

Water chemistry of salmon-bearing streams and floodplain wetlands in the North Thompson River watershed

Julian C.L. Gan, Sean M. Naman, Glenn S. Block, Douglas C. Braun, Amanda M. Martens, Daniella LoScerbo, Sarah M. Hnytka, Kara J. Pitman, Lindsey Boyd

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TABLE OF CONTENTS

LIST OF FIGURES.....	iv
LIST OF TABLES.....	v
PREFACE	vii
ABSTRACT	viii
RÉSUMÉ.....	ix
1.0 INTRODUCTION	1
2.0 METHODS.....	2
2.1 STUDY AREA.....	2
2.2 FIELD SAMPLING	6
2.3 SPATIAL ANALYSIS.....	7
2.3.1 Bedrock lithology	8
2.3.2 Land use	10
2.4 LABORATORY ANALYSES.....	10
2.5 DATA PREPARATION AND ANALYSIS.....	11
3.0 RESULTS	14
3.1 GENERAL CHEMICAL RELATIONSHIPS.....	15
3.2 PRINCIPAL COMPONENT ANALYSIS (PCA).....	19
3.3 REDUNDANCY ANALYSIS (RDA)	20
3.4 VARIANCE PARTITIONING	24
3.5 UNIVARIATE TRENDS.....	24
4.0 DISCUSSION	25
5.0 ACKNOWLEDGEMENTS.....	29
6.0 REFERENCES.....	30
APPENDICES	37

LIST OF FIGURES

Figure 1. Stream and wetland sampling locations in the North Thompson watershed. Highlighted tributaries denote the specific streams sampled.....	4
Figure 2. Reclassified bedrock lithology map of the North Thompson River watershed. Coloured polygons represent the six simplified lithological groupings constrained within the boundaries of the catchment area. Base geological data were derived from the British Columbia Digital Geology dataset (Cui et al. 2017).....	10
Figure 3. Mean water chemistry measurements from tributary streams in the North Thompson River watershed (2022–2024). Sites are arranged in increasing latitude. Error bars represent ± 1 standard error from the mean.....	16
Figure 4. Mean water chemistry measurements from wetland sites in the North Thompson River watershed, (2022–2024). Sites are arranged in increasing latitude. Error bars represent ± 1 standard error from the mean.....	17
Figure 5. Spearman’s rank correlation matrix of water chemistry variables from stream sites in the North Thompson watershed (2022–2024). Blue circles indicate positive correlations; red circles indicate negative correlations. The size and colour intensity of the circle are proportional to the correlation coefficient, ρ	18
Figure 6. Spearman’s rank correlation matrix of water chemistry variables from wetland sites in the North Thompson watershed (2022–2024). Blue circles indicate positive correlations; red circles indicate negative correlations. The size and colour intensity of the circle are proportional to the correlation coefficient, ρ	19
Figure 7. Principal component analysis (PCA) of water chemistry metrics for sites in the North Thompson watershed (2022–2024). (A) Ordination plot displaying vectors for water chemistry variables (solid black arrows) and passively projected site-level environmental attributes (dashed red arrows). (B) Site ordination scores coloured by habitat type. The percentage of variance explained by each principal component is indicated on the axes.	20
Figure 8. Redundancy Analysis (RDA) triplot for North Thompson stream sites. Grey points represent individual site-date observations. Red text indicates response variables (water chemistry parameters). Blue arrows represent environmental predictors selected via <i>a priori</i> hypotheses. Predictors include isometric log-ratio (ILR) balances of lithology (e.g., <i>crys_v_sed</i> , <i>mafic_v_felsic_int</i>), land use percentages (<i>For_10Yrs_pct</i> , <i>Agr_pct</i>), and temporal factors (months).	22
Figure 9. Redundancy Analysis (RDA) triplot for North Thompson wetland sites. Grey points represent individual site-date observations. Red text indicates response variables (water chemistry species). Blue arrows represent environmental predictors selected via <i>a priori</i> hypotheses. Predictors include isometric log-ratio (ILR) balances of lithology (e.g., <i>crys_v_sed</i> , <i>mafic_v_felsic_int</i>), land use percentages (<i>For_10Yrs_pct</i> , <i>Agr_pct</i>), and temporal factors (months).	23

Figure 10. Variance partitioning analysis (VPA) for stream (left) and wetland (right) water chemistry. Values represent the percentage of adjusted variance (<i>Radj2</i>) explained uniquely by lithology (blue), land use (green), and shared between both predictor sets (intersection). “Residuals” indicate the percentage of variance not explained by the selected predictors.	24
Figure A1.1 Sampling schedule for all stream (blue) and wetland (green) sites from 2022-2024.	37

LIST OF TABLES

Table 1 Stream and wetland sampling locations in the North Thompson watershed. Sites are arranged in order of descending latitude.	5
Table 2. Water quality and chemistry parameters measured at each sampling site, with analytical units and detection limits for laboratory analyses and accuracy specifications for field instruments.	6
Table 3. Catchment delineation methods for wetland sampling sites. “FWA” = wetland polygon sources from BC Freshwater Atlas; “50 m buffer” = manually applied boundary used where no FWA polygon was available.	8
Table 4. Sequential Binary Partition structure and associated geochemical hypotheses for lithological predictors of surface water chemistry patterns in the North Thompson watershed.....	12
Table A1.1. Catchment size and bedrock lithological composition as determined from the Freshwater Atlas and BC Digital Geology, respectively, for tributary streams in the North Thompson River watershed.....	38
Table A1.2. Catchment size and bedrock lithological composition as determined from the Freshwater Atlas and BC Digital Geology, respectively, for floodplain wetlands in the North Thompson River watershed.....	42
Table A1.3. Catchment characteristics for stream sites in the North Thompson watershed. Lithology values represent the proportional composition of the catchment area. Land use values represent the percentage of the total watershed area affected by agricultural development and forestry activities (historic and recent).	43
Table A1.4. Catchment characteristics for wetland sites in the North Thompson watershed. Lithology values represent the proportional composition of the catchment area. Land use values represent the percentage of the total watershed area affected by agricultural development and forestry activities (historic and recent).	44
Table A3.1. Albreda River monthly water quality and chemistry.....	46
Table A3.2. Barriere River monthly water quality and chemistry.	47
Table A3.3. Cedar Creek monthly water quality and chemistry.	48

Table A3.4. Chuck Creek monthly water quality and chemistry.	49
Table A3.5. Cook Creek monthly water quality and chemistry.	50
Table A3.6. Darlington Creek monthly water quality and chemistry.	50
Table A3.7. Dora Creek monthly water quality and chemistry.	51
Table A3.8. East Barriere River monthly water quality and chemistry.	51
Table A3.9. Haggard Creek monthly water quality and chemistry.	52
Table A3.10. Jamieson Creek monthly water quality and chemistry.	53
Table A3.11. Lemieux Creek monthly water quality and chemistry.	54
Table A3.12. Lindquist Creek monthly water quality and chemistry.	55
Table A3.13. Louis Creek monthly water quality and chemistry.	56
Table A3.14. Reg Christie Creek monthly water quality and chemistry.	57
Table A3.15. Shannon Creek monthly water quality and chemistry.	58
Table A3.16. Tumtum Creek monthly water quality and chemistry.	59
Table A4.1. Barriere Wetland monthly water quality and chemistry.	60
Table A4.2. Cook Wetland monthly water quality and chemistry.	61
Table A4.3. Goose Wetland monthly water quality and chemistry.	62
Table A4.4. Little Fort Wetland monthly water quality and chemistry.	62
Table A4.5. Lost Creek Wetland km9 monthly water quality and chemistry.	63
Table A4.6. Miledge Wetland monthly water quality and chemistry.	64
Table A4.7. Northwest Finn Wetland monthly water quality and chemistry.	64
Table A4.8. Pyramid Wetland monthly water quality and chemistry.	65
Table A4.9. Stillwater Wetland monthly water quality and chemistry.	66
Table A4.10. Struggle Puddle Wetland monthly water quality and chemistry.	67
Table A4.11. Tumtum Wetland monthly water quality and chemistry.	68
Table A4.12. Wirecache Wetland monthly water quality and chemistry.	68

PREFACE

This report is part of the North Thompson Salmon Ecosystem Research Program, which focuses on Interior Fraser coho salmon (*O. kisutch*) in the North Thompson watershed. The broad program aims to: (1) identify important juvenile Pacific salmon habitat and areas; (2) understand how those habitats and areas contribute to Pacific salmon productivity; and (3) investigate how human activities impact Pacific salmon and their ecosystems. Studies within the program investigate numerous ecosystem components ranging from physical habitat and hydrology to fish. Subsequent reports will focus on these other components and provide a more thorough overview of the broader program context.

ABSTRACT

Gan, J.C.L., Naman, S.M., Block, G.S., Braun, D.C., Martens, A.M., LoScerbo, D., Hnytka, S.M., Pitman, K.J., Boyd, L. 2026. Water chemistry of salmon-bearing streams and floodplain wetlands in the North Thompson River watershed. Can. Tech. Rep. Fish. Aquat. Sci. 3808: ix + 80 p. <https://doi.org/10.60825/vssy-ck38>

Water chemistry is foundational to aquatic ecosystems, influencing basal productivity and habitat quality for Pacific salmon (*Oncorhynchus spp.*). To establish baselines for the North Thompson River watershed, we profiled physicochemical water parameters (hereafter “water chemistry”) across 16 tributary streams and 12 floodplain wetlands from 2022 to 2024, analyzing major ions, nutrients, electrical conductivity, pH, and turbidity. We employed redundancy and variance partitioning analyses to assess the relative influence of catchment lithology and anthropogenic land use (forestry and agriculture) on observed chemical profiles. Stream chemistry was moderately correlated with lithological composition; catchments underlain by weatherable sedimentary and mafic units exhibited higher ionic concentrations than those with resistant felsic, crystalline bedrock. While land use correlated with elevated nutrients in streams, their combined influence with lithology explained more variation than either factor alone. This high spatial collinearity suggests land use impacts are closely coupled with more reactive geology, confounding the isolation of individual anthropogenic drivers. Conversely, shared variance was minor in floodplain wetlands, where chemistry was largely decoupled from landscape-scale drivers, and exhibited high spatiotemporal variability. Distinct nitrogen dynamics in wetlands, specifically low nitrate and elevated ammonia, likely indicate localized biogeochemical processing and hypoxic conditions driven by seasonal variability in flooding and primary productivity. Collectively, these findings establish a regional baseline for ecosystem monitoring and highlight the importance of integrating geological context and habitat-specific dynamics into the management and protection of salmonid habitats in mixed-use watersheds.

RÉSUMÉ

Gan, J.C.L., Naman, S.M., Block, G.S., Braun, D.C., Martens, A.M., LoScerbo, D., Hnytka, S.M., Pitman, K.J., Boyd, L. 2026. Water chemistry of salmon-bearing streams and floodplain wetlands in the North Thompson River watershed. Can. Tech. Rep. Fish. Aquat. Sci. 3808: ix + 80 p. <https://doi.org/10.60825/vssy-ck38>

La chimie de l'eau est fondamentale pour les écosystèmes aquatiques, influençant la productivité basale et la qualité de l'habitat du saumon du Pacifique (*Oncorhynchus* spp.). Afin d'établir des valeurs de référence pour le bassin versant de la rivière North Thompson, nous avons analysé les paramètres physico-chimiques de l'eau (ci-après « chimie de l'eau ») de 16 affluents et de 12 zones humides de plaine inondable de 2022 à 2024, en étudiant les principaux ions, les nutriments, la conductivité électrique, le pH et la turbidité. Nous avons utilisé des analyses de redondance et de partitionnement de la variance pour évaluer l'influence relative de la lithologie du bassin versant et de l'utilisation anthropique des terres (foresterie et agriculture) sur les profils chimiques observés. La chimie des cours d'eau était modérément corrélée à la composition lithologique ; les bassins versants reposant sur des unités sédimentaires et mafiques altérables présentaient des concentrations ioniques plus élevées que ceux reposant sur un substrat rocheux felsique et cristallin résistant. Bien que l'utilisation des terres soit corrélée à des concentrations élevées de nutriments dans les cours d'eau, leur influence combinée avec la lithologie expliquait une plus grande part de la variation que chaque facteur pris isolément. Cette forte colinéarité spatiale suggère que les impacts de l'utilisation des terres sont étroitement liés à une géologie plus réactive, ce qui rend difficile l'isolement des facteurs anthropiques individuels. À l'inverse, la variance partagée était faible dans les milieux humides des plaines inondables, où la chimie était largement découplée des facteurs à l'échelle du paysage et présentait une forte variabilité spatio-temporelle. La dynamique distincte de l'azote dans les milieux humides, en particulier la faible concentration de nitrate et la concentration élevée d'ammoniac, indique probablement des processus biogéochimiques localisés et des conditions hypoxiques induites par la variabilité saisonnière des inondations et de la productivité primaire. Collectivement, ces résultats établissent une base de référence régionale pour la surveillance des écosystèmes et soulignent l'importance d'intégrer le contexte géologique et la dynamique propre à l'habitat dans la gestion et la protection des habitats des salmonidés dans les bassins versants à usages mixtes.

1.0 INTRODUCTION

Water chemistry, defined here as the physical and chemical characteristics of water, strongly shapes aquatic ecosystems. Water chemistry is foundational in aquatic systems, influencing basal productivity, food web stability (Miltner et al. 1998; Layer et al. 2010; Hogsden and Harding 2012; Lapworth et al. 2013), and the capacity of habitats to support highly valued taxa like Pacific salmon (*Oncorhynchus* spp.). (Rosenfeld et al. 2024). Physical and chemical parameters (e.g., conductivity, pH, and ion concentrations) are frequently used as indicators of ecosystem condition and to assess the impacts of anthropogenic activities (Bolstad and Swank 1997; Feller 2005). The utility of this approach requires an understanding of baseline variation in water chemistry. This may be substantial in large watersheds, which are spatially complex habitat mosaics, influenced by dynamic interactions among larger rivers and their floodplains, tributary stream networks, and upland catchment characteristics (Ward et al. 2002; Stanford et al. 2005; Eloegi et al. 2010).

Surface water chemistry across watersheds is shaped by the interplay between natural landscape features such as catchment lithology and anthropogenic land use (Johnson et al. 1997; Allan 2004; Xie et al. 2005). Catchment lithology determines the makeup of solute loads; for example, streams with more weatherable and reactive bedrock material (e.g., sedimentary and mafic lithology) often yield distinct ionic signatures and higher nutrient concentrations compared to streams with more resistant crystalline formations (Gibbs 1970; Meybeck 1987; Olson and Hawkins 2012). Anthropogenic land use is often superimposed on these geological gradients. Activities such as forestry and agriculture can add external material (e.g., fertilizer), alter hydrological pathways, and amplify the mobilization of solutes and fine sediments (Bolstad and Swank 1997; Feller 2005). Thus, in mixed-use watersheds, the spatial arrangement of diverse bedrock units, as well as the intensity and type of human land use activities, have the potential to create distinct regional patterns in water chemistry.

The influence of broader landscape drivers on water chemistry is modulated by smaller-scale hydrogeomorphic differences among habitats. In particular, differences in hydrology and biogeochemical processes in flowing streams and floodplain wetlands likely drive contrasting chemical patterns. Tributary streams are high-energy solute transporters; they actively weather underlying bedrock and propagate upstream signals—including lithological weathering products, runoff, and sediment pulses—resulting in a chemical signature that integrates the cumulative inputs of the catchment (Vannote et al. 1980; Anderson and Dietrich 2001; Jarvie et al. 2008). In contrast, floodplain wetlands are dynamic systems defined by the convergence of multiple water sources (Junk et al. 1989). During freshet, wetlands are often highly connected with the river channel, which homogenizes chemistry. However, as floodwater recedes and river-floodplain connectivity declines, internal processing associated with extended water residence times becomes more influential (Tockner et al. 2000; Thomaz et al. 2007).

This can transform wetlands into biogeochemical reactors where groundwater inputs, redox cycling, and biological uptake can drive divergent chemical profiles (McClain et al. 2003; Reddy and DeLaune 2008).

This study aimed to better understand spatiotemporal variation in water chemistry across streams and floodplain wetlands and its linkages to anthropogenic and geologic landscape features. The work is situated in the North Thompson region, a large salmon-bearing watershed in the Interior of British Columbia, which has considerable landscape variation in lithologic composition and land use intensity (e.g., Cunningham et al. 2023).

The specific objectives of this report were to:

1. Characterize basic spatiotemporal patterns in water chemistry in streams and floodplain wetlands across the watershed from 2022–2024.
2. Assess the relative influence of catchment lithology versus anthropogenic land use in driving variability.
3. Provide a foundational dataset as a baseline for future research and management applications.

2.0 METHODS

This study is part of the broader North Thompson Salmon Ecosystem Research Program, which focuses on Interior Fraser coho (*O. kisutch*) and aims to: (1) identify important juvenile Pacific salmon habitat and areas; (2) understand how those habitats and areas contribute to Pacific salmon productivity; and (3) investigate how human activities impact Pacific salmon and their ecosystems (Cunningham et al. 2023; Hodgson et al. 2025; Fleming et al. 2026; Parsons et al. 2026). Given this program's focus, water chemistry is considered here largely in the context of watershed ecosystems and fish habitat.

2.1 STUDY AREA

The study was conducted in the North Thompson River watershed, located in Secwepemcúl'ecw, predominantly Simpcw territory, in south-central British Columbia. The North Thompson River forms a major tributary of the Thompson River, which in turn flows into the Fraser River. The watershed encompasses a wide range of biogeoclimatic zones, including Engelmann Spruce–Subalpine Fir, Interior Cedar–Hemlock, and Interior Douglas-fir (GeoBC 2021) as well as a variety of landscape types, such as glacier covered mountains, tributary valleys, broad floodplains, and wetland complexes. Seasonal hydrology is snowmelt-dominated, with peak flows typically occurring from late May through June and declining to low flow conditions in late summer and early fall

(Déry et al. 2012). Several higher latitude streams are influenced by glacial melt and do not follow this pattern.

Land use within the watershed varies spatially and includes forestry; transportation corridors (notably Highway 5 and the CN rail line); agriculture in valley bottoms; rural communities, such as Blue River, Avola, and Clearwater; and extensive recreational use. Forestry is the dominant land use across many sub-basins, with both current and legacy impacts associated with road networks and forest harvest in proximity to stream and wetland habitats (Cunningham et al. 2023).

To capture this landscape heterogeneity, sampling sites included 16 tributary streams draining to the North Thompson River and 12 floodplain wetland habitats distributed along a latitudinal gradient from near Valemount in the upper watershed to Kamloops in the lower watershed (Figure 1,

Table 1). Floodplain wetlands were selected on the basis of seasonal inundation by North Thompson mainstem floodwaters, representing off-channel habitats with hydrological connectivity to the river during elevated flow periods (Milner et al. 2025; Chaudhuri et al. 2025). These wetlands generally connect to the mainstem North Thompson during freshet, but then experience varying periods of disconnection depending on local bathymetry and inter-annual hydrology variation (Chaudhuri et al. 2025).

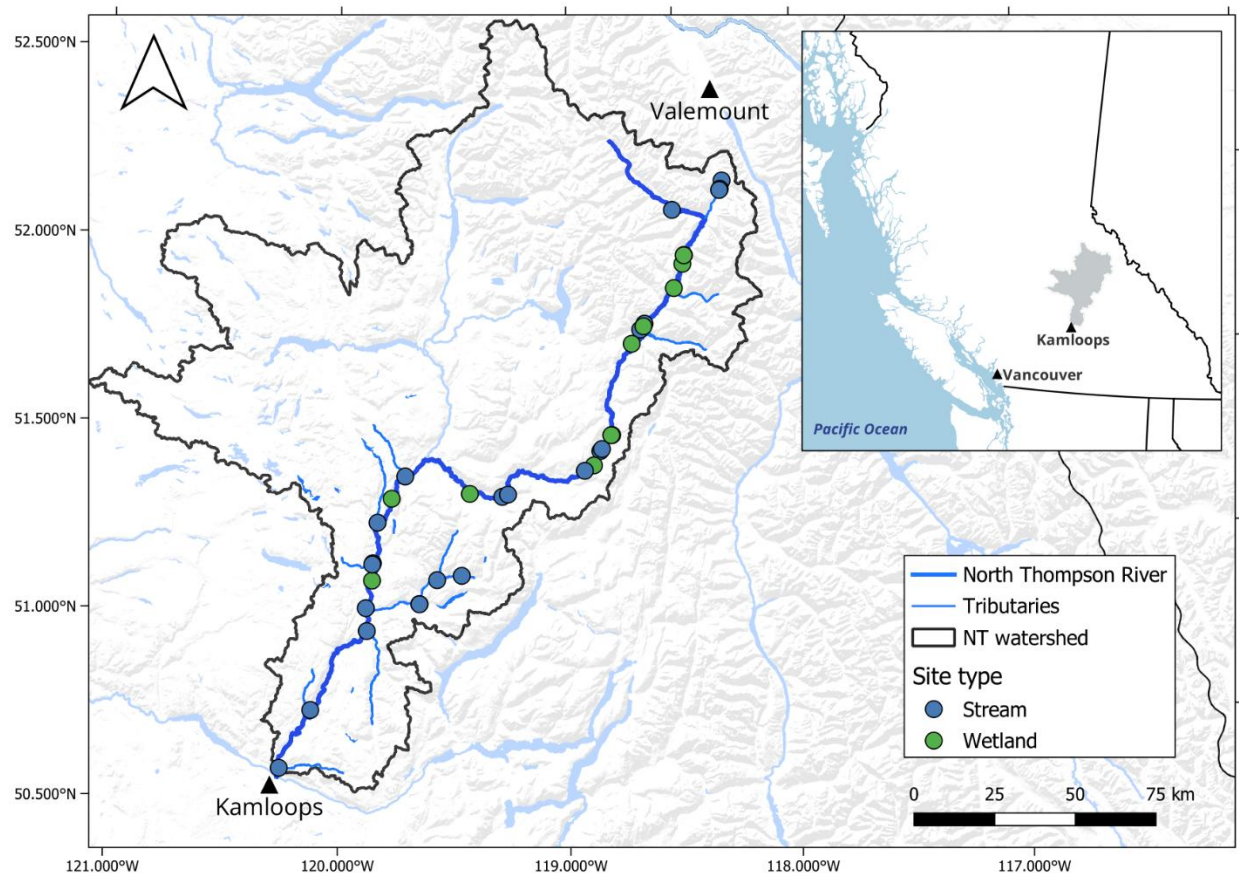


Figure 1. Stream and wetland sampling locations in the North Thompson watershed. Highlighted tributaries denote the specific streams sampled.

Table 1 Stream and wetland sampling locations in the North Thompson watershed. Sites are arranged in order of descending latitude.

Site Name	Latitude	Longitude
Streams		
Albreda River	52.58976	-119.1004
Dora Creek	52.56272	-119.1003
Cook Creek	52.15233	-119.2746
Cedar Creek	52.13320	-119.2865
Tumtum Creek	51.83099	-119.2872
Shannon Creek	51.78645	-119.3153
Reg Christie Creek	51.59938	-119.6735
Chuck Creek	51.58943	-119.6958
Lemieux Creek	51.43238	-120.2082
Lindquist Creek	51.31685	-120.1811
East Barriere River	51.24409	-119.9301
Haggard Creek	51.24369	-119.9297
Louis Creek	51.13479	-120.1260
Jamieson Creek	50.88327	-120.2760
Wetlands		
Pyramid Wetland	52.36369	-119.1808
Struggle Puddle Wetland	52.33901	-119.1769
Miledge Wetland	52.26787	-119.1864
Cook Wetland	52.14463	-119.2761
Goose Wetland	52.08958	-119.3075
Northwest Finn Wetland	52.04194	-119.3281
Tumtum Wetland	51.83015	-119.2907
Stillwater Wetland	51.73702	-119.3316
Wirecache Wetland	51.71708	-119.3655
Lost Creek Wetland km9	51.57469	-119.8409
Little Fort Wetland	51.50673	-120.1753
Barriere Wetland	51.27360	-120.1630

2.2 FIELD SAMPLING

Our analysis focused on physicochemical parameters listed in Table 2. Water samples were collected seasonally between 2022 and 2024 (April to October) to capture variability across pre- and post-freshet periods, as well as baseflow conditions during summer and early-to-mid autumn. Logistical constraints resulted in irregular sampling frequency for some sites across the duration of the study (Appendix A3). Sampling followed standardized protocols to minimize contamination and ensure consistency across sites (Canadian Council of Ministers of the Environment 2011). Water was collected from mid-depth (minimum ≥ 10 cm below the surface) in areas representative of site conditions and where water was free from recent disturbance.

Table 2. Water chemistry parameters measured at each sampling site, with analytical units and detection limits for laboratory analyses and accuracy specifications for field instruments.

Parameter	Abbreviation/ formula	Units	Detection limit/ accuracy
Total phosphorus	TP	$\mu\text{g}\cdot\text{L}^{-1}$ as P	0.29
Soluble reactive phosphorus	SRP	$\mu\text{g}\cdot\text{L}^{-1}$ as P	0.29
Ammonia	NH_3	$\mu\text{g}\cdot\text{L}^{-1}$ as N	0.50
Calcium	Ca^{2+}	$\mu\text{g}\cdot\text{L}^{-1}$	0.50
Chloride	Cl^-	$\mu\text{g}\cdot\text{L}^{-1}$	0.50
Fluoride	F^-	$\mu\text{g}\cdot\text{L}^{-1}$	0.50
Potassium	K^+	$\mu\text{g}\cdot\text{L}^{-1}$	0.50
Magnesium	Mg^{2+}	$\mu\text{g}\cdot\text{L}^{-1}$	0.50
Sodium	Na^+	$\mu\text{g}\cdot\text{L}^{-1}$	0.50
Nitrate	NO_3^-	$\mu\text{g}\cdot\text{L}^{-1}$ as N	0.50
Sulphate	SO_4^{2-}	$\mu\text{g}\cdot\text{L}^{-1}$	0.50
Specific conductance	SPC	$\mu\text{S}\cdot\text{cm}^{-1}$	± 1 or 0.5%
pH	-	-	± 0.2
Turbidity	-	NTU	± 0.05 or 2%

Sampling for TP was conducted prior to other activities or upstream of site access to avoid sediment resuspension. Total phosphorus samples were collected into a clean glass culture tube was rinsed and then filled to the shoulder with unfiltered site water. TP samples were stored within a cooler at ambient field temperature and shielded from direct sunlight until return to the laboratory.

Samples for dissolved ions (including nitrate and ammonia) and soluble reactive phosphorus (SRP) were collected using a $0.45\ \mu\text{m}$ acrodisc filter, which was primed with

approximately 10 mL of sample water prior to use. Separate 125 mL Nalgene bottles were used for ion and SRP samples. Bottles were rinsed three times with filtered sample water before collection of approximately 50 mL of filtered water. Filters were replaced if clogging occurred. Samples were stored in clean Ziploc bags on dry ice in the field and transferred to a -20°C freezer upon return.

Field blanks were collected for TP, SRP, and ion samples to assess potential contamination. Ultrapure water was dispensed into clean, pre-rinsed containers using the same procedures as field samples. Ion and SRP blanks were filtered through a clean, primed acrodisc. All blanks were stored and transported alongside regular samples.

In situ measurements of specific conductivity, pH, and turbidity were recorded using either a YSI ProQuatro or YSI Professional Plus multiparameter instrument (YSI Inc., Yellow Springs, Ohio, USA). The probe was submerged in a flowing section of the stream or positioned in a stable location within wetlands and allowed to equilibrate for 10-15 minutes. Turbidity was measured using a LaMotte 2020i turbidimeter (LaMotte Company, Chestertown, Maryland, USA). The sample vial was rinsed three times with site water and filled from an undisturbed location upstream of sampling activity. Three replicate turbidity readings from a single sample were recorded per site.

2.3 SPATIAL ANALYSIS

To quantify the landscape context of each sampling site, we delineated upstream catchment boundaries (the area of land draining to each site), which served as the basis for calculating lithology composition and land use coverage for each sampling location. Watershed delineation was performed using a 30 m digital elevation model (DEM) in ArcGIS Pro (version 3.2; Esri 2023) using the Hydrology toolset. For stream sites, watershed boundaries were delineated from the contributing watershed area upstream of latitude-longitude points corresponding to the location of established hydrometric stations.

