Yaak River Watershed Council 2021-2024 Water Quality Data Analysis – MSU Student Project

Authors:

Noah Barbery – MSU Undergraduate Student

Gabrielle Jawer – Extension Water Quality Research Assistant

Dr. Adam Sigler – Extension Water Quality Specialist & Assistant Professor in Land Resources and Environmental Sciences Department, MSU

December 19th, 2025

Forward 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 Gabrielle Jawer. Noah Barbery was the undergraduate student assigned to the Yaak program for the course.

This work was conducted in consultation with the Yaak Valley Forest Council representative Anthony South.

Fall 2025 was the second year of this pilot course, with the intention to produce useful data summaries for volunteer monitoring programs while simultaneously providing hands on student learning opportunities.

This work is supported by funding from Montana Department of Environmental Quality (MDEQ) and Abbie Ebert with MDEQ provided valuable comments on report drafts.

Contents

Introduction

The majority of the Yaak watershed is located in northwest Montana, near Lincoln County, with some land extending into Canada. The Yaak watershed has an area of roughly 507,660 acres, with Montana containing approximately 393,822 acres of that extent (DEQ, 2008). The Northern Rockies ecoregion encompasses the entirety of the Yaak watershed. The "modified Pacific maritime" climate of the region is characterized by both high precipitation and deep snowpack, with annual temperatures ranging between 82 and 16 degrees Fahrenheit. The tributaries of the Yaak river maintain cold temperatures year-round, providing a suitable habitat for native cutthroat trout. These tributaries feed the Yaak River, which has a historical mean monthly discharge below 500 cfs between August and February, and an average peak flow of around 3,500 cfs in the summer (DEQ, 2008).

Concern has been raised over human activity in the region threatening the Yaak River. Increased home construction as well as sedimentation from logging and road building poses a risk in increasing suspended sediment concentrations. Didymo and algae blooms have also increased throughout the Yaak watershed over the last twenty years, prompting worries regarding elevated nutrient concentrations (Yaak Valley Forest Council, 2024). Further, expanding coal mining operations in Canada's Elk River Watershed, upstream of the nearby Kootenai River, have led to elevated selenium concentrations in the Kootenai (Storb et al., 2023). In response, the Yaak Valley Forest Council (YVFC) began monitoring the Yaak River for nutrients, sediment, and selenium, with the goal of preserving natural conditions in the watershed. The YVFC established 15 sampling sites throughout the Yaak watershed, as well as five sites along the Kootenai river to contrast results.

Methods

Data Sources

The Yaak Valley Forest Council collected this report's primary data and uploaded their findings to MDEQ's MT-eWQX for storage. The data for this report was downloaded from the National Water Quality Exchange (WQX) database through the national water quality portal (US EPA, 2019). Data uploaded to the WQX database must meet rigorous quality standards and structural requirements.

This report also uses daily average discharge data from USGS stream gauge 12304500 at the Yaak River Outlet. Flow data from 2021-2024 was downloaded directly from the USGS website to compare against YVGC data collected during the study period (cite USGS website).

Data Curation and Analysis

The YVFC collected data from 20 sites over a period from 2021 to 2024. There were two monitoring events per year, one at high flow (May-June) and one at baseflow (September). Samples were submitted to the FLBS Freshwater Research Lab and analyzed for total nitrogen (TN), total phosphorus (TP), nitrate-N, total suspended solids (TSS), and selenium concentrations.

This study primarily used Excel for data plotting and analysis. A copy of the raw WQX data was stored in a worksheet and kept unaltered for the duration of this work. R statistical software was used to transform the data from the long format downloaded from WQX to crosstab format and to change non-detect values to zero and remove quality control samples (blanks and duplicates). In visual representations of this data, monitoring sites use shortened names for legibility (Figure 1). The Analysis Toolpak add-in for Excel was used for statistical analysis. All Excel files and R related files supporting this report are available through an MSU website (MSUEWQ, 2025).

Reference nutrient values and selenium standards

In addition to sunlight and temperature, the amount of nitrogen and phosphorus present in stream water are the top controls on nuisance algae growth. The concentration of nitrogen and phosphorus naturally present in streams varies by season, by ecoregion, and there is natural variability among streams within ecoregions. With increases in nitrogen and phosphorus above natural background levels, nuisance algae growth is more likely. The TN lab analyses accounts for all forms of nitrogen including particulate, dissolved organic, and dissolved inorganic forms (which includes nitrate and nitrite). Soluble forms of nitrogen and phosphorus are the more plant-available and are the most direct indicator of potential nuisance algae growth. However, these soluble forms can be taken up by algae during the growing season, masking the nutrient issue when looking only at instream soluble nutrient concentration. Nitrate-N (a soluble form of nitrogen) is interpreted relative to a 0.1 mg/L threshold identified by MDEQ as a concentration above which nuisance algae is more common (MDEQ 2013). Lab analysis and reports are for “nitrate plus nitrite as N”, but we simplify to presenting this data as simply “nitrate” in this report because nitrite concentrations are typically very low in surface water. TN and TP are interpreted relative to MDEQ observations at reference sites during growing season months (July through September) for different ecoregions (Suplee and Watson, 2013). During runoff when sediment loads are naturally higher in streams, the levels of TN and TP are also expected to be higher. It is useful to assess nutrient concentrations during different seasons and flow levels to get a full picture of nutrient loss to streams, but the high flow TN and TP

concentrations are not directly comparable to the reference site data that was only collected during July-September.

This report does not attempt to explicitly attribute nutrients in streams to specific sources. We present information about land use relative to nitrate concentration to explore the patterns for clues about possible sources, which must be followed up in more detail to accomplish source attribution. Sources of nitrogen to water can include septic systems, municipal wastewater, residential fertilizer application, farming practices, livestock operations, and industrial facilities (US EPA, 2021). Nitrate is an inorganic form of nitrogen that is dissolved and commonly reaches streams through groundwater, making it useful as an indicator of groundwater-based sources of nitrogen in some cases. Nitrate in groundwater can come from a variety of sources including septic tanks, animal waste, or farming practices (US EPA, 2021) and can also be generated from explosives used in mining operations (Dignazio, et al. 1998; Storb, et al., 2023). Phosphorus sources generally align with those listed above for nitrogen (except explosives) and are commonly tightly coupled with sediment that enters streams with soil and stream bank erosion (Novotny, 2003).

The MT DEQ selenium standard for aquatic life acute exposure is 20 µg/L and for chronic exposure is 5 µg/L (MT DEQ Circular 7). The chronic water column standard specific to the Kootenai river is 3.1 µg/L (MT DEQ, 2022). Selenium concentrations will be interpreted in relation to these thresholds.

