BRPA 2018-23 Water Quality Data Analysis MSU Student Project

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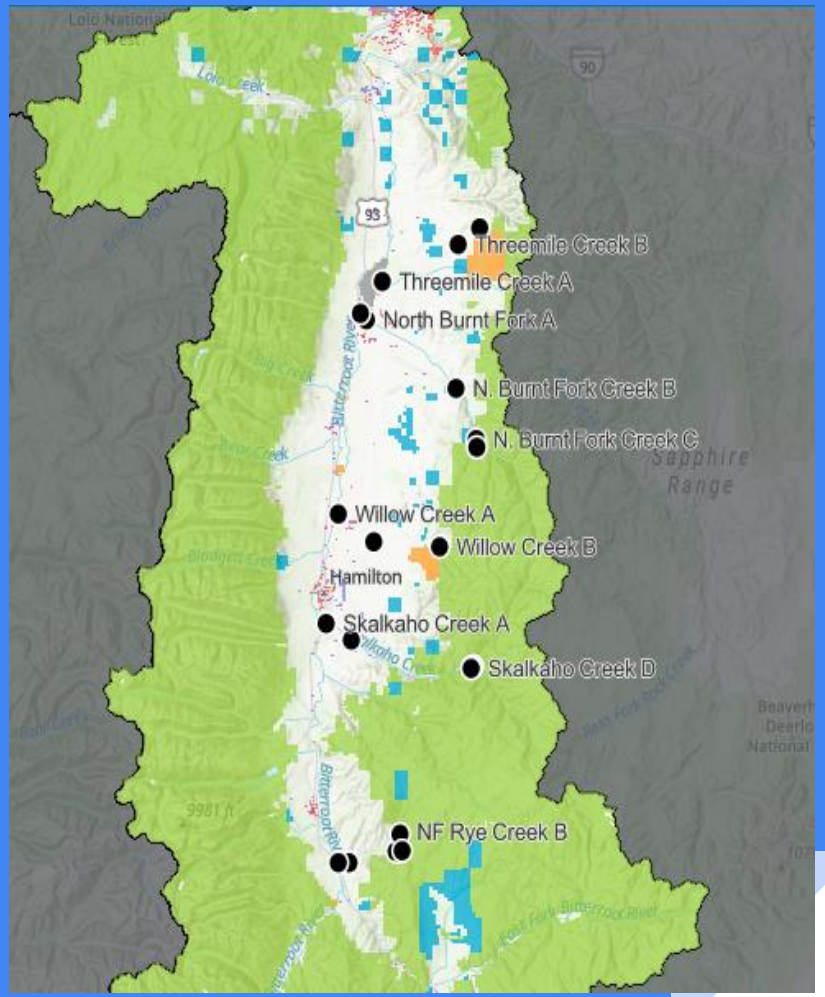


Foreword and Acknowledgements

This work was conducted as part of a one semester Montana State University undergraduate research course, led by Dr. Adam Sigler with support from Bridget Warrenfeltz. Olivia Lynch was the undergraduate student assigned to the Bitterroot program for the course.

This work was conducted in consultation with the Bitterroot River Protection Association representatives Michael Howell and Chris Clancy.

Fall 2024 was the initial pilot of this course, with the intention to produce useful data summaries for volunteer monitoring programs while simultaneously providing hands on student learning opportunities.

This work was supported by funding from Montana Department of Environmental Quality (MDEQ).

Introduction

Watershed Description

The Bitterroot Watershed is located in southwestern Montana and encompasses 2,899 square miles.

It's characterized by a wide valley floor surrounded by the rugged Bitterroot and Sapphire Mountains. The Bitterroot River meanders through the Bitterroot Valley, providing various benefits such as recreation, irrigation, and more.

Agriculture plays a significant role in the watershed, with irrigation practices modifying natural water flow. (Bitterroot Watershed Restoration Plan, 2019). These alterations have impacted stream flow patterns, posing challenges for water availability, water quality data analysis, and overall ecosystem health.

Project Description

The Bitterroot River Protection Association's (BRPA) Sapphire Front Project started in 2017 and focuses on the water quality in tributaries that flow west from the Sapphire Front mountains into the Bitterroot River.

Sample sites for this project are located on five tributaries: Rye Creek, Skalkaho Creek, Willow Creek, North Burnt Fork Creek, and Threemile Creek. The BRPA SAP states that one monitoring station has been located on each creek near the mouth, and a second station has been positioned near the Forest Service boundary (Figure 2; Howell, 2024).

Goal	Objective	Data Analysis
Goal # 1 is to determine current conditions of nutrients and in situ field measurements on six tributaries along the Sapphire Front.	To measure nutrients and discharge on six tributaries along the Sapphire Front to evaluate nutrient concentrations from Forest Service land and agricultural land.	Compare nutrient concentrations to the recommended ranges of nitrogen and phosphorus that protect beneficial uses.
	Document the general condition of each location by taking photographs upstream, across and downstream during each sampling	Photos taken over time can be compared to identify any significant alteration to the environment in the area of the sampling
Goal # 2 is to quantify nutrient loads in tributaries at the mountain-valley transition and at the confluence with the Bitterroot to distinguish forest versus agriculture/residential land use.	Characterize tributary nutrient loads by collecting water samples for nutrientanalysis and measuring discharge at two locations on each tributary.	Combined nutrient concentration data with flow data to determine the total nutrient loaddelivered to the river by each stream. The data can be used in subsequent years to evaluate how nutrient loads differ from yearto year.

