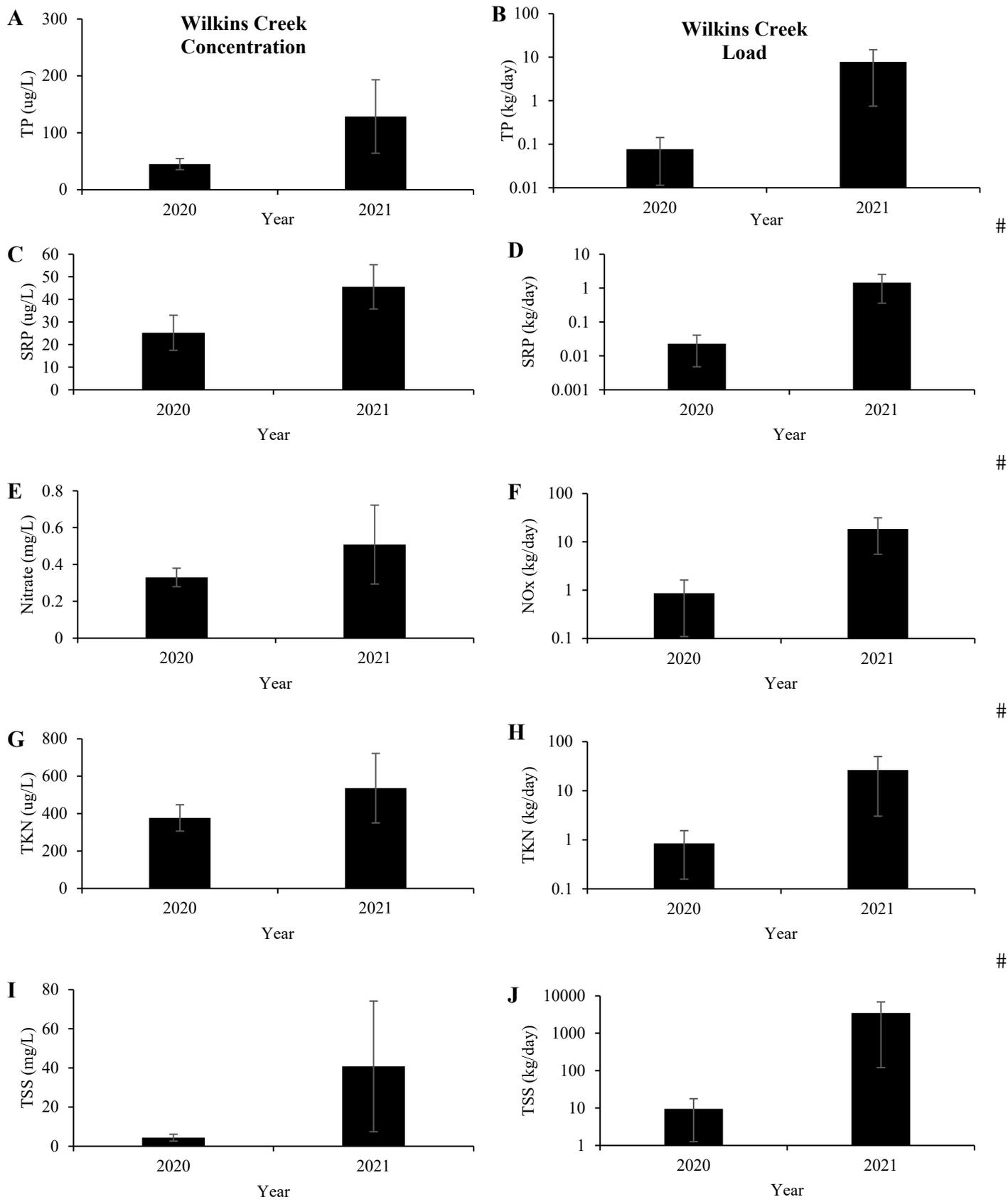


Figure 18: Average (+/- SE) concentrations and average nutrient load (May through August) of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (C and D), NO_x (E and F), total Kjeldahl nitrogen (TKN) (G and H), and total suspended solids (TSS) (I and J) in Wilkins Creek from 2020-2021. S.E.=standard error. Some graphs have log transformed Y axes.

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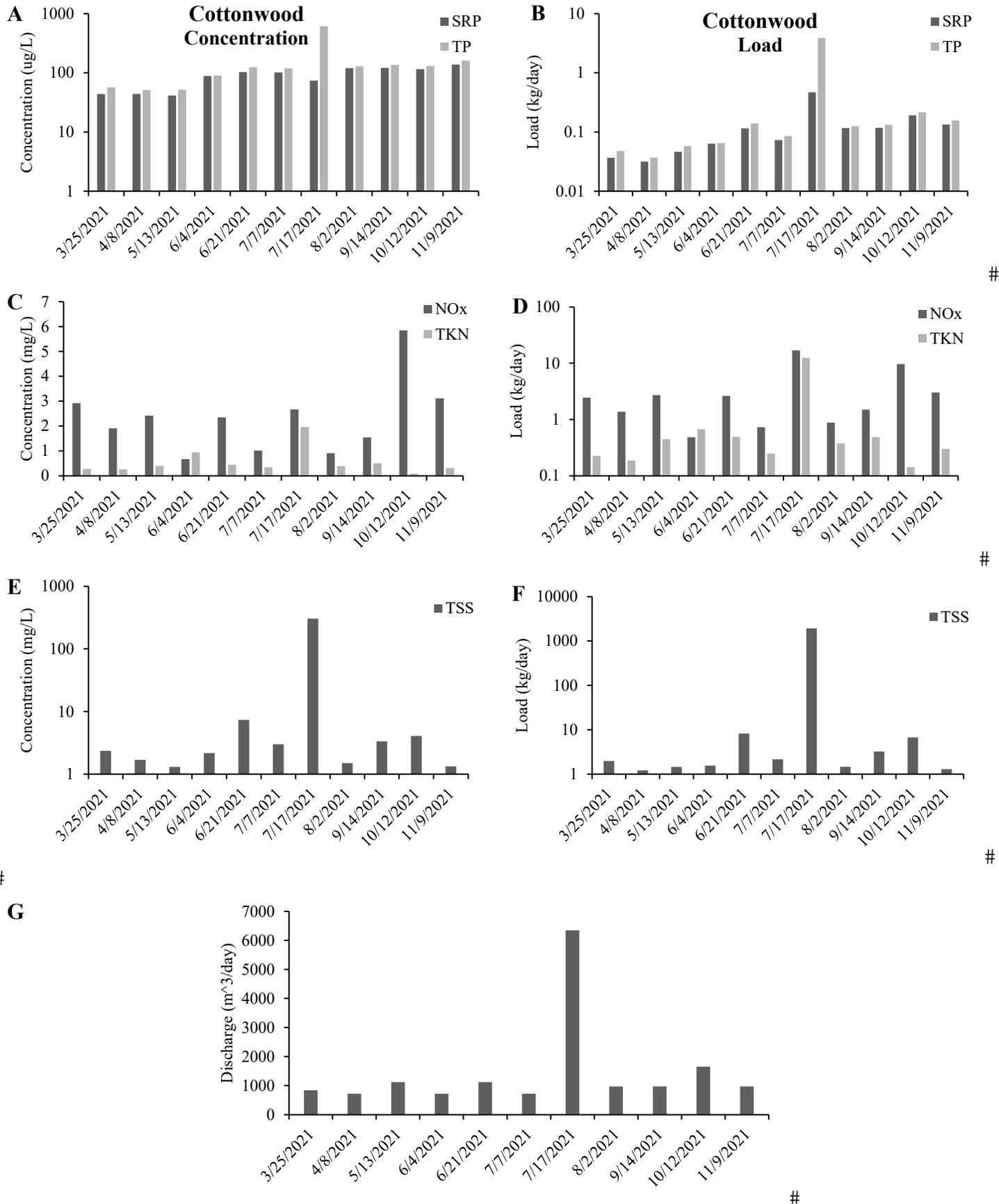


Figure 19: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive
 # phosphorus (SRP) (A and B), NOx (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total
 # suspended solids (TSS) (E and F) in Cottonwood Gully from 2021 sampling dates. Discharge (G) is also
 # plotted for each sample date. Some graphs have log transformed Y axes. 44#

