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Assiniboine River; Photo: Paul Mutch

ASSINIBOINE WEST
WATERSHED DISTRICT

2022 regional report

LAKE WINNIPEG
community-based monitoring network



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Lake Winnipeg Community-Based Monitoring Network: Overview

The Lake Winnipeg Community-Based Monitoring Network (LWCBMN), coordinated by the Lake Winnipeg Foundation (LWF), mobilizes citizens and watershed partners to collect water samples across Manitoba in order to measure phosphorus concentration. Phosphorus is the nutrient responsible for blue-green algae blooms on Lake Winnipeg. Phosphorus comes from diverse sources across the watershed, including municipal wastewater and agricultural runoff.

Different sub-watersheds contribute different proportions of Lake Winnipeg’s total phosphorus load. With the help of a strong network of watershed partners and citizen scientists, this long-term monitoring program is identifying phosphorus hotspots – localized areas that contribute higher amounts of phosphorus to waterways than other areas. Targeting actions to reduce phosphorus loading in hotspots will reduce the amount of phosphorus entering Manitoba’s lakes and rivers, and improve the health of Lake Winnipeg.

Snow melts, floods and heavy rainfall events are responsible for most of the phosphorus that is flushed from the land and carried into our waterways. LWCBMN samples frequently throughout the season, and particularly during the spring melt, to ensure we capture phosphorus runoff during these high-water events.

Most LWCBMN sampling is conducted at stations where water flow is continuously monitored by the [Water Survey of Canada](#) (WSC). By tracking flow online using the WSC’s real-time data, the network can notify partners and citizen scientists across the watershed to ensure frequent sampling during peak flows.

Sites with flow data can be coupled with LWCBMN data to calculate **phosphorus loads**. We need several samples throughout the season, corresponding to changes in flow, to accurately calculate these loads. Phosphorus loads can subsequently be used to calculate **phosphorus export**, based on the area of the watershed.

Phosphorus load is the total amount of phosphorus flowing past a sample site over a given period of time, expressed as tonnes per year.

Phosphorus export is the amount of phosphorus exported by each hectare of land in a year, expressed as kg/ha/y.

Sample Collection & Site Map

Water samples are collected using a weighted sampling device that collects source water directly into a 500 mL Nalgene polyethylene bottle. The sampling device is lowered into the water just before it hits the bottom, the bottle is filled, then brought back to the surface. It is rinsed three times prior to sample collection. Next, a 60 mL Nalgene polyethylene bottle containing 1 mL 4N H₂SO₄ is filled with whole water from the collection bottle.

In 2022, 1588 unfiltered water samples were collected and analyzed from 110 sites. Of these 110 LWCBMN sampling sites, 92 are located near flow-metered WSC stations, five are located near non-flow-metered WSC stations, and one is located near a USGS station, and twelve are not located near any stations.