Results

Analysis for this project focused on nutrients (TN, nitrate-N, and TP), sediment, and selenium. Mean and median concentrations are tabulated below (Table 1) and plots for each parameter group are organized in results subsections.

Table 1. Mean and median concentrations for each site.

	TN		Nitrate-Nitrite		TP		TSS		Selenium	
	mean	median	mean	median	mean	median	mean	median	mean	median
Basin Creek	0.0915	0.0841	0.0035	0.0027	0.0073	0.0042	1.1	1.1	NA	NA
North Fork Yaak River	0.0922	0.0920	0.0061	0.0037	0.0056	0.0052	2.8	1.3	0.00003	0.00004
East Fork Yaak River	0.0727	0.0743	0.0018	0.0012	0.0033	0.0033	1.3	1.3	NA	NA
West Fork Yaak River	0.0799	0.0786	0.0007	0.0000	0.0033	0.0029	0.9	0.6	0.00003	0.00004
Upper Ford Yaak River	0.0824	0.0827	0.0140	0.0109	0.0031	0.0032	1.0	0.9	0.00002	0.00003
Lap Creek	0.1173	0.1153	0.0039	0.0020	0.0090	0.0087	0.6	0.6	NA	NA
South Fork Yaak River	0.0968	0.0890	0.0020	0.0019	0.0068	0.0068	1.1	1.1	NA	NA
Pete Creek	0.0892	0.0878	0.0005	0.0000	0.0035	0.0044	0.6	0.6	0.00000	0.00000
Spread Creek	0.0752	0.0606	0.0009	0.0000	0.0027	0.0025	0.7	1.0	NA	NA
Middle Yaak River	0.0862	0.0901	0.0006	0.0000	0.0043	0.0045	1.1	1.1	NA	NA
Meadow Creek	0.0564	0.0575	0.0066	0.0040	0.0013	0.0015	0.2	0.2	NA	NA
Grizzly Creek	0.1379	0.1445	0.0637	0.0611	0.0024	0.0022	0.9	0.6	NA	NA
Burnt Creek	0.0710	0.0722	0.0083	0.0061	0.0019	0.0021	0.5	0.5	NA	NA
Lower 17-mile Creek	0.0685	0.0620	0.0003	0.0000	0.0037	0.0038	2.0	2.5	NA	NA
Yaak River Outlet	0.0841	0.0866	0.0000	0.0000	0.0034	0.003	1.1	1.0	NA	NA
Kootenai River - Riverfront Park	0.2923	0.3000	0.2023	0.2075	0.0041	0.0043	4.4	4.1	0.00104	0.001035
O'Brien Creek	0.0777	0.0759	0.0115	0.0120	0.0054	0.0048	2.7	2.9	NA	NA
Kootenai River - Roosevelt Park	0.2920	0.3225	0.1955	0.2130	0.0046	0.0040	2.5	2.5	0.00097	0.00094
Kootenai River - Kootenai Campground	0.2995	0.3110	0.2095	0.2180	0.0035	0.0036	1.3	1.2	0.00099	0.00102
Pine Creek	0.1039	0.1020	0.0013	0.0008	0.0117	0.0124	1.1	0.8	NA	NA

Total Nitrogen

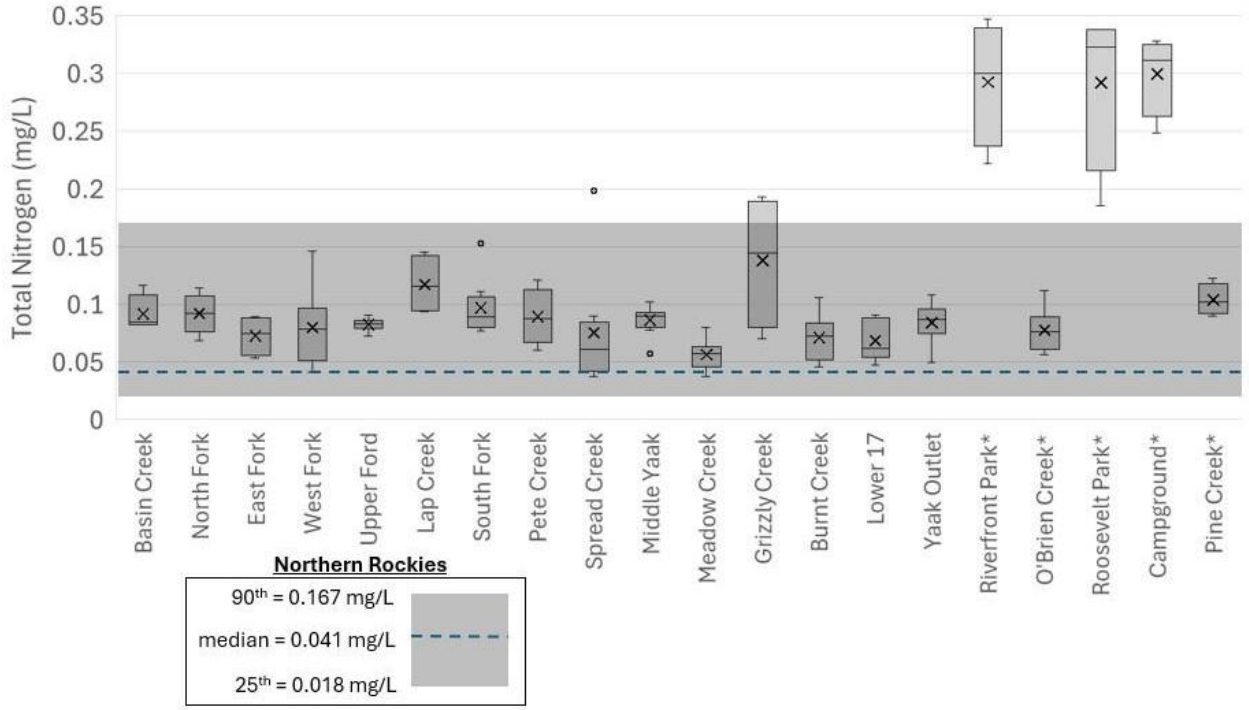

Figure 1. Total nitrogen concentrations across Yaak and Kootenai Watersheds. *Total nitrogen (TN) concentrations (mg/L, y-axis) are represented for samples collected by YVFC between June 8th, 2021 and September 16th, 2024. Sites are organized from upstream to downstream (left to right, x-axis). Sites marked with an asterisk (*) are located within the Kootenai watershed. The lines within the boxes are the median concentrations and X's are mean concentrations. Box plots follow standard notation where the box indicates the interquartile range (25th and 75th percentiles). The whiskers extend to the furthest concentration that is not classified as an outlier. The points beyond the whiskers are outliers, defined as values more than 1.5 times the interquartile range away from the box. The shaded range and dashed line are concentrations observed at reference sites within the Northern Rockies Ecoregion (Suplee and Watson, 2013; Table 3-8A). The lower extent of the shading is the 25th percentile of reference site observations, the upper extent of shading at the 90th percentile, and the dashed line is the median observed concentration at reference sites for each ecoregion.*