Delineating wetland contributing areas required a two-tiered approach (Table 3). We used existing delineated wetland polygons from the Freshwater Atlas (FWA; Government of British Columbia 2023) for our sample sites that overlapped. However, the wetland database within the FWA is incomplete and did not include four of our sites. Delineation with the DEM was not possible given insufficient topographic relief in these sites, so instead we approximated an immediate drainage area by applying a 50 m circular buffer around the sampling location coordinates. While more precise area measurement is possible (e.g., from satellite images), we did not pursue this for several reasons. First, it also introduces additional subjectivity. Second, increases in resolution of the wetland boundaries would be inconsequential given the coarser resolution of the landscape predictors. In other words, more precise wetland boundaries at these sites

would result in no differences in the spatial predictors for the contributing catchment. Third, exploratory analysis using images for two wetlands minimal differences in area (less than 100 m²). For wetlands receiving inflow from tributaries, upstream contributing areas were delineated manually to include all contributing area from the corresponding source. Importantly, these wetlands also receive substantial input from the mainstem North Thompson. We did not consider this as part of the wetland catchment given our focus on the role of local landscape features.

Table 3. Catchment delineation methods for wetland sampling sites. “FWA” = wetland polygon sources from BC Freshwater Atlas; “50 m buffer” = manually applied boundary used where no FWA polygon was available.

Wetland	Method used	Upstream watershed?
Barriere Wetland	50m buffer	No
Cook Wetland	FWA	No
Goose Wetland	FWA	Yes
Little Fort Wetland	FWA	Yes
Lost Creek Wetland km9	50m buffer	No
Miledge Wetland	FWA	Yes
NW Finn Wetland	50m buffer	Yes
Pyramid Wetland	FWA	No
Stillwater Wetland	FWA	Yes
Tumtum Wetland	FWA	Yes
Wirecache Wetland	FWA	Yes
Struggle Puddle Wetland	50m buffer	Yes

2.3.1 Bedrock lithology

Bedrock lithology was characterized using BC digital geology polygons (Cui et al. 2017). The proportional coverage of each distinct rock type was calculated as a percentage of the total delineated catchment area (0, **Error! Reference source not found.** and **Error! Reference source not found.**). To facilitate multivariate analysis, these unit-specific percentages ($n = 21$) were then summed into six broad categories based on similarities in chemical composition, mineralogy, and protolith (Figure 2). This approach followed established regional classification schemes (Robinson, 1997; Hegg et al., 2013), with modifications informed through consultation with the British Columbia Geological Survey (A. Rukhlov, pers. comm.). The resulting classification categories were:

1. *Felsic and crystalline*: Felsic intrusive and other crystalline metamorphic rocks, primarily granites, granodiorites, gneisses, and quartz. These units are rich in silica and are highly resistant to weathering, generally yield solute-poor, dilute waters (Goldich 1938).

2. *Mafic to ultramafic*: Volcanic and metamorphic units rich in ferromagnesian minerals, including basalts, greenstones, and pyroxenites. These rocks typically exhibit higher weathering rates than felsic units and contribute high amounts of calcium and magnesium (Dessert et al. 2003; Ibarra et al. 2016).
3. *Intermediate igneous*: Intrusive and volcanic rocks with transitional compositions (e.g., diorites and andesites) between the mafic and felsic compositions
4. *Carbonate*: units dominated by limestone and calcareous sedimentary rocks. These units are characterized by rapid dissolution rates and are the primary geological source of alkalinity, calcium, and magnesium in surface waters (Meybeck 1987).
5. *Siliciclastic*: clastic sedimentary rocks, including sandstone, siltstone, and shale. While less reactive than pure carbonates, these units can still yield high Na^+ and sometimes Ca^{2+} and SO_4^- concentrations in surface water with higher dissolved loads than crystalline felsic rocks (Meybeck 1987; Amiotte Suchet and Probst 1995).
6. *Mixed sedimentary and volcanic*: complexes of interbedded sedimentary and volcanic lithologies, such as semipelite amphibolite, quartzite, argillite, and phyllite, where no single rock type is spatially dominant and individual lithologies cannot be further differentiated based on the available data (this includes the “metasediments” and “metamorphic rocks, undivided” categories).

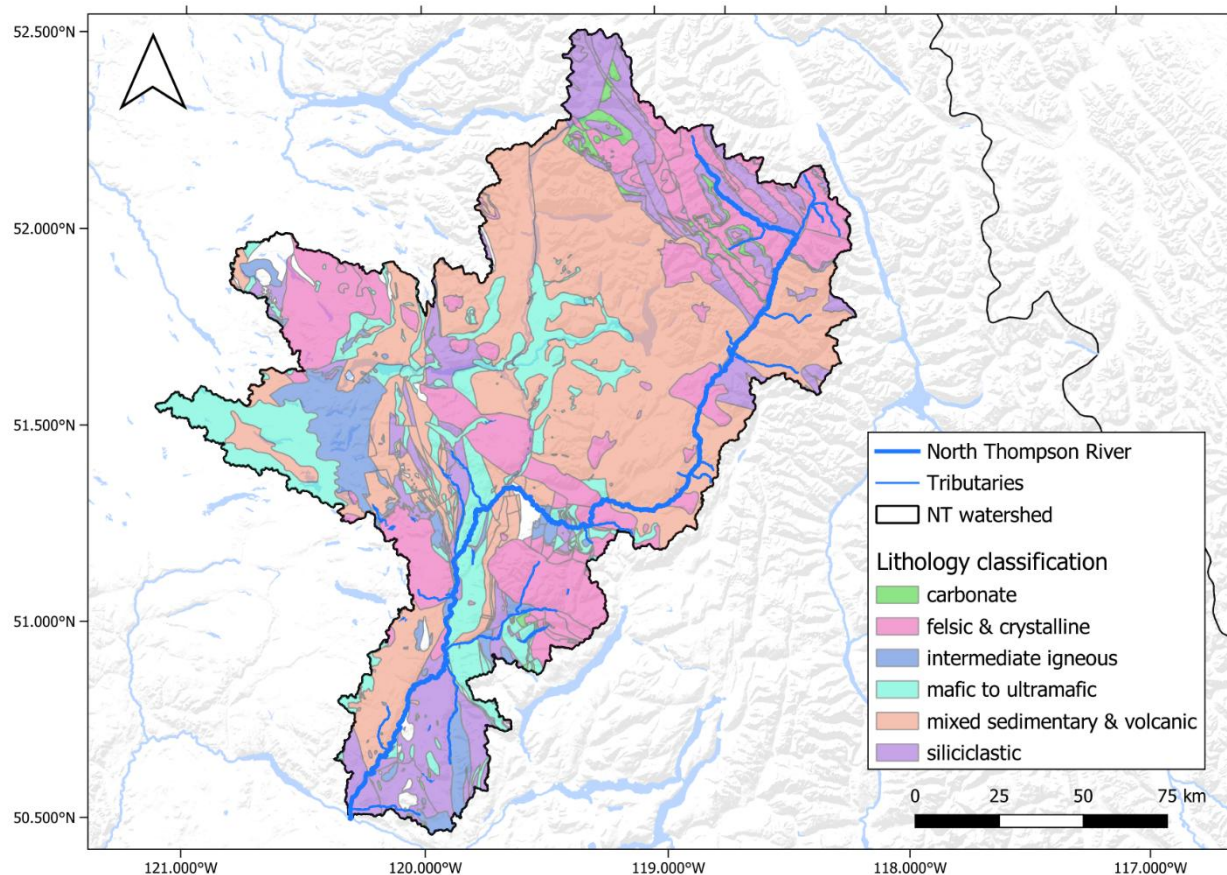


Figure 2. Reclassified bedrock lithology map of the North Thompson River watershed. Coloured polygons represent the six simplified lithological groupings constrained within the boundaries of the catchment area. Base geological data were derived from the British Columbia Digital Geology dataset (Cui et al. 2017).

2.3.2 Land use

Anthropogenic land use was quantified using spatial inventories of forestry and agriculture. Forestry activity was quantified using the Consolidated Cutblocks layer to calculate the percentage of catchment area harvested, separated into recent harvest (cutblocks < 10 years old) and total historical harvest (all recorded years) (Forest Analysis and Inventory Branch 2024). Agricultural intensity was represented by the proportion of the catchment overlapping the Agricultural Land Reserve (Agricultural Land Commission 2024). This does not encompass all land use across the watershed, but captures the two dominant activities with clear links to water chemistry.

2.4 LABORATORY ANALYSES

Water chemistry analyses were performed at Cultus Lake Laboratory, Fisheries and Oceans Canada. Total phosphorus and soluble reactive phosphorus (SRP) was

measured using an automated colorimetric method adapted from Murphy and Riley (1962). Total phosphorus determination included an initial acid digestion step to convert all phosphorus forms into ortho-phosphate. In this method, ortho-phosphate reacts with molybdate and antimony ions under acidic conditions to form a phospho-molybdenum complex, which is then reduced by stannous chloride to produce a blue-coloured compound. The absorbance of this complex was measured at 880 nm using a digital colorimeter. Analyses were conducted using a segmented flow analyser (AA3; Seal Analytical, Mequon, WI, USA), an XY-2 autosampler, and a Chem Platform MT19 heating bath maintained at 37 °C. This method has a working range of 0–50 µg/L as phosphorus and a detection limit of 0.29 µg/L as phosphorus.

Major anions and cations were quantified by capillary ion chromatography using a dual-channel system (Dionex ICS-5000; Thermo Fisher Scientific, Sunnyvale, CA, USA), which enables simultaneous analysis of anions and cations. Anions were separated using IonPac AS18-Fast (0.4 × 150 mm) and AG18-Fast (0.4 × 35 mm) columns, and cations were separated using IonPac CS16 (0.5 × 250 mm) and CG16 (0.5 × 50 mm) columns (Thermo Fisher Scientific). Nitrate and ammonium concentrations are reported as nitrate-nitrogen (NO₃-N) and ammonium-nitrogen (NH₄-N).

2.5 DATA PREPARATION AND ANALYSIS

To characterize the underlying variable associations driving watershed-scale patterns, we examined relationships among water chemistry parameters separately for streams and wetlands. Ion concentrations reported below the detection limit (DL) were substituted with half the sample-specific DL ($DL/2$) prior to analysis. Non-detects accounted for less than 15% of values for any parameter, a threshold below which $DL/2$ substitution introduces negligible bias (Farnham et al. 2002; Antweiler and Taylor 2008). Data distributions were evaluated via visual inspection of histograms. Given the widespread non-normality observed, Spearman's rank correlation coefficients (ρ) were calculated. This non-parametric approach was selected to provide a robust measure of association that minimizes the influence of outliers and captures monotonic trends without assuming linearity. Patterns in water chemistry were subsequently visualized using a Principal Component Analysis (PCA) on the complete dataset. Prior to ordination, chemical variables were centered and scaled to unit variance (z-scores) to account for differences in measurement units and magnitudes. Catchment predictors, including reclassified lithology percentages and land use metrics, were subsequently projected onto the ordination space as passive vectors using the `envfit` function from the *vegan* package (Oksanen et al., 2022). To identify the primary landscape drivers of chemical variability while maintaining visual clarity, only environmental vectors with significant correlations ($p \leq 0.05$, based on 999 permutations) were retained in the final biplots.

While PCA provides a robust visualization of the underlying structure of the water chemistry data, it is an unconstrained technique that identifies gradients of maximum variation regardless of their source. To explicitly quantify the proportion of this variation attributable to specific landscape drivers, Redundancy Analyses (RDA) were subsequently employed using the `rda` function from the package `vegan` (Oksanen et al., 2022). Unlike a PCA, RDA constrains the ordination axes to be linear combinations of the provided environmental variables, allowing for a direct assessment of the explanatory power of catchment lithology and land use on the observed water chemistry profiles (Legendre and Legendre 2012).

The initial dataset comprised 251 samples collected over the three-year study period. Prior to multivariate analysis, 51 samples were excluded due to incomplete water chemistry profiles (missing values for one or more parameters). To confirm the exclusion did not introduce systematic bias, non-parametric Wilcoxon rank-sum tests with a Holm correction for multiple comparisons were performed, and no significant differences in parameter distributions were detected between complete and incomplete samples (all $p_{adj} > 0.05$). This exclusion resulted in a final dataset of 200 observations.

To investigate whether stream and wetland environments exhibited different responses to landscape drivers, separate RDA models were developed for each habitat type for this filtered dataset (streams: $n = 123$; wetlands: $n = 77$). Prior to ordination, the response matrix was $\log_{10}(x + 1)$ transformed (excluding pH) and scaled to unit variance to satisfy assumptions of normality and to account for differences in measurement scales. Land use predictors were similarly standardized to z-scores.

Geological predictors, representing closed compositional data, were transformed using the Isometric Log-Ratio (ILR) method (Egozcue et al. 2003), which avoids spurious correlations associated with the constant-sum constraint (Aitchison 1982; Pawlowsky-Glahn and Egozcue 2006). A Sequential Binary Partition (SBP) was defined to map the six lithological categories into five orthogonal balances, representing statistically independent geological gradients suitable for linear modeling (Table 4, Appendix 2).

Table 4. Sequential Binary Partition structure and associated geochemical hypotheses for lithological predictors of surface water chemistry patterns in the North Thompson watershed.

Balance	Hypothesis
1. <i>Carbonate vs. non-carbonate</i>	Catchments with higher carbonate proportions would exhibit higher alkalinity and specific conductivity, as these rocks weather up to 12 times faster than other major rock types and dominate solute loads (particularly Ca^{2+} and Mg^{2+}), even when present in minor amounts (Meybeck 1987; Bluth and Kump 1994).

2. <i>Crystalline vs. sedimentary</i>	Sedimentary (siliciclastic, mixed sedimentary/volcanic) catchments would yield higher ion concentrations relative to crystalline (mafic, felsic, intermediate igneous, and their metamorphic equivalents) ones, as their higher porosity and soluble cements facilitate greater water-rock interaction compared to the more impermeable, fracture-limited flow paths of crystalline basements (Freeze and Cherry 1979; Amiotte Suchet and Probst 1995; Xie et al. 2005; Nelson et al. 2011).
3. <i>Mixed vs. siliciclastic</i>	Mixed (volcanic/sedimentary) lithologies would yield higher ionic loads than pure siliciclastic units due to the presence of reactive volcanic and sedimentary components (e.g., metabasalts, gabbro, calcsilicate schist), which are rich in ferromagnesian minerals and trace carbonates; conversely, the siliciclastic group is dominated by more stable assemblages of quartz, shale, and psammite, which weather significantly more slowly (Goldich 1938; Colman 1982; Hartmann and Moosdorf 2011; Weibel et al. 2023).
4. <i>Mafic vs. felsic/intermediate</i>	Within the crystalline group, mafic rocks would be more susceptible to weathering and cation export than felsic or intermediate rocks, acting as a stronger source of dissolved Ca^{2+} and Mg^{2+} (Meybeck 1987; Ibarra et al. 2016).
5. <i>Felsic vs. intermediate</i>	Intermediate rocks (e.g., diorite, andesite) would weather faster than felsic rocks (e.g., granite), and thus release more Ca^{2+} and Na^{2+} (Nesbitt and Young 1984; Ohta and Arai 2007).

The construction of balances based on geochemical knowledge is an established method for characterizing compositional environmental data for multivariate analyses (Owen et al. 2016; Wang et al. 2021). This ensures the resulting ordination axes correspond to interpretable gradients (e.g., carbonate vs. silicate weathering) and addresses the challenge of heterogenous lithological mixtures found in broad-scale survey data (Owen et al. 2016).

Prior to the final RDAs, the environmental predictor set was refined to minimize multicollinearity. Variance Inflation Factors (VIF) were calculated to assess variable redundancy, and predictors exhibiting high VIF scores (>10) were removed. This selection process was further guided by *a priori* hypotheses to ensure the retained variables represented distinct landscape drivers. Specifically, latitude was excluded to isolate local landscape effects from broader spatial gradients, and the total historic harvest variable was dropped to favour more recent forestry activity (i.e., forestry in last 10 years). Furthermore, the carbonate ILR balance was excluded from the wetland analysis as carbonate lithology was absent across the sampled catchments. Additionally, sampling month was encoded as a set of binary dummy variables (i.e., each month is a predictor set as “1” when sampled vs. “0” when unsampled) to avoid

imposing an artificial linear gradient on the data, thereby accommodating inter-annual variability in hydrologic timing (i.e., samples collected during base flows versus shortly after freshet recession). Year was excluded as a predictor due to incomplete site coverage across sampling years.

To explore specific pairwise trends identified in the RDAs, we performed post-hoc Spearman's rank correlation analyses on the land use predictors (recent forestry and agriculture) against site-averaged measurements of conductivity, TP, SRP, NO_3^- , and NH_3 . These correlations were conducted on site means ($n_{\text{stream}} = 16$, $n_{\text{wetland}} = 12$) rather than the full dataset to avoid pseudoreplication from repeated measures.

Finally, to disentangle the confounding influence of spatially correlated drivers (e.g., agricultural development occurring on specific rock types), Variance Partitioning Analysis (VPA) was conducted on the optimized models using the `varpart` function in *vegan*. This broke down the total proportion of explained variation (R_{adj}^2) of the water chemistry matrix into fractions uniquely attributed to lithological drivers (pure lithology), uniquely attributed to anthropogenic factors (pure land use), and to the shared variance indistinguishable between the two predictor sets due to collinearity. The statistical significance of the unique fractions was subsequently tested using partial Redundancy Analysis (pRDA) with Monte Carlo permutation tests (999 permutations) (Borcard et al. 1992; Legendre and Legendre 2012).

All statistical analyses were conducted using R version 4.5.1 (R Core Team, 2025).

3.0 RESULTS

Across the sampling period (2022–2024), water chemistry varied substantially among sites in the North Thompson watershed, with electrical conductivity (specific conductance) and major ion concentrations (Ca^{2+} , Mg^{2+} , SO_4^{2-}) spanning orders of magnitude. These signatures differed spatially and between stream (Appendix 3) and wetland (Appendix 4) sites. Streams exhibited a general trend of increasing ion concentrations towards the southern end of the watershed; for example, Louis and Jamieson Creeks consistently had the highest conductivity values ($391.2 \pm 13.0 \mu\text{S}\cdot\text{cm}^{-1}$ and $336.8 \pm 23.2 \mu\text{S}\cdot\text{cm}^{-1}$, respectively) and major ion concentrations (e.g., for Ca^{2+} , $49,309 \pm 3,747 \mu\text{g}\cdot\text{L}^{-1}$ and $37,910 \pm 4,180 \mu\text{g}\cdot\text{L}^{-1}$, respectively), whereas northern sites, such as Cedar and Cook Creeks, were among the most dilute (Figure 3). In contrast, the wetland sites lacked a strong spatial pattern (Figure 4). While the study design did not capture full seasonal gradients (e.g., sampling was not conducted during freshet), some sites did exhibit seasonal and inter-annual variation (streams, Appendix 5; and wetlands, Appendix 6). These patterns were not consistent, although wetlands were generally more temporally variable than streams.

3.1 GENERAL CHEMICAL RELATIONSHIPS

Spearman's rank correlation matrices revealed distinct covariance structures between the stream and wetland datasets. In streams (Figure 5), electrical conductivity was strongly positively correlated with major ions, including Mg^{2+} ($\rho = 0.92$), Ca^{2+} ($\rho = 0.91$), and SO_4^{2-} ($\rho = 0.79$), as well as pH ($\rho = 0.88$), and soluble reactive phosphorus (SRP; $\rho = 0.80$). Calcium and magnesium were strongly intercorrelated ($\rho = 0.95$). Spatially, these variables were negatively associated with latitude, with conductivity ($\rho = -0.71$) decreasing in northern sites. Sampling month displayed negligible correlations ($|\rho| < 0.2$) with nearly all measured parameters, with the exception of NH_3 ($\rho = -0.48$).

In wetlands (Figure 6), correlations between conductivity and chemical variables were generally lower. While conductivity retained a strong positive association with Ca^{2+} ($\rho = 0.83$), coefficients for Mg^{2+} ($\rho = 0.64$), SO_4^{2-} ($\rho = 0.65$), and SRP ($\rho = 0.64$) were reduced compared to the stream sites. Additionally, the latitudinal gradients observed in streams were absent in the wetland dataset, where conductivity showed virtually no correlation with latitude ($\rho = -0.06$) and associations between nitrogen (NO_3^- , NH_3) and other variables were consistently weak ($|\rho| < 0.50$). Similar to streams, month showed negligible association with all variables.

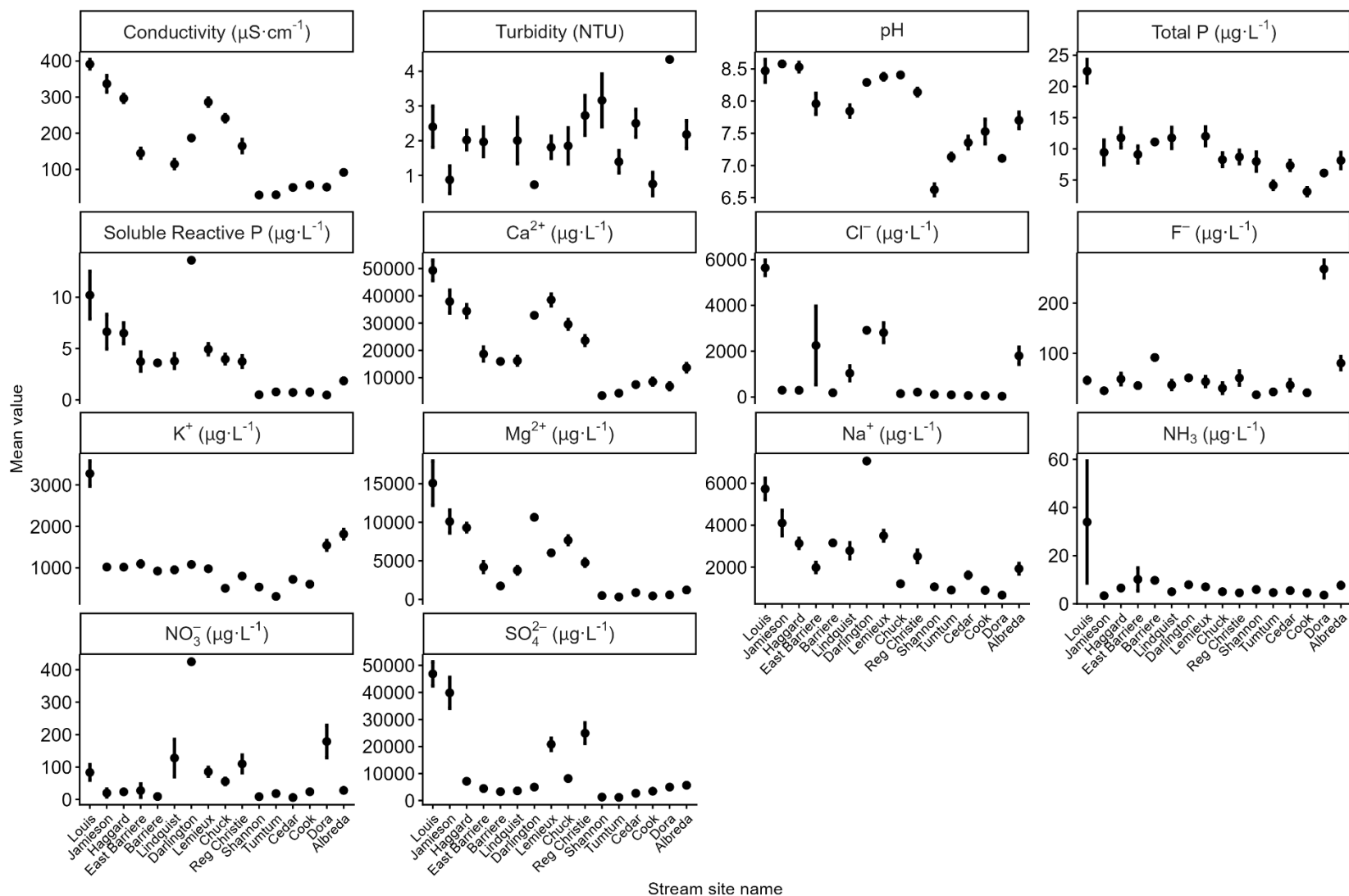


Figure 3. Mean water chemistry measurements from tributary streams in the North Thompson River watershed (2022–2024). Sites are arranged in increasing latitude. Error bars represent ± 1 standard error from the mean.

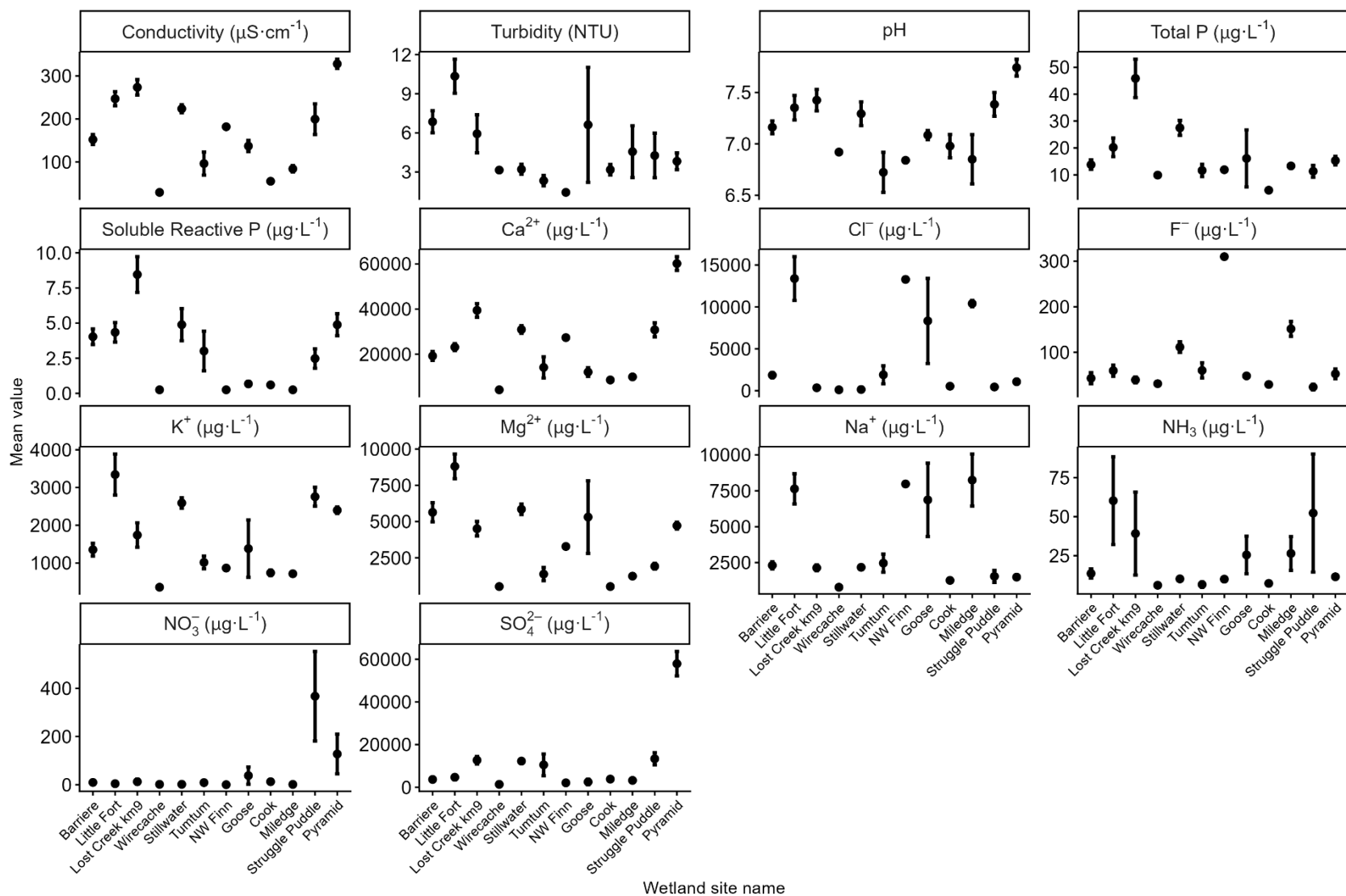


Figure 4. Mean water chemistry measurements from wetland sites in the North Thompson River watershed, (2022–2024). Sites are arranged in increasing latitude. Error bars represent ± 1 standard error from the mean.