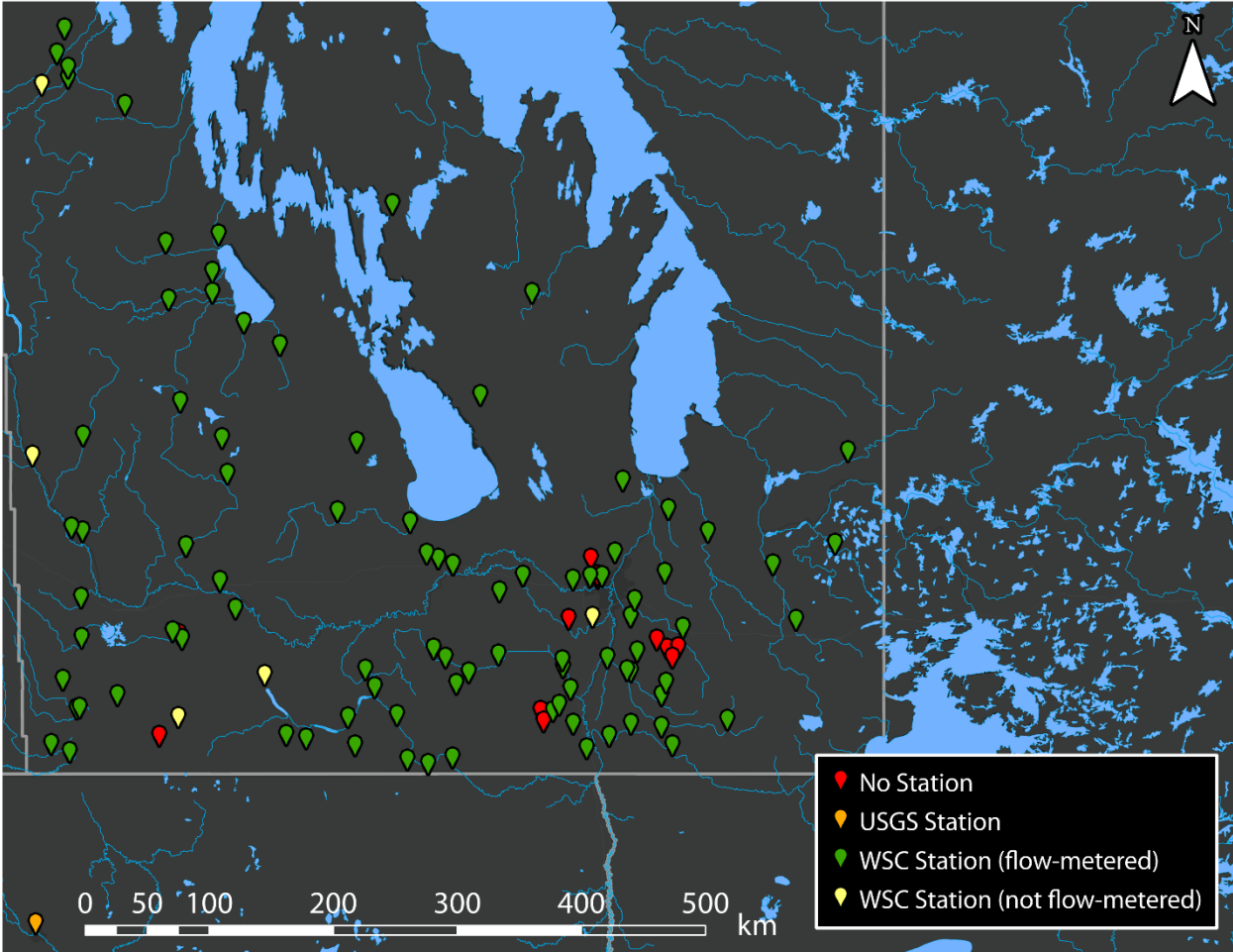


Figure 1: Map of LWCBMN sampling sites in 2022. Locations shown provided at least one sample. Colours indicate nearby station type.

Laboratory & Data Analysis

LWCBMN water samples are analysed for total phosphorus concentration. The analysis of a sample for total phosphorus (TP) is a two-step procedure involving first the chemical digestion/conversion of all P forms to orthophosphate (PO_4^{3-}) followed by the analysis of the concentration of PO_4^{3-} . The digestion procedure is patterned after USGS [Water-Resources Investigations Report 03-4174](#). The concentration of PO_4^{3-} in the sample was determined following [Murphy & Riley \(1962\)](#). The result of this analytical method is determination of unfiltered total phosphorus in mg/L.

Laboratory analysis on LWCBMN water samples was conducted in partnership with Dr. Nora Casson at her laboratory at the University of Winnipeg. Quality assurance of laboratory methods for the determination of total phosphorus was completed on samples sent from [Proficiency Testing Canada](#). Proficiency testing allows us to assess the quality of our results as compared to the results of other laboratories across the country. We received excellent passing grades of 92/100 in November 2023 and 94/100 in May 2024, further highlighting the consistency and accuracy of our laboratory methods.