Figure 1. BRPA Goals and Objectives. *This figure is Table 4 from the BRPA SAP (Howell, 2024) and outlines the organization's goals, objectives, and data analysis.*

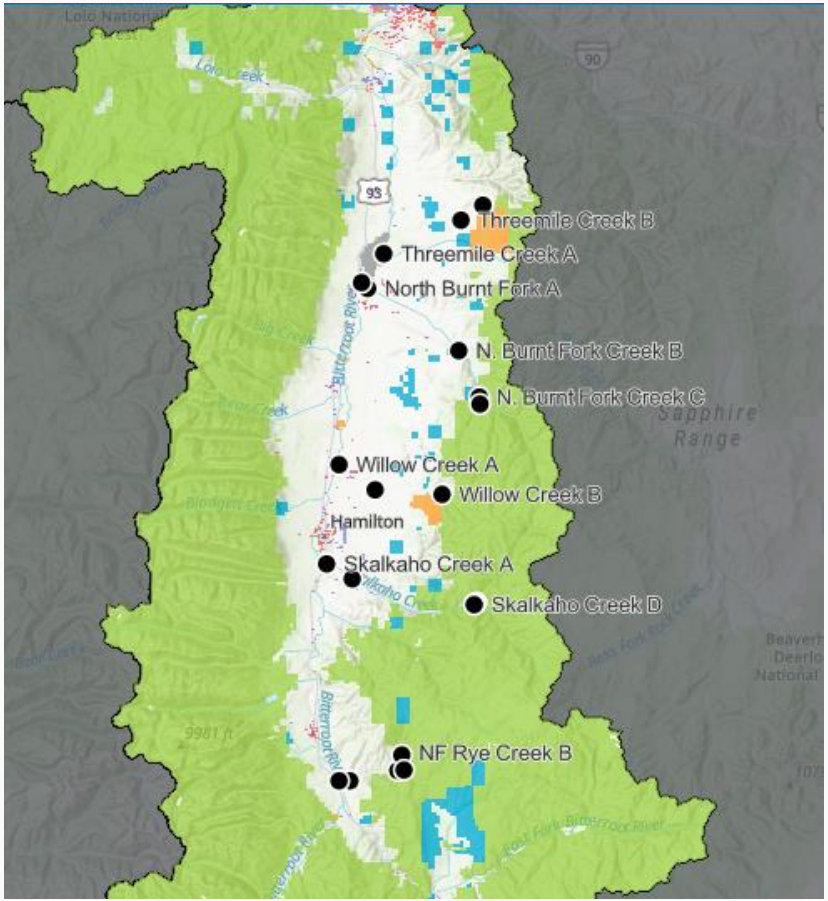


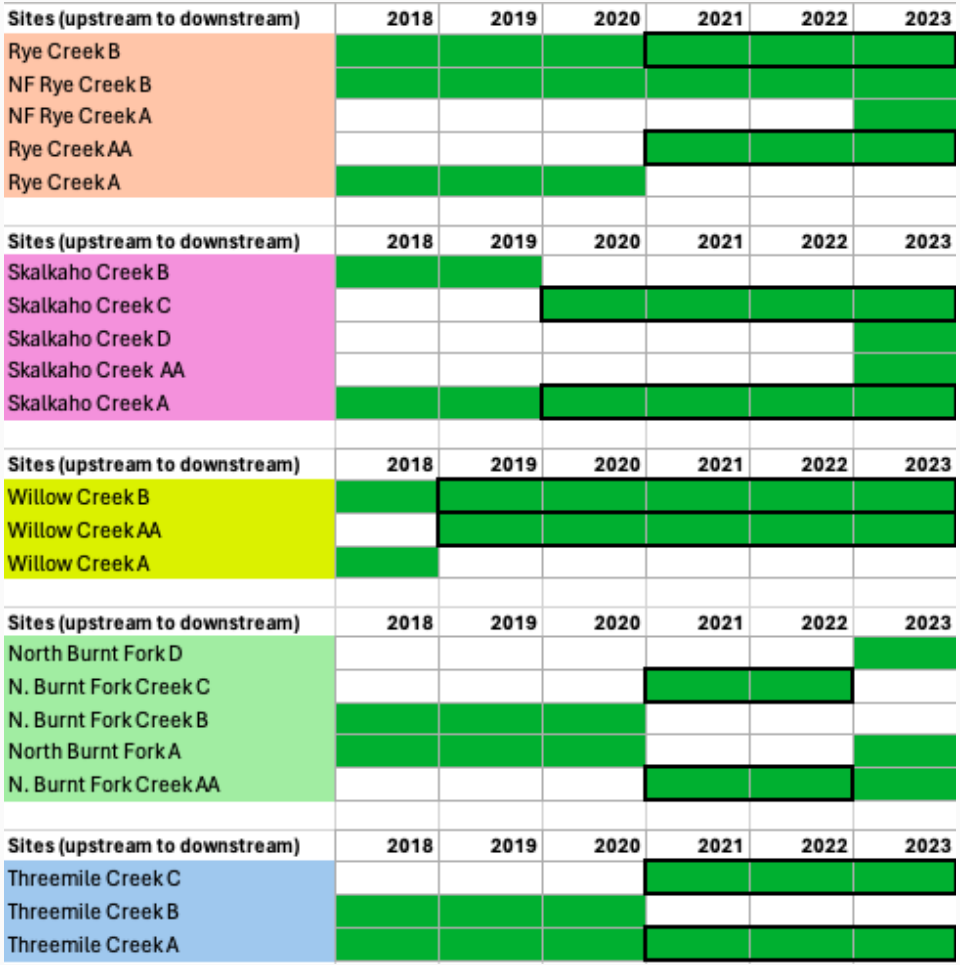
Figure 2. Sample Site Map. *This map shows locations of Bitterroot Protection Association sample sites. Some sites are not shown as they're closely grouped but can be viewed as interactive map via this link.* https://sscmsu.maps.arcgis.com/apps/mapviewer/index.html?webmap=271fc8c282884ac7ad207dacc250bd20