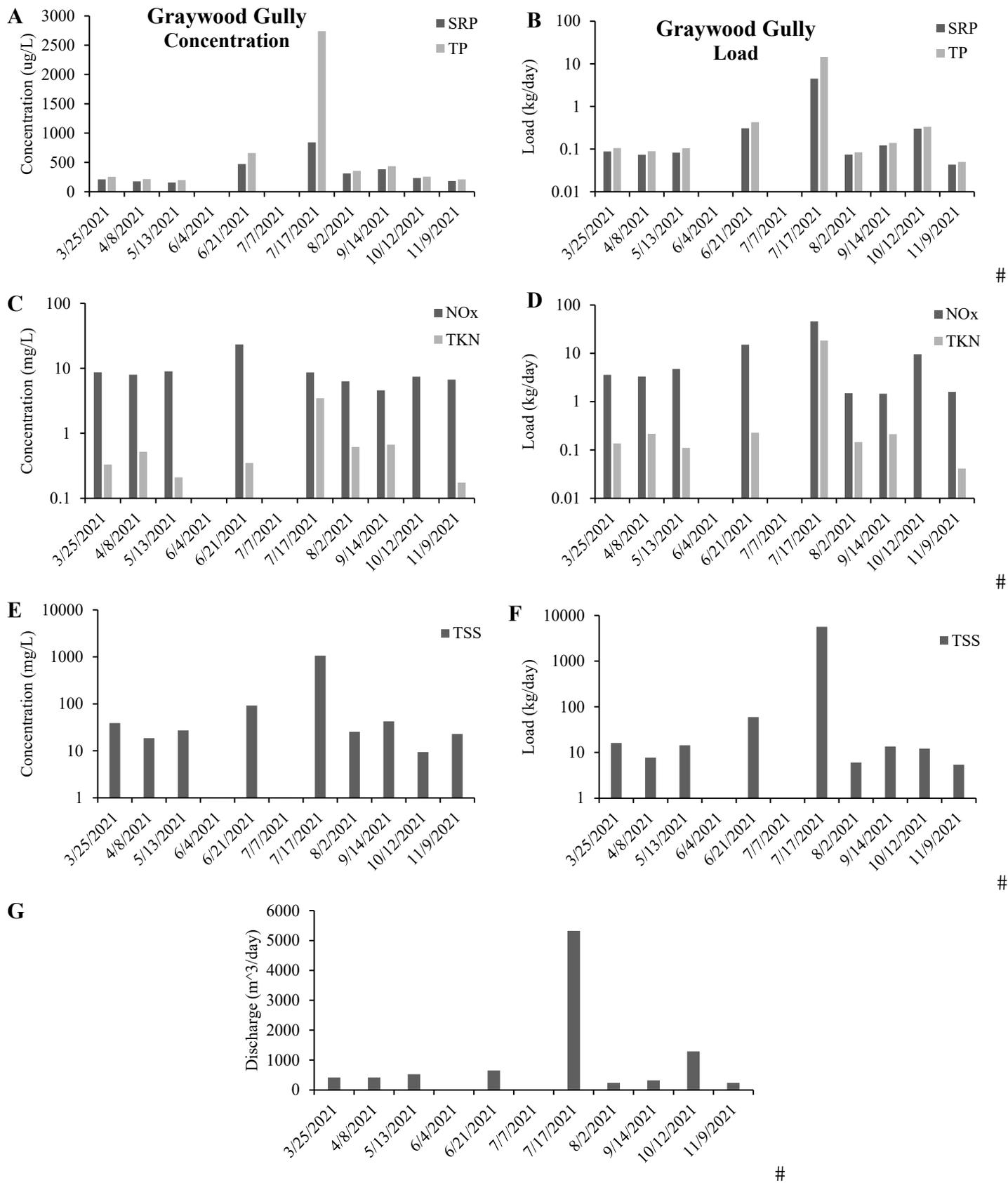


Figure 20: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), NOx (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in Graywood Gully from 2021 sampling dates. Discharge (G) is also plotted for each sample date. Some graphs have log transformed Y axes.

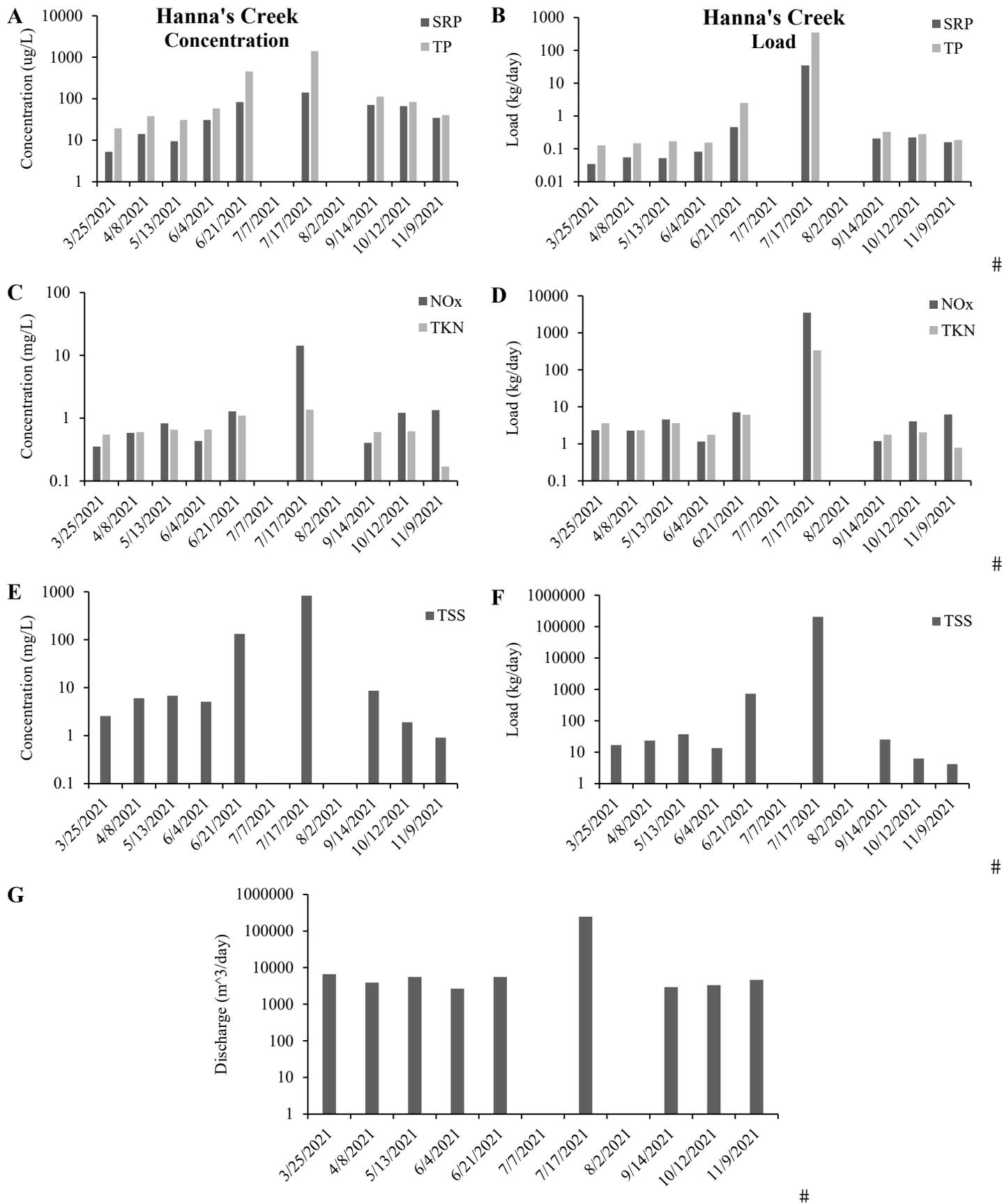


Figure 21: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), NOx (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in Hanna's Creek from 2021 sampling dates. Discharge (G) is also plotted for each sample date. Some graphs have log transformed Y axes.