The range of TN concentrations across all sites is 0.037 to 0.347 mg/L (Figure 1). Three of the twenty sites (Riverfront Park, Roosevelt Park, and Kootenai Campground; all on the Kootenai River) had all concentrations above the 90th percentile of concentrations (0.167 mg/L) observed for the Northern Rockies ecoregion. The other two Kootenai river sites (O'Brien Creek and Pine Creek) are tributaries of the Kootenai river and had concentrations more similar to Yaak sites. All median TN values for the Yaak watershed sites are below the 90th percentile of concentrations observed for the Northern Rockies ecoregion. Median TN concentrations for the Yaak watershed sites range from 0.058 to 0.145 mg/L, and the

highest concentration observed for a Yaak watershed site is 0.198 mg/L at the Spread Creek site. Within the Yaak, two sites had a median concentration above 0.1 mg/L (Grizzly Creek and Lap Creek). Grizzly Creek has both the highest median TN concentration (0.145 mg/L) and highest variability (0.07 to 0.19 mg/L) among Yaak watershed sites.

Total nitrogen concentration in the Yaak River Outlet has a positive relationship with discharge, but the relationship is weak ($p = 0.10$). On June 16th 2023, the total nitrogen concentration was 0.108 mg/L at 767 cfs flow and on September 18th 2023, when flow had returned to baseflow conditions (84 cfs), TN concentration was 0.074 mg/L. Similar relationships appear between each year's pair of points. Nitrate-N was not detected (<0.002 mg/L) in any samples collected by YVFC at the Yaak outlet site.

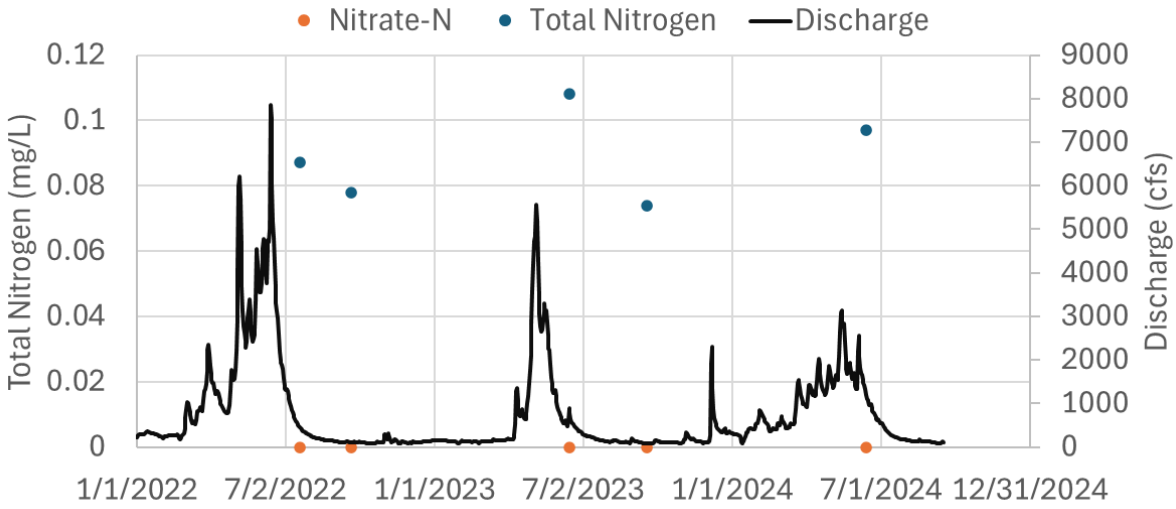

Figure 2: Scatterplot comparison between total nitrogen concentration and discharge at the Yaak River Outlet. *Total nitrogen concentrations and nitrate-N concentrations (left y-axis) are represented for samples collected by YVFC between 2021 and 2023, downloaded from WQX. Discharge (right Y axis) is represented for data collected by the Yaak River Outlet USGS stream gauge, downloaded from USGS. Points representing total nitrogen concentration (blue) and nitrate-nitrite concentration (orange) are distinguished by color. The black line represents discharge from the Yaak River Outlet.*

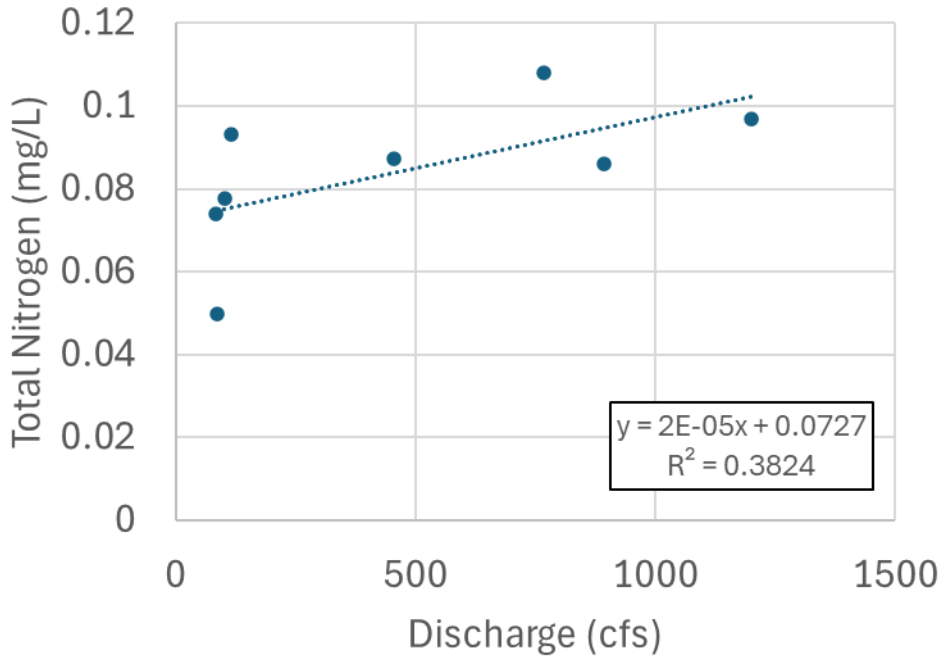

Figure 3: Total Nitrogen Regression at Yaak River Outlet: *Total nitrogen concentrations (y-axis) are represented for samples collected by YVFC between 2021 and 2023, downloaded from WQX. Discharge (x-axis) is represented for data collected by the Yaak River Outlet USGS stream gauge, downloaded from USGS. Points represent total nitrogen at given discharge values. The dashed line represents the relationship between total nitrogen concentration and discharge with relationship and r^2 on on the plot (p = 0.10).*