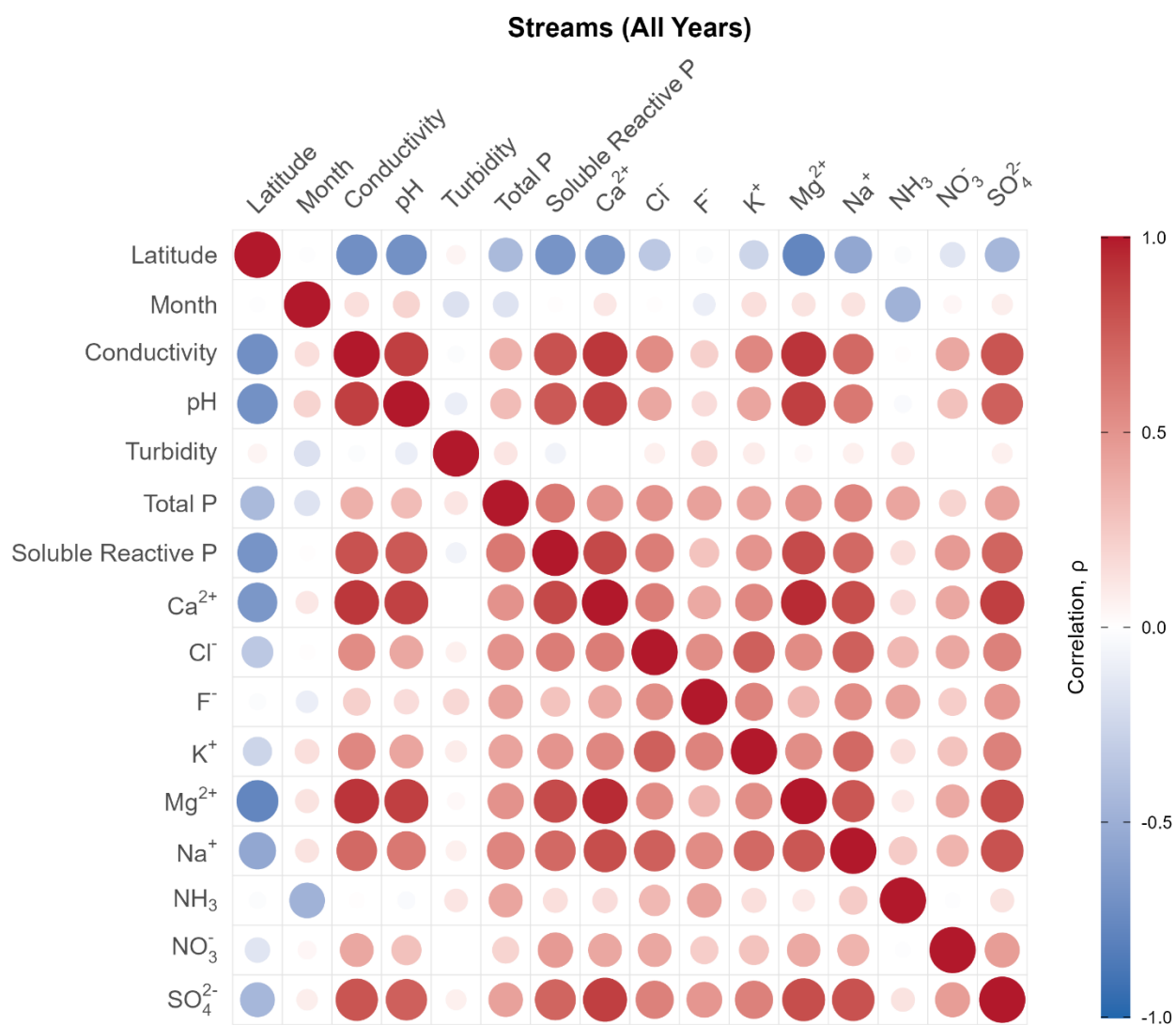


Figure 5. Spearman's rank correlation matrix of water chemistry variables from stream sites in the North Thompson watershed (2022–2024). Blue circles indicate positive correlations; red circles indicate negative correlations. The size and colour intensity of the circle are proportional to the correlation coefficient, ρ .

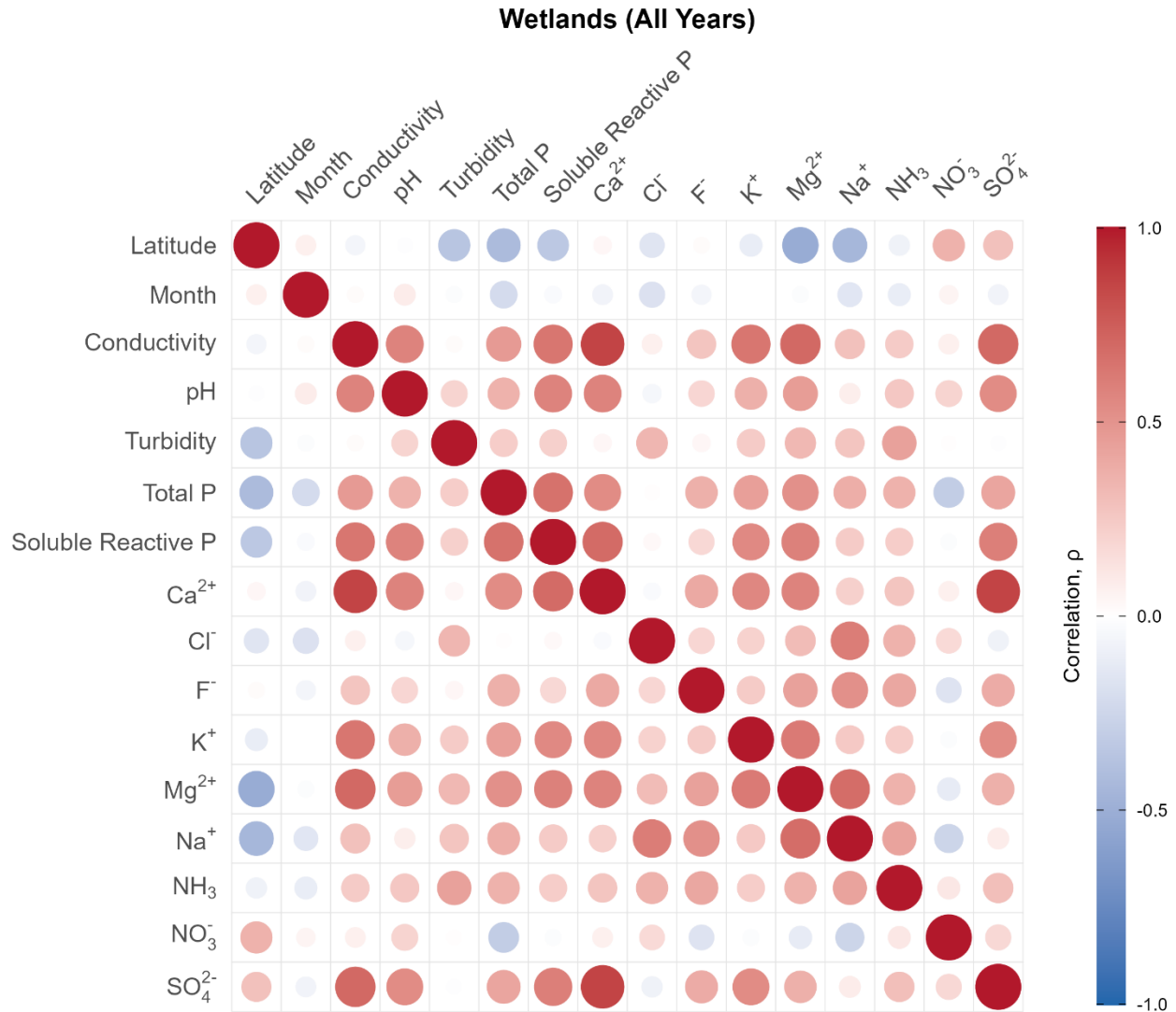


Figure 6. Spearman's rank correlation matrix of water chemistry variables from wetland sites in the North Thompson watershed (2022–2024). Blue circles indicate positive correlations; red circles indicate negative correlations. The size and colour intensity of the circle are proportional to the correlation coefficient, ρ

3.2 PRINCIPAL COMPONENT ANALYSIS (PCA)

Principal component analysis (PCA) revealed the dominant water chemistry gradients and characterized the separation between stream and wetland sites (Figure 7). The first two principal components (PCs) cumulatively explained 55.26% of the total variance in the dataset. The first principal component axis (PC1) accounted for 36.84% of the variance and represented the main gradient of ionic concentration. It was defined by strong negative loadings for specific conductance (spc), calcium (Ca^{2+}), magnesium

significant ($p < 0.001$) and explained 45.2% and 8% of the explained variance, respectively. The first RDA axis (RDA1) represented a primary geochemical gradient defined by the contrast between weathering-resistant crystalline lithology and more actively-weathering basin sources; the positive direction was driven by the ILR balance increasing with crystalline rock. Conversely, the negative direction of RDA1 was defined by recent forestry (past 10 years), agriculture, and the mafic vs. felsic/intermediate lithology balance. The second RDA axis (RDA2) captured a gradient largely defined by the carbonate vs. non-carbonate sedimentary rock balance. However, carbonate lithology was rare across the study area, occurring in only three catchments (Haggard, East Barriere, and Chuck Creeks) at low proportions (<7%, **Error! Reference source not found.**). Temporal variables (month vectors) were a statistically significant driver of chemistry ($F_{5,110} = 6.04, p < 0.001$). However, these vectors exhibited relatively shorter lengths relative to the dominant spatial predictors, with the exception of July (“month7”)

For wetlands, the first two axes were also significant ($p < 0.001$) and explained 28.7% and 9.7% of the explained variance, respectively. The negative direction of the RDA1 was defined solely by the crystalline vs. sedimentary balance and the positive direction was associated with the mafic vs. felsic/intermediate and mixed vs. sedimentary lithology balances, as well as forestry. Specific conductance, major dissolved ions (Ca^{2+} , Mg^{2+} , Na^+ , SO_4^{2-}), and nutrients (TP, SRP, NH_3) all increased along this axis. The second RDA axis (RDA2) was driven by agriculture and the felsic vs. intermediate balance, which correlated strongly with Na^+ , Cl^- , and turbidity. The month vectors, largely clustered near the origin, were not statistically significant in the wetlands sites ($F_{5,65} = 1.26, p = 0.173$).

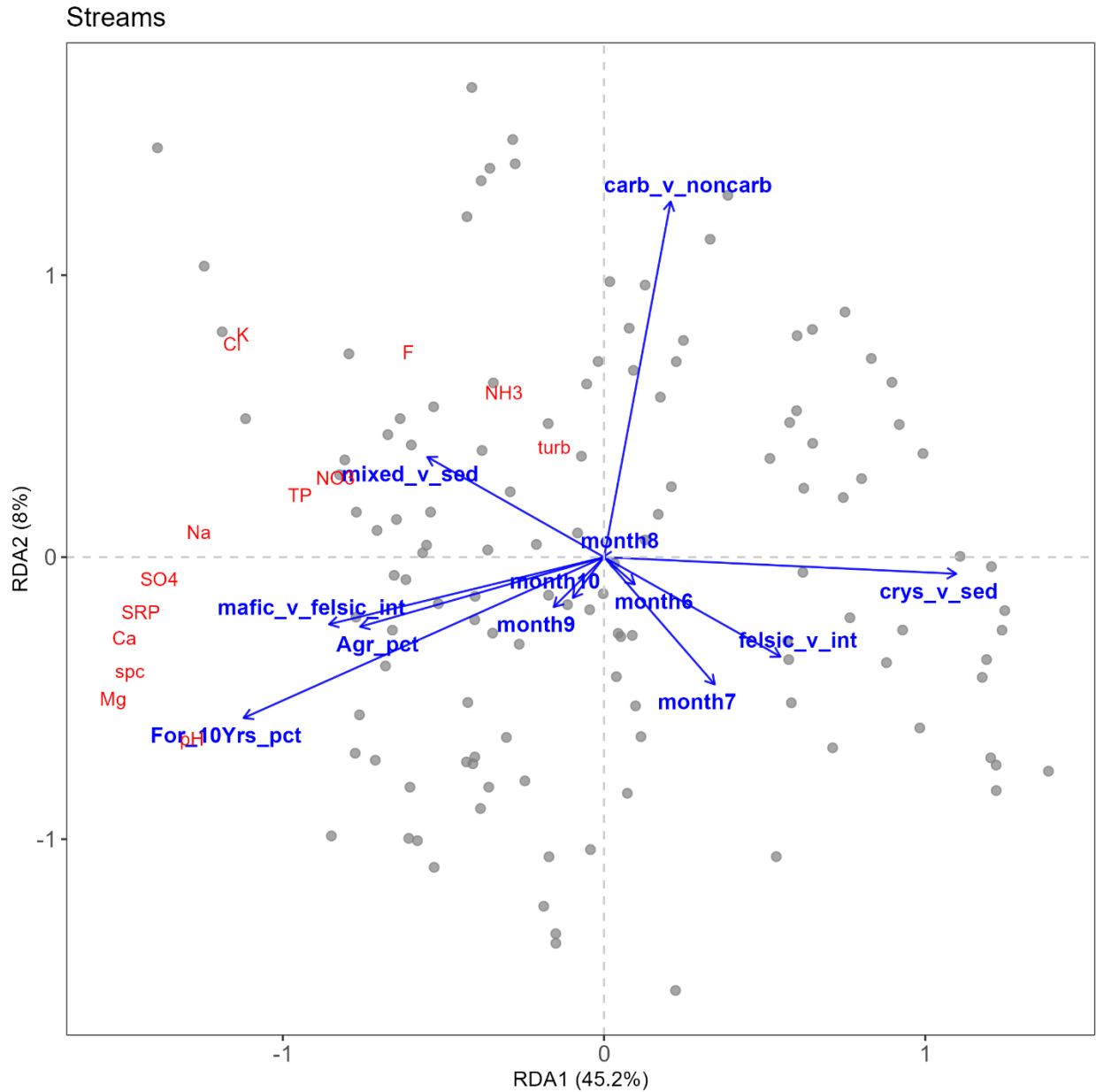


Figure 8. Redundancy Analysis (RDA) triplot for North Thompson stream sites. Grey points represent individual site-date observations. Red text indicates response variables (water chemistry parameters). Blue arrows represent environmental predictors selected via *a priori* hypotheses. Predictors include isometric log-ratio (ILR) balances of lithology (e.g., *crys_v_sed*, *mafic_v_felsic_int*), land use percentages (*For_10Yrs_pct*, *Agr_pct*), and temporal factors (months).

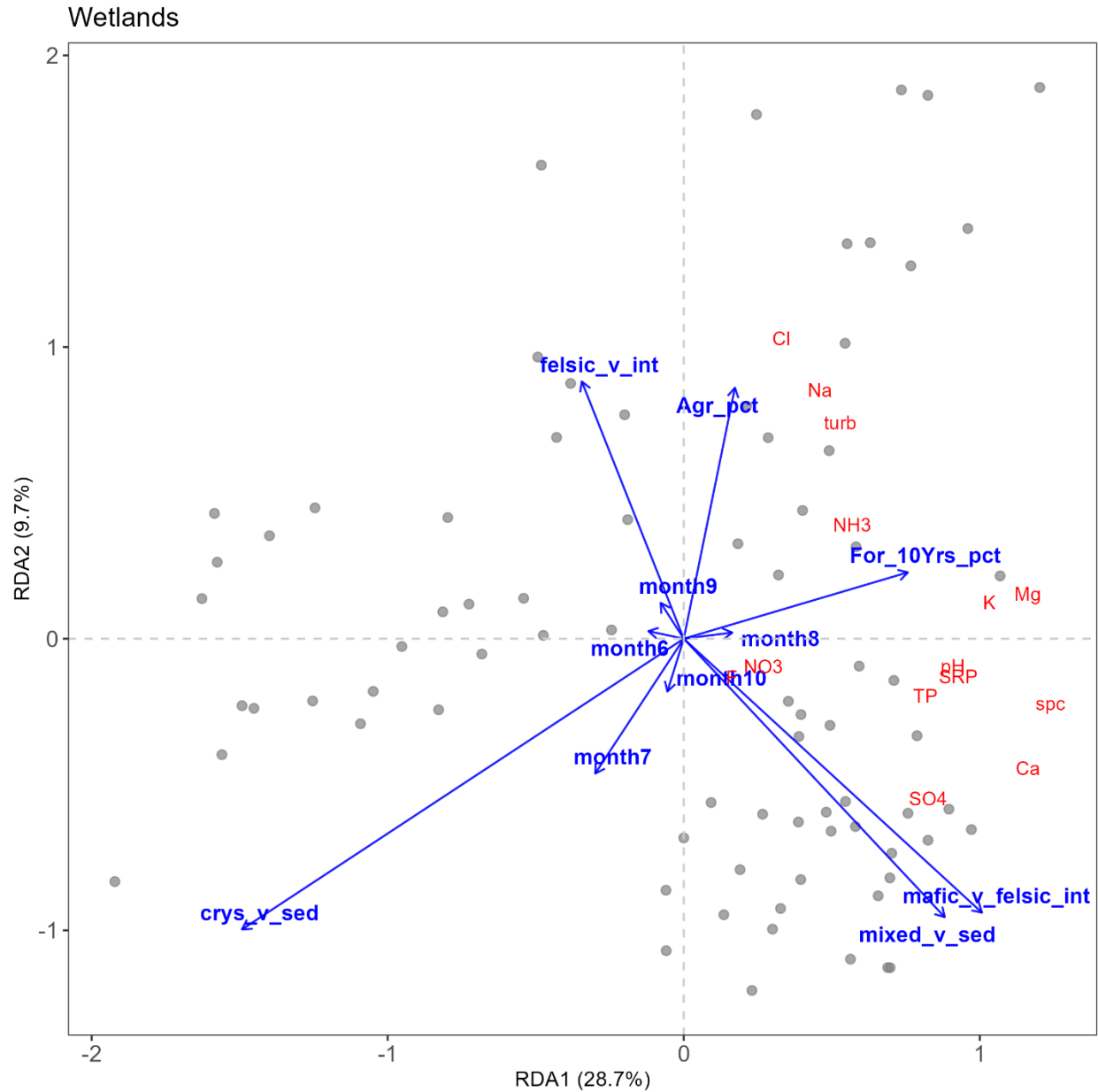


Figure 9. Redundancy Analysis (RDA) triplot for North Thompson wetland sites. Grey points represent individual site-date observations. Red text indicates response variables (water chemistry species). Blue arrows represent environmental predictors selected via *a priori* hypotheses. Predictors include isometric log-ratio (ILR) balances of lithology (e.g., *crys_v_sed*, *mafic_v_felsic_int*), land use percentages (*For_10Yrs_pct*, *Agr_pct*), and temporal factors (months).

3.4 VARIANCE PARTITIONING

Variance partitioning analysis (VPA) quantified the unique and shared contributions of landscape drivers (Figure 10). In stream catchments, the selected predictors explained a total of 60.1% of the constrained variation in water chemistry and lithology and land use shared a substantial proportion of this explanatory power (33.6%). When isolated, lithology explained 17.3% of the unique variance ($F_{5,114} = 11.31, p < 0.001$), whereas land use explained 9.2% ($F_{3,114} = 10.03, p < 0.001$). For wetland sites, the total explained variance was lower (44.0%) and the shared variance was minimal (3.7%) relative to in streams. Lithology was the dominant driver with 27.6% of variance explained ($F_{4,69} = 9.98, p < 0.001$), while land use explained 12.8% ($F_{3,69} = 6.49, p < 0.001$).

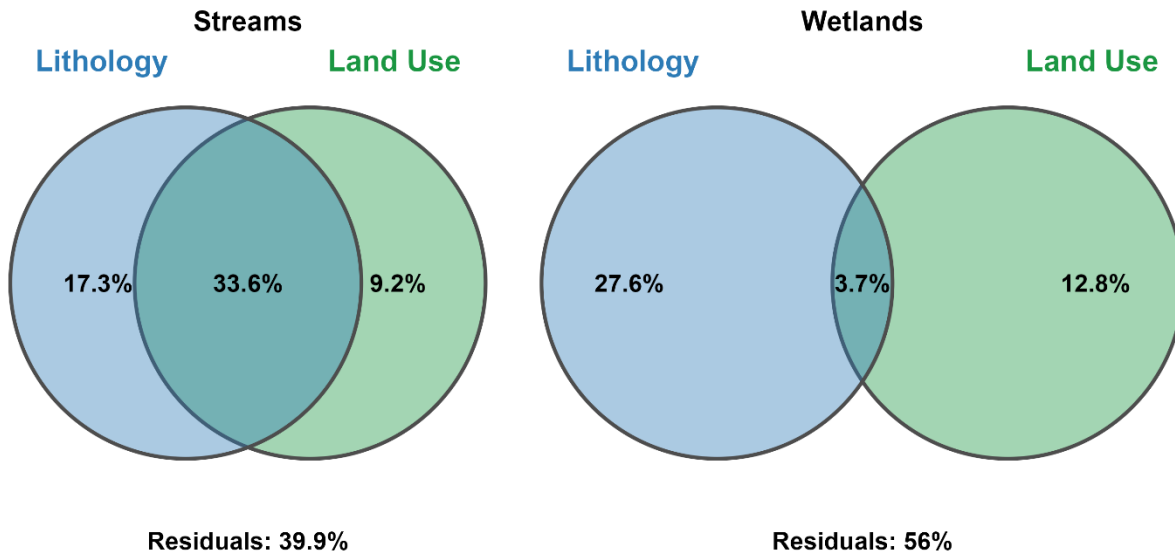


Figure 10. Variance partitioning analysis (VPA) for stream (left) and wetland (right) water chemistry. Values represent the percentage of adjusted variance (R^2_{adj}) explained uniquely by lithology (blue), land use (green), and shared between both predictor sets (intersection). “Residuals” indicate the percentage of variance not explained by the selected predictors.

3.5 UNIVARIATE TRENDS

Given the strong covariance between landscape drivers identified in the VPA and RDA, we explored univariate correlations in a subset of parameters (Appendix 7). The aim of this post-hoc analysis was to illustrate the direction and strength of individual relationships, rather than to test independent causal hypotheses. These assessments corroborated the distinct response patterns observed between streams and wetlands in

the multivariate models. In streams, site-averaged measurements of conductivity, total phosphorus, and soluble reactive phosphorus exhibited moderate-to-strong positive correlations with both recent forestry ($\rho = 0.70 - 0.78$) and agricultural extent ($\rho = 0.62 - 0.79$) (Figure A7.1). Wetlands, in contrast showed NH_3 was moderately correlated with recent forestry ($\rho = 0.40$), while TP and SRP were moderately correlated with agriculture ($\rho = 0.43 - 0.44$) (Figure A7.2).

4.0 DISCUSSION

Our analyses of stream and wetland water chemistry across a three-year period in the North Thompson watershed revealed diverse chemical dynamics. For example, conductivity, pH, ion, and nutrient concentrations exhibited diverse seasonal patterns and varied strikingly among sites and habitat types. The aggregate spatial variability appeared to be partially associated with catchment lithology and cumulative land use. Redundancy analysis indicated that the composition of chemical constituents was related to the contrast between weatherable sedimentary/mafic units and resistant crystalline bedrock, as well as recent forestry and agricultural intensity (Figure 8 and Figure 9). However, these landscape factors did not account for a substantial portion of the total variance (unexplained variance: 39.9% for streams, 56.0% for wetlands; Figure 10). This suggests that while broad-scale landscape features provide a background template, water chemistry is heavily influenced by unmeasured drivers. These likely include temporally dynamic hydrological processes such as surface runoff or localized groundwater exchange that we did not directly investigate.

Within the variance explained by landscape factors, clear lithological signals emerged. Catchments dominated by weatherable sedimentary (e.g., Louis Creek) or mafic units (e.g., Haggard Creek) consistently exhibited elevated ionic (Ca^{2+} , Mg^{2+} , SO_4^{2-}) and nutrient (TP, SRP) concentrations compared to those on resistant felsic bedrock (Figure 3). This aligns with global hydrogeochemical patterns where the rapid dissolution of fine-grained sedimentary rocks (e.g., shales) and mafic volcanics (rich in ferromagnesian silicates) can yield solute loads orders of magnitude higher than slow weathering granitic and crystalline metamorphic lithologies (Meybeck 1987; Sato et al. 2000; Amiotte Suchet et al. 2003; Nelson et al. 2011; Ibarra et al. 2016). There is considerable variation in lithology across the North Thompson (Cui et al. 2017; Hodgson et al. 2025) given its large extent and glacial history. Our results link that variation to chemistry and highlight the potential importance of lithologic context for aquatic ecosystems. Future work integrating higher resolution geologic information could better resolve these linkages (e.g., Dralle et al. 2023).

Land use intensity was not as strongly associated with chemical variation as illustrated by the RDA and Variance Partitioning Analyses. However, inference that land use is not a strong driver of water chemistry should be tempered by several considerations. First,

high spatial collinearity with geology and latitude limited our ability to isolate land use impacts. This spatial confounding is widely documented in catchment-scale assessments, where anthropogenic signals are frequently superimposed upon natural variation in lithology (Johnson et al. 1997; Dow et al. 2006; Chuman et al. 2013). In the North Thompson, forestry represents the dominant anthropogenic impact across the watershed, with agricultural development occurring to a much smaller extent (Cunningham et al. 2023). Despite their differing footprints, both activities frequently overlap with naturally high-solute sedimentary geologies. The underlying geology dictates a catchment's intrinsic sensitivity to nutrient inputs; for example, forested catchments underlain by sedimentary geology can inherently export phosphorus at rates over double those of crystalline formations (Dillon and Kirchner 1975). While some studies have demonstrated that land use can emerge as the primary driver of nutrient patterns once these geological baselines are accounted for (Dow et al. 2006), our models detected a more mixed and limited independent effect. This suggests that in the North Thompson, the anthropogenic signal is so heavily collinear with other landscape drivers (and the agricultural footprint so limited in our catchment areas) that its individual contribution remains difficult to statistically disentangle.

The influence of landscape drivers also differed markedly between system types. Catchment characteristics moderately influenced stream chemistry (RDA; $R_{adj}^2 = 0.60$), with electrical conductivity highly correlated to dominant ions (Mg^{2+} , $\rho = 0.92$; Ca^{2+} , $\rho = 0.91$), nutrients (SRP, $\rho = 0.80$), and latitude ($\rho = -0.71$). This suggests that while stream chemistry is still subject to considerable variation from seasonal flow patterns, it is generally reflective of regional lithology and climate. In contrast, wetland chemistry was characterized by high spatiotemporal variability, weaker univariate correlations among chemical parameters, and a greater decoupling from landscape drivers ($R_{adj}^2 = 0.39$). This divergence suggests that wetland water chemistry is driven less by local catchment features and more by broader seasonal variation in hydrological connectivity and internal biogeochemical processing (Roley et al. 2012; Weidner et al. 2025). This is consistent with the concept of wetlands as dynamic "biogeochemical reactors" governed by fluctuating river–floodplain connectivity. This includes periods of disconnection where increased residence times favor nutrient retention and processing over downstream transport (Junk et al. 1989; Amoros and Bornette 2002). This importance of biogeochemical processing is evident in the distinct nitrogen dynamics of the wetland sites. The prevalence of low nitrate concentrations (mean $< 10 \mu\text{g}\cdot\text{L}^{-1}$ at 7 out of 12 sites) in wetlands relative to streams (mean $> 10 \mu\text{g}\cdot\text{L}^{-1}$ at 13 out of 16 of sites; range: $6.2\text{--}424.5 \mu\text{g}\cdot\text{L}^{-1}$) is consistent with denitrification, a process commonly observed in hypoxic floodplain environments (Forshay and Stanley 2005; Saunders and Kalff 2021). Concurrently, elevated ammonia concentrations in wetlands (often twice as high as those in streams) suggest instances of stalled nitrification, where the same hypoxic conditions that drive denitrification prevent the aerobic oxidation of ammonia, leading to its accumulation (Bowden 1987). These findings align with parallel observations of hypoxia in these wetland sites (Milner et al. 2024, Parsons et al. 2026).