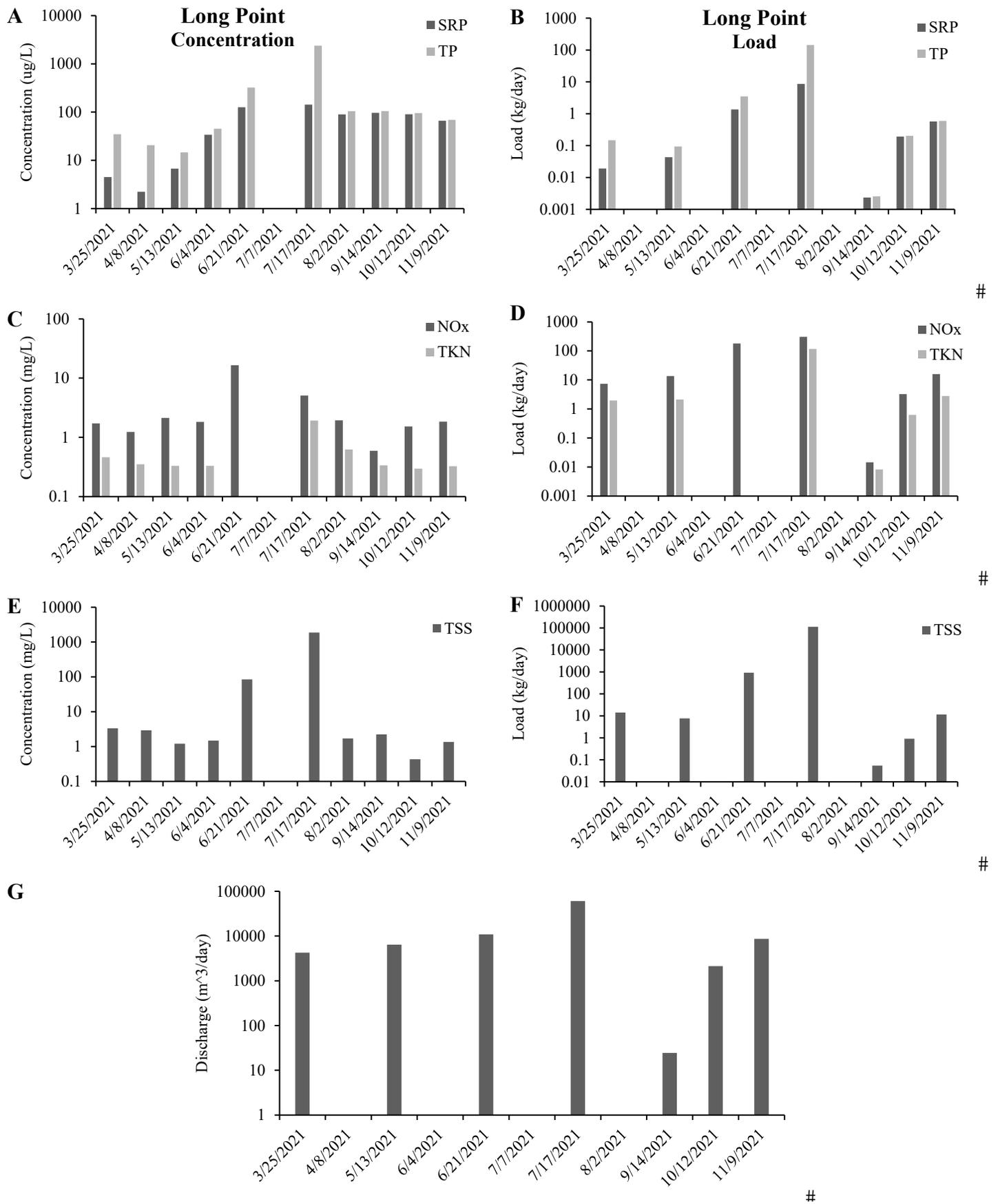


Figure 22: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), NOx (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in Long Point Gully from 2021 sampling dates. Discharge (G) is also plotted for each sample date. Some graphs have log transformed Y axes. 47#

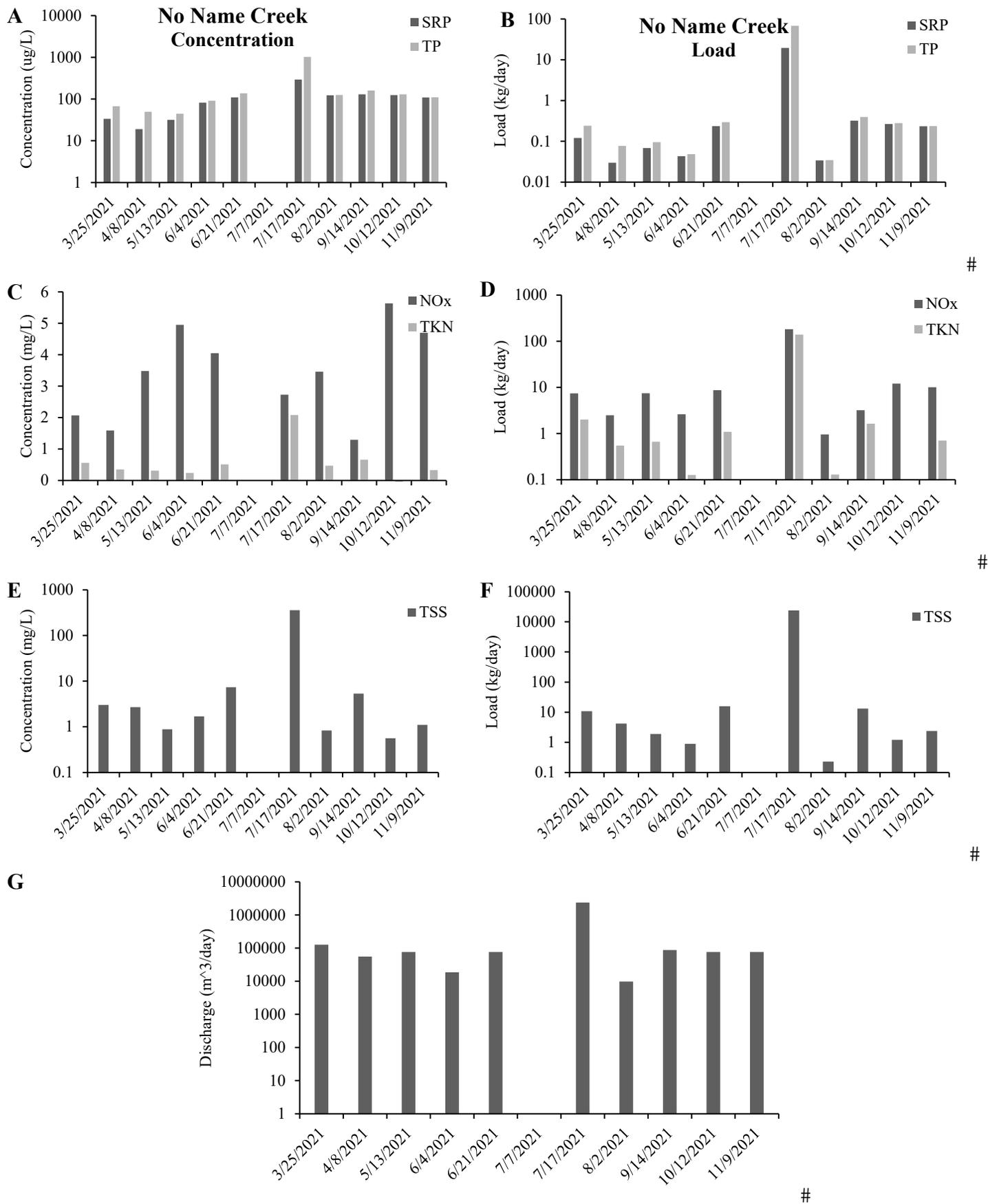


Figure 23: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), NOx (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in No Name Creek from 2021 sampling dates. Discharge (G) is also plotted for each sample date. Some graphs have log transformed Y axes.

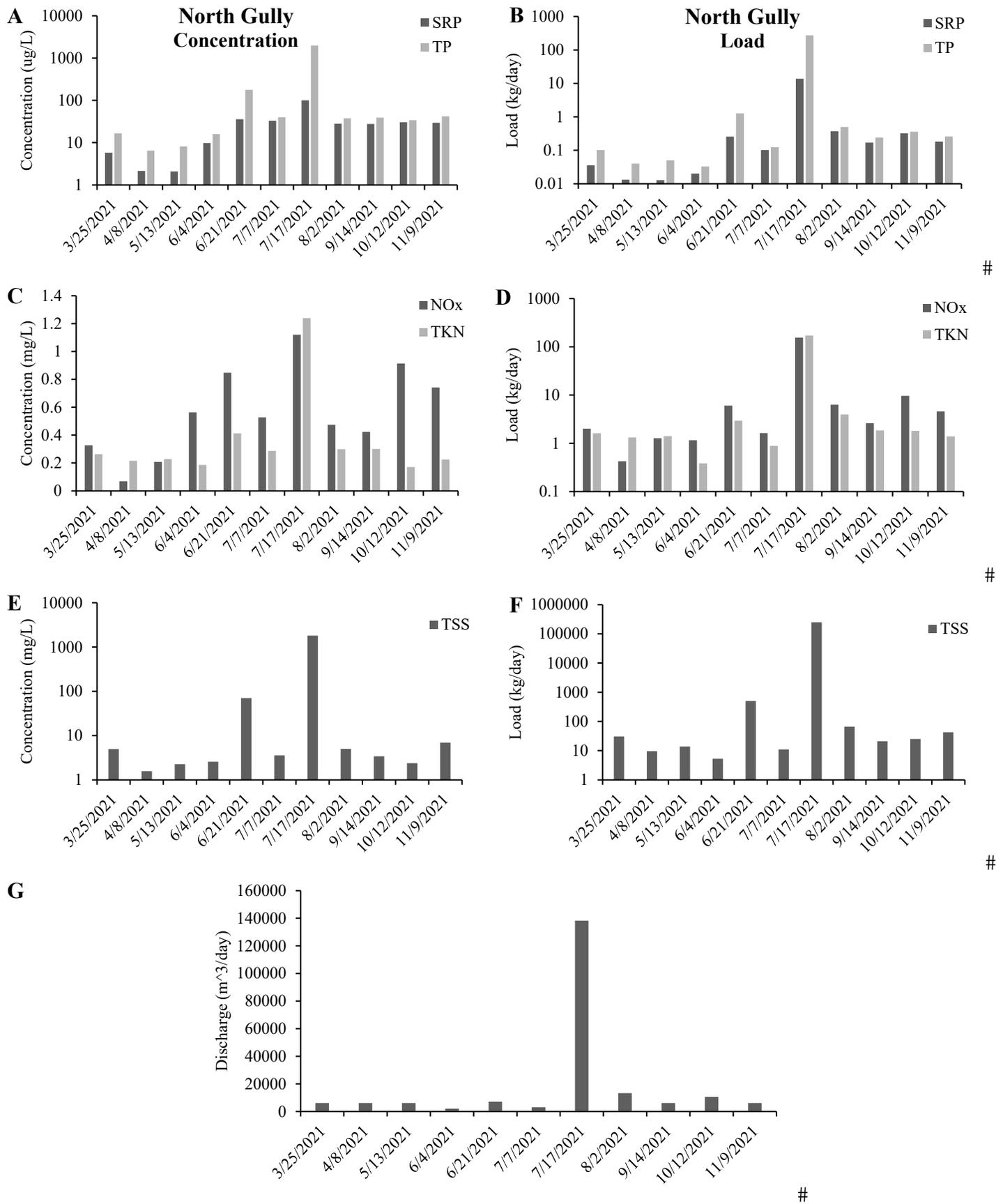


Figure 24: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), NOx (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in North Gully from 2021 sampling dates. Discharge (G) is also plotted for each sample date. Some graphs have log transformed Y axes.