Nitrate

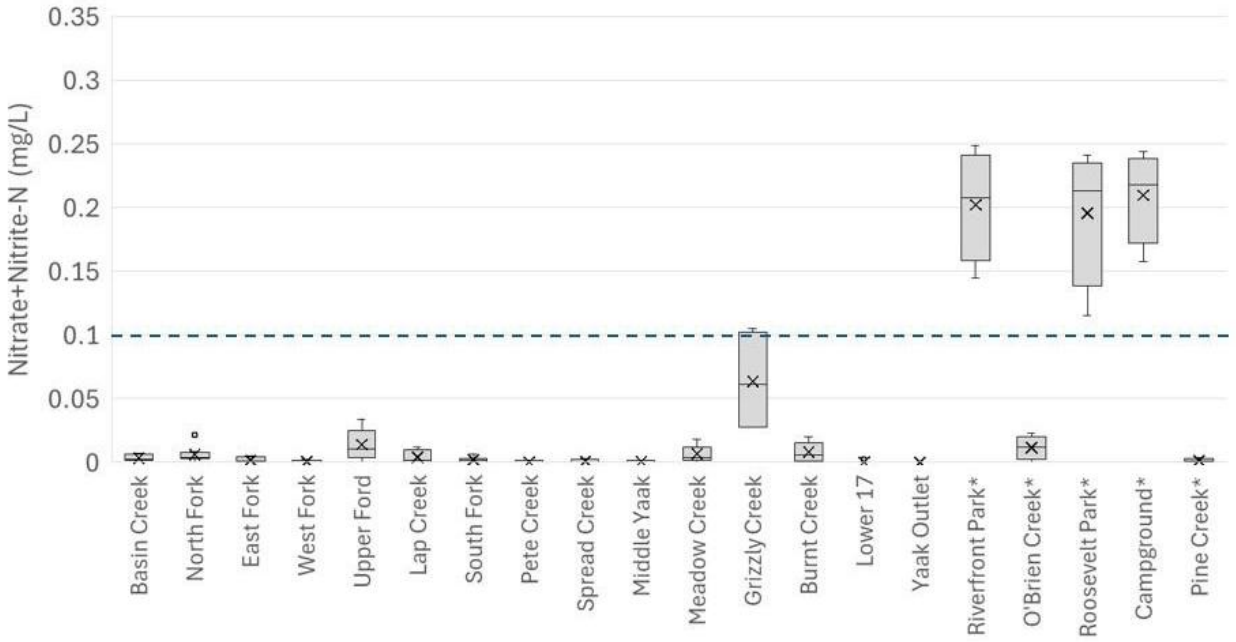

Figure 4: Nitrate concentrations across Yaak and Kootenai watersheds. *Nitrate-N concentrations (y-axis) are represented for samples collected by YVFC between June 8th, 2021 and September 16th, 2024. Sites are organized from upstream to downstream (left to right), on the x-axis. Sites marked with an asterisk (*) are located within the Kootenai watershed. The horizontal line is the nitrate threshold of 0.1 mg/L, from MT DEQ memorandum (MTDEQ, 2013). The X's within the boxes are the mean and the lines are the median concentrations. Boxplots follow standard notation where the box indicates the interquartile range (25th and 75th percentiles). The whiskers extend to the furthest concentration that is not classified as an outlier. The points beyond the whiskers are outliers, defined as values more than 1.5 times the interquartile range away from the box.*

The range of nitrate-N concentrations across all sites is non-detect (< 0.0015) to 0.249 mg/L (Figure 4). Median nitrate-N concentrations for the Yaak watershed sites range from non-detect (< 0.0015) to 0.061 mg/L and the highest concentration observed for a Yaak watershed site is 0.105 mg/L at the Grizzly Creek site. Grizzly Creek has the highest observed median nitrate-N concentration of 0.061 mg/L. Amongst the Yaak watershed sites the variability in concentration is also the highest at Grizzly Creek. The three sites along the main stem of the Kootenai River (Riverfront Park, Roosevelt Park, and Kootenai Campground) exhibit the highest observed median nitrate-N concentrations ranging from 0.21 to 0.22 mg/L. The other two Kootenai river sites (O'Brien Creek and Pine Creek) are tributaries of the Kootenai river. The median nitrate-N concentrations for these sites are in line with the Yaak watershed sites.