Our results broadly align with parallel studies on floodplain wetlands in the North Thompson, which have focused on fish and other abiotic habitat attributes (dissolved oxygen, water temperature; Milner et al. 2025), as well as invertebrates (Parsons et al. 2026). Specifically, the observation of high seasonal and inter-annual variability in water chemistry parameters in wetlands supports the inference that these are highly dynamic habitats that strongly fluctuate in their physical, chemical, and biological conditions. Future work integrating these ecosystem components could better resolve the specific ecohydrological drivers of ecosystem dynamics in the wetlands and their function as fish habitat. For example, biogeochemical processing and its subsequent implications for trophic dynamics is likely influenced by the extent of wetland-mainstem connectivity as well as water residence time (Wegener et al. 2017), both of which are not currently quantified at a high resolution in the North Thompson.

Inferences from this study should be tempered by several limitations. First, the magnitude of unexplained variance across our RDA models (39.9% for streams, 56.2% for wetlands), along with the substantial residual variability in our exploratory PCA (where the first two axes captured only 55.1% of the total variance) underscores the critical role of unmeasured hydrological dynamics. Our "snapshot" seasonal sampling likely underestimated the influence of high-intensity hydrological events; specifically, sampling did not coincide with runoff events such as rainfall, snowmelt, or floods that often drive nutrient inputs, particularly in catchments with forestry and agricultural activity (Lloyd et al. 2016; Sherriff et al. 2016; Blaen et al. 2017; Nieminen et al. 2017). This temporal variability is often expressed as hysteresis loops during storm events, where solute concentrations vary significantly whether the hydrograph is rising or falling (Aubert et al. 2013; B  thke and Schuetz 2025). Second, given the challenges of accessing sites at high flows, our sampling design did not capture the full temporal extent of the North Thompson River's freshet. Thus, our inferences into seasonal patterns associated with higher discharge and fluctuating wetland connectivity are limited (Chaudhuri et al. 2025). Third, while grouping lithology into broad categories was necessary given the spatial data resolution, it likely overlooked important variation in subsurface characteristics that drive water chemistry. For example, our lithologic predictors did not consider the critical zone in the more shallow subsurface, which is an important driver of solute loads and water chemistry (Chorover et al. 2017; Pedrazas et al. 2021). Finally, the exclusion of latitude to resolve collinearity likely shifted meaningful climatic variance into the residual fraction (White and Blum 1995; Weyhenmeyer 2008). It also means that latitude remains a confounding effect in our landscape analysis and all inferences from that analysis should be considered with that in mind.

Despite these limitations, our findings provide foundational information on water chemistry across the North Thompson watershed, which has several linkages to management. First, this information provides baseline data to inform future monitoring of salmon habitat, ecosystem condition, and water quality across the region. These more focused assessments are already ongoing in some North Thompson watersheds and may accompany future development (Scott et al. 2025). Notably, all measured

values in our dataset were below water quality guidelines for British Columbia (BC Water Land and Resource Stewardship 2026), but this should be tempered given our sampling did not target runoff events. Second, our analyses may inform more efficient broad-scale monitoring by identifying associations among water chemistry parameters and between chemistry parameters and landscape attributes. For example, correlation analysis suggests that conductivity may be an effective proxy for reactive phosphorus in stream habitats, implying that conductivity monitoring may be a cost effective approach for tracking high frequency nutrient inputs (Dow and Zampella 2000; Moore et al. 2008; Marandi et al. 2013). Finally, our results support the broader narrative that ecosystem processes in floodplain wetlands are distinctly different from streams and that these areas provide unique benefits to salmon ecosystems (Brown 2002; Henning et al. 2006; Rosenfeld et al. 2008).

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6.0 REFERENCES

- Agricultural Land Commission. 2024. ALC ALR Polygons. BC Data Catalogue. Available from <https://catalogue.data.gov.bc.ca/dataset/alc-alr-polygons> [accessed 20 January 2024].
- Aitchison, J. 1982. The Statistical Analysis of Compositional Data. *J. R. Stat. Soc. Ser. B* **44**(2): 139–177.
- Allan, J.D. 2004. Landscapes and Riverscapes: The Influence of Land Use on Stream Ecosystems. *Annu. Rev. Ecol. Evol. Syst.* **35**: 257–284. doi:10.1146/annurev.ecolsys.35.120202.110122.
- Amiotte Suchet, P., and Probst, J.L. 1995. A global model for present-day atmospheric/soil CO₂ consumption by chemical erosion of continental rocks (GEM-CO₂). *Tellus B Chem. Phys. Meteorol.* **47**(1–2): 273–280. doi:10.1034/j.1600-0889.47.issue1.23.x.
- Amiotte Suchet, P., Probst, J.-L., and Ludwig, W. 2003. Worldwide distribution of continental rock lithology: Implications for the atmospheric/soil CO₂ uptake by continental weathering and alkalinity river transport to the oceans. *Glob. Biogeochem. Cycles* **17**(2). doi:10.1029/2002GB001891.
- Amoros, C., and Bornette, G. 2002. Connectivity and biocomplexity in waterbodies of riverine floodplains. *Freshw. Biol.* **47**(4): 761–776. doi:10.1046/j.1365-2427.2002.00905.x.
- Anderson, S.P., and Dietrich, W.E. 2001. Chemical weathering and runoff chemistry in a steep headwater catchment. *Hydrol. Process.* **15**(10): 1791–1815. doi:10.1002/hyp.240.
- Antweiler, R.C., and Taylor, H.E. 2008. Evaluation of Statistical Treatments of Left-Censored Environmental Data using Coincident Uncensored Data Sets: I. Summary Statistics. *Environ. Sci. Technol.* **42**(10): 3732–3738. doi:10.1021/es071301c.
- Aubert, A.H., Gascuel-Oudoux, C., and Merot, P. 2013. Annual hysteresis of water quality: A method to analyse the effect of intra- and inter-annual climatic conditions. *J. Hydrol.* **478**: 29–39. doi:10.1016/j.jhydrol.2012.11.027.
- Bäthke, L., and Schuetz, T. 2025. Hysteresis between groundwater and surface water levels indicates the states of hydrological turnover affecting solute transport and redox processes. *EGUsphere*: 1–22. doi:10.5194/egusphere-2025-1674.
- British Columbia Ministry of Water, Land and Resource Stewardship. 2026. British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture - Guideline Summary. Water Quality Guideline Series, WQG-20. Prov. B.C., Victoria B.C.
- Blaen, P.J., Khamis, K., Lloyd, C., Comer-Warner, S., Ciocca, F., Thomas, R.M., MacKenzie, A.R., and Krause, S. 2017. High-frequency monitoring of catchment nutrient exports reveals highly variable storm event responses and dynamic source zone activation. *J. Geophys. Res. Biogeosciences* **122**(9): 2265–2281. doi:10.1002/2017JG003904.
- Bluth, G.J.S., and Kump, L.R. 1994. Lithologic and climatologic controls of river chemistry. *Geochim. Cosmochim. Acta* **58**(10): 2341–2359. doi:10.1016/0016-7037(94)90015-9.

- Bolstad, P.V., and Swank, W.T. 1997. Cumulative Impacts Of Landuse On Water Quality In A Southern Appalachian Watershed. *J. Am. Water Resour. Assoc.* **33**(3): 519–533. doi:10.1111/j.1752-1688.1997.tb03529.x.
- Borcard, D., Legendre, P., and Drapeau, P. 1992. Partialling out the Spatial Component of Ecological Variation. *Ecology* **73**(3): 1045–1055. doi:10.2307/1940179.
- Bowden, W.B. 1987. The biogeochemistry of nitrogen in freshwater wetlands. *Biogeochemistry* **4**(3): 313–348. doi:10.1007/BF02187373.
- Brown, T.G. 2002. Floodplains, flooding, and salmon rearing habitats in British Columbia : a review. Canadian Science Advisory Secretariat research document, 1480-4883. 2002/007. Fisheries and Oceans Canada, Ottawa. Available from <https://publications.gc.ca/site/eng/9.807470/publication.html>.
- Canadian Council of Ministers of the Environment. 2011. Protocols manual for water quality sampling in Canada. Government of Canada. Available from <https://publications.gc.ca/site/eng/444867/publication.html> [accessed 17 February 2026].
- Chaudhuri, C., Braun, D., Hodgson, E., and Robertson, C. 2025. Quantifying flood-pulse dynamics and associated wetland habitats for juvenile salmon in a large free-flowing river. *Sci. Total Environ.* **1009**: 181038. doi:10.1016/j.scitotenv.2025.181038.
- Chorover, J., Derry, L.A., and McDowell, W.H. 2017. Concentration-Discharge Relations in the Critical Zone: Implications for Resolving Critical Zone Structure, Function, and Evolution. *Water Resour. Res.* **53**(11): 8654–8659. doi:10.1002/2017WR021111.
- Chuman, T., Hruška, J., Oulehle, F., Gürtlerová, P., and Majer, V. 2013. Does stream water chemistry reflect watershed characteristics? *Environ. Monit. Assess.* **185**(7): 5683–5701. doi:10.1007/s10661-012-2976-3.
- Colman, S.M. 1982. Chemical weathering of basalts and andesites; evidence from weathering rinds. 1246. U.S. G.P.O.,. Available from <https://pubs.usgs.gov/publication/pp1246> [accessed 3 February 2026].
- Cui, Y., Miller, D., Schiarizza, P., and Diakow, L.J. 2017. British Columbia digital geology. British Columbia Ministry of Energy, Mines and Petroleum Resources. Available from <https://www2.gov.bc.ca/gov/content/industry/mineral-exploration-mining/british-columbia-geological-survey/geology/bcdigitalgeology> [accessed 3 January 2024].
- Cunningham, D.S., Braun, D.C., Moore, J.W., and Martens, A.M. 2023. Forestry influences on salmonid habitat in the North Thompson River watershed, British Columbia. *Can. J. Fish. Aquat. Sci.* **80**(7): 1053–1070. doi:10.1139/cjfas-2022-0255.
- Déry, S.J., Hernández-Henríquez, M.A., Owens, P.N., Parkes, M.W., and Petticrew, E.L. 2012. A century of hydrological variability and trends in the Fraser River Basin. *Environ. Res. Lett.* **7**(2): 024019. doi:10.1088/1748-9326/7/2/024019.
- Dessert, C., Dupré, B., Gaillardet, J., François, L.M., and Allègre, C.J. 2003. Basalt weathering laws and the impact of basalt weathering on the global carbon cycle. *Chem. Geol.* **202**(3): 257–273. Controls on Chemical Weathering. doi:10.1016/j.chemgeo.2002.10.001.

- Dillon, P.J., and Kirchner, W.B. 1975. The effects of geology and land use on the export of phosphorus from watersheds. *Water Res.* **9**(2): 135–148. doi:10.1016/0043-1354(75)90002-0.
- Dow, C.L., Arscott, D.B., and Newbold, J.D. 2006. Relating major ions and nutrients to watershed conditions across a mixed-use, water-supply watershed. *J. North Am. Benthol. Soc.* **25**(4): 887–911. doi:10.1899/0887-3593(2006)025[0887:RMIANT]2.0.CO;2.
- Dow, C.L., and Zampella, R.A. 2000. Specific Conductance and pH as Indicators of Watershed Disturbance in Streams of the New Jersey Pinelands, USA. *Environ. Manage.* **26**(4): 437–445. doi:10.1007/s002670010101.
- Dralle, D.N., Rossi, G., Georgakakos, P., Hahm, W.J., Rempe, D.M., Blanchard, M., Power, M.E., Dietrich, W.E., and Carlson, S.M. 2023. The salmonid and the subsurface: Hillslope storage capacity determines the quality and distribution of fish habitat. *Ecosphere* **14**(2): e4436. doi:10.1002/ecs2.4436.
- Egozcue, J.J., Pawlowsky-Glahn, V., Mateu-Figueras, G., and Barceló-Vidal, C. 2003. Isometric Logratio Transformations for Compositional Data Analysis. *Math. Geol.* **35**(3): 279–300. doi:10.1023/A:1023818214614.
- Elosegi, A., Díez, J., and Mutz, M. 2010. Effects of hydromorphological integrity on biodiversity and functioning of river ecosystems. *Hydrobiologia* **657**(1): 199–215. doi:10.1007/s10750-009-0083-4.
- Farnham, I.M., Singh, A.K., Stetzenbach, K.J., and Johannesson, K.H. 2002. Treatment of nondetects in multivariate analysis of groundwater geochemistry data. *Chemom. Intell. Lab. Syst.* **60**(1): 265–281. Fourth International Conference on Environ metrics and Chemometrics held in Las Vegas, NV, USA, 18-20 September 2000. doi:10.1016/S0169-7439(01)00201-5.
- Feller, M.C. 2005. Forest Harvesting and Streamwater Inorganic Chemistry in Western North America: A Review. *JAWRA J. Am. Water Resour. Assoc.* **41**(4): 785–811. doi:10.1111/j.1752-1688.2005.tb03771.x.
- Fleming, W.L., Braun, D.C., Moore, J.W., Patterson, D.A., Wilson, S.M., LoScerbo, D., Martens, A.M., Cunningham, D.S., and Naman, S.M. 2026. Associations between stream habitat and energetic condition in juvenile coho salmon (*Oncorhynchus kisutch*). *Canadian Journal of Fisheries and Aquatic Sciences*. **83**: 1-17. <https://doi.org/10.1139/cjfas-2025-0426>
- Forest Analysis and Inventory Branch. 2024. Harvested Areas of BC (Consolidated Cutblocks). BC Data Catalogue. Available from <https://catalogue.data.gov.bc.ca/dataset/harvested-areas-of-bc-consolidated-cutblocks-> [accessed 20 January 2024].
- Forshay, K., and Stanley, E. 2005. Rapid Nitrate Loss and Denitrification in a Temperate River Floodplain. *Biogeochemistry* **75**: 43–64. doi:10.1007/s10533-004-6016-4.
- Freeze, R.A., and Cherry, J.A. 1979. Groundwater. Prentice-Hall, New Jersey.
- GeoBC. 2021. BEC Map. Forest Analysis and Inventory Branch. Available from <https://catalogue.data.gov.bc.ca/dataset/bec-map> [accessed 26 June 2025].
- Gibbs, R.J. 1970. Mechanisms Controlling World Water Chemistry. *Science* **170**(3962): 1088–1090.
- Goldich, S.S. 1938. A Study in Rock-Weathering. *J. Geol.* **46**(1): 17–58. doi:10.1086/624619.

- Hartmann, J., and Moosdorf, N. 2011. Chemical weathering rates of silicate-dominated lithological classes and associated liberation rates of phosphorus on the Japanese Archipelago—Implications for global scale analysis. *Chem. Geol.* **287**(3): 125–157. doi:10.1016/j.chemgeo.2010.12.004.
- Henning, J.A., Gresswell, R.E., and Fleming, I.A. 2006. Juvenile Salmonid Use of Freshwater Emergent Wetlands in the Floodplain and Its Implications for Conservation Management. *North Am. J. Fish. Manag.* **26**(2): 367–376. doi:10.1577/M05-057.1.
- Hodgson, E., Pemberton-Renaud, V., Brennan, K., and Fernandez, D. 2025. Strontium isoscape for the North Thompson River watershed, British Columbia. Canadian technical report of fisheries and aquatic sciences, 1488-5379. 3648. Fisheries and Oceans Canada, Cultus Lake, BC. Available from <https://publications.gc.ca/site/eng/9.945300/publication.html>.
- Hogsden, K.L., and Harding, J.S. 2012. Anthropogenic and natural sources of acidity and metals and their influence on the structure of stream food webs. *Environ. Pollut.* **162**: 466–474. doi:10.1016/j.envpol.2011.10.024.
- Ibarra, D.E., Caves, J.K., Moon, S., Thomas, D.L., Hartmann, J., Chamberlain, C.P., and Maher, K. 2016. Differential weathering of basaltic and granitic catchments from concentration–discharge relationships. *Geochim. Cosmochim. Acta* **190**: 265–293. doi:10.1016/j.gca.2016.07.006.
- Jarvie, H.P., Haygarth, P.M., Neal, C., Butler, P., Smith, B., Naden, P.S., Joynes, A., Neal, M., Wickham, H., Armstrong, L., Harman, S., and Palmer-Felgate, E.J. 2008. Stream water chemistry and quality along an upland–lowland rural land-use continuum, south west England. *J. Hydrol.* **350**(3): 215–231. doi:10.1016/j.jhydrol.2007.10.040.
- Johnson, L., Richards, C., Host, G., and Arthur, J. 1997. Landscape influences on water chemistry in Midwestern stream ecosystems. *Freshw. Biol.* **37**(1): 193–208. doi:10.1046/j.1365-2427.1997.d01-539.x.
- Junk, W., Bayley, P., and Sparks, R. 1989. The Flood Pulse Concept in River-Floodplain Systems. *In* Dodge, D.P., Ed., *Proceedings of the International Large River Symposium (LARS)*. Canadian Journal of Fisheries and Aquatic Sciences Special Publication. NRC Research Press, Ottawa. pp. 110–127.
- Lapworth, D.J., Goody, D.C., Kent, F., Heaton, T.H.E., Cole, S.J., and Allen, D. 2013. A combined geochemical and hydrological approach for understanding macronutrient sources. *J. Hydrol.* **500**: 226–242. doi:10.1016/j.jhydrol.2013.07.006.
- Layer, K., Riede, J.O., Hildrew, A.G., and Woodward, G. 2010. Food Web Structure and Stability in 20 Streams Across a Wide pH Gradient. *In* *Ecological Networks. Advances in Ecological Research*. Academic Press. pp. 265–299.
- Legendre, P., and Legendre, L. 2012. Numerical ecology. *In* 3rd edition. *Developments in environmental modelling*. Elsevier, Amsterdam.
- Lloyd, C.E.M., Freer, J.E., Johnes, P.J., and Collins, A.L. 2016. Using hysteresis analysis of high-resolution water quality monitoring data, including uncertainty, to infer controls on nutrient and sediment transfer in catchments. *Sci. Total Environ.* **543**: 388–404. doi:10.1016/j.scitotenv.2015.11.028.

- Marandi, A., Polikarpus, M., and Jöeleht, A. 2013. A new approach for describing the relationship between electrical conductivity and major anion concentration in natural waters. *Appl. Geochem.* **38**: 103–109. doi:10.1016/j.apgeochem.2013.09.003.
- McClain, M.E., Boyer, E.W., Dent, C.L., Gergel, S.E., Grimm, N.B., Groffman, P.M., Hart, S.C., Harvey, J.W., Johnston, C.A., Mayorga, E., McDowell, W.H., and Pinay, G. 2003. Biogeochemical Hot Spots and Hot Moments at the Interface of Terrestrial and Aquatic Ecosystems. *Ecosystems* **6**(4): 301–312. doi:10.1007/s10021-003-0161-9.
- Meybeck, M. 1987. Global chemical weathering of surficial rocks estimated from river dissolved loads. *Am. J. Sci.* **287**(5): 401–428. doi:10.2475/ajs.287.5.401.
- Milner, B.L., Braun, D., Moore, J.W., Martens, A.M., LoScerbo, D., and Naman, S. 2025. Seasonal dynamics of juvenile coho salmon (*Oncorhynchus kisutch*) in wetlands of the North Thompson River, British Columbia. *Can. J. Fish. Aquat. Sci.* **82**: 1–19. doi:10.1139/cjfas-2024-0177.
- Miltner, R.J., Rankin, and T, E. 1998. Primary nutrients and the biotic integrity of rivers and streams. *Freshw. Biol.* **40**(1): 145–158. doi:10.1046/j.1365-2427.1998.00324.x.
- Moore, R.D., Richards, G., and Story, A. 2008. Electrical Conductivity as an Indicator of Water Chemistry and Hydrologic Process. *Streamline Watershed Manag. Bull.* **11**(2): 25–29.
- Murphy, J., and Riley, J.P. 1962. A modified single solution method for the determination of phosphate in natural waters. *Anal. Chim. Acta* **27**: 31–36. doi:10.1016/S0003-2670(00)88444-5.
- Nelson, M.L., Rhoades, C.C., and Dwire, K.A. 2011. Influence of Bedrock Geology on Water Chemistry of Slope Wetlands and Headwater Streams in the Southern Rocky Mountains. *Wetlands* **31**(2): 251–261. doi:10.1007/s13157-011-0157-8.
- Nesbitt, H.W., and Young, G.M. 1984. Prediction of some weathering trends of plutonic and volcanic rocks based on thermodynamic and kinetic considerations. *Geochim. Cosmochim. Acta* **48**(7): 1523–1534. doi:10.1016/0016-7037(84)90408-3.
- Nieminen, M., Sarkkola, S., and Laurén, A. 2017. Impacts of forest harvesting on nutrient, sediment and dissolved organic carbon exports from drained peatlands: A literature review, synthesis and suggestions for the future. *For. Ecol. Manag.* **392**: 13–20. doi:10.1016/j.foreco.2017.02.046.
- Ohta, T., and Arai, H. 2007. Statistical empirical index of chemical weathering in igneous rocks: A new tool for evaluating the degree of weathering. *Chem. Geol.* **240**(3): 280–297. doi:10.1016/j.chemgeo.2007.02.017.
- Olson, J.R., and Hawkins, C.P. 2012. Predicting natural base-flow stream water chemistry in the western United States. *Water Resour. Res.* **48**(2). doi:https://doi.org/10.1029/2011WR011088.
- Owen, D.Des.R., Pawlowsky-Glahn, V., Egozcue, J.J., Buccianti, A., and Bradd, J.M. 2016. Compositional data analysis as a robust tool to delineate hydrochemical facies within and between gas-bearing aquifers. *Water Resour. Res.* **52**(8): 5771–5793. doi:10.1002/2015WR018386.

- Parsons, S., Naman, S.N., Tsui, C., Braun, D.C., LoScerbo, D., Martens, A.M., and Little, C.J. 2026. Spatiotemporal dynamics of food availability for juvenile Coho Salmon (*Oncorhynchus kisutch*) across a watershed habitat mosaic. *Canadian Journal of Fisheries and Aquatic Sciences*. **83**: 1-17. <https://doi.org/10.1139/cjfas-2025-0364>
- Pawlowsky-Glahn, V., and Egozcue, J.J. 2006. Compositional data and their analysis: an introduction. *Geol. Soc. Lond. Spec. Publ.* **264**(1): 1–10. doi:10.1144/GSL.SP.2006.264.01.01.
- Pedrazas, M.A., Hahm, W.J., Huang, M.-H., Dralle, D., Nelson, M.D., Breunig, R.E., Fauria, K.E., Bryk, A.B., Dietrich, W.E., and Rempe, D.M. 2021. The Relationship Between Topography, Bedrock Weathering, and Water Storage Across a Sequence of Ridges and Valleys. *J. Geophys. Res. Earth Surf.* **126**(4): e2020JF005848. doi:10.1029/2020JF005848.
- Reddy, K.R., and DeLaune, R.D. 2008. *Biogeochemistry of Wetlands: Science and Applications*. CRC Press, Boca Raton.
- Roley, S.S., Tank, J.L., and Williams, M.A. 2012. Hydrologic connectivity increases denitrification in the hyporheic zone and restored floodplains of an agricultural stream. *J. Geophys. Res. Biogeosciences* **117**(G3): 2012JG001950. doi:10.1029/2012JG001950.
- Rosenfeld, J.S., Ayllón, D., Grant, J.W.A., Naman, S.M., Post, J.R., Matte, J.-M., and Monnet, G. 2024. Determinants of Productive Capacity for Stream Salmonids. *In* *Advances in the Ecology of Stream-Dwelling Salmonids. Edited by J. Lobon-Cervia, P. Budy, and R. Gresswell*. Springer International Publishing, Cham. pp. 491–549.
- Rosenfeld, J.S., Raeburn, E., Carrier, P.C., and Johnson, R. 2008. Effects of Side Channel Structure on Productivity of Floodplain Habitats for Juvenile Coho Salmon. *North Am. J. Fish. Manag.* **28**(4): 1108–1119. doi:10.1577/M07-027.1.
- Sato, A., Sakurai, T., Fukushima, K., and Nakajima, R. 2000. Relationships between stream water chemistry and catchment geology in a mountainous region in Nagano Prefecture, Japan II: mid to southern part along the Median Tectonic Line. *Limnology* **1**(2): 117–127. doi:10.1007/s102010070017.
- Saunders, D., and Kalff, J. 2021. Nitrogen Retention in Wetlands, Lakes and Rivers. *Hydrobiologia* **443**: 205–212. doi:10.1023/A:1017506914063.
- Scott, S., Donald, T., Noel, M., and Ross, P.S. 2025. Louis Creek watershed: Water quality report for the 2024 dry season. Raincoast Conservation Foundation. Available from <https://doi.org/10.70766/86831.4> [accessed 4 February 2026].
- Sherriff, S.C., Rowan, J.S., Fenton, O., Jordan, P., Melland, A.R., Mellander, P.-E., and hUallacháin, D.Ó. 2016. Storm Event Suspended Sediment-Discharge Hysteresis and Controls in Agricultural Watersheds: Implications for Watershed Scale Sediment Management. *Environ. Sci. Technol.* **50**(4): 1769–1778. doi:10.1021/acs.est.5b04573.
- Stanford, J.A., Lorang, M.S., and Hauer, F.R. 2005. The shifting habitat mosaic of river ecosystems. *SIL Proc. 1922-2010* **29**(1): 123–136. doi:10.1080/03680770.2005.11901979.

- Thomaz, S.M., Bini, L.M., and Bozelli, R.L. 2007. Floods increase similarity among aquatic habitats in river-floodplain systems. *Hydrobiologia* **579**(1): 1–13. doi:10.1007/s10750-006-0285-y.
- Tockner, K., Malard, F., and Ward, J.V. 2000. An extension of the flood pulse concept. *Hydrol. Process.* **14**(16–17): 2861–2883. doi:10.1002/1099-1085(200011/12)14:16/17<2861::AID-HYP124>3.0.CO;2-F.
- Vannote, R.L., Minshall, G.W., Cummins, K.W., Sedell, J.R., and Cushing, C.E. 1980. The River Continuum Concept. *Can. J. Fish. Aquat. Sci.* **37**(1): 130–137. doi:https://doi.org/10.1139/f80-017.
- Wang, L., Liu, B., McKinley, J.M., Cooper, M.R., Li, C., Kong, Y., and Shan, M. 2021. Compositional data analysis of regional geochemical data in the Lhasa area of Tibet, China. *Appl. Geochem.* **135**: 105108. doi:10.1016/j.apgeochem.2021.105108.
- Ward, J.V., Tockner, K., Arscott, D.B., and Claret, C. 2002. Riverine landscape diversity. *Freshw. Biol.* **47**(4): 517–539. doi:10.1046/j.1365-2427.2002.00893.x.
- Weibel, R., Vosgerau, H., Larsen, M., Guarnieri, P., Kokfelt, T.F., Dideriksen, K., Balić-Žunić, T., and Bell, B. 2023. Diagenetic effect on reservoir quality of siliciclastic and volcanoclastic sandstones from a Paleogene volcanic rifted margin, East Greenland. *J. Sediment. Res.* **93**(12): 895–931. doi:10.2110/jsr.2021.127.
- Weidner, C.R., Zarnetske, J.P., Kendall, A.D., Martin, S.L., Nesheim, S., and Shogren, A.J. 2025. Wetlands, Groundwater and Seasonality Influence the Spatial Distribution of Stream Chemistry in a Low-Relief Catchment. *J. Geophys. Res. Biogeosciences* **130**(8): e2025JG008989. doi:10.1029/2025JG008989.
- Wegener, P., Covino, T. and Wohl, E., 2017. Beaver-mediated lateral hydrologic connectivity, fluvial carbon and nutrient flux, and aquatic ecosystem metabolism. *Water Resources Research*, 53(6), pp.4606-4623.
- Weyhenmeyer, G.A. 2008. Water chemical changes along a latitudinal gradient in relation to climate and atmospheric deposition. *Clim. Change* **88**(2): 199–208. doi:10.1007/s10584-007-9331-7.
- White, A.F., and Blum, A.E. 1995. Effects of climate on chemical weathering in watersheds. *Geochim. Cosmochim. Acta* **59**(9): 1729–1747. doi:10.1016/0016-7037(95)00078-E.
- Xie, X., Norra, S., Berner, Z., and Stüben, D. 2005. A Gis-Supported Multivariate Statistical Analysis of Relationships Among Stream Water Chemistry, Geology and Land Use in Baden-Württemberg, Germany. *Water. Air. Soil Pollut.* **167**(1–4): 39–57. doi:10.1007/s11270-005-0613-2.