Methods

Data Sources and Curation

Monitoring for this project was conducted by the BRPA. Data for this report was downloaded from the National Water Quality Exchange ((WQX) Database. Data was curated and assessed for errors that may have occurred in the collection or upload process. A list of corrections necessary to be made in the WQX database were identified in partnership with BRPA program representatives and are inventoried in Appendix B.

Nutrient concentrations for total nitrogen (TN) and total phosphorus (TP) are interpreted relative to the MDEQ Circular 12A document (MDEQ, 2013). Concentrations for nitrate-N are interpreted relative to the 0.1 mg/L threshold identified by MDEQ for a general value above which nuisance algae may be expected (MDEQ, 2013).



Sites (upstream to downstream)	2018	2019	2020	2021	2022	2023
Rye Creek B	■	■	■	■	■	■
NF Rye Creek B	■	■	■	■	■	■
NF Rye Creek A						■
Rye Creek AA				■	■	■
Rye Creek A	■	■	■			

Sites (upstream to downstream)	2018	2019	2020	2021	2022	2023
Skalkaho Creek B	■	■				
Skalkaho Creek C			■	■	■	■
Skalkaho Creek D						■
Skalkaho Creek AA						■
Skalkaho Creek A	■	■	■	■	■	■

Sites (upstream to downstream)	2018	2019	2020	2021	2022	2023
Willow Creek B	■	■	■	■	■	■
Willow Creek AA		■	■	■	■	■
Willow Creek A	■					

Sites (upstream to downstream)	2018	2019	2020	2021	2022	2023
North Burnt Fork D						■
N. Burnt Fork Creek C				■	■	
N. Burnt Fork Creek B	■	■	■			
North Burnt Fork A	■	■	■			■
N. Burnt Fork Creek AA				■	■	■

Sites (upstream to downstream)	2018	2019	2020	2021	2022	2023
Threemile Creek C				■	■	■
Threemile Creek B	■	■	■			
Threemile Creek A	■	■	■	■	■	■

Figure 3. Site list indicating years sampled. The green boxes represent the years each site was sampled, and the black outlines represent the upstream and downstream sites with the most consistent overlapping flow and nutrient data.

Results

Total Nitrogen Concentrations

Total Nitrogen (TN) concentrations range from 0.0382 mg/L to 1.09 mg/L across all sample sites and dates (Figure 4). With the exception of two outlier points, concentrations are consistently below the 0.3 mg/L threshold (DEQ Circular 12A) at headwaters sites and generally increase downstream.