Our laboratory results provide a record of the phosphorus concentrations for every day that water samples were collected, but we are equally interested in reporting the actual load of phosphorus each year in each watershed that we sample. To create this record, we multiply concentrations by the volume of water that flowed past the station every day. The Water Survey of Canada (WSC) records daily flows at most of our stations. For each station, gaps between concentration observations are filled by linear interpolation to create a continuous daily record. For the WSC flow record before or after the first or last water sample collected, we estimate the missing daily mean concentrations to be equal to the first or last measured concentration, respectively. These measured and estimated daily concentrations are then multiplied by daily flow to create a record of daily phosphorus loads.

Larger watersheds generate greater river flow and typically larger phosphorus loads. Comparing the intensity of phosphorus sources, especially among watersheds of varying sizes, is possible through the calculation of average load exported from each unit area of the watershed. Hence, we also report phosphorus export, which is simply the annual load divided by the watershed area that contributed to this load.

The export per unit area is indicative of the relative intensity of the sources generating phosphorus export, even among watersheds of different sizes. This is why we display maps of phosphorus export (and not load) in this report. Hotspots identified in these reports export several times more phosphorus per hectare than non-hotspot watersheds. Identifying hotspots can help government agencies to focus phosphorus reduction programs efficiently throughout the Province.

LWCBMN By the Numbers - 2022

Table 1: Summary of 2022 LWCBMN sampling activity by region.

Region	Number of sites	Number of samples	Site with highest regional total phosphorus (TP) export (kg/ha/y)	Mean % of spring* water load	Mean % of spring* TP load
Assiniboine West	10	170	Little Saskatchewan River near Minnedosa (0.44)	58.63	60.54
Central Assiniboine	2	48	Cypress River near Bruxelles (1.37)	87.85	80.32
City of Winnipeg	5	103	Omand's Creek near Empress Street (1.45)	87.84	91.60
East Interlake	3	24	Netley Creek near Petersfield (0.91)	67.88	81.05
Inter-Mountain	7	110	Ochre River near Ochre River (2.72)	66.73	77.45
Northeast Red	4	34	Devil's Creek near Libau (1.31)	63.71	68.56
Pembina Valley	16	216	Rivière aux Marais near Christie (3.22)	80.87	83.45
Redboine	15	195	South Tobacco Creek near Miami (3.99)	80.86	84.10
Souris River	13	122	Elgin Creek near Souris (0.26)	63.41	54.70
Seine Rat Roseau	19	333	Joubert Creek at St-Pierre-Jolys (2.74)	70.73	74.38
Swan Lake	6	90	Birch River near Birch River (0.83)	79.69	92.88
West Interlake	2	39	Burnt Lake Drain Northwest of Lundar (0.077)	19.56	17.44
Whitemud	4	54	Big Grass River near Glenella (0.78)	59.70	56.13
Winnipeg River	4	50	Bird River outlet of Bird Lake (0.20)	47.54	48.72

*LWCBMN defines "Spring" as March 1 to May 31, inclusive.

Raw data (phosphorus concentration and water flow) from LWCBMN's 2020 field season is available online at LakeWinnipegDataStream.ca, an open access hub for sharing water data.

Assiniboine West Watershed District

The Assiniboine West Watershed District (AWWD) is located in western Manitoba along the Manitoba-Saskatchewan border. The Assiniboine River is the main waterway in this region, receiving water from many tributaries. The primary land use in AWWD is agriculture, specifically annual cropland and forage grasslands (Assiniboine-Birdtail State of the Watershed Report, 2008). In addition to agricultural activities, wastewater treatment plants and lagoons in municipalities throughout AWWD contribute phosphorus to local waterways. Major municipalities include Virden, Russel and Miniota.

In partnership with LWCBMN, AWWD staff and volunteers sampled ten different sites in the AWWD region, all of which were located near actively monitored flow meters.