APPENDICES

APPENDIX 1 — Sampling Schedule and Catchment Lithology and Land Use Classification

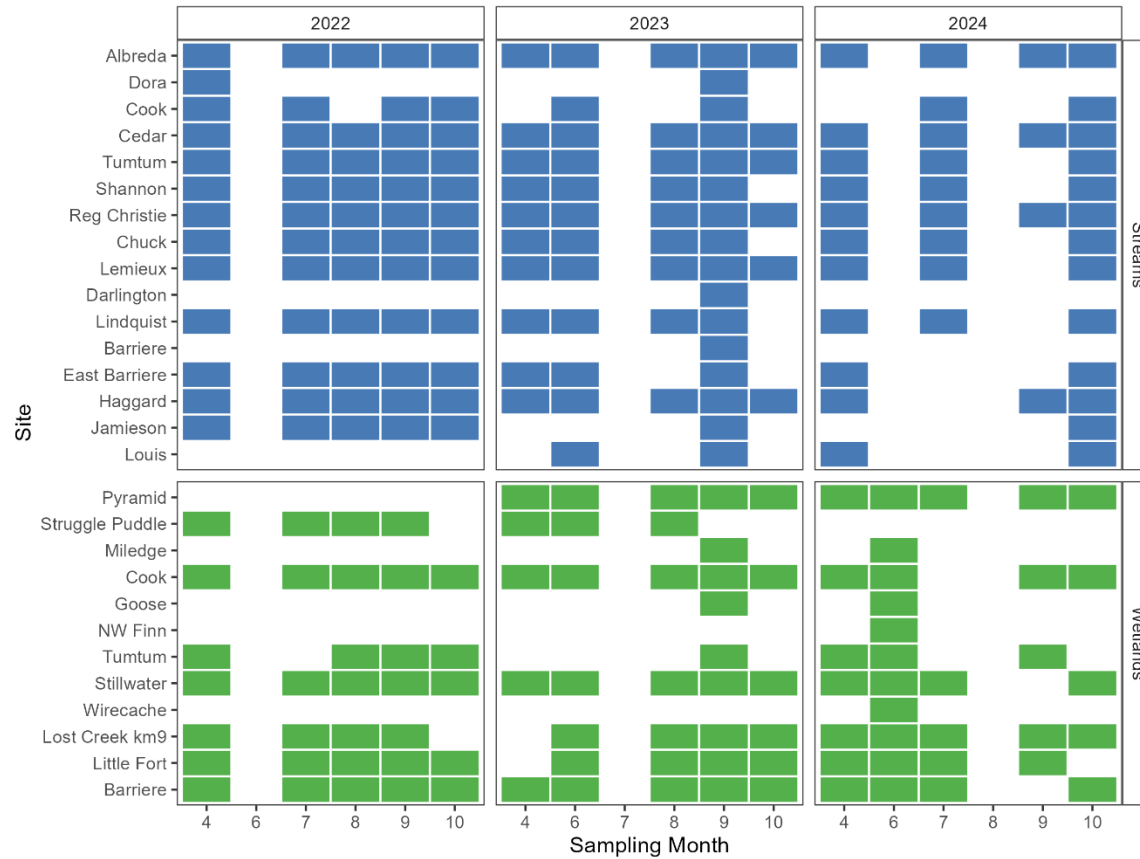


Figure A11 Sampling schedule for all stream (blue) and wetland (green) sites from 2022-2024.

Table A1.1. Catchment size and bedrock lithological composition as determined from the Freshwater Atlas and BC Digital Geology, respectively, for tributary streams in the North Thompson River watershed.

Site Name	Watershed Area (km ²)	Lithology (Original)	Lithology (Reclassified)	Lith. Area (km ²)	Lith. Area (% wtshd.)
Albreda River	72.549	coarse clastic sedimentary rocks	siliciclastic	12.328	0.170
		mudstone, siltstone, shale fine clastic sedimentary rocks	siliciclastic	14.243	0.196
		orthogneiss metamorphic rocks	felsic & crystalline	35.362	0.487
		quartzite, quartz arenite sedimentary rocks	felsic & crystalline	10.616	0.146
Barriere River	0.899	paragneiss metamorphic rocks	felsic & crystalline	0.818	0.909
		quartz monzonitic intrusive rocks	felsic & crystalline	0.081	0.091
Cedar Creek	11.416	metasediments	mixed sedimentary & volcanic	11.416	1.000
Chuck Creek	47.500	andesitic volcanic rocks	intermediate igneous	5.626	0.118
		greenstone, greenschist metamorphic rocks	mafic to ultramafic	17.132	0.361
		limestone, marble, calcareous sedimentary rocks	carbonate	0.910	0.019
		mudstone, siltstone, shale fine clastic sedimentary rocks	siliciclastic	0.662	0.014
		orthogneiss metamorphic rocks	felsic & crystalline	2.392	0.050
		quartzite, quartz arenite sedimentary rocks	felsic & crystalline	20.778	0.437
Cook Creek	10.979	metasediments	mixed sedimentary & volcanic	10.979	1.000
Darlington Creek	74.389	granodioritic intrusive rocks	felsic & crystalline	73.974	0.994
		undivided volcanic rocks	intermediate igneous	0.415	0.006
Dora Creek	16.578	orthogneiss metamorphic rocks	felsic & crystalline	16.511	0.996
		quartzite, quartz arenite sedimentary rocks	felsic & crystalline	0.067	0.004
East Barriere River	220.683	greenstone, greenschist metamorphic rocks	mafic to ultramafic	52.754	0.239

Site Name	Watershed Area (km ²)	Lithology (Original)	Lithology (Reclassified)	Lith. Area (km ²)	Lith. Area (% wtshd.)
		limestone, marble, calcareous sedimentary rocks	carbonate	0.323	0.001
		limestone, slate, siltstone, argillite	carbonate	6.479	0.029
		mudstone, siltstone, shale fine clastic sedimentary rocks	siliciclastic	4.668	0.021
		orthogneiss metamorphic rocks	felsic & crystalline	1.372	0.006
		paragneiss metamorphic rocks	felsic & crystalline	38.784	0.176
		quartz monzonitic intrusive rocks	felsic & crystalline	69.613	0.315
		quartzite, quartz arenite sedimentary rocks	felsic & crystalline	46.688	0.212
Haggard Creek	95.527	greenstone, greenschist metamorphic rocks	mafic to ultramafic	36.570	0.383
		limestone, marble, calcareous sedimentary rocks	carbonate	1.889	0.020
		limestone, slate, siltstone, argillite	carbonate	4.340	0.045
		mudstone, siltstone, shale fine clastic sedimentary rocks	siliciclastic	14.418	0.151
		quartzite, quartz arenite sedimentary rocks	felsic & crystalline	25.038	0.262
		undivided volcanic rocks	intermediate igneous	13.273	0.139
Jamieson Creek	234.100	basaltic volcanic rocks	mafic to ultramafic	38.677	0.165
		dioritic intrusive rocks	intermediate igneous	1.691	0.007
		granite, alkali feldspar granite intrusive rocks	felsic & crystalline	0.196	0.001
		granodioritic intrusive rocks	felsic & crystalline	1.041	0.004
		marine sedimentary and volcanic rocks	mixed sedimentary & volcanic	192.494	0.822
Lemieux Creek	522.120	basaltic volcanic rocks	mafic to ultramafic	62.473	0.120
		dioritic intrusive rocks	intermediate igneous	50.199	0.096
		granite, alkali feldspar granite intrusive rocks	felsic & crystalline	1.702	0.003
		granodioritic intrusive rocks	felsic & crystalline	142.063	0.272
		limestone, slate, siltstone, argillite	carbonate	8.548	0.016

Site Name	Watershed Area (km ²)	Lithology (Original)	Lithology (Reclassified)	Lith. Area (km ²)	Lith. Area (% wtshd.)
		marine sedimentary and volcanic rocks	mixed sedimentary & volcanic	143.364	0.275
		mudstone, siltstone, shale fine clastic sedimentary rocks	siliciclastic	78.805	0.151
		ultramafic rocks	mafic to ultramafic	3.573	0.007
		undivided sedimentary rocks	siliciclastic	21.391	0.041
		undivided volcanic rocks	intermediate igneous	10.002	0.019
Lindquist Creek	65.875	granodioritic intrusive rocks	felsic & crystalline	59.090	0.897
		marine sedimentary and volcanic rocks	mixed sedimentary & volcanic	6.378	0.097
		undivided volcanic rocks	intermediate igneous	0.407	0.006
Louis Creek	128.438	basaltic volcanic rocks	mafic to ultramafic	2.296	0.018
		greenstone, greenschist metamorphic rocks	mafic to ultramafic	11.620	0.090
		mudstone, siltstone, shale fine clastic sedimentary rocks	siliciclastic	63.614	0.495
		orthogneiss metamorphic rocks	felsic & crystalline	0.954	0.007
		undivided volcanic rocks	intermediate igneous	49.954	0.389
Reg Christie Creek	75.940	calc-alkaline volcanic rocks	intermediate igneous	0.252	0.003
		granite, alkali feldspar granite intrusive rocks	felsic & crystalline	8.082	0.106
		greenstone, greenschist metamorphic rocks	mafic to ultramafic	20.897	0.275
		metasediments	mixed sedimentary & volcanic	1.414	0.019
		mudstone, siltstone, shale fine clastic sedimentary rocks	siliciclastic	1.403	0.018
		orthogneiss metamorphic rocks	felsic & crystalline	3.981	0.052
		quartzite, quartz arenite sedimentary rocks	felsic & crystalline	39.911	0.526
Shannon Creek	17.996	metasediments	mixed sedimentary & volcanic	17.996	1.000

Site Name	Watershed Area (km ²)	Lithology (Original)	Lithology (Reclassified)	Lith. Area (km ²)	Lith. Area (% wtshd.)
Tumtum Creek	22.520	metasediments	mixed sedimentary & volcanic	22.520	1.000

Table A1.2. Catchment size and bedrock lithological composition as determined from the Freshwater Atlas and BC Digital Geology, respectively, for floodplain wetlands in the North Thompson River watershed.

Site Name	Watershed Area (km ²)	Lithology (Original)	Lithology (Reclassified)	Lith. Area (km ²)	Lith. Area (% wtshd.)
Barriere Pond	0.008	basaltic volcanic rocks	mafic to ultramafic	0.008	1.000
Cook Wetland	0.686	coarse clastic sedimentary rocks	siliciclastic	0.000	0.000
		metamorphic rocks, undivided	mixed sedimentary & volcanic	0.038	0.056
		metasediments	mixed sedimentary & volcanic	0.648	0.944
		granite, alkali feldspar granite intrusive rocks	felsic & crystalline	2.991	0.370
Goose Wetland	8.093	metasediments	mixed sedimentary & volcanic	5.102	0.630
Little Fort Wetland	2.473	basaltic volcanic rocks	mafic to ultramafic	2.473	1.000
Lost Creek Wetland km9	0.008	andesitic volcanic rocks	intermediate igneous	0.008	1.000
Miledge Wetland	65.943	limestone, marble, calcareous sedimentary rocks	carbonate	9.281	0.141
		quartzite, quartz arenite sedimentary rocks	felsic & crystalline	55.500	0.842
		undivided sedimentary rocks	siliciclastic	1.162	0.018
NW Finn Wetland	0.226	granite, alkali feldspar granite intrusive rocks	felsic & crystalline	0.226	1.000
Pyramid Wetland	0.021	quartzite, quartz arenite sedimentary rocks	felsic & crystalline	0.021	1.000
Stillwater Wetland	6.330	metasediments	mixed sedimentary & volcanic	0.543	0.086
		quartz monzonitic intrusive rocks	felsic & crystalline	5.787	0.914
Struggle Puddle Wetland	1.111	quartzite, quartz arenite sedimentary rocks	felsic & crystalline	1.111	1.000
Tumtum Wetland	0.433	metasediments	mixed sedimentary & volcanic	0.433	1.000
Wirecache Wetland	10.862	metasediments	mixed sedimentary & volcanic	10.862	1.000

Table A1.3. Catchment characteristics for stream sites in the North Thompson watershed. Lithology values represent the proportional composition of the catchment area. Land use values represent the percentage of the total watershed area affected by agricultural development and forestry activities (historic and recent).

Site Name	Lithology (proportion composition)						Land Use (proportion watershed)		
	Felsic & Crystalline	Mafic	Intermediate	Carbonate	Siliciclastic	Mixed Sedimentary & Volcanic	Agriculture	Forestry (All Historic)	Forestry (2015–2024)
Albreda River	0.634	0.000	0.000	0.000	0.366	0.000	0.000	0.197	0.087
Cedar Creek	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.077	0.001
Chuck Creek	0.488	0.361	0.118	0.019	0.014	0.000	0.001	0.600	0.187
Cook Creek	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.031	0.003
Darlington Creek	0.994	0.000	0.006	0.000	0.000	0.000	0.004	0.603	0.345
Dora Creek	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.087	0.029
E Barriere River	0.709	0.239	0.000	0.031	0.021	0.000	0.000	0.411	0.164
Barriere River	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.752	0.251
Haggard Creek	0.262	0.383	0.139	0.065	0.151	0.000	0.000	0.576	0.252
Jamieson Creek	0.005	0.165	0.007	0.000	0.000	0.822	0.057	0.507	0.287
Lemieux Creek	0.275	0.126	0.115	0.016	0.192	0.275	0.008	0.355	0.215
Lindquist Creek	0.897	0.000	0.006	0.000	0.000	0.097	0.003	0.493	0.251
Louis Creek	0.007	0.108	0.389	0.000	0.495	0.000	0.052	0.376	0.104
Reg Christie Creek	0.684	0.275	0.003	0.000	0.018	0.019	0.003	0.571	0.216
Shannon Creek	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.286	0.094
Tumtum Creek	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.256	0.038

Table A1.4. Catchment characteristics for wetland sites in the North Thompson watershed. Lithology values represent the proportional composition of the catchment area. Land use values represent the percentage of the total watershed area affected by agricultural development and forestry activities (historic and recent).

Site Name	Lithology (% composition)						Land Use (proportion watershed)		
	Felsic & Crystalline	Mafic	Intermediate	Carbonate	Siliciclastic	Mixed Sedimentary & Volcanic	Agriculture	Forestry (All Historic)	Forestry (2015–2024)
Barriere Wetland	0.000	1.000	0.000	0.000	0.000	0.000	0.430	0.000	0.000
Cook Wetland	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
Goose Wetland	0.370	0.000	0.000	0.000	0.000	0.630	0.000	0.540	0.148
Little Fort Wetland	0.000	1.000	0.000	0.000	0.000	0.000	0.112	0.136	0.072
Lost Creek Wetland km9	0.000	0.000	1.000	0.000	0.000	0.000	0.000	1.000	0.000
Miledge Wetland	0.842	0.000	0.000	0.141	0.018	0.000	0.000	0.138	0.010
NW Finn Wetland	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.304	0.000
Pyramid Wetland	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stillwater Wetland	0.914	0.000	0.000	0.000	0.000	0.086	0.025	0.245	0.092
Struggle Puddle Wetland	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.544	0.163
Tumtum Wetland	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
Wirecache Wetland	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.253	0.024

APPENDIX 2 — Sequential Binary Partition matrix

Sequential binary partition (SBP) matrix used to calculate Isometric Log-Ratio (ILR) balances. Values indicate the grouping for each balance: (+1) represents the numerator group, (-1) represents the denominator group, and (0) indicates exclusion from the balance.

Balance variable	Description	Felsic	Mafic	Intermediate	Carbonate	Siliciclastic	Mixed
ILR1	Carbonate vs. non-carbonate	-1	-1	-1	+1	-1	-1
ILR2	Crystalline vs. sedimentary	+1	+1	+1	0	-1	-1
ILR3	Mixed vs. siliciclastic	0	0	0	0	-1	+1
ILR4	Mafic vs. felsic/intermediate	-1	+1	-1	0	0	0
ILR5	Felsic vs. intermediate	+1	0	-1	0	0	0

APPENDIX 3 — Raw Data (Streams)

Table A3.1. Albreda River monthly water quality and chemistry.

Time		Water Quality					Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)								
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca ²⁺	Cl ⁻	F ⁻	K ⁺	Mg ²⁺	Na ⁺	NH ₃	NO ₃ ⁻	SO ₄ ²⁻
2022	4	88.6	7.47	1.59	5.40	1.35	9929.50	1472.00	57.85	1663.50	990.50	1711.50	3.35	67.50	4682.50
2022	7	42.9	7.34	3.78	6.65	0.60	4671.00	263.50	22.35	1018.50	390.00	586.50	9.70	1.95	1729.00
2022	8	91.5	7.60	1.51	4.85	2.00	7278.50	444.50	42.05	1344.50	616.50	799.50	7.85	28.10	2733.50
2022	9	103.5	7.54	1.41	3.15	1.40	11135.00	1048.00	55.35	1789.00	989.50	1502.00	3.80	35.65	3774.00
2022	10	122.4	7.42	1.42	3.15	0.75	12220.00	1077.50	48.10	1848.50	1055.50	1545.00	1.90	42.85	4762.50
2023	4	113.6	7.72	1.89	5.10	3.10	20577.00	5319.00	64.20	2131.50	1721.00	3304.50	18.55	6.85	9476.00
2023	6	79.2	7.46	3.01	6.85	0.65	12310.00	947.50	22.10	1511.50	995.00	1701.50	13.10	6.30	4872.00
2023	8	78.7	7.68	0.70	7.45	1.90	18261.00	3355.00	182.50	2114.50	1632.50	2740.00	10.25	8.60	8947.00
2023	9	109.3	7.59	0.86	9.40	2.35	23583.50	2359.50	147.50	2462.50	1925.50	3207.00	7.00	14.55	7996.50
2023	10	106.8	7.70	0.70	22.00	2.20	21328.50	2461.50	128.00	2359.00	1959.00	3227.00	4.25	14.15	7561.00
2024	4	110.3	7.50	3.54	12.70	3.60	17929.00	3070.00	129.00	2290.00	1636.00	2719.00	8.10	30.90	6986.00
2024	7	74.6	9.22	-	10.50	2.00	9953.00	914.00	62.90	1555.00	948.00	1190.00	3.00	28.70	4939.00
2024	9	99.5	7.88	5.89	9.10	3.40	14605.00	1789.00	104.00	1959.00	1305.00	1706.00	6.50	34.50	6320.00
2024	10	60.5	-	2.00	7.60	0.60	7668.00	663.00	61.90	1353.00	971.00	1026.00	10.20	72.40	4292.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH₃) and nitrate (NO₃) reported as concentration of N.

Table A3.2. Barriere River monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca^{2+}	Cl^{-}	F^{-}	K^{+}	Mg^{2+}	Na^{+}	NH_3	NO_3^{-}	SO_4^{2-}
2023	9	-	-	-	11.10	3.60	15957.50	184.50	91.85	922.50	1740.00	3157.00	9.75	9.30	3282.50

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH_3) and nitrate (NO_3) reported as concentration of N.

Table A3.3. Cedar Creek monthly water quality and chemistry.

Time		Water Quality					Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)								
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca ²⁺	Cl ⁻	F ⁻	K ⁺	Mg ²⁺	Na ⁺	NH ₃	NO ₃ ⁻	SO ₄ ²⁻
2022	4	36.0	6.39	0.93	4.80	0.30	3966.00	66.30	26.00	525.00	618.00	889.00	10.15	3.00	790.00
2022	7	38.9	7.34	0.59	4.50	0.30	3777.50	25.05	15.45	456.50	419.00	808.00	2.25	0.90	1019.00
2022	8	61.3	7.40	1.35	9.60	1.35	6235.50	28.40	12.60	692.00	717.00	1249.00	1.80	3.90	1666.00
2022	9	69.2	7.50	1.46	1.25	<0.5	7116.50	43.25	14.95	751.50	846.00	1425.50	1.15	2.70	2028.50
2022	10	69.2	7.46	3.85	3.30	<0.5	7505.50	49.45	15.90	794.50	908.50	1575.50	1.40	7.40	2371.50
2023	4	34.6	7.17	3.72	6.45	0.95	5644.50	61.10	19.15	562.50	698.50	1458.50	12.55	14.15	1832.50
2023	6	39.0	7.20	3.62	9.15	0.75	7321.50	15.05	14.95	559.00	784.50	1681.50	8.05	1.50	2509.50
2023	8	58.3	7.69	2.55	8.95	1.05	10816.00	44.80	175.00	827.50	1207.50	2328.50	5.20	4.85	5074.00
2023	9	63.1	7.91	2.65	6.05	<0.5	12505.50	77.70	51.05	997.50	1414.00	2726.50	5.05	4.45	4861.00
2023	10	52.1	7.43	4.97	9.20	<0.5	10836.50	310.00	45.95	1068.50	1181.50	2406.50	2.75	8.45	3757.00
2024	4	35.6	7.14	3.78	10.90	<0.5	5360.00	34.10	32.90	625.00	747.00	1339.00	7.50	9.20	2071.00
2024	7	55.3	7.66	-	11.50	2.30	7895.00	25.70	23.60	701.00	908.00	1487.00	2.70	12.60	3646.00
2024	9	-	-	-	9.30	1.70	9832.00	36.30	40.30	917.00	1109.00	2022.00	5.70	10.30	4086.00
2024	10	36.6	7.33	0.53	7.70	<0.5	5708.00	81.50	26.80	632.00	850.00	1263.00	10.60	2.80	1824.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH₃) and nitrate (NO₃) reported as concentration of N. < indicates a concentration below the detection limit (DL) for SRP and NO₃.

Table A3.4. Chuck Creek monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca ²⁺	Cl ⁻	F ⁻	K ⁺	Mg ²⁺	Na ⁺	NH ₃	NO ₃ ⁻	SO ₄ ²⁻
2022	4	271.1	8.25	0.20	4.75	3.75	26678.50	176.50	-	589.50	7401.50	1170.50	2.40	58.10	7682.00
2022	7	209.8	8.43	0.03	4.05	2.15	20637.00	56.65	11.85	369.50	4479.00	643.00	5.25	12.30	2744.50
2022	8	265.5	8.45	0.41	12.80	4.75	24801.50	79.25	12.70	524.50	6216.50	907.50	2.85	46.85	4596.00
2022	9	285.3	8.49	2.75	6.55	4.45	26923.50	119.50	12.50	539.50	6946.00	1038.50	1.60	90.50	6096.00
2022	10	300.4	8.49	0.69	4.20	3.20	24043.00	134.00	15.05	564.93	7332.50	1149.50	1.45	100.50	7298.50
2023	4	241.6	8.38	5.70	5.55	3.85	42942.50	324.00	-	458.00	10259.50	1845.50	8.55	101.15	14373.00
2023	6	210.1	8.52	2.33	6.35	2.55	32575.00	84.55	21.15	383.00	6851.50	1037.50	8.90	3.40	6178.00
2023	8	236.4	8.44	2.45	7.75	2.70	28302.00	112.00	130.50	577.00	9766.00	1571.50	5.85	28.20	12279.50
2023	9	254.0	8.52	1.82	7.20	3.60	36758.50	205.00	26.15	644.00	11625.50	1926.00	5.00	88.60	11992.50
2024	4	185.4	8.07	3.82	13.40	4.00	31691.00	194.00	38.20	488.00	6507.00	1093.00	5.70	56.10	8227.00
2024	7	211.8	8.43	-	14.40	4.20	25910.00	93.90	13.60	421.00	6384.00	895.00	2.40	34.90	7437.00
2024	10	226.8	-	0.15	12.10	8.40	33166.00	164.00	24.80	526.00	8268.00	1217.00	10.60	48.40	8846.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH₃) and nitrate (NO₃) reported as concentration of N.

Table A3.5. Cook Creek monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca ²⁺	Cl ⁻	F ⁻	K ⁺	Mg ²⁺	Na ⁺	NH ₃	NO ₃ ⁻	SO ₄ ²⁻
2022	4	60.1	6.75	0.35	2.15	<0.3	7371.00	29.10	20.85	719.50	495.00	915.00	2.10	35.05	2990.50
2022	7	32.1	7.29	0.06	2.50	0.35	3437.50	28.25	12.00	332.50	173.50	371.00	2.85	3.90	989.50
2022	9	58.5	8.53	0.08	1.40	2.25	8558.00	56.15	13.80	650.00	445.50	815.00	1.70	17.60	2912.00
2022	10	84.6	7.47	2.13	1.30	0.55	9643.00	65.15	17.65	733.00	525.00	975.50	1.45	42.20	3558.00
2023	6	-	-	-	3.70	<0.5	7956.00	63.65	9.45	404.50	374.00	938.50	9.65	1.80	2658.50
2023	9	70.8	7.52	0.11	5.80	1.50	15726.00	78.55	55.75	902.50	830.00	1657.50	5.45	36.10	7851.50
2024	7	55.1	7.37	-	5.10	<0.5	9562.00	134.00	19.40	620.00	460.00	840.00	4.00	17.60	3654.00
2024	10	35.7	7.76	1.78	-	-	5952.00	60.00	25.00	487.00	318.00	651.00	9.20	36.60	2926.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH₃) and nitrate (NO₃) reported as concentration of N. < indicates a concentration below the detection limit (DL) for SRP and NO₃.

Table A3.6. Darlington Creek monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca ²⁺	Cl ⁻	F ⁻	K ⁺	Mg ²⁺	Na ⁺	NH ₃	NO ₃ ⁻	SO ₄ ²⁻
2023	9	186.9	8.29	0.73	-	13.60	32863.50	2912.00	51.20	1081.00	10645.50	7063.50	7.95	424.50	4965.50

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH₃) and nitrate (NO₃) reported as concentration of N.

Table A3.7. Dora Creek monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca ²⁺	Cl ⁻	F ⁻	K ⁺	Mg ²⁺	Na ⁺	NH ₃	NO ₃ ⁻	SO ₄ ²⁻
2022	4	50.8	7.11	4.34	5.90	0.40	5575.50	27.30	250.50	1426.50	642.00	760.50	2.85	228.50	4188.50
2023	9	-	-	-	6.35	0.55	8117.50	40.40	285.50	1660.50	531.50	571.50	4.40	129.00	5747.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH₃) and nitrate (NO₃) reported as concentration of N.