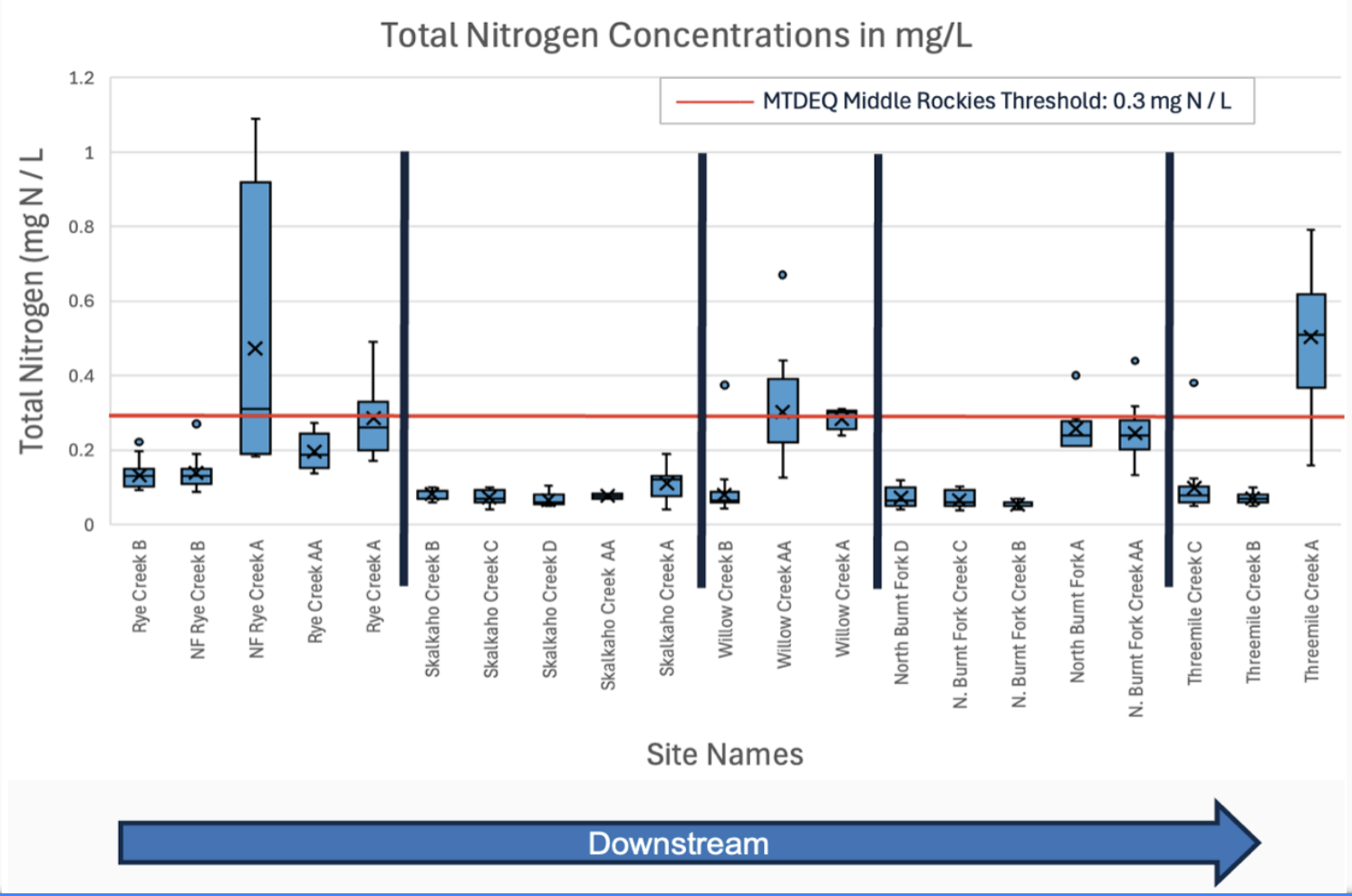


Figure 4: Total Nitrogen Concentrations. *The y axis is the concentration of total nitrogen. Sites are organized from upstream to downstream within tributary, moving from left to right. Tributaries are organized based on location of confluence with the mainstem Bitterroot, from upstream to downstream, moving from left to right. Boxes indicate the interquartile range of data (25th to 75th percentile), the horizontal line within the box is the median, and the X symbol indicates the mean concentration. Whiskers extend to the farthest point within 1.5 times the interquartile range from the interquartile box and points beyond the whiskers are considered outliers. The red line is the MDEQ Middle Rockies TN threshold of 0.3 mg/L (DEQ Circular 12A).*

Nitrate-N Concentrations

Nitrate and Nitrite concentrations range from 0.002 mg/L to 0.72 mg/L across all sample sites and dates (Figure 5). With the exception of one outlier point, concentrations are consistently below the 0.1 mg/L threshold (DEQ Circular 12A) at headwaters sites and generally increase downstream.