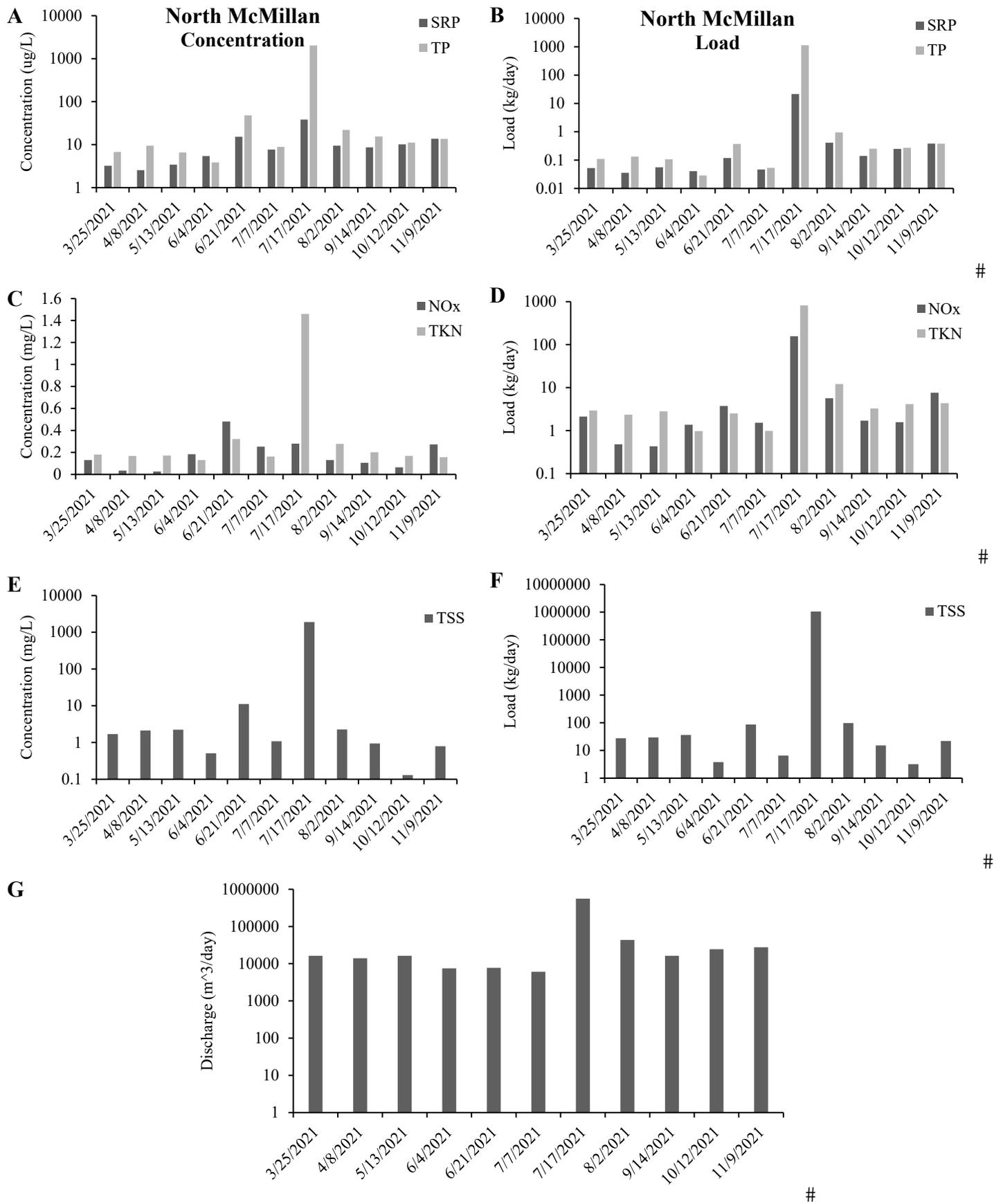


Figure 25: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), NOx (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in North McMillan Creek from 2021 sampling dates. Discharge (G) is also plotted for each sample date. Some graphs have log transformed Y axes.

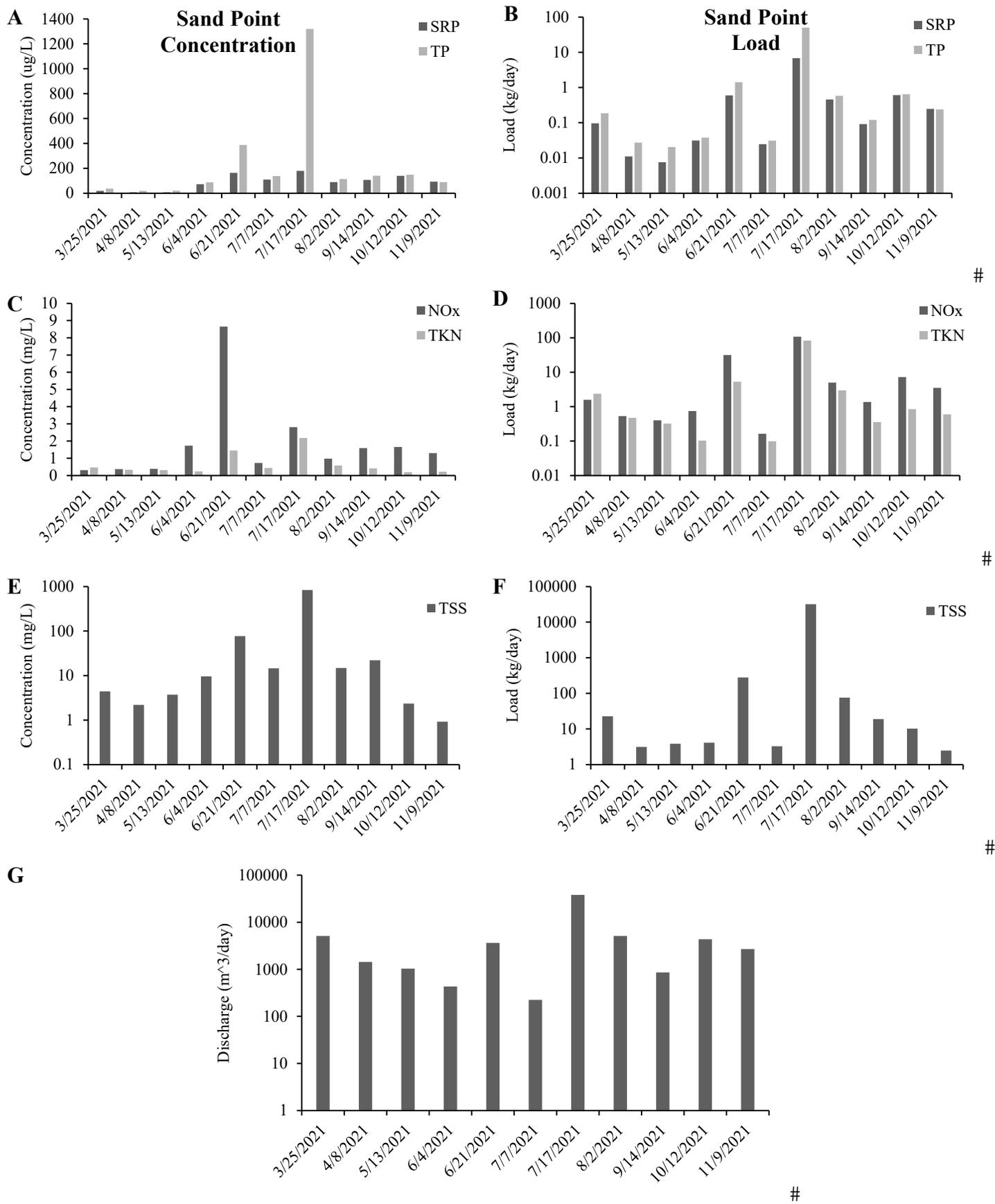


Figure 26: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), NOx (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in Sand Point Gully from 2021 sampling dates. Discharge (G) is also plotted for each sample date. Some graphs have log transformed Y axes.