Table A3.8. East Barriere River monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca ²⁺	Cl ⁻	F ⁻	K ⁺	Mg ²⁺	Na ⁺	NH ₃	NO ₃ ⁻	SO ₄ ²⁻
2022	4	158.7	7.81	0.86	9.70	3.10	17532.50	406.50	72.60	1051.00	3757.00	1527.00	10.50	33.00	2440.50
2022	7	118.7	8.18	0.94	12.85	1.30	12041.00	198.50	22.25	999.00	2457.50	1398.00	3.95	4.35	2637.50
2022	8	128.7	8.23	1.75	7.40	2.10	13219.50	253.50	21.45	1043.50	2776.00	1483.00	4.10	5.00	2678.50
2022	9	145.1	8.25	2.68	1.70	2.70	15156.00	559.00	18.95	983.50	3475.00	1576.00	2.60	1.45	2784.50
2022	10	170.9	8.19	1.45	4.35	1.45	14873.00	896.50	28.35	1001.50	4098.50	1588.00	1.70	1.35	2821.50
2023	4	124.9	8.25	2.69	8.05	3.55	21748.50	1506.00	36.50	963.50	4530.50	2293.50	8.50	4.30	7567.00
2023	6	113.6	7.98	2.12	7.30	0.80	17166.50	264.00	27.20	997.00	3383.50	2189.00	6.65	1.60	4989.50
2023	9	253.7	6.64	-	11.50	4.70	40088.50	17669.50	39.10	1738.50	10276.50	4033.50	52.70	212.50	7066.00
2024	4	124.2	8.10	4.84	16.10	9.90	19488.00	378.00	56.50	1119.00	3900.00	1801.00	6.40	11.70	5958.00
2024	10	107.8	-	0.36	12.00	7.70	15526.00	374.00	35.40	1069.00	3331.00	1936.00	4.70	0.25	5433.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH₃) and nitrate (NO₃) reported as concentration of N.

Table A3.9. Haggard Creek monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca^{2+}	Cl^{-}	F^{-}	K^{+}	Mg^{2+}	Na^{+}	NH_3	NO_3^{-}	SO_4^{2-}
2022	4	287.5	8.25	2.21	12.20	5.65	34356.50	294.50	69.20	969.50	7234.00	3221.50	11.50	23.30	4638.00
2022	7	295.2	8.51	1.39	7.05	3.70	26745.50	158.00	19.55	930.00	6404.50	1858.00	3.85	16.30	3193.00
2022	8	315.7	8.48	1.25	10.35	5.70	29861.50	158.00	20.10	1020.50	7748.00	2182.00	4.05	29.30	4469.00
2022	9	357.9	8.54	2.96	4.45	5.95	28395.50	188.50	16.40	1005.00	8436.00	2537.00	2.20	41.10	4758.00
2022	10	368.5	8.54	4.07	7.20	3.50	27397.50	194.00	22.10	1073.50	8642.50	2699.00	1.60	34.60	5216.50
2023	4	302.6	8.58	2.48	7.35	4.55	47321.00	1065.00	66.80	911.50	11401.50	4328.50	11.30	25.85	11639.50
2023	6	283.0	8.46	2.75	8.00	4.45	45661.00	137.00	34.55	909.00	8905.50	2829.00	7.80	3.85	7018.00
2023	8	296.5	8.53	1.97	7.85	3.60	24131.00	194.50	167.00	1057.50	11708.50	4049.50	5.30	16.40	10278.00
2023	9	217.1	8.50	-	11.65	3.80	34187.00	315.50	44.20	1136.00	13011.50	4842.00	13.25	29.30	9261.50
2023	10	282.2	8.48	1.40	19.65	-	-	-	-	-	-	-	-	-	-
2024	4	238.4	8.20	2.37	22.90	12.80	31165.00	333.00	50.50	979.00	7608.00	2752.00	6.10	11.50	7997.00
2024	9	298.8	9.33	1.20	16.00	10.60	33884.00	225.00	36.80	1109.00	10286.00	3158.00	8.40	30.00	8179.00
2024	10	309.2	8.47	0.19	18.30	13.60	49716.00	225.00	39.50	1108.00	10195.00	3141.00	3.50	22.30	8859.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH_3) and nitrate (NO_3) reported as concentration of N.

Table A3.10. Jamieson Creek monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca^{2+}	Cl^{-}	F^{-}	K^{+}	Mg^{2+}	Na^{+}	NH_3	NO_3^{-}	SO_4^{2-}
2022	4	285.0	8.42	0.06	6.70	5.30	32807.00	341.00	11.55	884.50	7868.50	3110.00	2.55	88.95	39072.50
2022	7	243.5	8.51	0.54	5.60	2.60	26897.50	95.30	21.40	886.00	4697.00	2231.00	3.70	1.10	14330.00
2022	8	327.4	8.60	0.16	12.75	6.55	31671.50	159.50	19.65	1008.00	7176.50	3001.00	6.15	37.30	29214.50
2022	9	377.9	8.69	1.16	4.35	7.00	30260.00	210.50	28.85	996.50	9568.00	3710.00	2.70	9.80	44336.50
2022	10	430.8	8.63	3.12	7.45	3.75	36703.00	311.00	21.40	1062.00	11857.00	4432.00	1.65	1.65	63596.50
2023	9	330.6	8.66	0.63	9.65	5.15	53042.00	539.50	42.60	1189.00	16145.50	6901.00	4.30	0.95	43043.50
2024	10	362.4	8.53	0.44	19.50	16.10	53994.00	407.00	33.90	1108.00	13374.00	5354.00	2.50	0.25	45426.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH_3) and nitrate (NO_3) reported as concentration of N.

Table A3.11. Lemieux Creek monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca^{2+}	Cl^{-}	F^{-}	K^{+}	Mg^{2+}	Na^{+}	NH_3	NO_3^{-}	SO_4^{2-}
2022	4	310.8	8.02	1.49	12.65	4.65	33026.50	2181.50	56.35	893.00	6133.00	2846.00	11.35	82.90	23407.50
2022	7	245.8	8.39	0.98	8.45	3.65	25914.00	1296.00	19.35	811.00	3771.00	2227.00	7.10	57.20	10365.50
2022	8	308.2	8.43	1.53	10.45	6.30	29002.00	1773.50	33.50	1013.50	5075.50	2796.00	4.15	118.50	17999.00
2022	9	348.4	8.48	1.77	5.90	5.50	44131.00	1916.00	19.95	1079.50	5777.50	3083.00	2.65	167.50	27421.50
2022	10	372.5	8.45	2.79	7.90	3.50	33076.00	1980.50	21.10	1100.50	6284.50	3173.00	2.20	140.50	31320.50
2023	4	276.4	8.50	2.24	7.70	4.45	52164.50	6190.50	34.55	870.00	7432.00	4618.50	12.65	85.95	36375.00
2023	6	248.7	8.51	2.43	11.10	3.55	39860.50	2360.50	36.15	855.50	5345.50	3556.00	9.30	3.80	13091.00
2023	8	267.5	8.35	1.20	8.45	3.85	35245.50	5759.00	151.00	1096.50	7075.00	4727.00	8.90	51.00	24040.50
2023	9	289.3	8.28	0.73	10.30	3.50	46950.50	3403.00	44.35	1140.00	8238.00	5277.00	10.20	154.50	21121.50
2023	10	285.8	8.65	0.67	11.10	-	-	-	-	-	-	-	-	-	-
2024	4	227.9	8.04	4.81	20.40	5.50	35905.00	2348.00	41.10	848.00	5204.00	2986.00	8.10	41.60	12115.00
2024	7	259.0	8.45	-	24.10	4.20	40605.00	2268.00	37.50	1042.00	5807.00	3305.00	4.60	77.80	14878.00
2024	10	279.4	8.36	1.09	17.60	10.50	46285.00	2223.00	31.40	987.00	6260.00	3391.00	3.50	45.50	17472.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH_3) and nitrate (NO_3) reported as concentration of N.

Table A3.12. Lindquist Creek monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca ²⁺	Cl ⁻	F ⁻	K ⁺	Mg ²⁺	Na ⁺	NH ₃	NO ₃ ⁻	SO ₄ ²⁻
2022	4	63.7	6.91	2.08	11.95	3.10	14797.00	661.50	31.30	1083.50	3243.00	2238.50	3.50	56.95	4449.50
2022	7	122.6	7.92	0.00	9.35	5.35	12923.00	466.00	19.05	889.50	2776.50	1926.00	5.95	89.60	2159.00
2022	8	105.5	8.03	1.28	11.55	3.85	10524.50	380.50	16.75	789.50	2445.00	1736.50	4.65	47.60	1506.50
2022	9	109.7	7.94	1.43	5.70	3.50	10833.00	498.00	17.20	731.50	2694.50	1814.00	2.75	56.55	1682.00
2022	10	149.9	7.94	2.90	5.95	3.90	14016.00	964.00	20.20	898.50	4082.00	2500.00	1.50	124.00	2561.00
2023	4	99.6	8.03	0.13	9.10	3.65	16661.50	617.00	34.30	787.00	3596.00	2734.50	8.60	48.95	4834.50
2023	6	75.6	7.93	2.56	10.20	1.20	14121.50	166.00	32.65	725.50	2395.00	2062.00	6.20	5.85	2293.50
2023	8	109.2	8.13	0.81	9.20	2.50	19320.50	1039.50	132.50	1049.00	4752.50	3358.00	7.00	31.85	4222.50
2023	9	87.9	7.92	2.52	8.65	0.80	16514.00	542.00	42.00	825.50	3812.00	2734.00	5.45	42.95	3121.00
2024	4	69.0	7.59	8.23	18.20	3.30	10864.00	332.00	41.60	815.00	2001.00	1683.00	5.00	29.50	2902.00
2024	7	183.1	7.77	-	26.80	3.50	25848.00	3202.00	27.60	1515.00	5593.00	4564.00	5.70	720.00	6600.00
2024	10	199.1	8.03	0.11	14.40	10.70	28172.00	3564.00	31.20	1302.00	7897.00	6061.00	4.10	281.00	6833.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH₃) and nitrate (NO₃) reported as concentration of N.

Table A3.13. Louis Creek monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca^{2+}	Cl^-	F^-	K^+	Mg^{2+}	Na^+	NH_3	NO_3^-	SO_4^{2-}
2023	6	376.9	8.82	3.46	17.40	5.10	56285.50	6215.50	34.30	2792.00	12871.00	5004.50	7.10	24.25	55171.00
2023	9	406.1	8.69	1.63	22.75	7.50	51169.50	4688.50	52.00	3507.00	23522.50	7127.50	110.00	130.50	53903.00
2024	4	362.4	8.33	3.37	26.50	13.30	38675.00	5696.00	38.50	2770.00	13255.00	4941.00	8.00	114.00	37537.00
2024	10	419.2	8.04	1.14	23.10	14.90	51108.00	5952.00	60.50	4028.00	10644.00	5846.00	10.80	65.10	40920.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH_3) and nitrate (NO_3) reported as concentration of N.

Table A3.14. Reg Christie Creek monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca ²⁺	Cl ⁻	F ⁻	K ⁺	Mg ²⁺	Na ⁺	NH ₃	NO ₃ ⁻	SO ₄ ²⁻
2022	4	124.8	7.91	2.95	7.65	1.80	14408.00	154.50	34.25	810.00	2869.00	1560.00	2.35	31.80	13608.00
2022	7	153.6	8.25	0.00	4.45	1.75	15895.50	80.80	23.20	562.50	2778.50	1143.50	5.25	48.45	8582.50
2022	8	230.8	8.32	0.19	6.80	5.15	22541.50	137.50	21.55	834.00	4591.00	1905.50	3.20	155.50	24232.00
2022	9	246.2	8.27	2.50	3.60	1.95	23965.50	139.50	23.65	856.00	5088.50	2320.00	1.95	193.00	33505.50
2022	10	268.0	8.31	4.47	7.30	2.75	26627.50	179.50	32.95	935.00	5812.00	2847.00	4.40	214.00	44705.00
2023	4	150.9	7.86	8.14	10.25	3.55	26705.50	494.50	45.70	777.50	5097.00	3088.50	7.15	370.00	36874.00
2023	6	123.1	8.11	4.28	6.15	1.85	20589.50	52.60	31.05	492.50	2996.00	1534.50	4.80	0.95	8907.50
2023	8	203.9	8.25	1.97	5.25	2.70	30592.50	349.00	223.50	961.50	7115.50	3870.00	6.25	75.20	48530.50
2023	9	222.9	8.27	3.13	6.95	2.40	38255.00	420.00	67.55	1049.50	8574.00	5085.00	5.15	99.40	39991.00
2023	10	191.3	8.09	2.53	6.40	-	-	-	-	-	-	-	-	-	-
2024	4	82.2	7.60	3.11	16.20	6.90	12882.00	148.00	33.50	644.00	2290.00	1408.00	5.20	29.40	9036.00
2024	7	166.3	8.25	-	15.70	3.80	23243.00	169.00	36.50	722.00	4115.00	2028.00	3.30	89.40	18317.00
2024	9	18.0	8.38	1.10	12.30	7.40	26362.00	205.00	49.90	880.00	5389.00	3009.00	4.30	91.50	24782.00
2024	10	121.7	8.08	1.06	12.70	6.60	25046.00	204.00	40.50	890.00	5216.00	2941.00	6.30	28.80	12715.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH₃) and nitrate (NO₃) reported as concentration of N.

Table A3.15. Shannon Creek monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca ²⁺	Cl ⁻	F ⁻	K ⁺	Mg ²⁺	Na ⁺	NH ₃	NO ₃ ⁻	SO ₄ ²⁻
2022	4	33.4	5.96	1.62	6.50	<0.3	3041.50	81.45	24.20	708.00	575.00	1049.50	2.95	9.05	1372.50
2022	7	23.7	6.85	0.42	4.65	<0.3	2020.50	30.80	14.15	342.50	292.50	602.50	3.90	2.35	480.00
2022	8	29.6	6.29	2.09	4.05	0.10	2603.00	24.55	7.55	420.50	368.50	688.50	4.35	7.75	491.00
2022	9	29.5	6.59	1.48	3.65	<0.5	2590.00	32.15	6.35	396.00	340.00	683.00	2.45	6.65	569.50
2022	10	33.5	6.52	2.27	2.30	<0.5	2947.50	37.15	7.55	457.00	396.50	742.00	5.30	17.20	591.50
2023	4	37.7	6.76	3.85	12.05	1.60	4710.50	364.50	20.35	979.50	923.00	1925.00	12.85	11.20	3699.00
2023	6	22.4	6.42	2.63	4.25	<0.5	2634.50	27.10	7.80	300.50	301.00	898.00	4.65	0.50	686.00
2023	8	27.7	6.90	4.46	7.80	<0.5	4224.50	65.40	36.00	461.00	492.50	1280.50	14.40	8.40	1108.00
2023	9	32.2	6.84	10.10	21.95	<0.5	5481.50	106.00	-	719.50	714.50	1478.00	6.05	4.55	1688.00
2024	4	28.8	6.62	1.46	10.60	1.00	3717.00	248.00	36.60	612.00	604.00	1265.00	5.40	9.80	2541.00
2024	7	26.3	7.16	-	9.50	1.50	3633.00	104.00	15.40	435.00	353.00	948.00	3.90	24.50	1088.00
2024	10	20.3	6.57	4.39	8.30	<0.5	3693.00	178.00	18.10	603.00	624.00	1190.00	5.20	2.40	1096.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH₃) and nitrate (NO₃) reported as concentration of N. < indicates a concentration below the detection limit (DL) for SRP and NO₃.

Table A3.16. Tumtum Creek monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca ²⁺	Cl ⁻	F ⁻	K ⁺	Mg ²⁺	Na ⁺	NH ₃	NO ₃ ⁻	SO ₄ ²⁻
2022	4	30.8	6.58	0.55	4.00	0.35	3388.50	45.15	23.35	389.50	307.50	787.00	11.50	15.90	890.00
2022	7	20.7	7.29	0.01	2.85	0.30	2599.00	10.20	11.60	202.00	179.50	433.00	6.15	4.70	294.50
2022	8	29.9	7.12	0.42	4.15	0.20	3154.50	16.70	10.85	280.00	231.00	577.50	1.95	8.40	417.50
2022	9	34.5	7.22	1.92	0.75	<0.5	3628.00	23.35	9.10	276.00	279.00	655.00	1.60	10.35	565.50
2022	10	33.3	7.05	0.97	1.40	<0.5	3656.00	47.30	-	306.00	307.00	770.50	1.35	24.00	871.50
2023	4	34.0	7.21	1.51	4.95	2.05	5506.00	421.50	16.45	414.00	455.00	1549.00	8.05	36.80	2211.00
2023	6	27.0	6.97	2.57	3.85	<0.5	4094.00	29.90	9.30	224.50	245.00	797.50	4.70	1.95	574.50
2023	8	28.8	7.26	2.09	3.45	<0.5	5145.50	55.45	46.70	335.00	354.00	1178.50	5.40	30.70	1295.50
2023	9	33.1	6.94	3.57	2.50	<0.5	6339.50	136.50	40.50	334.00	452.00	1391.00	1.95	33.25	2316.50
2023	10	27.9	7.16	0.35	3.15	0.75	5799.00	129.00	34.05	302.00	394.50	1107.50	2.10	0.60	1791.00
2024	4	27.7	7.28	2.62	9.30	1.90	4371.00	142.00	31.90	368.00	372.00	920.00	6.70	11.20	1663.00
2024	7	29.6	7.33	-	5.90	2.80	4360.00	59.10	25.60	282.00	268.00	789.00	4.70	59.20	1194.00
2024	10	25.0	7.32	0.12	7.90	0.50	4147.00	92.00	20.80	321.00	353.00	822.00	4.90	0.80	984.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH₃) and nitrate (NO₃) reported as concentration of N.

APPENDIX 4 — Raw Data (Wetlands)

Table A4.1. Barriere Wetland monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca^{2+}	Cl^{-}	F^{-}	K^{+}	Mg^{2+}	Na^{+}	NH_3	NO_3^{-}	SO_4^{2-}
2022	4	170.4	7.12	-	6.65	4.25	18139.00	2244.00	61.65	1085.50	5219.00	2119.00	13.75	45.95	3851.50
2022	7	84.8	7.12	4.25	17.50	1.90	15375.00	808.50	60.25	1866.50	2745.50	1081.00	9.55	6.75	2052.50
2022	8	150.9	6.70	3.39	12.10	4.10	14479.50	1983.50	20.30	1383.50	5346.00	2009.50	8.30	2.55	1763.50
2022	9	155.0	7.18	5.55	3.80	3.25	14352.50	250.50	17.75	459.50	4202.50	1895.00	2.65	1.75	846.50
2022	10	151.6	7.47	6.65	11.65	1.10	14485.50	126.00	16.70	423.00	4236.50	1952.50	2.50	1.50	932.00
2023	4	48.8	7.28	13.07	24.90	4.05	5543.00	1180.00	3.70	2573.00	1560.50	823.00	16.80	6.35	819.50
2023	6	203.1	6.94	8.18	11.03	2.30	22739.50	4284.50	31.38	1443.00	6581.75	3139.00	16.75	11.15	5527.50
2023	8	200.5	7.14	2.86	11.00	3.10	34274.00	3146.50	187.00	920.50	9660.50	3765.00	18.30	23.05	7980.50
2023	9	194.4	7.57	-	8.75	2.25	29838.00	1827.50	32.45	884.00	10363.50	4079.00	42.85	2.00	4105.00
2023	10	174.8	7.42	10.47	13.00	-	-	-	-	-	-	-	-	-	-
2024	4	187.1	7.11	8.01	25.70	7.40	25486.00	2376.00	31.30	1524.00	7420.00	2679.00	8.10	17.10	4439.00
2024	6	122.0	6.92	8.49	-	6.60	17487.00	1721.00	36.10	1414.00	4965.00	2100.00	24.60	2.10	5708.00
2024	7	139.7	7.29	-	19.40	4.50	17377.00	1586.00	29.70	1301.00	4902.00	1923.00	6.30	1.90	4118.00
2024	10	145.4	7.00	4.46	13.60	7.60	20124.00	2571.00	32.30	2299.00	6069.00	2458.00	5.70	1.00	5875.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH_3) and nitrate (NO_3) reported as concentration of N.

Table A4.2. Cook Wetland monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca ²⁺	Cl ⁻	F ⁻	K ⁺	Mg ²⁺	Na ⁺	NH ₃	NO ₃ ⁻	SO ₄ ²⁻
2022	4	45.9	7.96	-	2.20	<0.3	6213.50	1215.00	24.70	682.00	453.00	1542.50	3.75	11.15	2195.00
2022	7	40.3	6.42	0.62	4.55	<0.3	3881.00	62.80	13.05	368.00	213.00	419.00	3.00	0.70	854.00
2022	8	59.6	6.90	2.53	0.00	0.00	7002.00	112.00	11.85	576.00	403.50	722.00	7.30	5.10	1698.00
2022	9	74.0	6.56	2.29	0.50	1.10	7924.00	244.00	15.70	681.50	501.00	995.00	4.90	15.15	2722.50
2022	10	75.3	6.97	2.12	2.85	<0.5	8625.00	286.00	19.50	713.50	538.00	1223.50	3.20	21.55	3072.00
2023	4	62.2	6.72	2.49	2.50	1.05	10701.50	2114.50	19.75	818.50	711.50	2389.50	17.65	9.40	8792.00
2023	6	49.1	6.71	5.57	9.95	<0.5	11919.50	544.00	53.55	1272.50	613.00	1364.50	5.50	4.10	4563.00
2023	8	60.2	6.94	-	-	-	-	-	-	-	-	-	-	-	-
2023	9	64.8	6.91	1.81	2.70	1.20	13836.00	351.50	47.75	934.50	757.00	1888.50	5.90	2.00	6339.00
2023	10	57.9	6.96	4.43	8.30	0.65	12039.00	899.00	42.20	1211.00	663.50	1824.00	3.40	2.85	5617.50
2024	4	50.8	6.83	4.00	6.00	0.50	8221.00	377.00	47.60	741.00	577.00	1351.00	7.40	21.30	4527.00
2024	6	28.5	6.90	2.65	6.30	0.50	4416.00	112.00	24.10	312.00	253.00	494.00	12.60	1.50	1914.00
2024	9	61.5	7.81	4.38	2.80	0.90	10315.00	418.00	35.40	708.00	702.00	1409.00	7.40	42.60	5016.00
2024	10	39.8	7.11	5.25	7.00	1.10	6568.00	138.00	27.80	592.00	363.00	818.00	11.40	26.80	2882.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH₃) and nitrate (NO₃) reported as concentration of N. < indicates a concentration below the detection limit (DL) for SRP and NO₃.

Table A4.3. Goose Wetland monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca ²⁺	Cl ⁻	F ⁻	K ⁺	Mg ²⁺	Na ⁺	NH ₃	NO ₃ ⁻	SO ₄ ²⁻
2023	9	150.0	7.13	11.03	5.50	0.85	14013.50	13419.50	43.80	2140.50	7808.00	9419.00	37.50	74.00	3819.00
2024	6	123.8	7.04	2.21	26.70	0.50	10181.00	3240.00	52.70	621.00	2809.00	4317.00	13.40	1.70	1252.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH₃) and nitrate (NO₃) reported as concentration of N.

Table A4.4. Little Fort Wetland monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca ²⁺	Cl ⁻	F ⁻	K ⁺	Mg ²⁺	Na ⁺	NH ₃	NO ₃ ⁻	SO ₄ ²⁻
2022	4	266.5	8.34	18.83	19.15	5.15	21757.00	17314.00	41.65	3923.00	10046.00	6956.00	6.15	2.50	6346.50
2022	7	325.0	7.03	1.28	19.85	2.75	28591.50	12893.50	42.25	4175.50	8338.00	7394.50	8.95	0.85	4949.50
2022	8	323.5	6.81	6.65	15.60	6.55	27472.50	10332.50	45.75	3345.50	10001.00	6798.50	4.65	3.80	3109.50
2022	9	-	7.27	13.10	11.20	5.20	23110.50	12914.00	64.00	2783.50	9147.00	6621.50	43.95	2.20	1814.00
2022	10	288.8	7.55	11.17	14.55	3.50	17395.00	14720.00	39.10	3408.00	8809.50	7042.50	287.50	24.30	2225.50
2023	6	258.8	6.92	8.78	15.45	3.65	30347.00	17155.00	35.20	3498.50	10627.50	9506.00	10.40	1.65	6845.50
2023	8	245.3	7.32	12.77	9.80	4.25	26530.50	33734.00	196.00	2539.00	12696.00	12885.50	32.40	<0.5	3731.00
2023	9	205.2	7.79	5.97	13.40	1.35	24037.00	8730.50	61.60	2384.50	12063.50	11034.50	20.60	5.75	2560.00
2023	10	202.1	7.18	15.73	6.15	-	-	-	-	-	-	-	-	-	-
2024	4	275.6	7.18	11.27	37.50	3.70	27399.00	24887.00	51.80	8900.00	8864.00	13635.00	264.00	0.90	15842.00
2024	6	-	-	7.37	52.60	1.50	10621.00	581.00	34.90	1341.00	2032.00	1217.00	9.70	2.40	3721.00
2024	7	127.5	7.12	-	22.40	3.70	18139.00	523.00	40.30	1583.00	3845.00	1799.00	5.80	5.10	2425.00
2024	9	198.2	7.71	11.20	25.10	10.80	21947.00	6846.00	65.10	2227.00	9157.00	6764.00	29.10	1.60	2934.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH₃) and nitrate (NO₃) reported as concentration of N.

Table A4.5. Lost Creek Wetland km9 monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca ²⁺	Cl ⁻	F ⁻	K ⁺	Mg ²⁺	Na ⁺	NH ₃	NO ₃ ⁻	SO ₄ ²⁻
2022	4	368.2	7.96	0.27	34.95	4.15	41098.00	568.00	39.60	1753.50	6594.50	2900.00	2.10	2.35	24953.50
2022	7	291.6	7.25	2.47	12.65	2.15	38696.50	188.50	27.50	1088.00	3556.50	1584.00	4.45	0.50	5130.50
2022	8	402.4	7.23	2.11	41.55	14.55	51700.00	256.50	68.75	2046.00	8591.50	3401.00	30.55	4.80	16650.00
2022	9	319.6	7.29	2.04	27.15	10.85	32758.50	327.00	27.05	2577.00	4732.00	2107.50	5.90	1.20	11344.50
2023	6	311.5	7.21	4.90	57.05	15.75	56749.50	304.00	36.05	1512.50	6427.00	3069.50	19.50	<0.5	11791.50
2023	8	229.6	7.72	9.57	35.40	3.20	35977.50	186.00	98.55	694.50	3568.00	2010.00	20.95	0.38	10777.00
2023	9	259.0	7.37	9.32	74.10	10.85	58826.00	513.50	52.10	1747.00	4924.00	2934.00	342.50	3.25	18814.00
2023	10	303.9	7.47	19.57	107.00	-	-	-	-	-	-	-	-	-	-
2024	4	181.2	7.18	6.15	33.30	9.80	32094.00	399.00	28.20	2664.00	2912.00	1518.00	6.70	0.80	9897.00
2024	6	214.1	7.34	3.54	28.70	9.90	31399.00	222.00	29.40	522.00	2875.00	1373.00	7.80	135.00	7585.00
2024	7	235.0	7.29	-	53.00	4.00	36259.00	116.00	20.80	738.00	3316.00	1573.00	2.40	1.10	5561.00
2024	9	219.8	8.32	3.18	22.30	5.00	22735.00	146.00	17.20	863.00	3464.00	1658.00	11.40	0.50	7900.00
2024	10	220.8	6.89	8.05	69.10	11.30	34748.00	904.00	28.70	4676.00	3102.00	1528.00	15.70	1.00	22075.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH₃) and nitrate (NO₃) reported as concentration of N. < indicates a concentration below the detection limit (DL) for SRP and NO₃.

Table A4.6. Miledge Wetland monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca^{2+}	Cl^{-}	F^{-}	K^{+}	Mg^{2+}	Na^{+}	NH_3	NO_3^{-}	SO_4^{2-}
2023	9	76.6	6.61	6.55	13.80	<0.5	9780.50	10776.00	168.00	663.00	1361.50	10058.00	37.20	2.30	2349.00
2024	6	91.2	7.09	2.57	12.80	<0.5	10115.00	10032.00	135.00	768.00	1112.00	6437.00	15.60	0.25	4150.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH_3) and nitrate (NO_3) reported as concentration of N. < indicates a concentration below the detection limit (DL) for SRP and NO_3 .

Table A4.7. Northwest Finn Wetland monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca^{2+}	Cl^{-}	F^{-}	K^{+}	Mg^{2+}	Na^{+}	NH_3	NO_3^{-}	SO_4^{2-}
2024	6	181.8	6.84	1.44	11.90	<0.5	27344.00	13287.00	310.00	866.00	3282.00	7977.00	9.90	0.25	2108.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH_3) and nitrate (NO_3) reported as concentration of N. < indicates a concentration below the detection limit (DL) for SRP and NO_3 .