Total Phosphorus

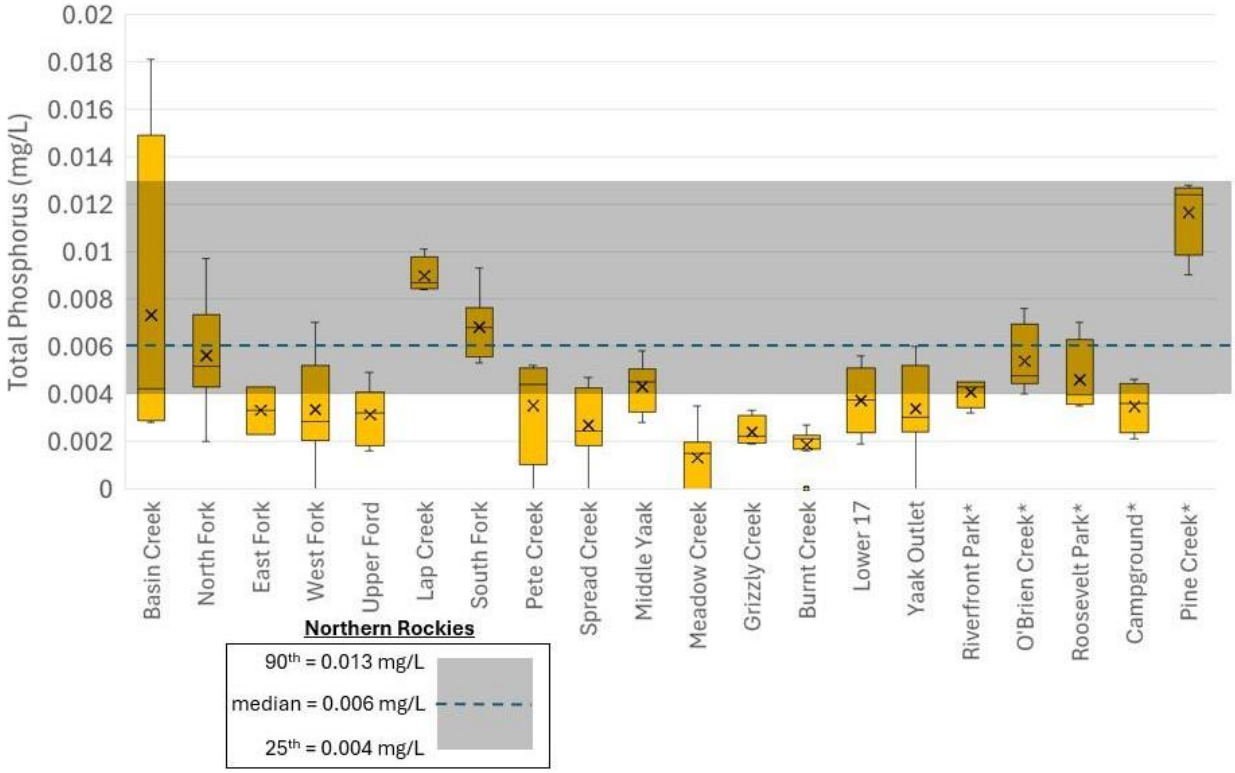

Figure 5: Total phosphorus concentrations across Yaak and Kootenai watersheds. *Total phosphorus (TP) concentrations (mg/L, y-axis) are represented for samples collected by YVFC between June 8th, 2021 and September 16th, 2024. Sites are organized from upstream to downstream (left to right, x-axis). The lines within the boxes are the median concentrations and X's are mean concentrations. Box plots follow standard notation where the box indicates the interquartile range (25th and 75th percentiles). The whiskers extend to the furthest concentration that is not classified as an outlier. The points beyond the whiskers are outliers, defined as values more than 1.5 times the interquartile range away from the box. The shaded range and dashed line are concentrations observed at reference sites within the Northern Rockies Ecoregion (Suplee and Watson, 2013; Table 3-8A). The lower extent of the shading is the 25th percentile of reference site observations, the upper extent of shading at the 90th percentile, and the dashed line is the median observed concentration at reference sites for each ecoregion.*

The range of TP concentrations across all sites is <0.0015 to 0.0181 mg/L (Figure 5). None of the twenty sites had median TP values above the 90th percentile of concentrations (0.013 mg/L) observed for the Northern Rockies ecoregion. Median TP concentrations for Yaak watershed sites range from 0.002 to 0.009 mg/L and the highest concentration observed for a Yaak watershed site is 0.018 mg/L at the Basin Creek site on September 15th, 2024. The median TP concentration for Basin Creek is 0.004 mg/L, but it exhibits the highest variability in concentration amongst the Yaak watershed sites (0.003 to 0.02 mg/L). The highest observed median TP concentration was 0.012 mg/L at the Pine Creek site in the Kootenai watershed on September 16th, 2024.

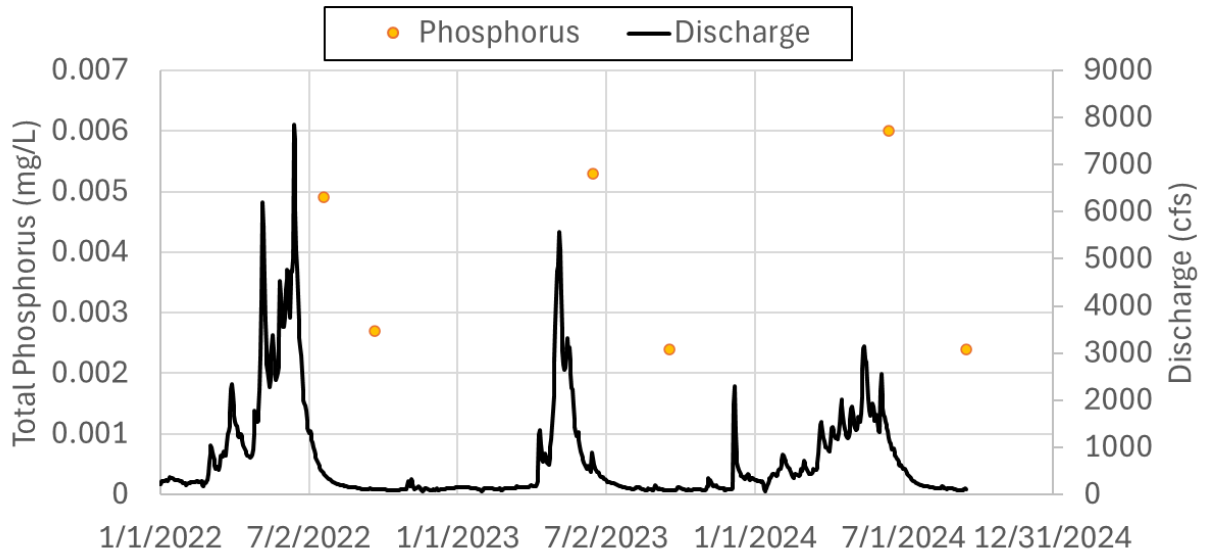

Figure 6: Scatterplot comparison between total phosphorus concentration and discharge at the Yaak River Outlet: *Total phosphorus concentrations (mg/L) (y-axis 1) are represented for samples collected by YVFC between 2021 and 2023, downloaded from WQX. Discharge (cfs) (y-axis 2) is represented for data collected by the Yaak River Outlet USGS stream gauge, downloaded from USGS. The orange points on the graph showcase total phosphorus concentration. The black line represents discharge from the Yaak River Outlet.*

Total phosphorus concentration in the Yaak River Outlet demonstrated a positive relationship with discharge ($p = 0.022$). 61% of the variability in total nitrogen can be predicted by discharge ($p=0.022$). This mobilization pattern indicates high flows move higher concentrations of total phosphorus. On June 16th, 2023 the total phosphorus concentration was 0.0053 mg/L at a flow of 767 cfs. This sample was collected soon after the river experienced peak flow, and discharge was still elevated compared to base flow conditions. The sample collected on September 18th, 2023 when flow (84 cfs) had leveled out, showed a total phosphorus concentration of 0.0024 mg/L. Similar relationships appear between the pairs of points from each year.