[AWWD Website \(myawwd.ca\)](http://myawwd.ca)

[AWWD Watershed Plans \(myawwd.ca/resources\)](http://myawwd.ca/resources)

Characteristics of the 2022 Field Season

The 2022 field season was historically wet. The winter of 2021-2022 provided most of southern Manitoba with 150+ cm of snow, the third highest amount of snowfall since 1872. Additionally, record precipitation in April and May saw large amounts of rain and snow falling on mostly frozen, impermeable soils. Specifically, in the month of April, southern Manitoba and the US portion of the Red River watershed received 400-600% of their normal precipitation (120-160 mm). Flooding was a huge issue across the southern part of the province, where almost all LWCBMN sites are located. The mean peak discharge date across all LWCBMN sites with analyzed water samples was May 10, 2022 (with a standard deviation of 19 days). In 2022, an average of 65.83% of stream discharge occurred in the spring (March 1 – May 31) across LWCBMN sites (with a standard deviation of 21.10%). During the period of extreme flooding, safety concerns prevented sampling from occurring at some sites. As a result, some load/export calculations may be less accurate than they would be had sampling remaining frequent during these times.

Manitoba Watershed District Map

Manitoba’s watershed districts are crucial partners contributing to the success of LWCBMN. In addition to assisting with sample collection, each district brings valuable community connections and a wealth of regional expertise to the network, helping us contextualize and better understand the data.

In 2022, 12 watershed districts participated in LWCBMN activities: Assiniboine West, Central Assiniboine, East Interlake; Inter-Mountain; Northeast Red, Pembina Valley, Redboine, Souris River, Seine Rat Roseau, Swan Lake, West Interlake, and Whitemud.