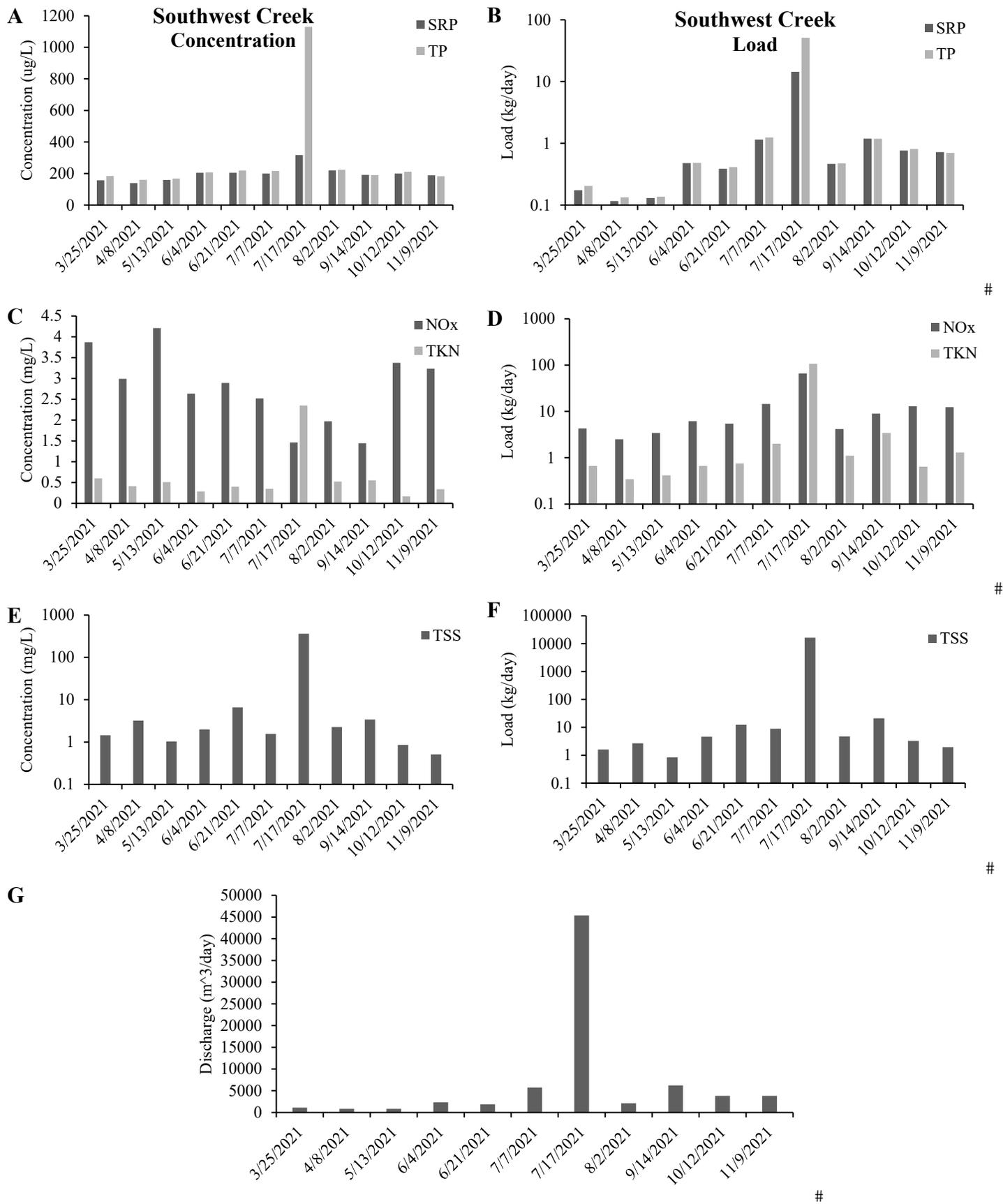


Figure 27: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), NOx (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in Southwest Creek from 2021 sampling dates. Discharge (G) is also plotted for each sample date. Some graphs have log transformed Y axes.

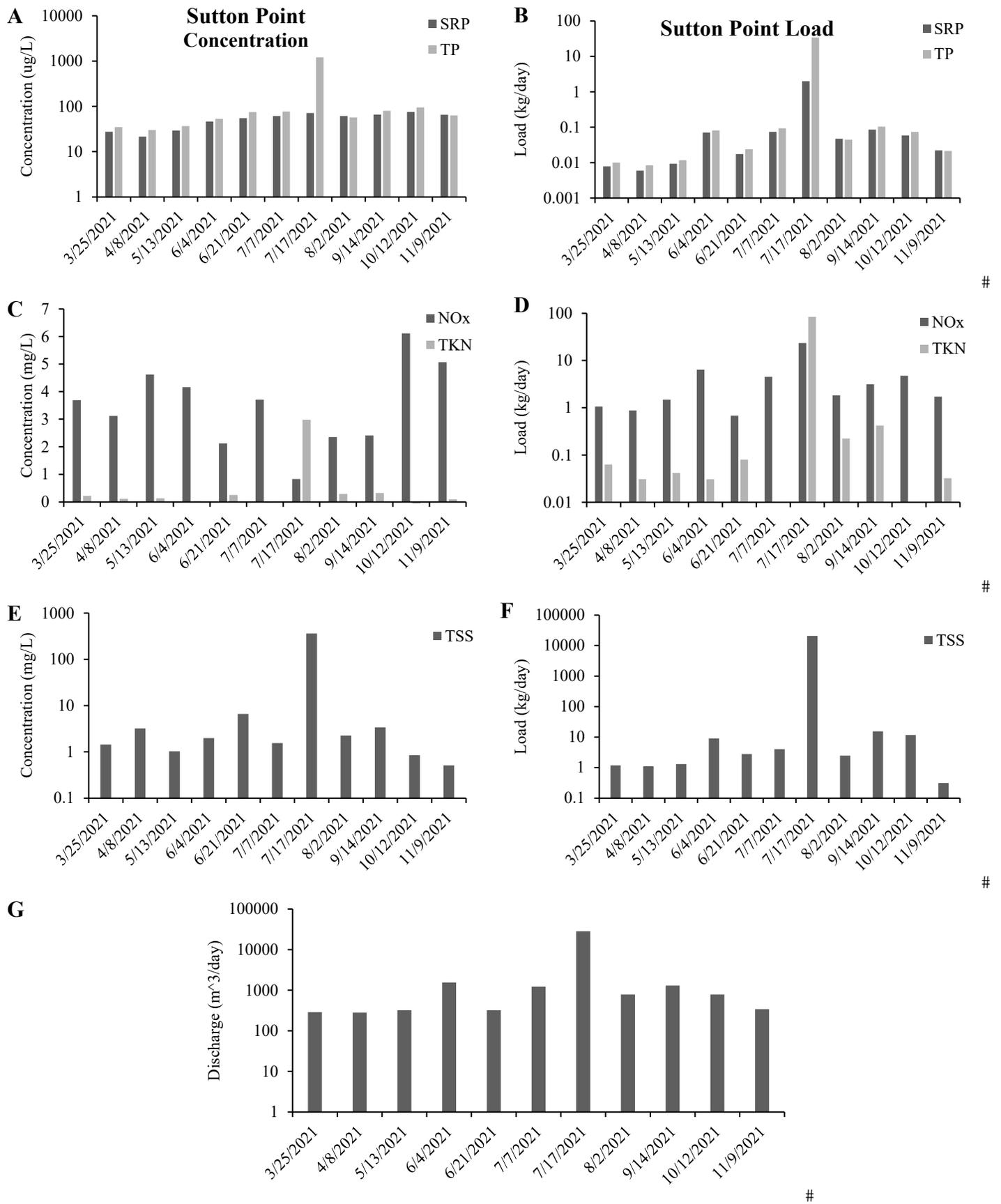


Figure 28: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), NOx (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in Sutton point Gully from 2021 sampling dates. Discharge (G) is also plotted for each sample date. Some graphs have log transformed Y axes.