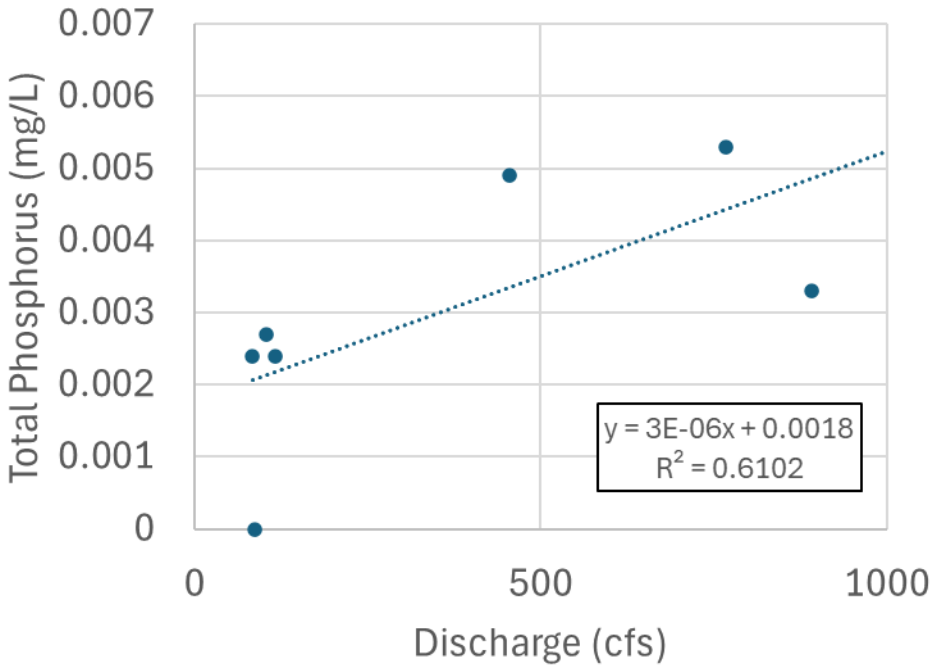

Figure 7: Total Phosphorus Regression at Yaak River Outlet: *Total phosphorus concentrations (y-axis) are represented for samples collected by YVFC between 2021 and 2023, downloaded from WQX. Discharge (x-axis) is represented for data collected by the Yaak River Outlet USGS stream gauge, downloaded from USGS. Points represent total phosphorus at given discharge values. The dashed line represents the relationship between total nitrogen concentration and discharge.*

Total Suspended Solids

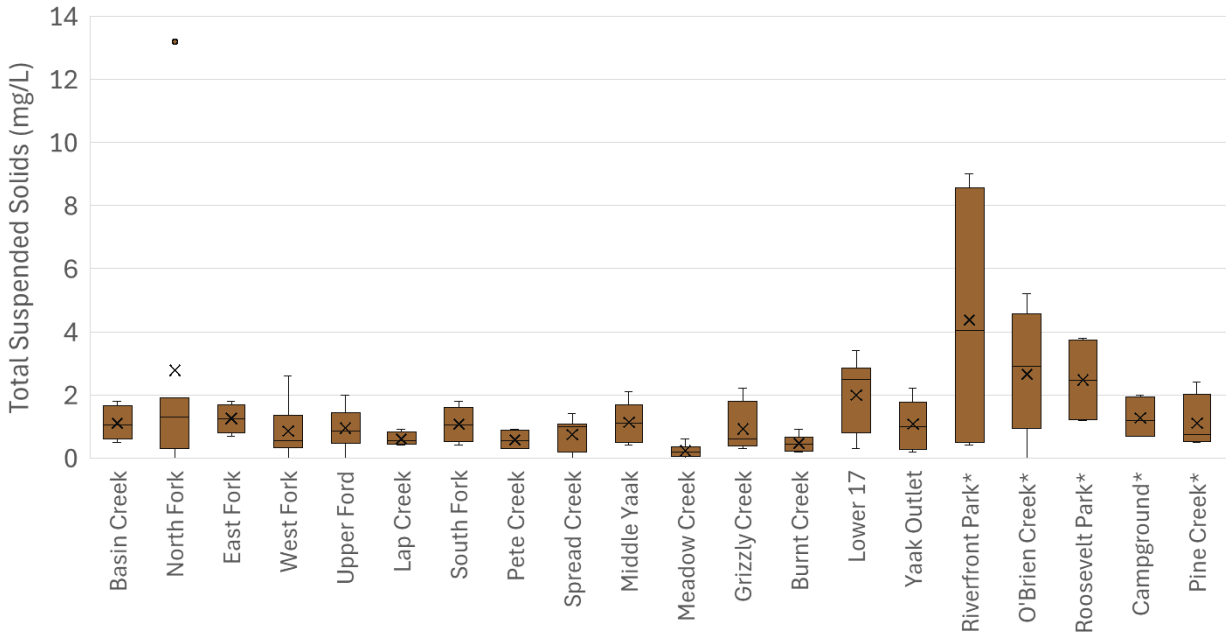

Figure 8: Total suspended solids concentrations across Yaak and Kootenai watersheds. *Total suspended solids concentrations (y-axis) are represented for samples collected by YVFC between 2021 and 2023, downloaded from WQX. Sites are organized from upstream to downstream (left to right), on the x-axis. Sites marked with an asterisk (*) are located within the Kootenai watershed. The X's within the boxes are the mean and the lines are the median concentrations. Boxplots follow standard notation where the box indicates the interquartile range (25th and 75th percentiles). The whiskers extend to the furthest concentration that is not classified as an outlier. The points beyond the whiskers are outliers, defined as values more than 1.5 times the interquartile range away from the box.*

The range of TSS concentrations across all sites is non-detect (< 0.2) to 13.2 mg/L (Figure 8). Median TSS concentrations for the Yaak watershed sites range from 0.2 to 2.5 mg/L and the highest concentration observed for a Yaak watershed site is 13.2 mg/L at the North Fork site on June 12th, 2024. North Fork has a mean TSS concentration of 2.79 mg/L, which is above its interquartile range due to the outlier high concentration of 13.2 mg/L. Two sites in the Kootenai watershed (Riverfront Park, O'Brien Creek) exhibit the highest observed median TSS concentrations. The median TSS concentration is 4.05 mg/L for the site at Riverfront Park, and 2.90 mg/L for the site at O'Brien Creek. TSS concentrations decrease progressively for downstream sites in the Kootenai watershed. O'Brien Creek, a tributary of the Kootenai River, exhibits a higher median TSS concentration than downstream sites on the main stem of the river. There is a positive relationship between TSS (mg/l) and discharge (cfs) at the Yaak River Outlet. 60% of the variability in total nitrogen can be predicted by discharge (p-value= 0.025). This mobilization pattern indicates high flows move more TSS.