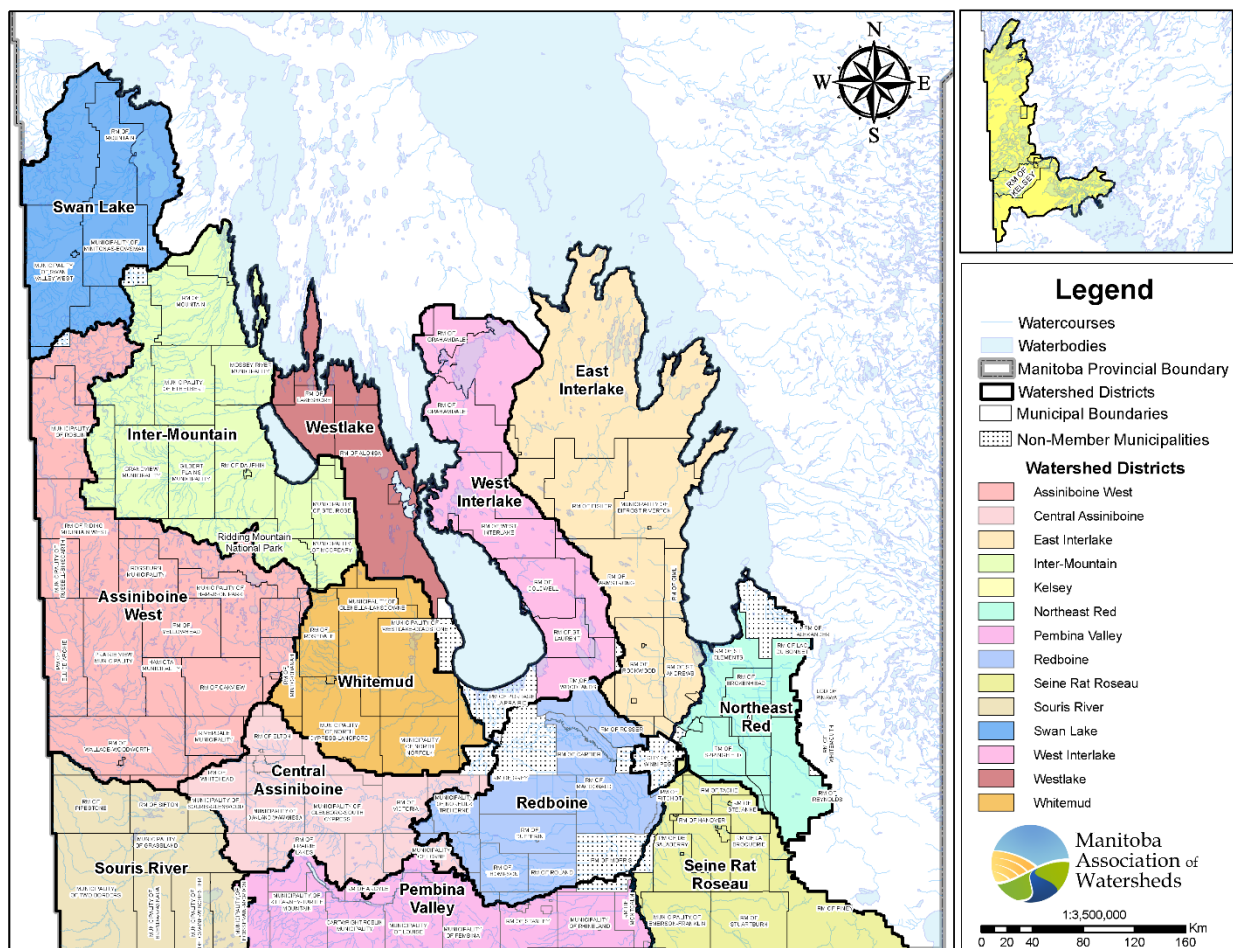


Figure 2: Manitoba Watershed District Boundaries. There are 14 total watershed districts. Map provided by Manitoba Association of Watersheds (updated July 2022).

2022 Results – Assiniboine West Summary

Table 2: Summary of 2022 LWCBMN results in Assiniboine West. Letters correspond to drainage areas in Figure 3. Data shown represents sites with sampling efforts adequate enough to calculate loads/exports. ¹See footnote for explanation of acronyms/abbreviations.

	Site Name	WSC Station	GDA (km ²)	IDA (km ²)	Gross/Incr.	TP load (tonnes/y)	TP export (kg/ha/y)
A	Arrow River near Arrow River	05MG001	566.47	NA	Gross	15.15	0.27
B	Assiniboine River near Brandon	05MH001	93866.7	5057.73	Incr.	107.09	0.21
C	Assiniboine River near Miniota	05ME006	84050	82959.60	Incr.	473.35	0.06
D	Birdtail River near Birtle	05ME003	1090.43	NA	Gross	38.54	0.35
E	Gopher Creek near Virden	05MG003	299.14	NA	Gross	7.84	0.26
F	Little Saskatchewan River near Horod	05MF024	667.97	NA	Gross	2.71	0.04
G	Little Saskatchewan River near Minnedosa	05MF001	2615.39	1944.62	Incr.	85.29	0.44
H	Little Saskatchewan River near Rivers	05MF018	3892.75	1277.36	Incr.	26.10	0.20

To compare 2022 results to other years of data, please see LWCBMN regional reports online at <https://lakewinnipegfoundation.org/lwcbmn-regional-reports>

¹ WSC = Water Survey of Canada.

GDA = gross drainage area (i.e., the total watershed area).

IDA = incremental drainage area (i.e., the total watershed area minus the total watershed area of any contained upstream sites with data adequate for load/export calculation).

Gross/Incr. = whether or not the adjacent TP load/export listed is from the gross or incremental (“Incr.”) drainage area of a site.