Table A4.8. Pyramid Wetland monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca^{2+}	Cl^{-}	F^{-}	K^{+}	Mg^{2+}	Na^{+}	NH_3	NO_3^{-}	SO_4^{2-}
2023	4	249.0	7.20	6.59	13.55	2.00	53278.00	3457.50	22.80	2100.00	3075.50	1984.50	14.20	863.50	66057.00
2023	6	-	-	-	22.70	3.20	74283.00	595.00	19.25	2065.00	4865.00	1750.00	16.30	66.10	92332.00
2023	8	342.4	7.54	4.62	8.95	2.15	60090.50	564.00	142.50	2188.50	5175.00	1564.50	13.90	94.95	84952.00
2023	9	328.0	7.78	1.26	9.55	3.50	74754.00	555.00	60.30	2809.50	5484.00	1458.50	7.70	49.30	54796.50
2023	10	338.5	7.87	1.61	9.45	4.50	71719.00	487.00	54.05	2568.00	5407.50	1464.50	5.80	22.30	57952.50
2024	4	306.7	7.74	4.90	14.00	7.60	56335.00	1416.00	46.30	2273.00	4093.00	1409.00	6.50	63.30	43473.00
2024	6	334.8	7.67	1.77	17.40	7.00	50916.00	1210.00	52.90	2161.00	4275.00	1408.00	12.80	25.30	38983.00
2024	7	364.5	7.91	-	18.50	3.00	51800.00	922.00	36.00	2489.00	4542.00	1292.00	9.30	66.50	46710.00
2024	9	359.8	8.12	5.75	22.40	8.20	54959.00	520.00	48.70	2680.00	5229.00	1317.00	17.50	3.00	49112.00
2024	10	329.3	7.84	4.09	16.50	7.70	53450.00	938.00	45.20	2638.00	5039.00	1283.00	10.30	20.10	44540.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH_3) and nitrate (NO_3) reported as concentration of N.

Table A4.9. Stillwater Wetland monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca ²⁺	Cl ⁻	F ⁻	K ⁺	Mg ²⁺	Na ⁺	NH ₃	NO ₃ ⁻	SO ₄ ²⁻
2022	4	192.3	7.34	-	12.50	1.23	20387.25	57.38	79.55	1975.00	3773.75	1559.50	4.08	2.35	11026.00
2022	7	254.1	6.65	0.48	17.30	1.25	26778.00	105.00	116.00	2158.50	4509.50	1669.00	6.85	2.60	9236.00
2022	8	270.2	6.46	3.57	20.30	1.85	30697.00	107.00	91.30	2421.00	5292.00	1802.50	7.10	0.50	7247.50
2022	9	233.7	6.91	1.98	18.50	3.65	26042.50	47.40	73.80	2773.50	4810.50	1664.50	6.00	0.50	9505.50
2022	10	266.4	7.49	2.46	17.35	4.85	25866.50	75.60	86.70	2318.00	5505.50	1843.00	12.35	0.50	16656.50
2023	4	150.8	7.20	5.48	25.95	4.50	27882.50	331.00	67.40	2583.50	4738.00	1951.50	12.85	<0.5	13888.00
2023	6	242.4	7.09	3.35	27.10	2.55	41102.00	14.05	41.65	2592.50	7027.50	2559.00	6.85	<0.5	10551.50
2023	8	241.5	7.41	4.38	26.25	1.10	38103.50	46.15	201.00	2243.00	7976.50	3068.50	17.30	0.38	17872.50
2023	9	-	-	-	45.35	12.75	39574.50	520.00	152.00	3613.00	8313.50	3416.00	15.55	1.70	17138.00
2023	10	210.8	7.63	2.87	30.60	-	-	-	-	-	-	-	-	-	-
2024	4	195.7	7.55	5.00	22.90	10.70	31456.00	115.00	149.00	2399.00	5559.00	2442.00	7.30	0.25	13606.00
2024	6	185.5	8.07	3.48	41.20	3.80	29214.00	173.00	138.00	2464.00	5736.00	1969.00	8.90	11.40	8834.00
2024	7	250.3	7.46	-	38.80	2.60	28594.00	73.10	136.00	2445.00	6477.00	2306.00	20.50	1.00	11355.00
2024	10	215.0	7.55	2.24	40.50	12.70	36385.00	149.00	117.00	3688.00	6302.00	2027.00	5.50	0.25	12696.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH₃) and nitrate (NO₃) reported as concentration of N. < indicates a concentration below the detection limit (DL) for SRP and NO₃.

Table A4.10. Struggle Puddle Wetland monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca^{2+}	Cl^{-}	F^{-}	K^{+}	Mg^{2+}	Na^{+}	NH_3	NO_3^{-}	SO_4^{2-}
2022	4	-	-	-	5.55	2.65	31603.00	373.50	20.85	2636.00	1798.00	1576.50	3.60	382.50	13818.00
2022	7	221.6	7.20	0.28	7.90	1.60	26596.50	693.50	25.75	2388.00	1692.00	1330.00	8.15	273.00	9680.00
2022	8	271.4	7.68	1.83	12.95	3.55	27964.50	71.25	15.05	2862.00	1817.50	741.50	11.45	190.50	9787.50
2022	9	301.5	7.63	4.41	3.80	4.70	35680.00	83.65	13.35	3082.00	2289.50	841.00	5.75	212.00	17683.00
2023	4	87.6	7.46	-	20.50	<0.5	20183.50	157.50	13.25	1527.50	1179.50	643.00	16.25	1443.50	3815.50
2023	6	-	-	-	14.30	4.35	46277.00	146.50	19.75	3270.50	2825.50	3812.00	43.50	64.25	11386.00
2023	8	115.7	6.95	10.54	14.30	<0.5	27218.50	1550.50	58.70	3524.50	1797.00	1877.00	277.50	4.35	27464.50

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH_3) and nitrate (NO_3) reported as concentration of N. < indicates a concentration below the detection limit (DL) for SRP and NO_3 .

Table A4.11. Tumtum Wetland monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca^{2+}	Cl^{-}	F^{-}	K^{+}	Mg^{2+}	Na^{+}	NH_3	NO_3^{-}	SO_4^{2-}
2022	4	46.8	5.73	0.27	5.85	0.30	3900.50	1856.50	27.30	952.00	483.50	2020.50	3.10	1.00	1085.50
2022	8	54.2	6.20	0.92	5.65	0.00	5699.00	598.50	19.35	618.00	524.00	1343.50	1.90	2.00	214.00
2022	9	43.0	6.81	3.45	2.45	<0.5	3986.00	467.50	14.40	864.50	395.50	1063.00	1.55	0.50	239.00
2022	10	42.0	6.94	3.81	10.40	<0.5	3694.00	403.50	18.35	873.50	391.00	1145.50	2.10	0.75	304.50
2023	9	38.2	6.26	2.03	15.10	<0.5	6386.50	1328.00	54.25	604.00	609.50	2470.50	5.10	6.40	875.50
2024	4	218.7	7.18	2.76	19.20	9.70	36741.00	10500.00	139.00	1796.00	3263.00	7119.00	9.10	2.20	33011.00
2024	6	33.6	6.55	2.28	9.90	<0.5	5124.00	669.00	36.30	339.00	469.00	1179.00	9.20	-	702.00
2024	6	175.4	7.38	3.45	23.60	9.00	29799.00	819.00	132.00	1457.00	2917.00	3017.00	17.50	52.50	23173.00
2024	9	213.2	7.46	2.07	12.60	7.10	31878.00	428.00	102.00	1641.00	3352.00	2841.00	8.60	4.70	35112.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH_3) and nitrate (NO_3) reported as concentration of N. < indicates a concentration below the detection limit (DL) for SRP and NO_3 .

Table A4.12. Wirecache Wetland monthly water quality and chemistry.

Time		Water Quality			Concentration ($\mu\text{g}\cdot\text{L}^{-1}$)										
Year	Month	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	pH	Turbidity (NTU)	TP	SRP	Ca^{2+}	Cl^{-}	F^{-}	K^{+}	Mg^{2+}	Na^{+}	NH_3	NO_3^{-}	SO_4^{2-}
2024	6	29.1	6.92	3.15	9.90	<0.5	4224.00	101.00	31.20	358.00	520.00	788.00	6.00	1.60	1397.00

Total phosphorus (TP) and soluble reactive phosphorus (SRP) reported as concentration of P; ammonia (NH_3) and nitrate (NO_3) reported as concentration of N. < indicates a concentration below the detection limit (DL) for SRP and NO_3 .

APPENDIX 5 — Seasonal Trends (Streams)

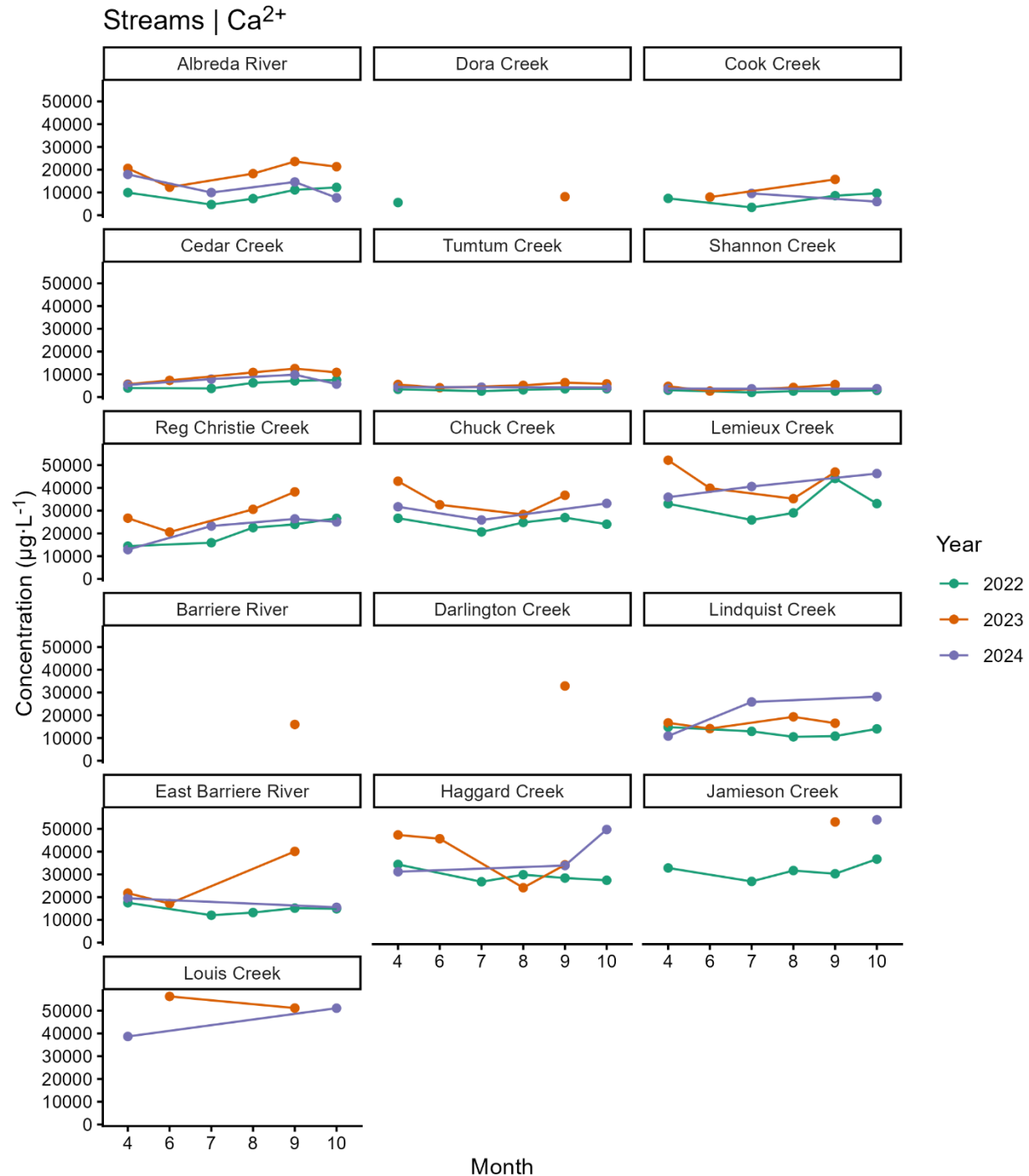


Figure A5.1. Spatiotemporal trends in calcium ion (Ca^{2+}) concentrations in surface water from stream sites in the North Thompson watershed from 2022–2024.

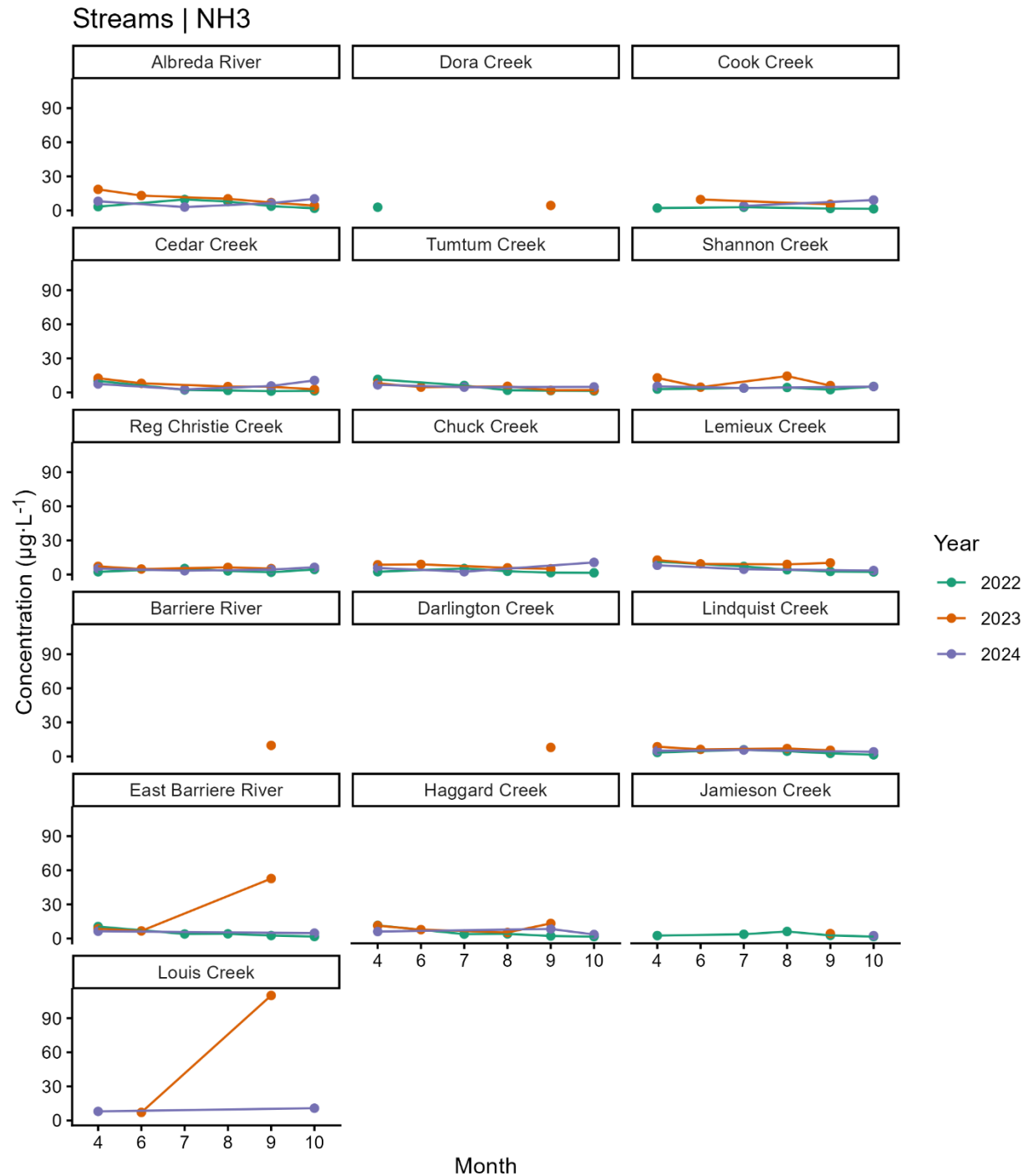


Figure A5.2. Spatiotemporal trends in ammonia (NH₃) concentrations in surface water from stream sites in the North Thompson watershed from 2022–2024.

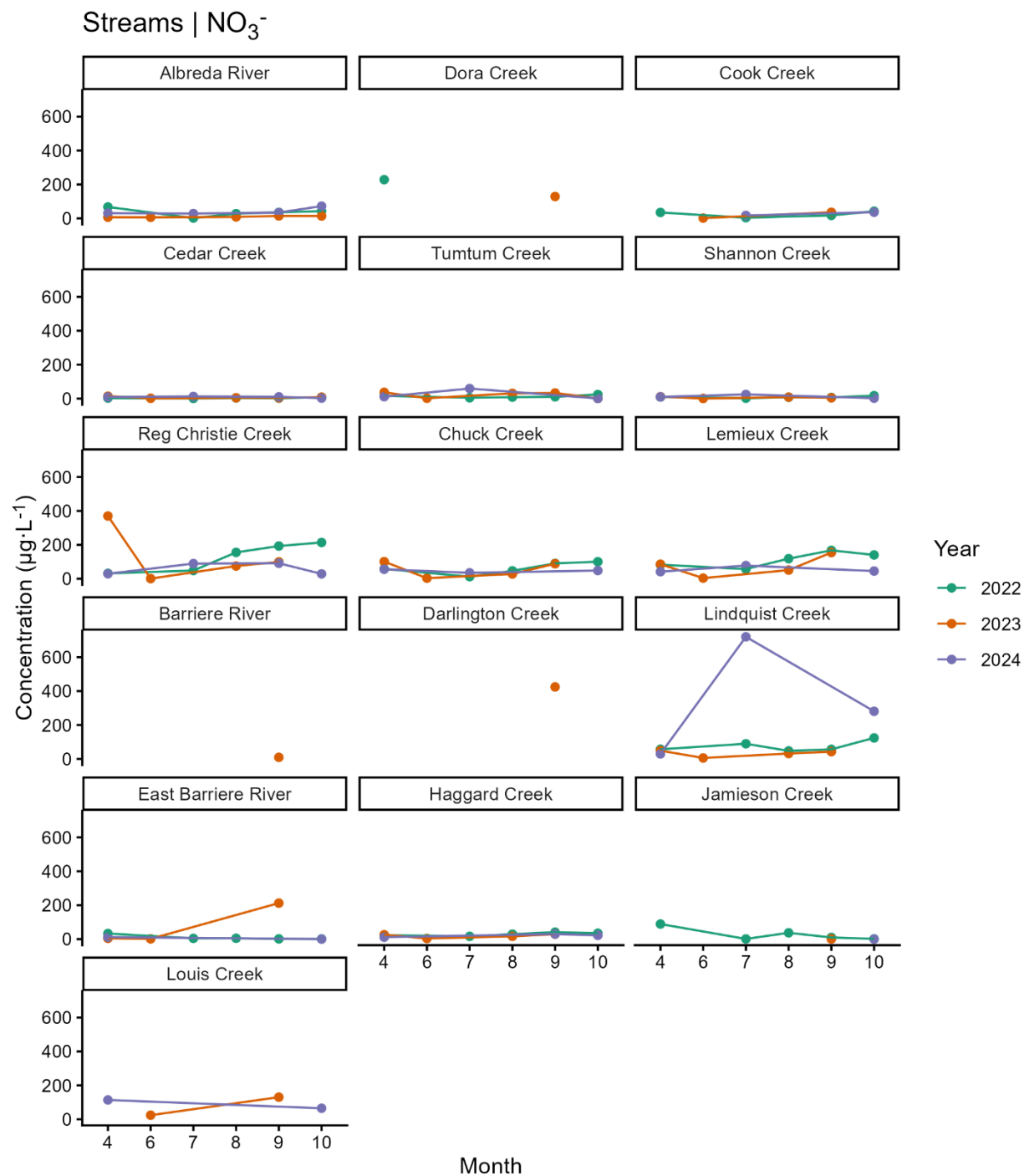


Figure A5.3. Spatiotemporal trends in nitrate ion (NO_3^-) concentrations in surface water from stream sites in the North Thompson watershed from 2022–2024.

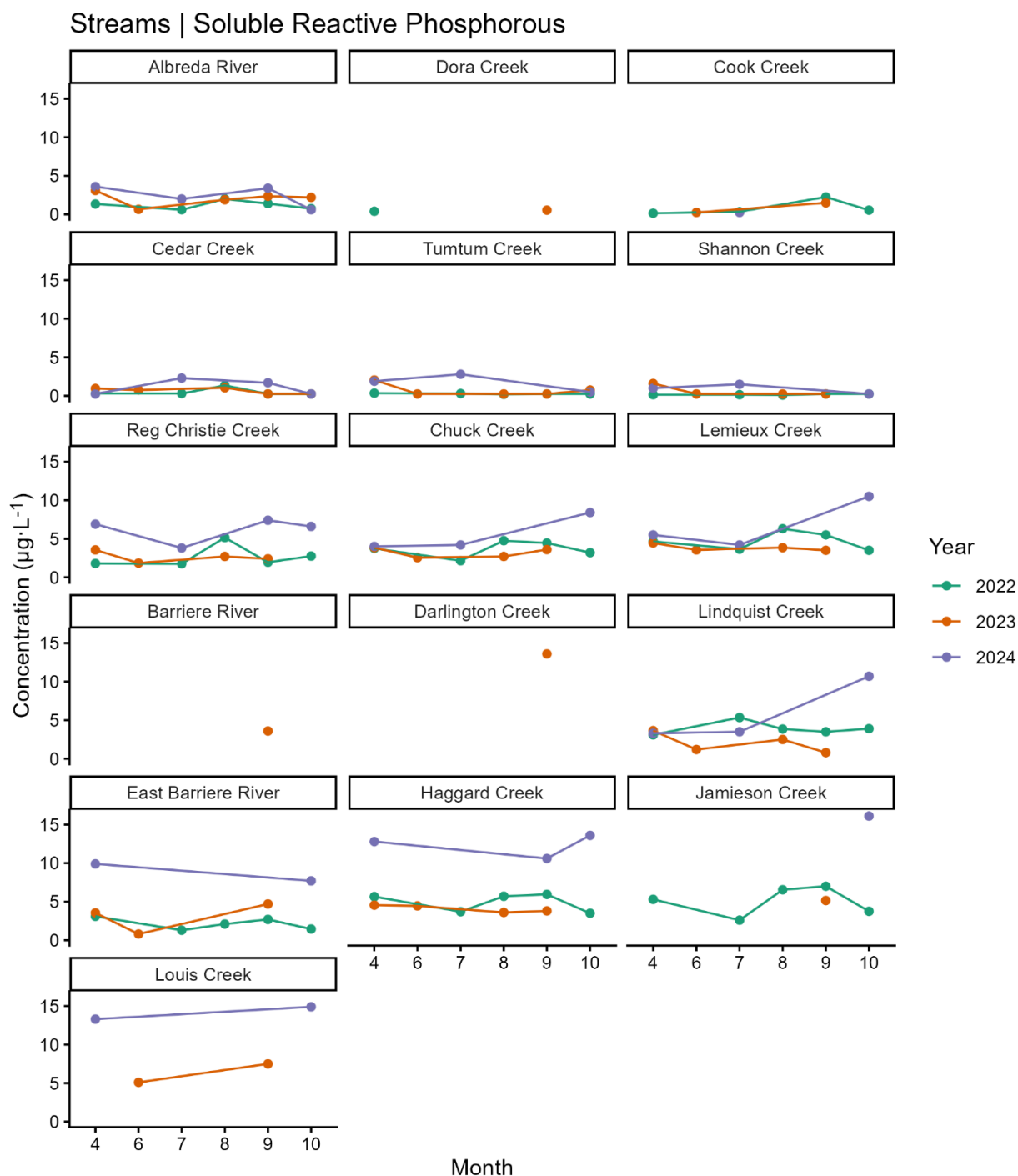


Figure A5.4. Spatiotemporal trends in soluble reactive phosphorus concentrations in surface water from stream sites in the North Thompson watershed from 2022–2024.

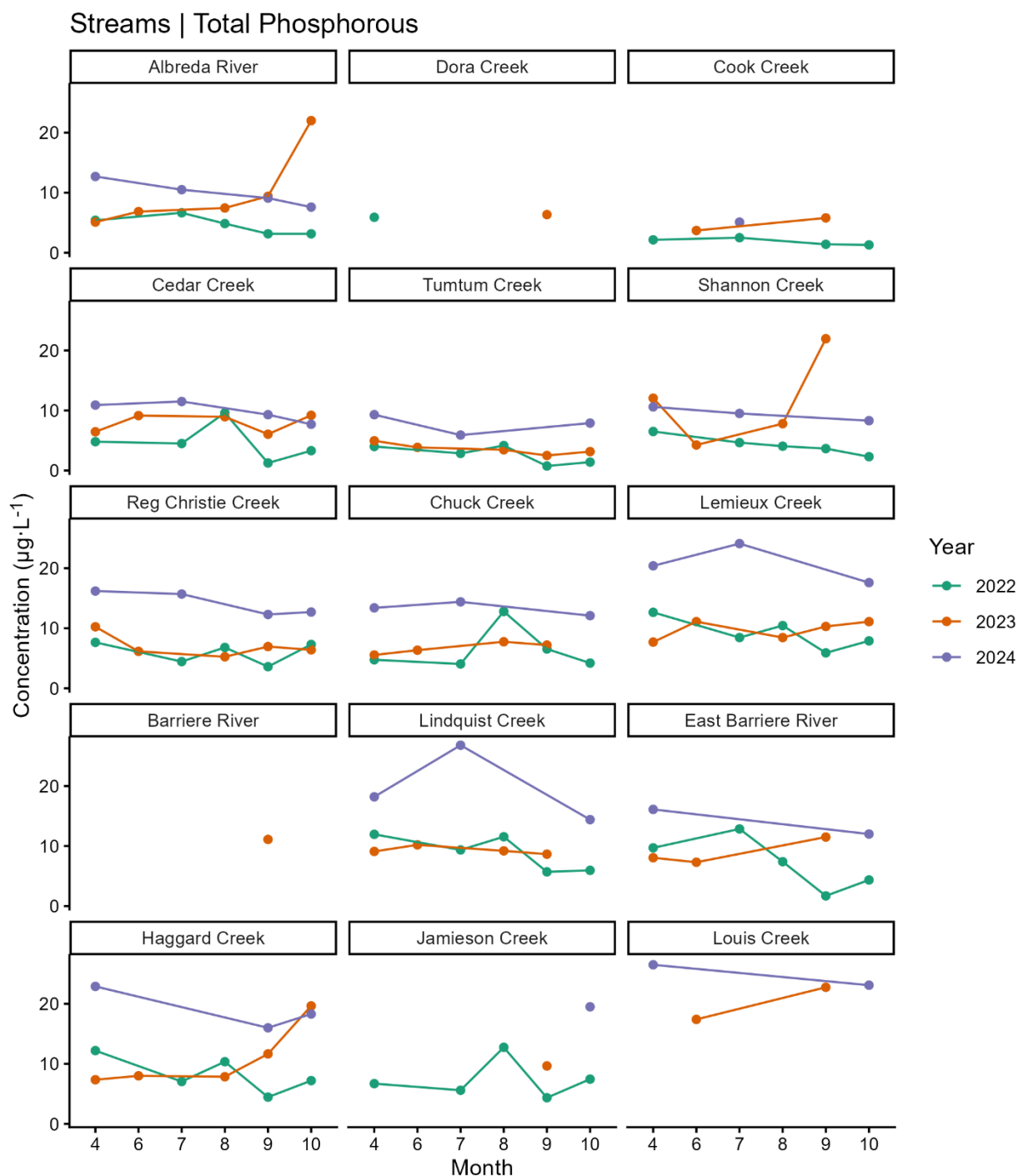


Figure A5.5. Spatiotemporal trends in total phosphorus concentrations in surface water from stream sites in the North Thompson watershed from 2022–2024.