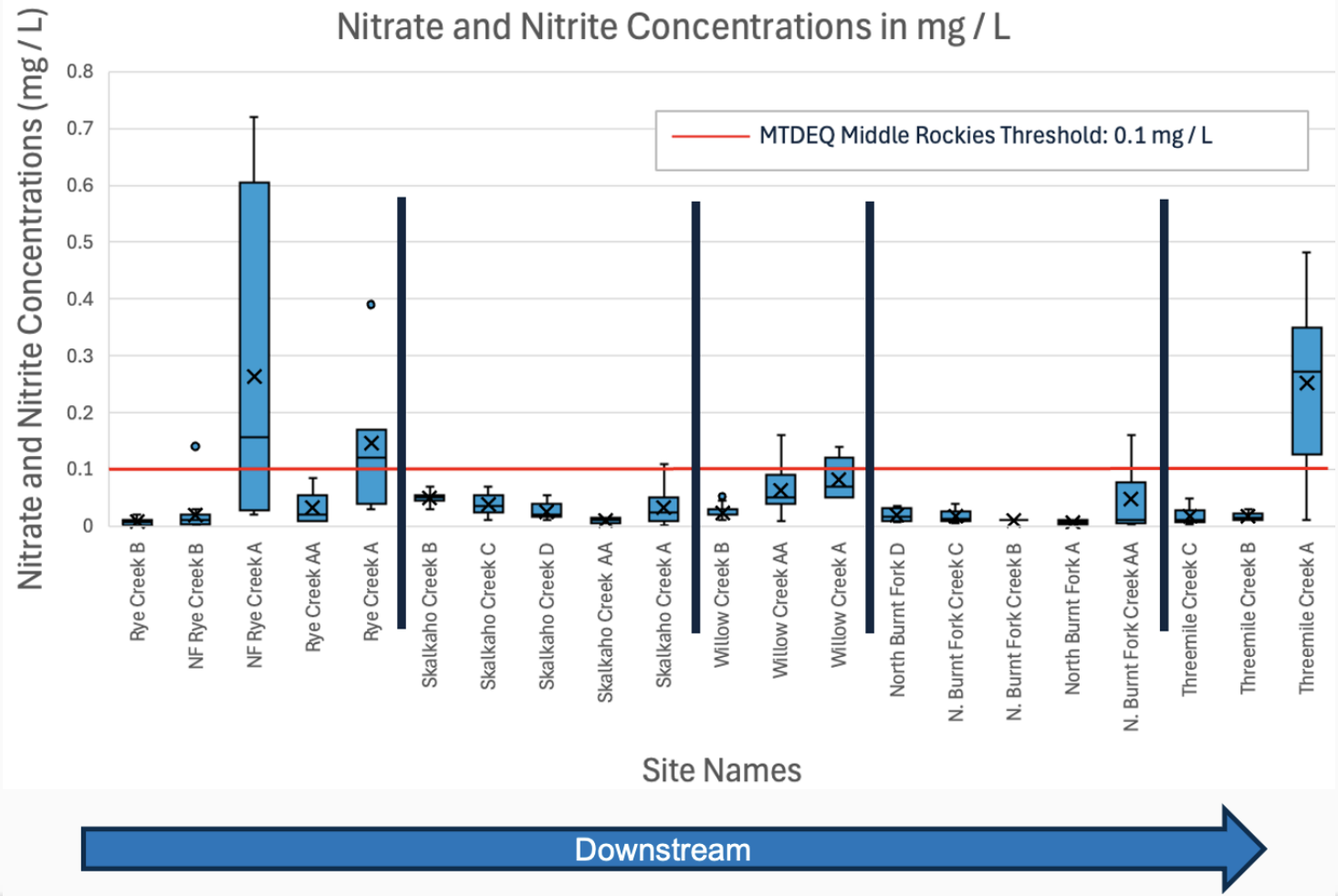


Figure 5: Nitrate/Nitrite Concentrations. *The y axis is the concentration of nitrate and nitrite Sites are organized from upstream to downstream within tributary, moving from left to right. Tributaries are organized based on location of confluence with the mainstem Bitterroot, from upstream to downstream, moving from left to right. Boxes indicate the interquartile range of data (25th to 75th percentile), the horizontal line within the box is the median, and the X symbol indicates the mean concentration. Whiskers extend to the farthest point within 1.5 times the interquartile range from the interquartile box and points beyond the whiskers are considered outliers. The red line is the MDEQ Middle Rockies* total nitrogen *threshold of 0.1 mg/L* (DEQ Circular 12A).

Total Phosphorous Concentrations

TP concentrations range from 0.001 mg/L to 0.484 mg/L across all sample sites and dates (Figure 6). In contrast to TN where upstream sites have concentrations consistently below thresholds, upstream concentrations of TP for both Rye and Threemile are above the 0.03 mg/L threshold.