2022 Results – Hotspot Map

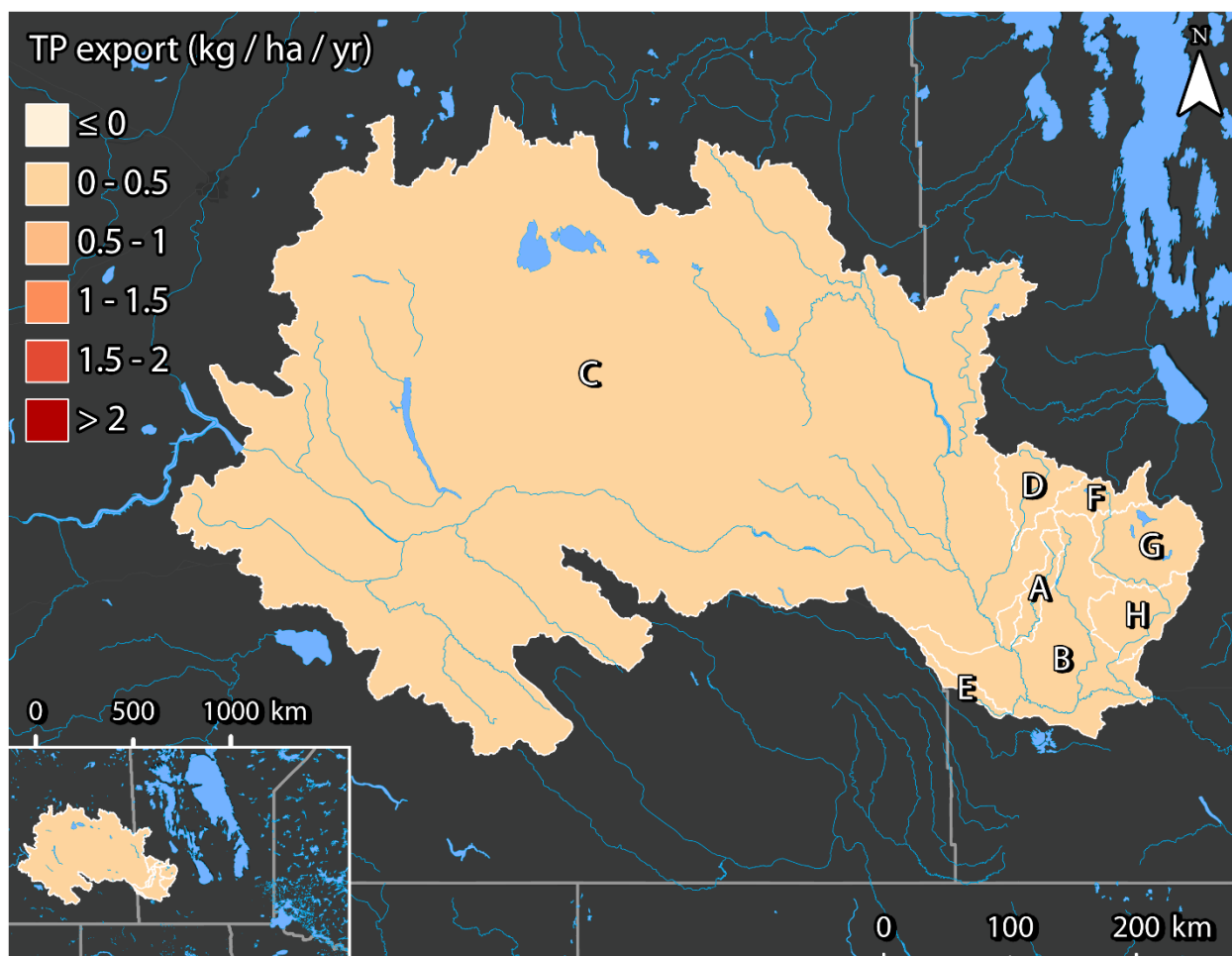


Figure 3: 2022 LWCBMN TP Export Hotspots in Assiniboine West. Letters correspond to sites listed in Table 2.

2022 Results – Individual Sites

Arrow River near Arrow River

Arrow River is part of the larger Arrow-Oak watershed. The Arrow River portion of the watershed flows south into the Assiniboine River. The drainage area contains a largely agricultural area with mainly annual cropland (Arrow-Oak State of the Watershed Report, 2008). This sampling site is located at Water Survey of Canada station 05MG001, near Arrow River. The sampling effort provided excellent coverage to calculate TP loads and exports.

Table 3: Indices of discharge and phosphorus from the gross drainage area of Arrow River near Arrow River (05MG001) in 2022.