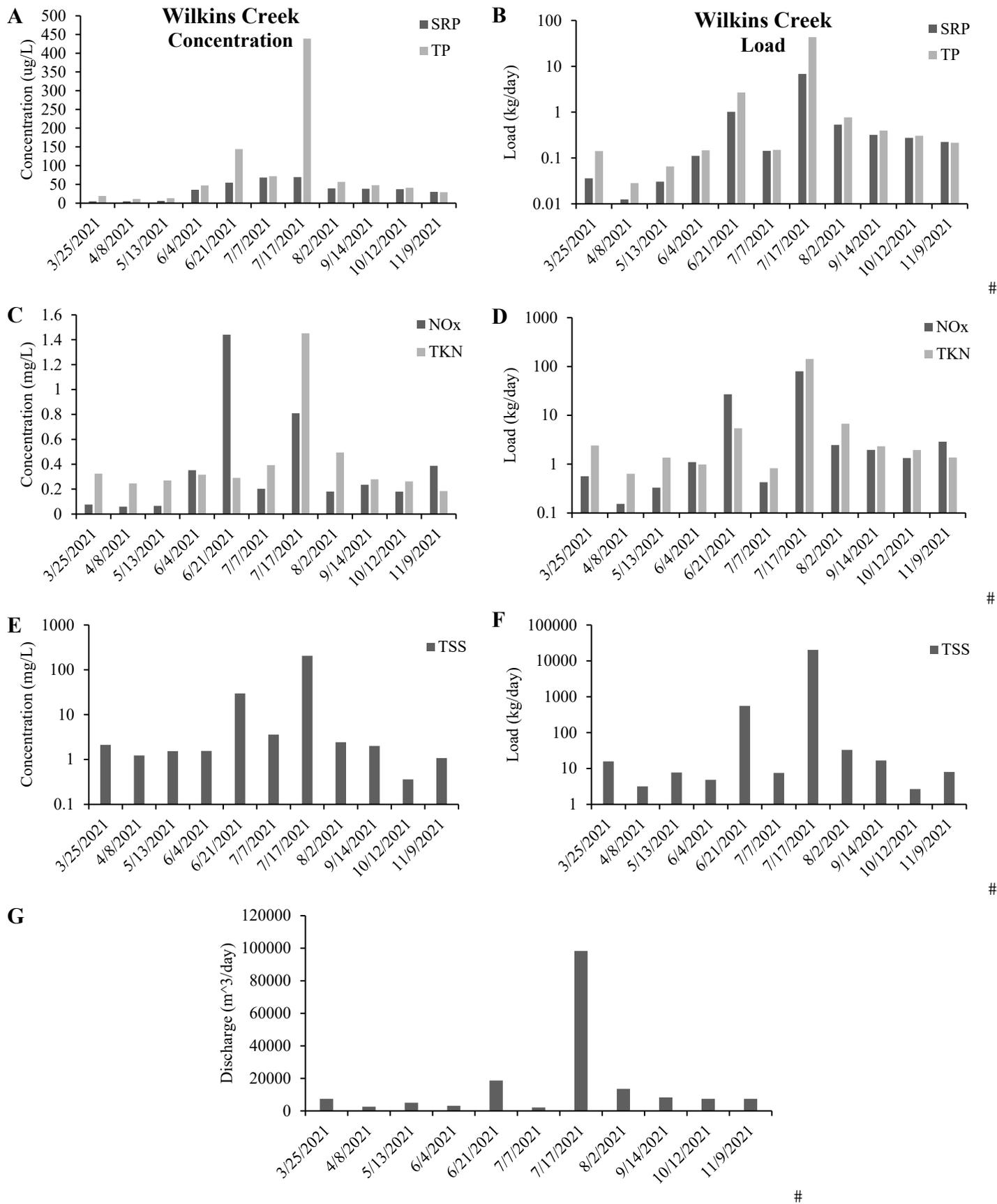
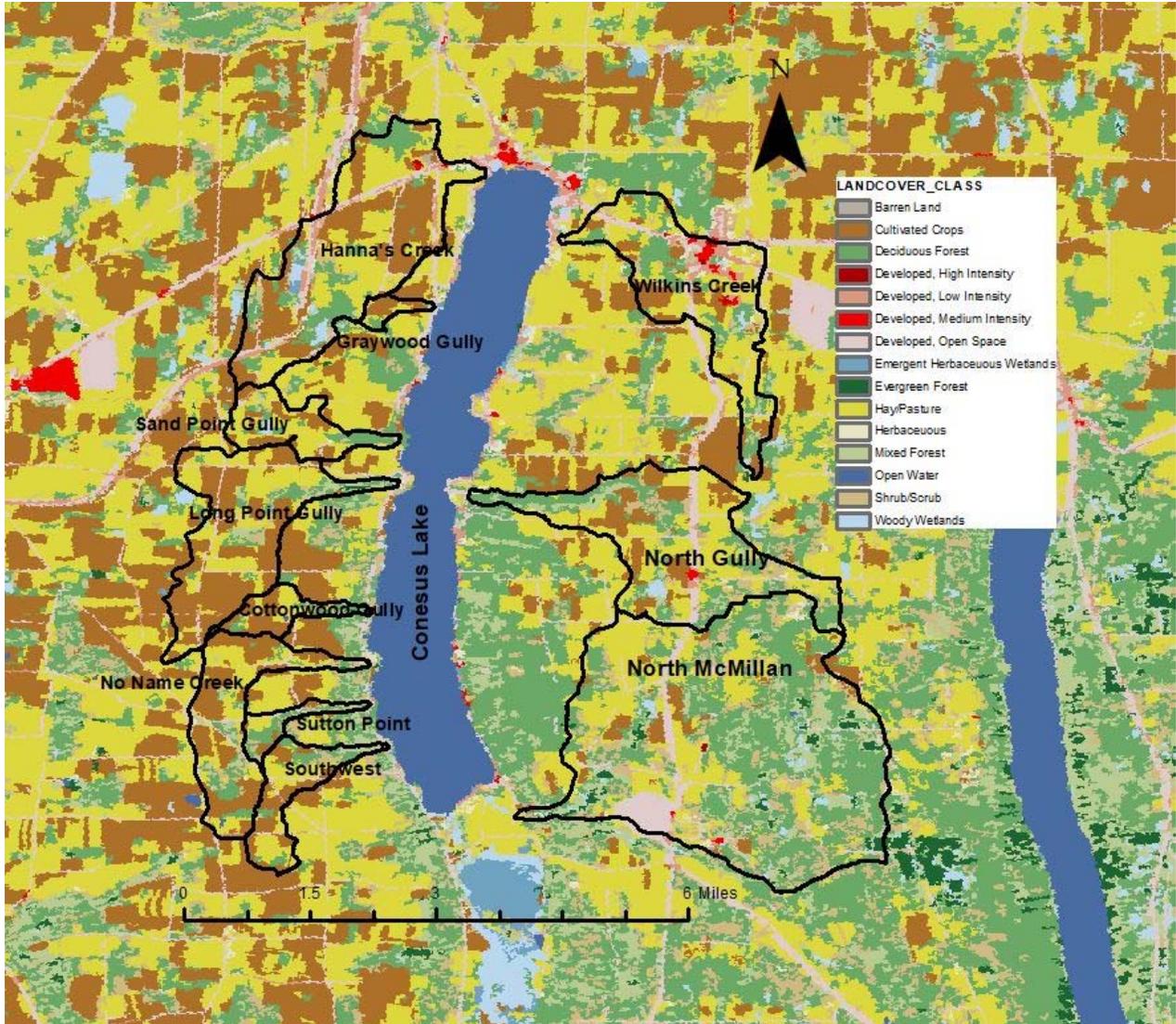


Figure 29: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), NOx (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in Wilkins Creek from 2021 sampling dates. Discharge (G) is also plotted for each sample date. Some graphs have log transformed Y axes.

Appendices:

Appendix 1: Map of site locations

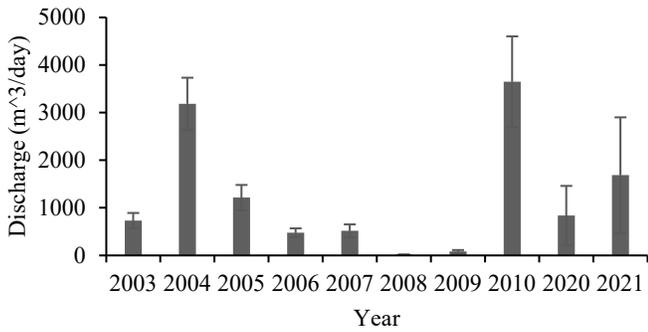


Map of 2021 streams and associated watershed boundaries and land use.

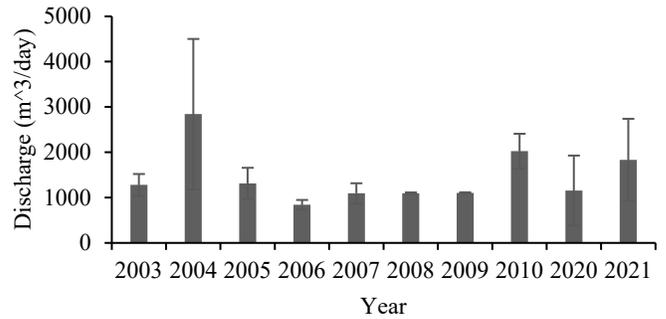
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Appendix 2: Average discharge 2003 to 2010, and 2020-2021 from May through August for former USDA study streams and additional non-BMP tributaries.