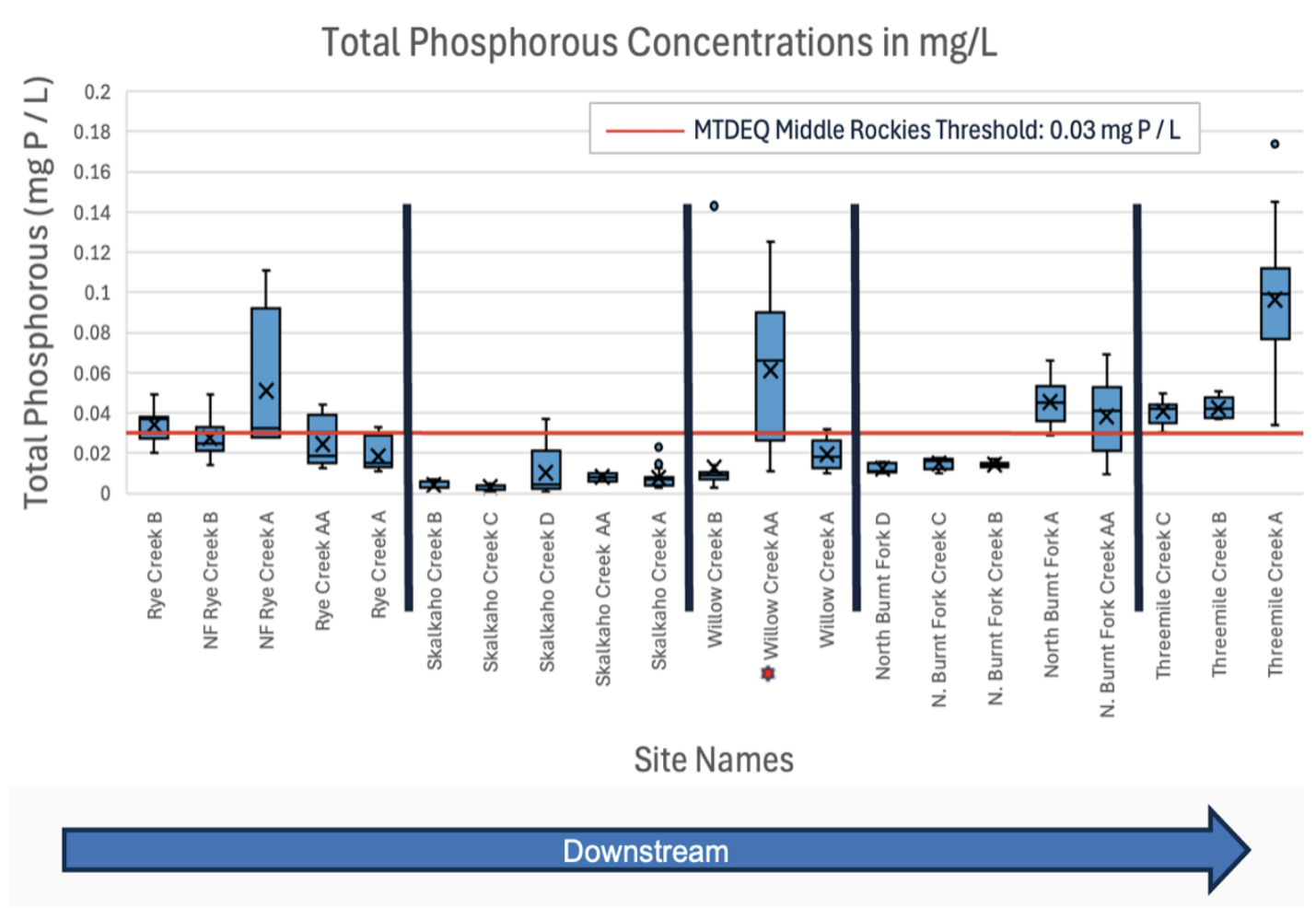


Figure 6: Total Phosphorous Concentrations. *The y axis is the concentration of total phosphorous. Sites are organized from upstream to downstream within tributary, moving from left to right. Tributaries are organized based on location of confluence with the mainstem Bitterroot, from upstream to downstream, moving from left to right. Boxes indicate the interquartile range of data (25th to 75th percentile), the horizontal line within the box is the median, and the X symbol indicates the mean concentration. Whiskers extend to the farthest point within 1.5 times the interquartile range from the interquartile box and points beyond the whiskers are considered outliers. The red line is the MDEQ Middle Rockies total phosphorous threshold of 0.03 mg/L (DEQ Circular 12A). *A strong outlier of 0.484 mg/L was measured on Willow Creek AA on 8/18/22. The outlier heavily skewed the graph and was omitted.*

Nutrient Loads

Loads were calculated for Threemile Creek C for all dates with overlapping flow and concentration data.

Across all three nutrient parameters, Threemile A (downstream site) has higher loads than Threemile C (upstream site; Figure 7). This pattern of consistently higher loads at downstream sites was not observed across all tributaries (Appendix A, Figures A1-A5).

Total Nitrogen Load

Total nitrogen load ranged from 0.21 kg/day to 2.65 kg/day at the upstream site and 1.13 kg/day to 11.32 kg/day at the downstream site. The difference between downstream and upstream loads, the load contributions attributable to the stream reach between sites, ranged from 0.86 kg/day to 10.7 kg/day. The average load at the upstream site was 1.17 kg/day and the average difference between sites was 5.14 kg/day.

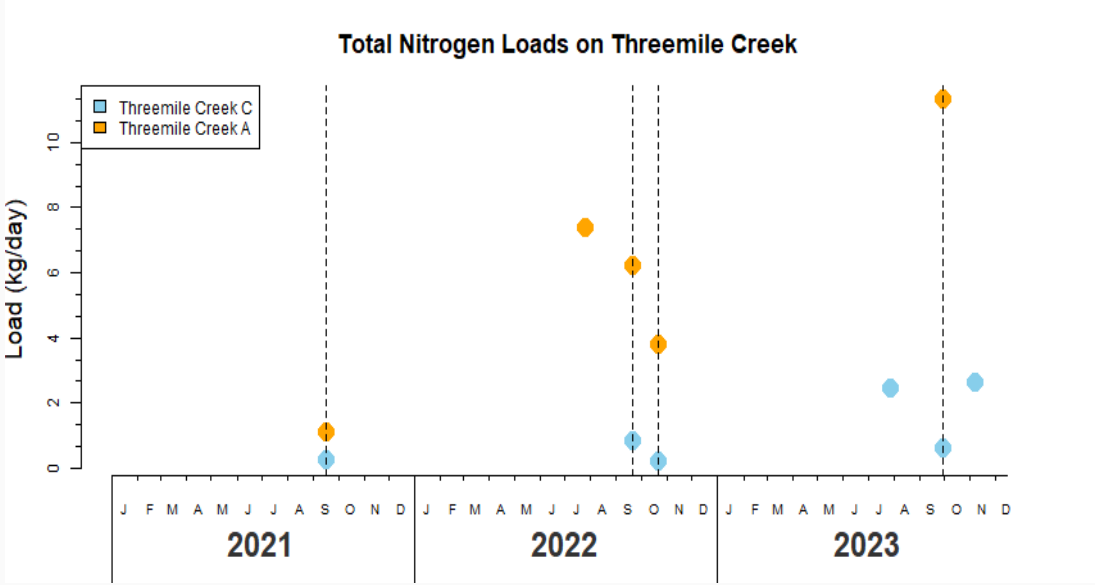
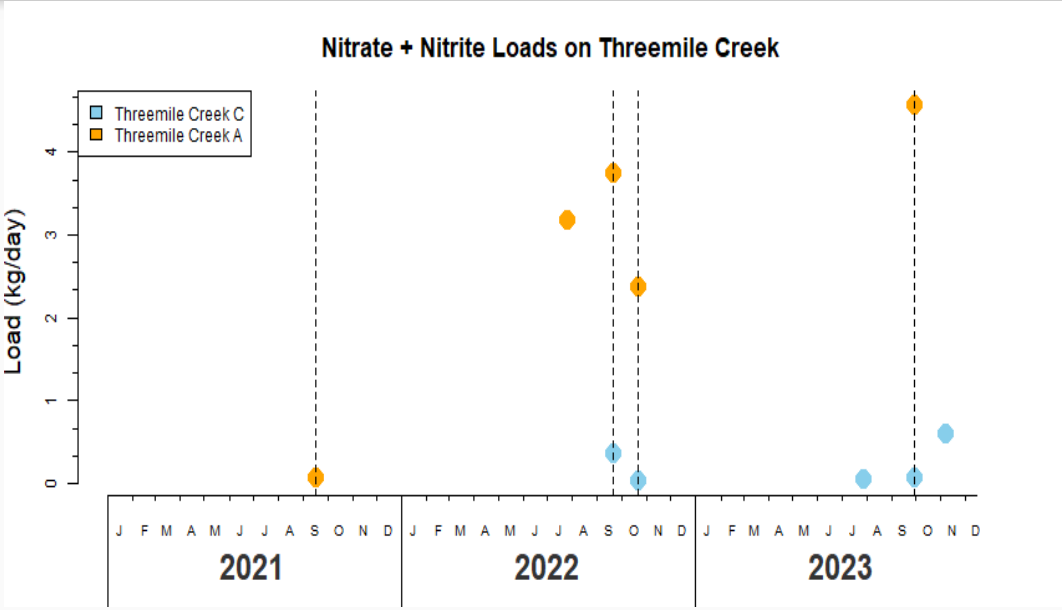