Gross drainage area:	566.47 km ²
Peak discharge:	20.53 m ³ s ⁻¹ (2022-04-06)
Peak TP concentration:	1.12 mg/L (2022-07-25)
% of water load in spring:	84.80%
% of TP load in spring:	83.27%
Water load:	0.024 km ³ y ⁻¹
TP load:	15.15 tonnes P y ⁻¹
Water export:	42.03 mm y ⁻¹
TP export:	0.27 kg P ha ⁻¹ y ⁻¹

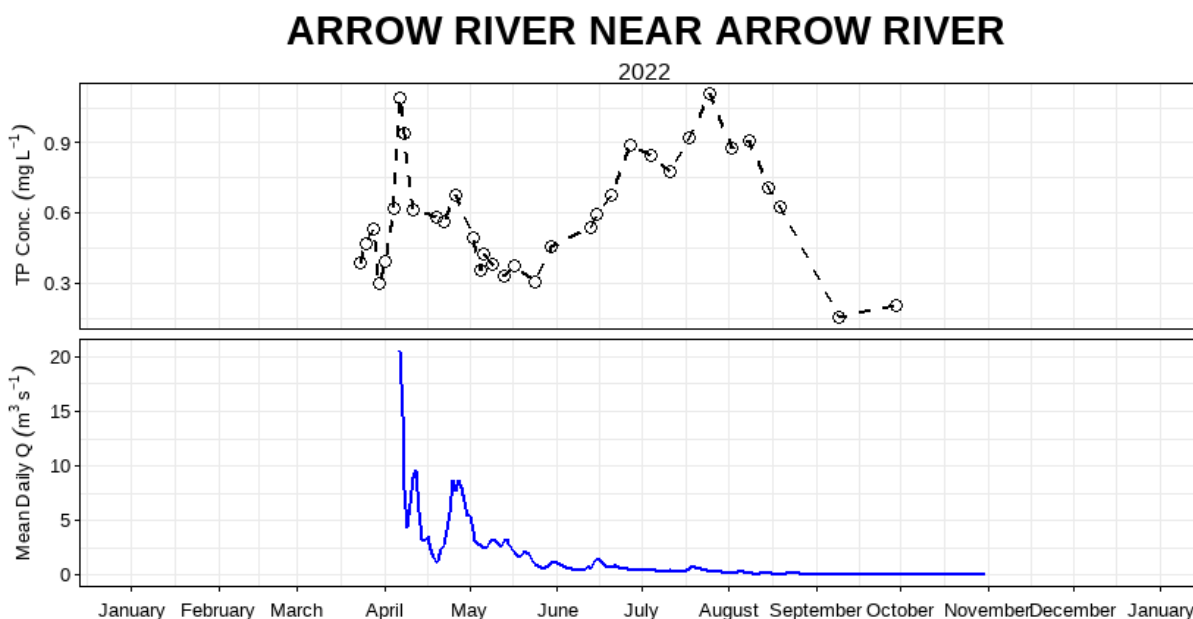


Figure 4: Mean daily discharge (m³ s⁻¹) and total phosphorus concentration (mg L⁻¹) over the 2022 sampling season at Arrow River near Arrow River (05MG001).