Graywood Gully

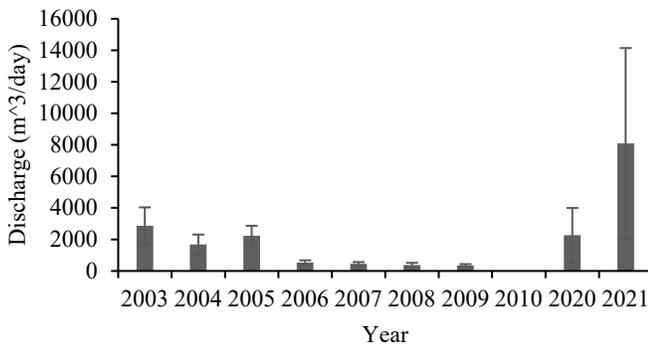


Cottonwood Gully

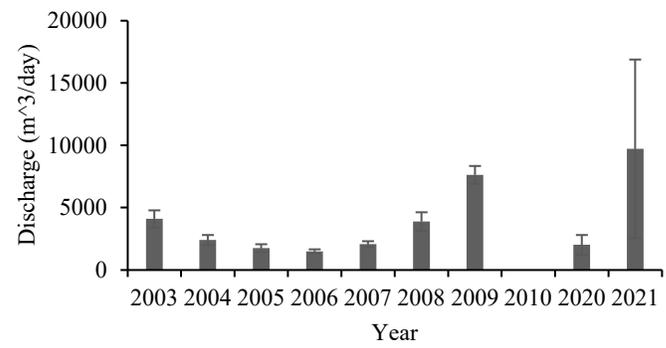


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Sandpoint Gully

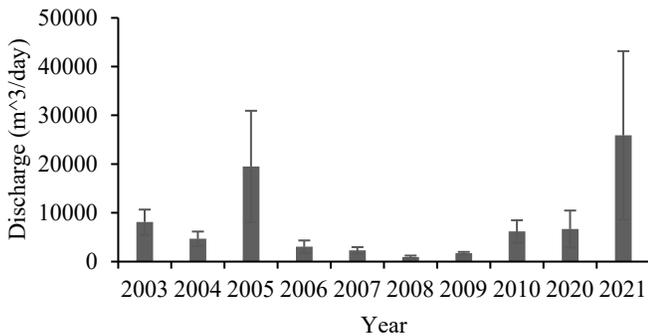


Southwest Creek

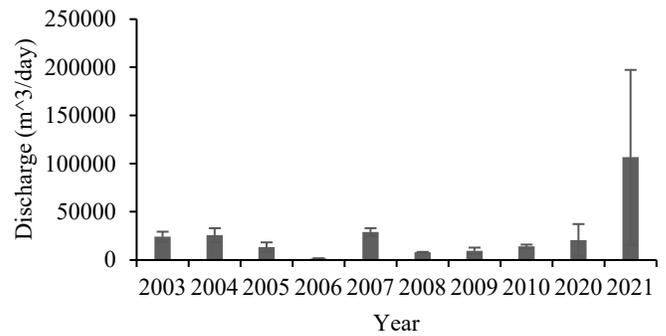


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Long Point Gully

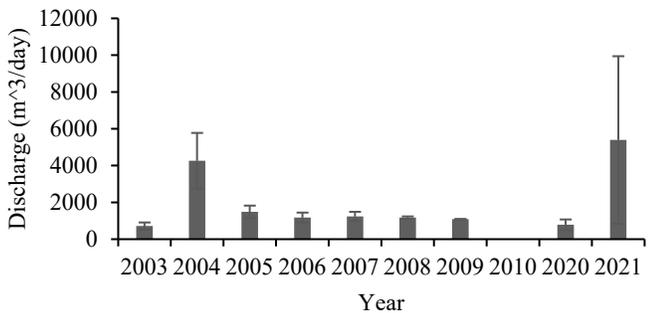


North McMillan Creek

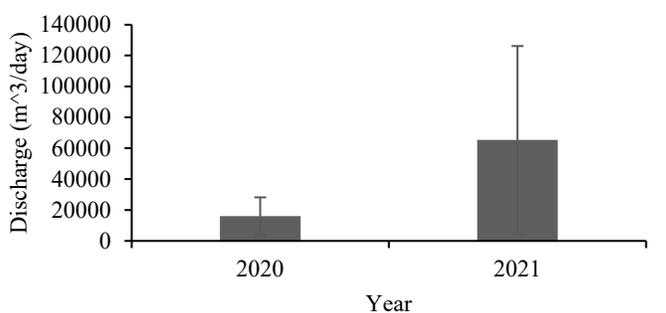


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Sutton Point Gully



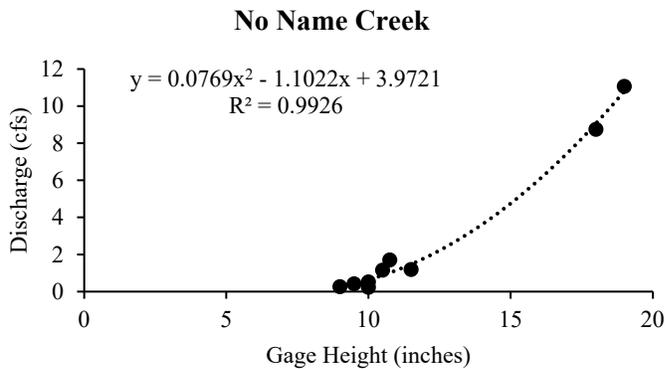
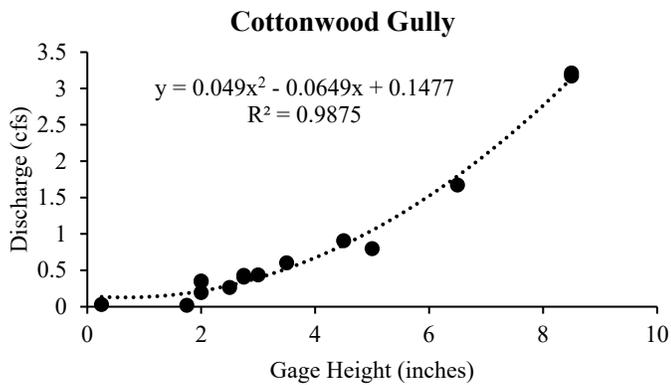
Hanna's Creek



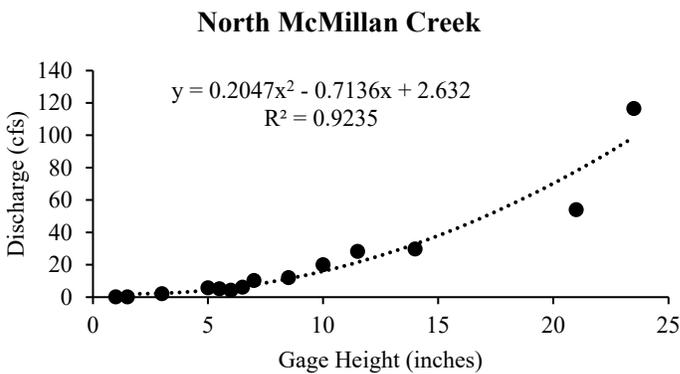
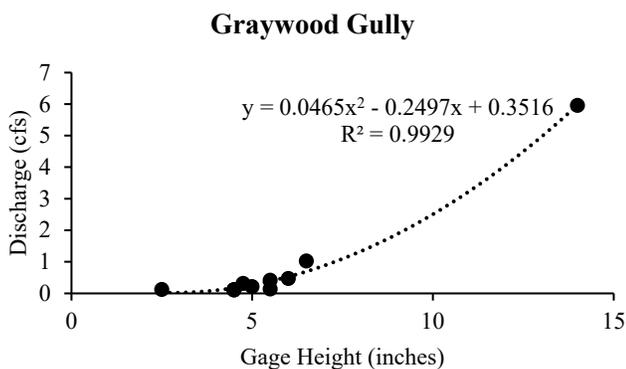
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Appendix 3: Rating curves for 2021 study tributaries. Developed 2020-2021.