Figure 7. Upstream and downstream nutrient loads on Threemile Creek. *Load in kg/day is on the y axis, and the time period of data collection on the x axis. Threemile Creek C (blue dots) is the upstream site, and Threemile Creek A (orange dots) is the downstream site. The vertical dashed lines represent days where concentration and flow measurement data were available for the upstream and downstream site to calculate nutrient loads and facilitate calculation of difference in load between sites. (Note: Nitrate concentration was not sampled at Threemile Creek C on Sept 2021, so load could not be calculated and is not shown on the plot.)*

Nitrate-N Load

Nitrate-N load ranged from 0.06 kg/day to 0.36 kg/day at the upstream site and 0.07 kg/day to 4.57 kg/day at the downstream site. The difference between downstream and upstream loads, the load contributions attributable to the stream reach between sites, ranged from 2.34 kg/day to 4.5 kg/day. The average load at the upstream site was 0.22 kg/day and the average difference between sites was 3.41 kg/day.



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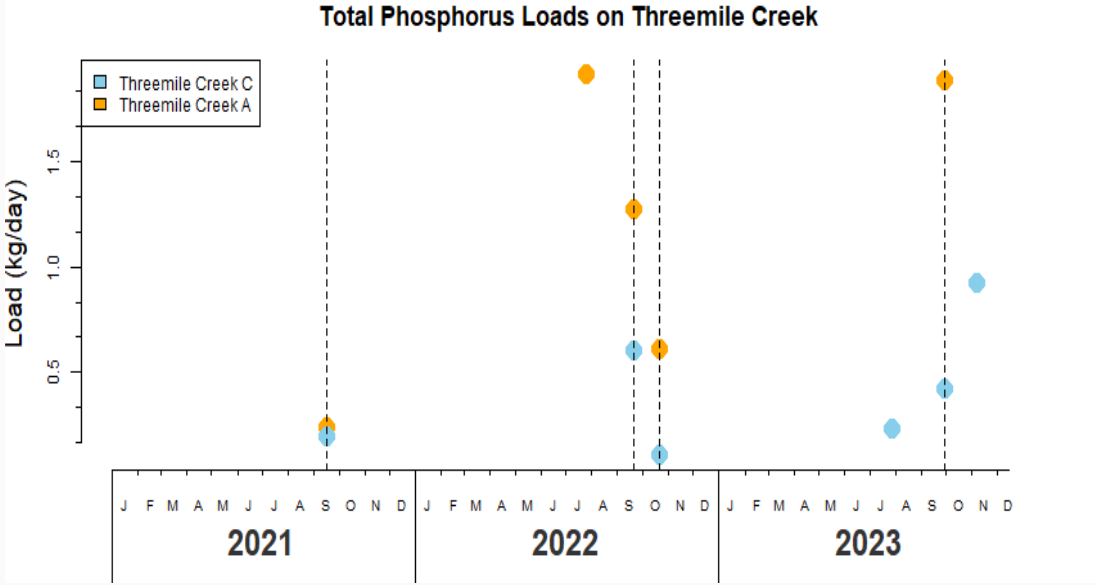
Total Phosphorous Load

Total phosphorus load ranged from 0.11 kg/day to 0.92 kg/day at the upstream site and 0.24 kg/day to 1.91 kg/day at the downstream site. The difference between downstream and upstream loads, the load contributions attributable to the stream reach between sites, ranged from 0.05 kg/day to 1.47 kg/day. The average load at the upstream site was 0.41 kg/day and the average difference between sites was 0.67 kg/day.



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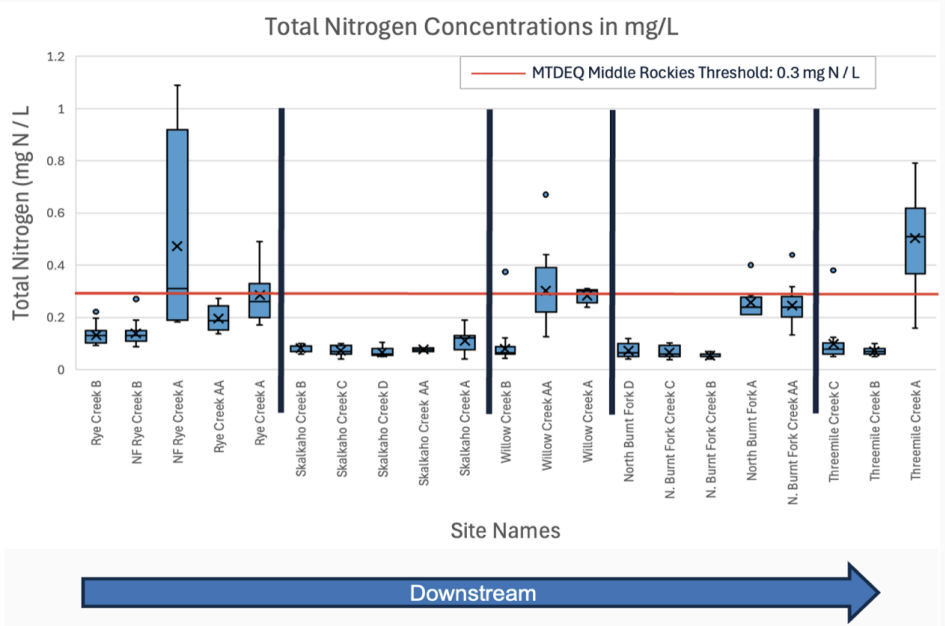
Discussion