APPENDIX 6 — Seasonal Trends (Wetlands)

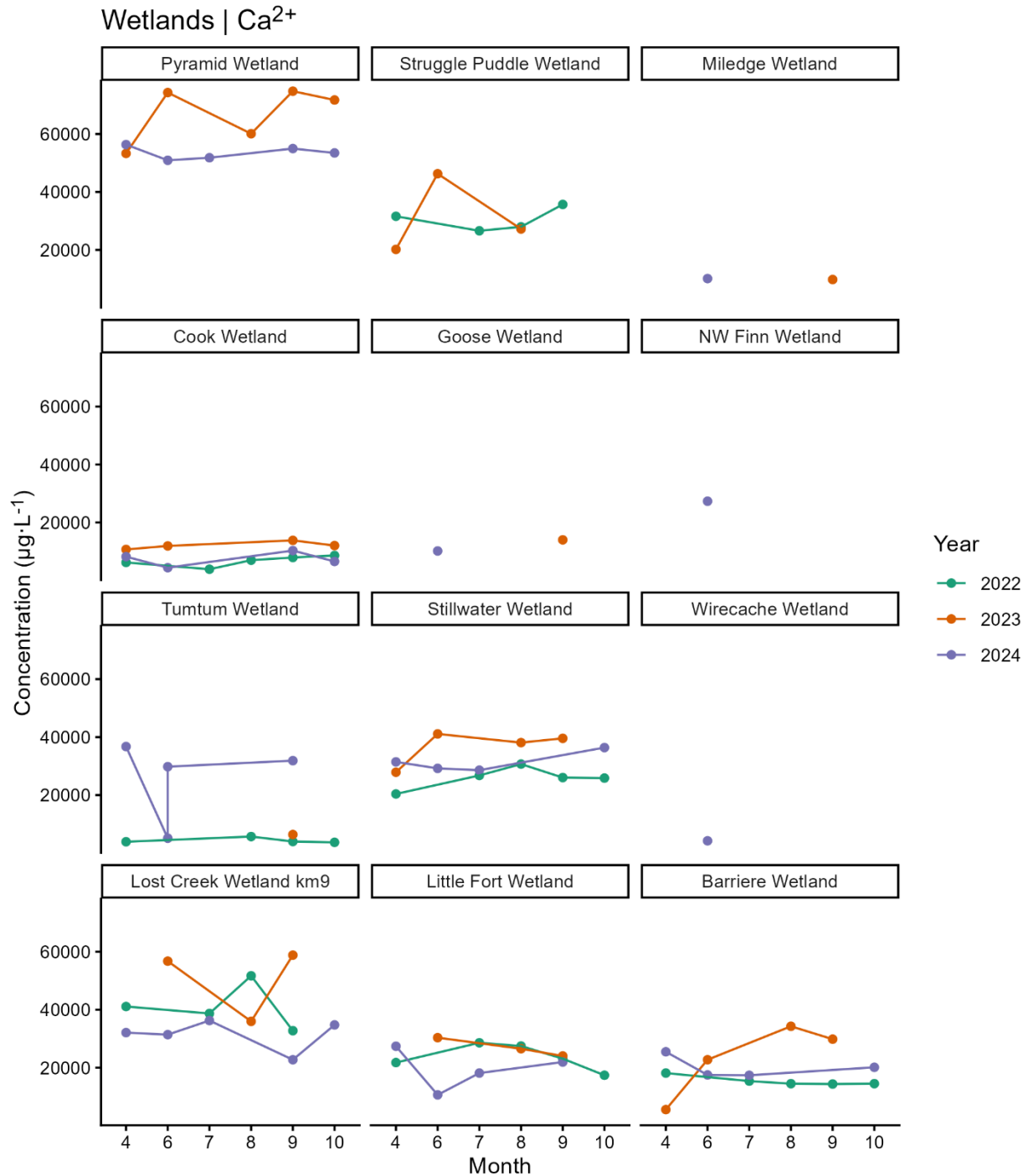


Figure A6.1. Spatiotemporal trends in calcium ion (Ca^{2+}) concentrations in surface water from wetland sites in the North Thompson watershed from 2022–2024.

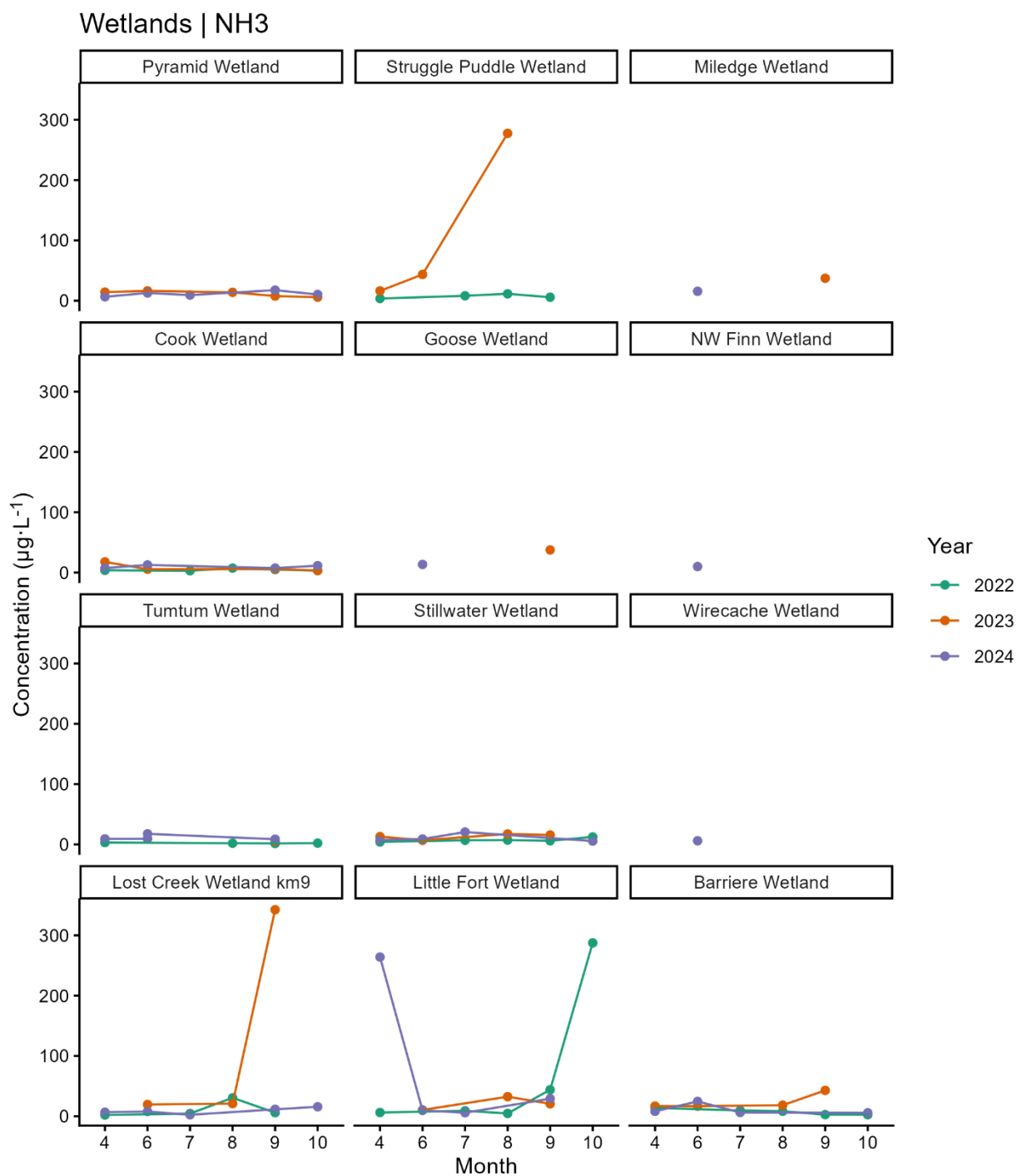


Figure A6.2. Spatiotemporal trends in ammonia (NH₃) concentrations in surface water from wetland sites in the North Thompson watershed from 2022–2024.

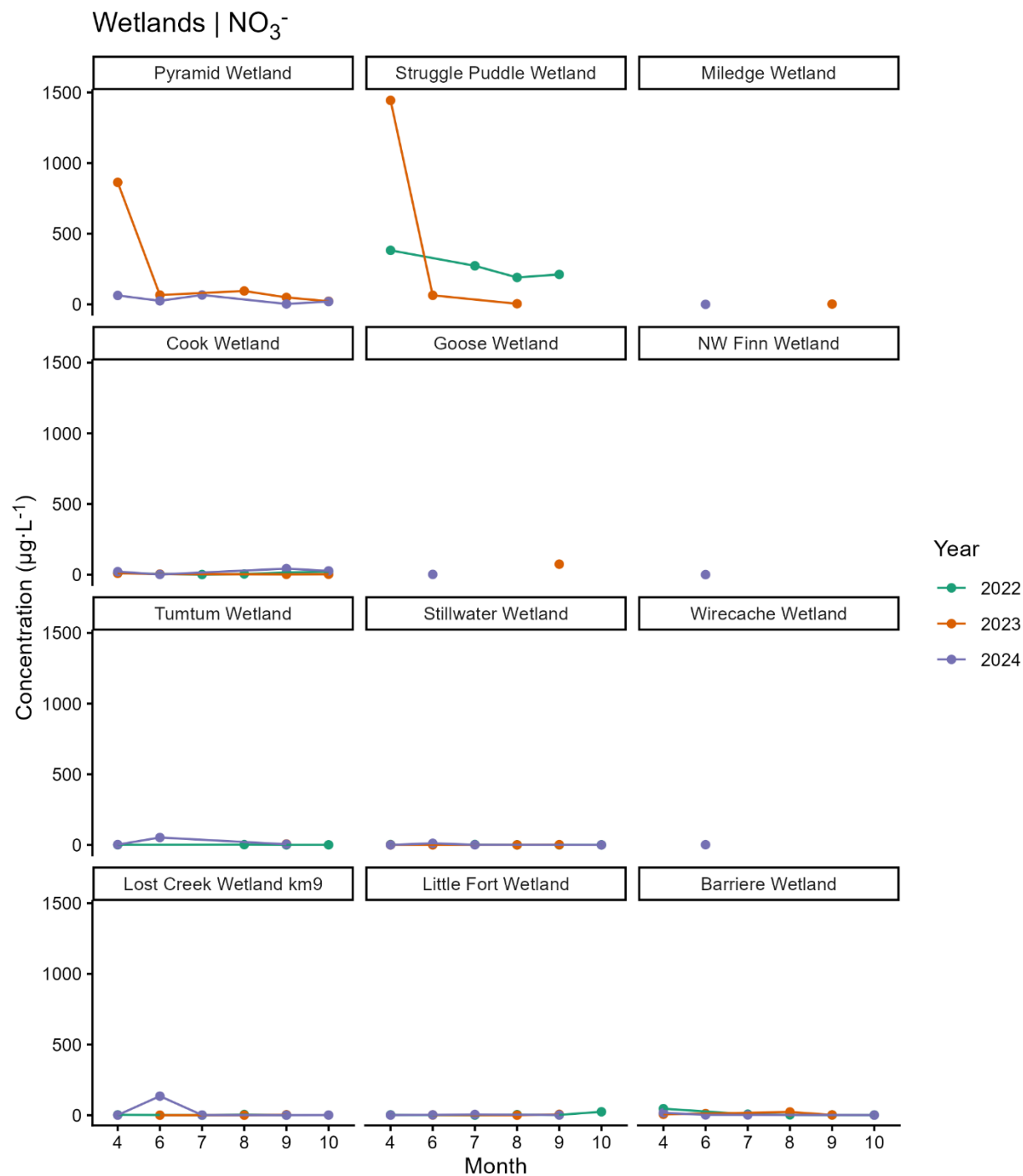


Figure A6.3. Spatiotemporal trends in nitrate ion (NO_3^-) concentrations in surface water from wetland sites in the North Thompson watershed from 2022–2024.

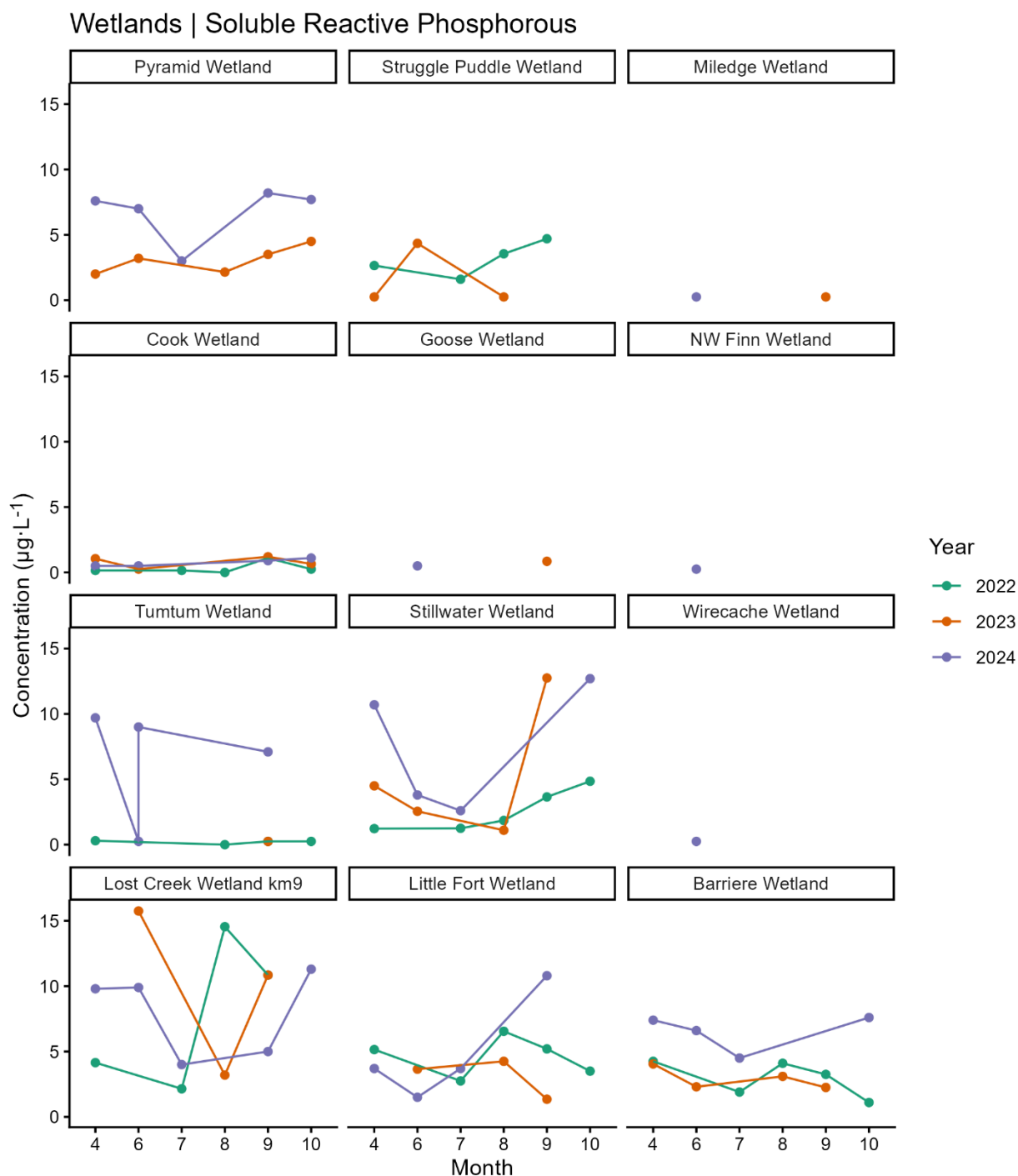


Figure A6.4. Spatiotemporal trends in soluble reactive phosphorus concentrations in surface water from wetland sites in the North Thompson watershed from 2022–2024.

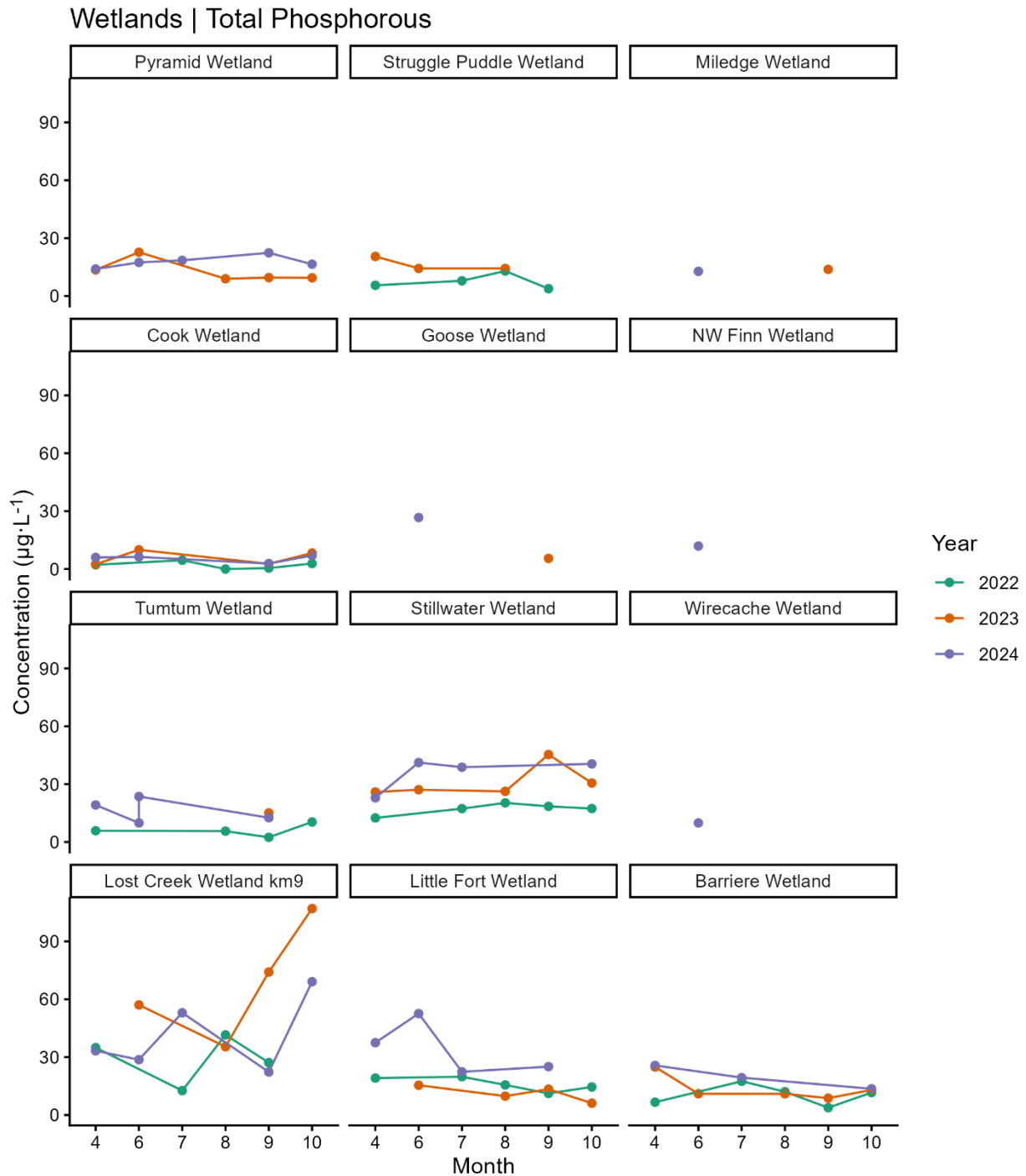


Figure A6.5. Spatiotemporal trends in total phosphorus concentrations in surface water from wetland sites in the North Thompson watershed from 2022–2024.

APPENDIX 7 — Univariate Trends

Streams

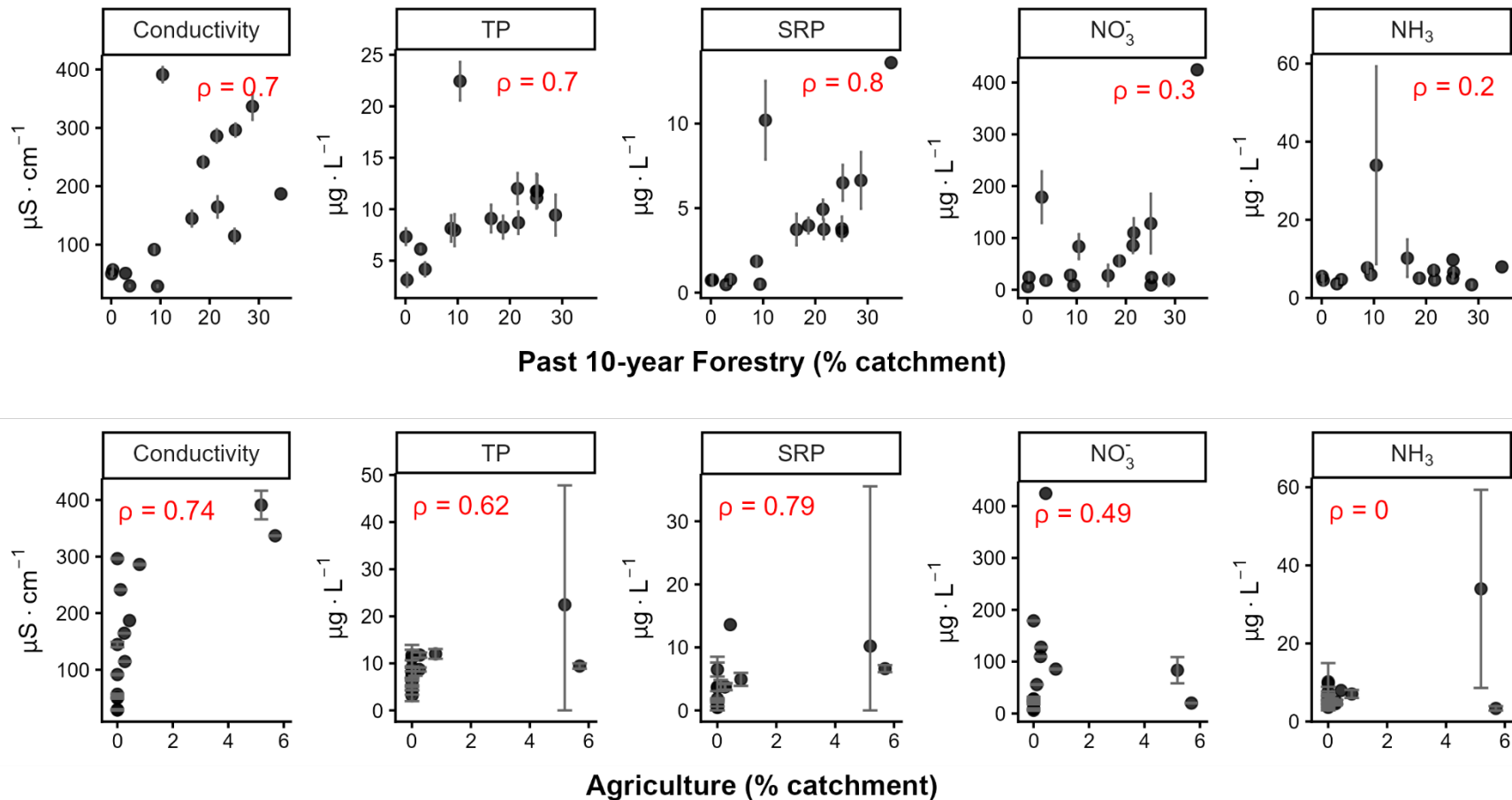


Figure A7.1. Relationships between catchment land use and mean water chemistry in North Thompson tributary stream sites (2022–2024). Panels display trends against recent forestry (top row; % harvested <10 years) and agricultural intensity (bottom row; % ALR). Data points represent site means ± 1 standard error, with Spearman's rank correlation coefficients (ρ) shown in red.

Wetlands

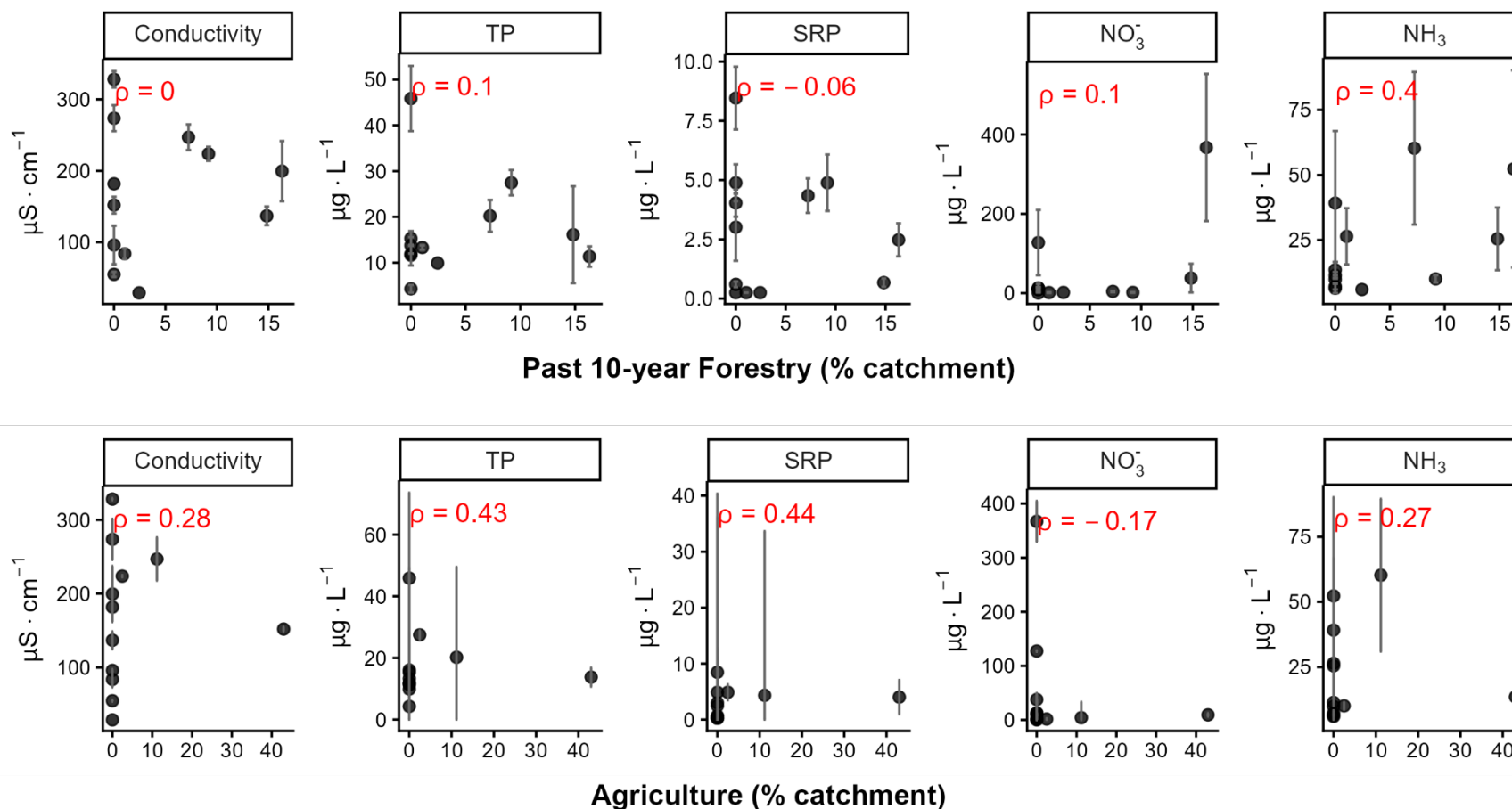


Figure A7.2. Relationships between catchment land use and mean water chemistry in North Thompson floodplain wetland sites (2022–2024). Panels display trends against recent forestry (top row; % harvested <10 years) and agricultural intensity (bottom row; % ALR). Data points represent site means ± 1 standard error, with Spearman's rank correlation coefficients (ρ) shown in red.