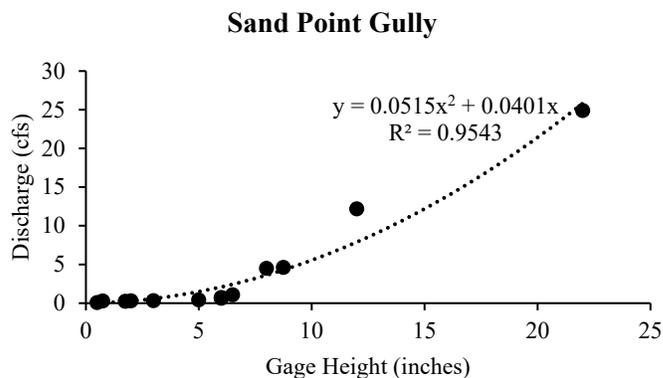
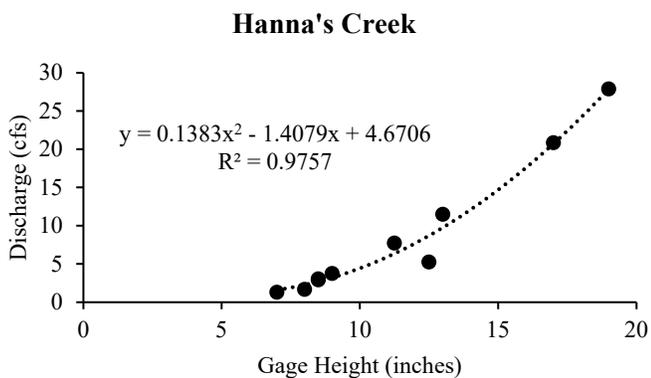
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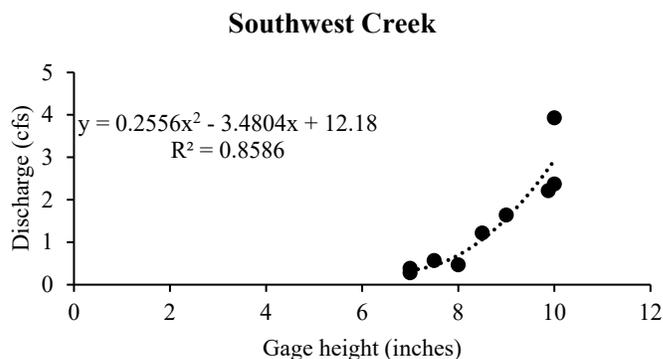
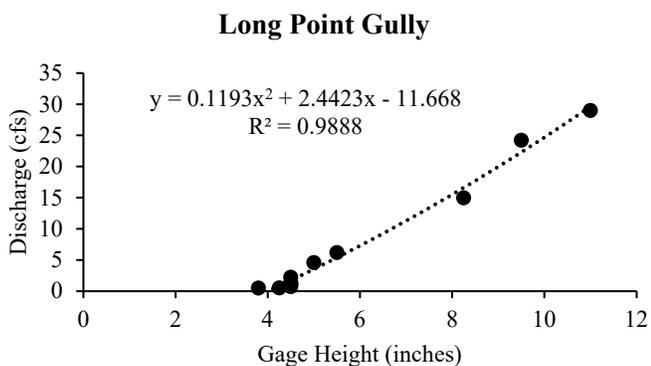
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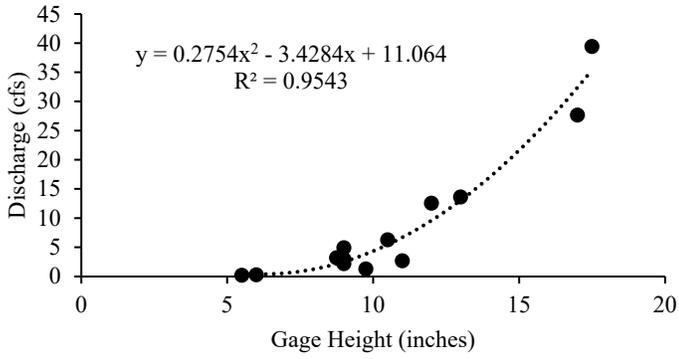
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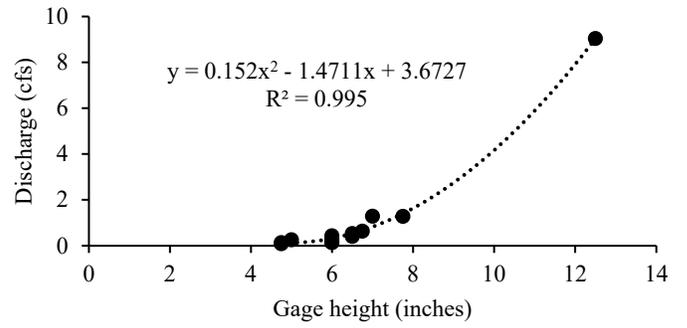
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North Gully

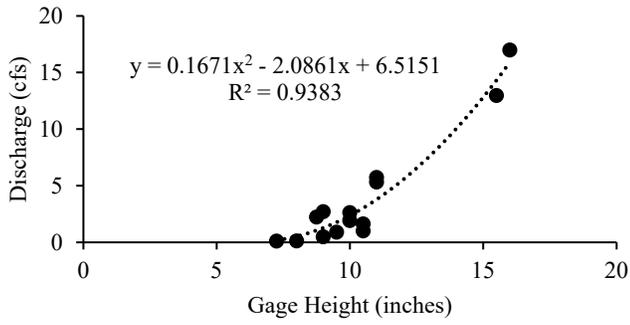


Sutton Point Gully



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Wilkins Creek

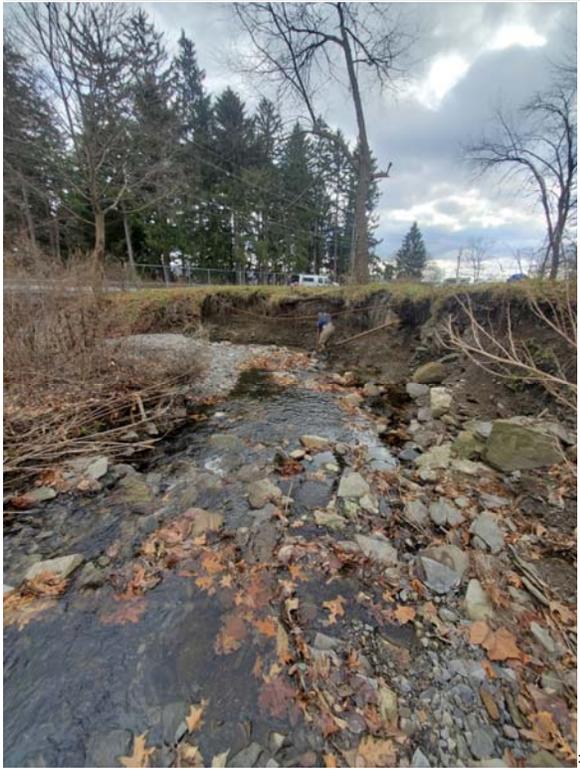


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Appendix 4: Site Pictures#



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Figure A1: Significant erosion of stream bank on No Name Creek (Photos taken near NYS RT 256 Bridge looking upstream).

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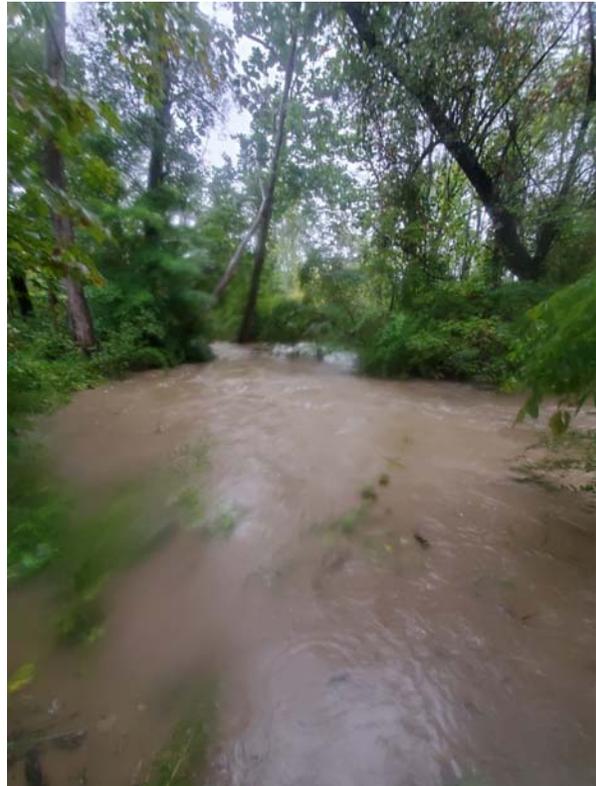


Figure A2: Photos showing highly sediment laden storm runoff in (from top left, to bottom right) North Gully, North McMillan, Sutton Point Gully, and Cottonwood Gully.



Figure A3: Photos showing mainly open fields in the Conesus Lake watershed during September 2021 after heavy rain.

Appendix 5: Additional graduate student thesis storm event TSS and nutrient concentrations. Values in bolded red are for attention. Orthophosphate and NOx were not collected in the afternoon of July 17th. ('NC' = not collected)

Site	Date	Turbidity (NTU's)	TSS (mg/L)	Total Phosphorus (ug/L)	Orthophosphate (ug/L)	NOx (mg/L)	Total Nitrogen (mg/L)
Long Point Gully	6/21/2021 (pm)	14.46	11.8	149	94.2	33.9	35.2
North McMillan	6/30/2021	534.87	1221	1897.5	53	0.58	3.27
North Gully	6/30/2021	510.12	1179.5	1710	139.5	1.39	3.42
Sand Point Gully	7/8/2021	830	1278.13	2272.5	118	6.18	8.02
Hanna's Creek	7/12/2021	14.53	18.85	225	129.5	33.9	34.02
Graywood Gully	7/12/2021	35.25	66.2	520	399	20.6	21.6
Hanna's Creek	7/14/2021	22.57	38.89	167	65.7	15.65	16.05
Graywood Gully	7/14/2021	105.35	191.43	825	461	14.8	15.4
Graywood Gully	7/17/2021 (pm)	613	1527.5	2495	NC	NC	9.34
Sandpoint Gully	7/17/2021 (pm)	461	1057.45	1420	NC	NC	3.45
Long Point Gully	7/17/2021 (pm)	702	2209.62	2675	NC	NC	6.93
Cottonwood Gully	7/17/2021 (pm)	863	2236	2490	NC	NC	4.79
No Name Creek	7/17/2021 (pm)	715	1161.25	1860	NC	NC	4.85
Sutton Point Gully	7/17/2021 (pm)	1731.4	5072.73	6950	NC	NC	3.23
Southwest Creek	7/17/2021 (pm)	255	477.08	1100	NC	NC	3.22
North McMillan	7/17/2021 (pm)	1320	3283.33	3355	NC	NC	1.95
North Gully	7/17/2021 (pm)	1191.9	3090.24	2855	NC	NC	2.54
Sutton Point Gully	8/19/2021	17.23	19.25	100.5	52	13.6	14.544
Sutton Point Gully	9/23/2021	699	1481.71	2180.5	189.5	3.851	6.314
North McMillan	9/23/2021	865	2045	2103.5	54.8	0.2311	2.032
North Gully	9/23/2021	1024.5	3022.73	2915.5	153	0.9715	2.551
North Gully	10/26/2021	931	2636.36	2825	133	0.6781	1.469