Preface

- In general, tributaries show relatively low concentrations of nutrients near the Forest Service boundary and increasing concentration at sites further downstream with an increasing diversity and intensity of human land use.
- Patterns differ between for phosphorus and nitrogen. Exceptions are likely caused by low land use intensity and by mixing of tributary flow with low nutrient irrigation ditch water in other cases.

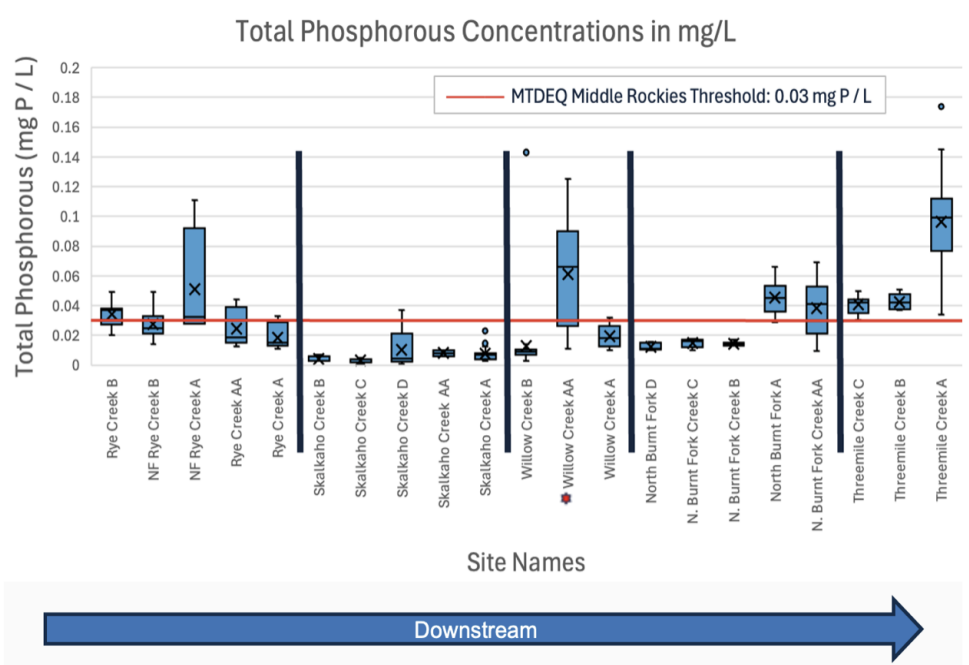
Nitrogen Concentration Patterns

- **For nitrogen, four of the five tributaries show clear increases in concentration from the upstream sites to downstream sites.**
- Threemile Creek shows the most pronounced increases in TN and has the highest median concentration across all tributaries and sites.
- North Burnt Creek also shows a clear increase in TN concentrations between the upstream and downstream sites, with most downstream samples below the threshold.
- Willow Creek and Rye Creek both show increases from clearly below the threshold at the upstream site to observations closer to and above the threshold at the downstream most sites.
- Skalkaho Creek is the only tributary with no TN concentrations above the threshold.



Phosphorous Concentration Patterns

- Concentrations of TP are elevated above threshold concentrations near the Forest Service boundary on Rye Creek and Threemile creek.
- While Threemile Creek has TP concentrations starting above the threshold at the forest boundary, the concentrations also increase notably downstream to produce the highest median concentration across all sites on all tributaries.
- Threemile Creek and North Burnt Fork Creek show the clearest increases in TP concentrations moving from the forest boundary downstream, indicating opportunities for phosphorus loading reduction in the lower elevation sections of these tributaries.



Flow Patterns

- In the simplest application of this design, concentration and flow values are measured on the same day
- In practice, concentration and flow measurements were sometimes made on adjacent days.
- While additional work could be done to pair measurement values from adjacent days and to assess the required assumption that concentration and flow were relatively stable across days, that was beyond the scope of possible analysis for this report.
- With the limited number of load values available for paired sites on the same day, **we were not able to make strong conclusions about differences in load on tributaries.**

Conclusion

Overall Observations

- Nutrient loss at the forest boundaries is generally low apart from Rye Creek and Threemile Creek, where sediment erosion rate assessments could provide more insights.
- Phosphorus observations on Threemile, North Burnt Fork, and Willow Creeks all show opportunities for phosphorus loading reduction in the lower portions of the watersheds.
- All tributaries show relatively low nitrogen at forest boundary and increases moving downstream.
- Four of the five tributaries (Rye, Willow, North Burnt, and Threemile) show pronounced concentration increases with downstream concentrations near or exceeding the threshold.
- Only Skalkaho Creek does not show any nitrogen values above the threshold at any site.

Thank you!

Photo: University of Montana