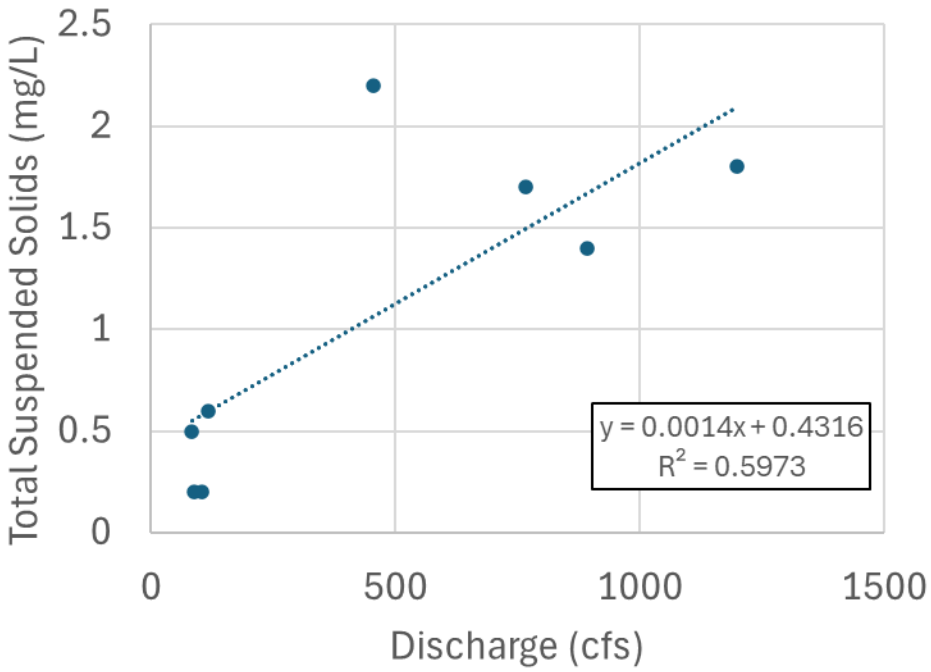

Figure 9: Total Suspended Solids Regression at Yaak River Outlet: *TSS concentrations (y-axis) are represented for samples collected by YVFC between 2021 and 2023, downloaded from WQX. Discharge (x-axis) is represented for data collected by the Yaak River Outlet USGS stream gauge, downloaded from USGS. Points represent TSS concentrations at given discharge values. The dashed line represents the relationship between total nitrogen concentration and discharge.*

Selenium

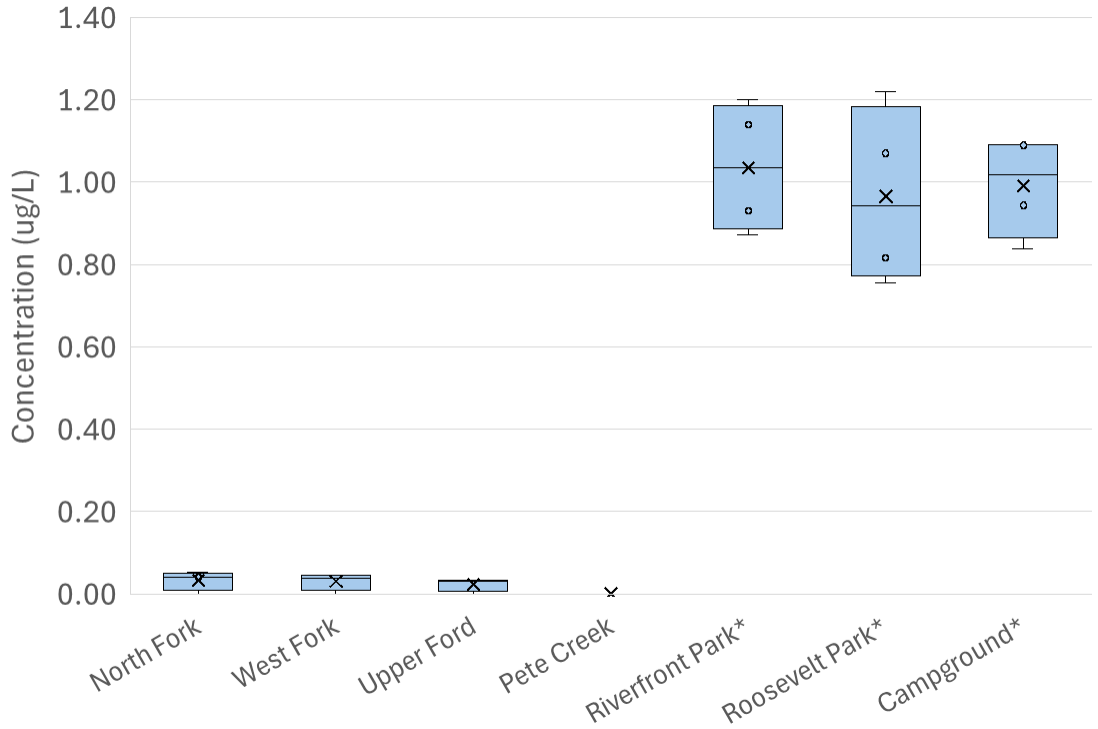

Figure 10: Boxplot of selenium concentrations organized by site order. *Total suspended solids concentrations (µg/L) (y-axis) are represented for samples collected by YVFC between 2021 and 2023, downloaded from WQX. Sites are organized from upstream to downstream (left to right), on the x-axis. Sites marked with an asterisk (*) are located within the Kootenai watershed. The X's within the boxes are the mean and the lines are the median concentrations. Boxplots follow standard notation where the box indicates the interquartile range (25th and 75th percentiles). The whiskers extend to the furthest concentration that is not classified as an outlier. The points beyond the whiskers are outliers, defined as values more than 1.5 times the interquartile range away from the box. Several measurements were j-flagged as between MDL and LRL** The MDEQ selenium standard for aquatic life acute exposure is 20 µg/L, for chronic exposure is 5 µg/L (DEQ Circular 7), and 3.1 µg/L for the Kootenai River specifically (MT DEQ, 2022)are all far higher than observed concentrations and off the top of this plot.*

Selenium concentrations across all sites ranged from non-detect (< 0.051) to 1.4 µg/L (Figure 10). Median selenium concentrations for the Yaak watershed sites range from non-detect (< 0.051) to 0.041 µg/L. Concentrations decrease marginally between sites as they move farther downstream. The only measurement conducted for the Pete Creek site yielded a selenium concentration of < 0.051 µg/L. The three sites from the Kootenai watershed (Riverfront Park, Roosevelt Park, Kootenai Campground) exhibit the highest observed median selenium concentrations. The median selenium concentration is 1.04 µg/L for the site at Riverfront Park, 0.94 µg/L for the site at Roosevelt Park, and 1.02 mg/L for the site at Kootenai Campground.

Discussion

Nitrogen

The sites on the Kootenai river were selected by YVFC to contrast those on the Yaak river. All three sites along the main stem of the Kootenai had median TN concentrations that are above 0.167 mg/L, the 90th percentile of observed concentrations for the Northern Rockies Ecoregion (Suplee and Watson, 2013). Median nitrate-N concentrations were also high, exceeding the threshold of 0.1 mg/L above which nuisance algae levels are more likely (MT DEQ, 2013). However, the tributaries of the Kootenai, O'Brien Creek and Pine Creek, do not have median TN concentrations that exceed the 90th percentile, and their nitrate-N concentrations are below the threshold of 0.1 mg/L. Previous studies in the region revealed that the elevated TN concentrations on the mainstem Kootenai could be caused by use of explosives in mining operations upstream in Canada (Storb et al., 2023).

TN concentrations in the Yaak watershed were lower than those observed from the sites along the mainstem of the Kootenai (Figure 1). None of the sites in the Yaak watershed had median TN concentrations above the 90th percentile of 0.167 mg/L. Median nitrate-N concentrations were also below 0.1 mg/L. However, every site in the Yaak watershed recorded median TN concentrations higher than the median of 0.041 mg/L observed at reference sites for the Northern Rockies Ecoregion (Suplee and Watson, 2013).

The site at Grizzly Creek exhibited the highest median TN concentrations, and 25% of the observations were higher than the 90th percentile of observations at reference sites (Suplee and Watson, 2013). YVFC has not identified any obvious human sources of nitrogen to Grizzly Creek that would set it apart from the other tributaries, raising questions about whether differences in geologic parent material or ecosystem function could be resulting in the higher TN values relative to other tributaries.

At the Yaak River outlet, TN dynamics with streamflow showed a positive correlation, which is expected when particulate nitrogen is the primary form present. While TN concentrations were generally higher at higher flows, (Figure 2), the relationship was not strong (Figure 3; $p = 0.10$), but this is likely due to a limited number of datapoints.

TN data included in Figure 1 includes data from high flows, while data from reference sites for comparison was only collected during growing season months (July – September). With higher TN values expected at higher flows, Yaak values are not directly comparable to reference site data from Suplee and Watson (2013). Even so, for most Yaak sites all data is above the Northern Rockies median value, so the Yaak sites do seem to have higher TN than most reference sites.

Phosphorus

In contrast to TN, median TP concentrations across the sites on the mainstem of the Kootenai were not above the median of 0.006 mg/L typical of the Northern Rockies Ecoregion (Suplee and Watson, 2013). The only Kootenai site that had a median TP concentration higher than 0.006 mg/L was Pine Creek (Figure 5). The median TP concentration at the Pine Creek site was 0.012 mg/L, which, while double the ecoregional median, still falls below the 90th percentile of 0.013 mg/L for the ecoregion (Suplee and Watson, 2013).

Ten of the fifteen sites within the Yaak watershed had median TP concentrations lower than the 25th percentile of 0.004 mg/L. Two sites, the North Fork and Middle Yaak, exhibited median TP concentrations higher than the 25th percentile, but lower than the median concentration typical of the ecoregion (Figure 5). The sites at Basin Creek, Lap Creek, and the South Fork all had median TP concentrations higher than the ecoregional median, but some of this is likely attributable to inclusion of high flow TP values where higher concentrations are expected. In general, phosphorus levels trend toward lower than reference sites for the ecoregion, which stands in contrast to the nitrogen values that trend toward the higher end of reference sites.

At the Yaak River Outlet, TP concentrations have a typical positive relationship with streamflow. Data collected in September shows lower TP concentrations compared to those recorded following peak flow conditions (Figure 6). Regression analysis also revealed a statistically significant correlation between TP concentration and streamflow. About 60% of variation in TP concentration could be explained by streamflow, with a p-value of 0.0221 (Figure 7).

Total Suspended Solids

The sampling sites in the Kootenai watershed showed higher TSS concentrations than the Yaak watershed sites. The site at Riverfront Park is on the mainstem of the Kootenai and is the most upstream of the Kootenai sampling sites. Riverfront Park recorded a median TSS concentration of 4.05 mg/L, along with high variability between points. TSS concentrations progressively decrease downstream from Riverfront Park, eventually lowering to 1.1 mg/L at Pine Creek (Figure 8). All of these observed TSS concentrations are relatively low, which is expected for relatively pristine sites sampled outside peak flow periods. TSS concentrations did increase with elevated discharge, similar to TP and TN. The regression between TSS and discharge revealed a positive relationship with a p-value of 0.0245. Statistical analysis indicated that discharge is responsible for 57% of TSS variability.

Selenium

The MT DEQ Circular 7 outlines selenium thresholds of 5 µg/L for chronic aquatic life exposure and 20 µg/L for acute aquatic life exposure (MT DEQ, 2019). The threshold for the water column in the Kootenai is 3.1 µg/L, lower than both DEQ thresholds. Median selenium concentrations for the three Kootenai sampling sites ranged from 0.97 µg/L to 1.04 µg/L (Figure 10), and all observed concentrations were below all three relevant selenium thresholds. In the Yaak, selenium values were lower than in the Kootenai with values ranging from non-detect values to 0.031µg/L. The elevated concentrations on the Kootenai are known to be derived from use of explosives associated with mining upstream in Canada (Storb et al., 2023) and these impacts are not present in the Yaak.

Conclusions

The Yaak watershed has generally low levels of nutrients, sediment, and selenium. Median concentrations of selenium and nitrate do not exceed thresholds dictated by the DEQ, and parameters like TN and TP fall between ranges expected of the Northern Rockies ecoregion. Nitrogen patterns in the Yaak are on the high side of concentrations observed for reference sites, which raises interesting questions about likely explanations in a relatively pristine watershed. Grizzly Creek demonstrated the highest TN and nitrate-N concentrations in comparison to the rest of the Yaak watershed, suggesting this watershed could be of specific interest for investigating possible explanations for nitrogen sources and dynamics. The positive relationships observed between streamflow and TN, TP, and TSS are characteristic of a snowmelt-driven watershed like the Yaak but these flow dependent patterns should be considered if follow up work on nitrogen sources is conducted.

The strategy to collect data during one relatively high flow period and one relatively low flow period is great for getting a sense for flow related controls on nutrient concentrations. If more detailed understanding of nutrient dynamics is pursued, it could be useful to identify a few sites for more regular sampling and to consider some form of flow monitoring at those sites. Continued data collection at consistent locations will help facilitate longer term assessment of nutrient concentrations relative to changes in climate, which is one stated goal of the YVFC.

References

Montana Department of Environmental Quality. (2008). *Yaak River Watershed: Sediment total maximum daily loads (TMDL)* (Publication No. K03-TMDL-01a). Montana Department of Environmental Quality.

Montana Department of Environmental Quality. (2019). *Circular DEQ-7: Montana numeric water quality standards*. Helena, MT: Montana Dept. of Environmental Quality.

Montana Department of Environmental Quality. (2022). *ARM 17.30.632: Selenium standards for Lake Koocanusa and the Kootenai River* [Administrative rule]. Montana Administrative Rules. https://archive.legmt.gov/content/Committees/Interim/2021-2022/Water-Policy/Jan2022/ARM-17-30-632-Selenium.pdf

Suplee, M. W., & Watson, V. (2013). Scientific and technical basis of the numeric nutrient criteria for Montana's wadeable streams and rivers: Update 1. Montana Department of Environmental Quality.