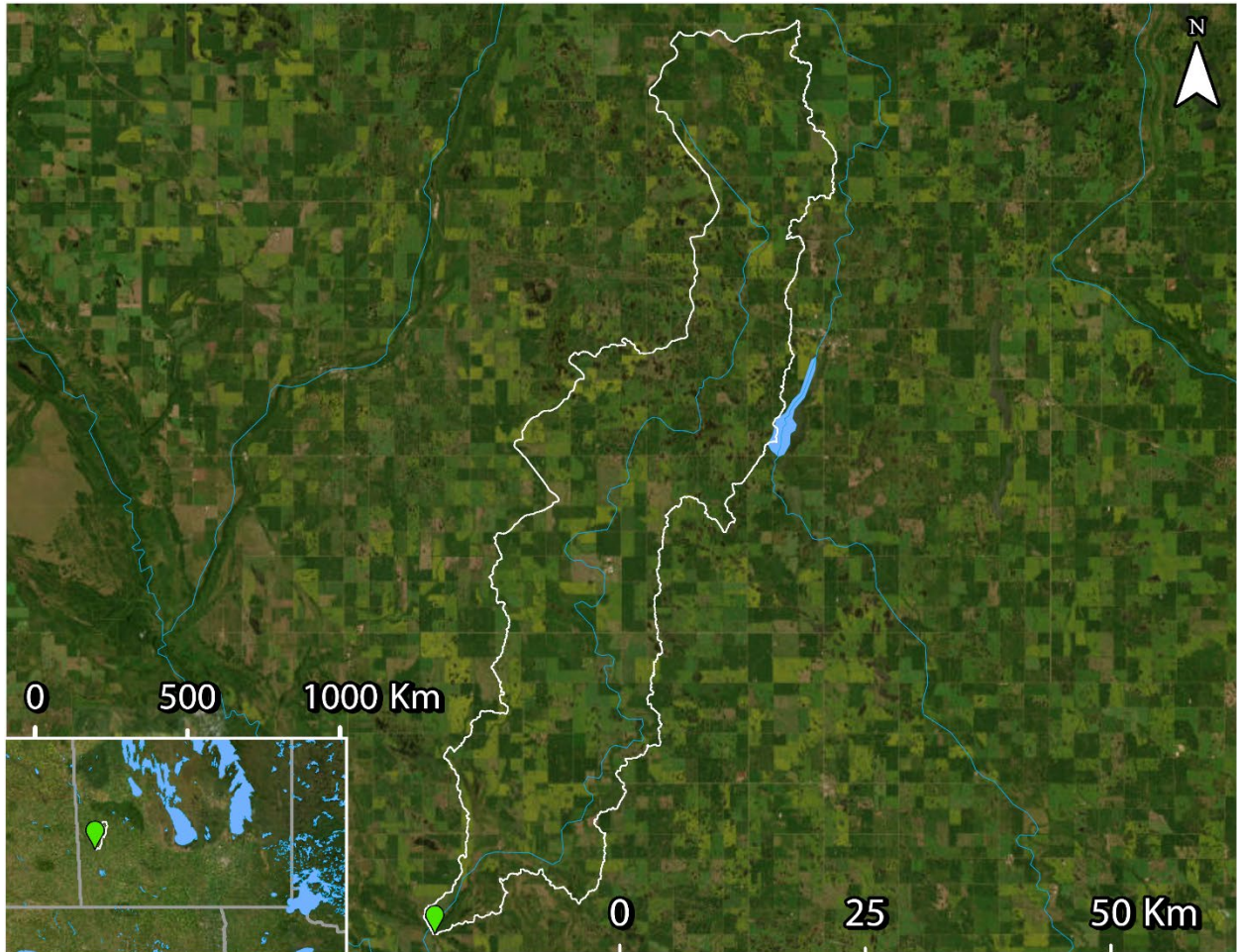


Figure 5: WSC station 05MG001 (green) and drainage area polygon (white - source: WSC). LWCBMN samples directly at the WSC station.

Gopher Creek near Virden

Gopher Creek flows east into the Assiniboine River. The drainage area for this sampling site drains a largely agricultural area, with portions in both Manitoba and Saskatchewan. This sampling site is located at Water Survey of Canada flow meter 05MG003, near Virden, MB. The sampling effort provided excellent coverage to calculate TP loads and exports.

Table 4: Indices of discharge and phosphorus from the gross drainage area of Gopher Creek near Virden (05MG003) in 2022.

Gross drainage area:	299.14 km ²
Peak discharge:	12.25 m ³ s ⁻¹ (2022-05-03)
Peak TP concentration:	0.84 mg/L (2022-03-28)
% of water load in spring:	70.53%
% of TP load in spring:	67.85%
Water load:	0.017 km ³ y ⁻¹
TP load:	7.84 tonnes P y ⁻¹
Water export:	55.62 mm y ⁻¹
TP export:	0.26 kg P ha ⁻¹ y ⁻¹

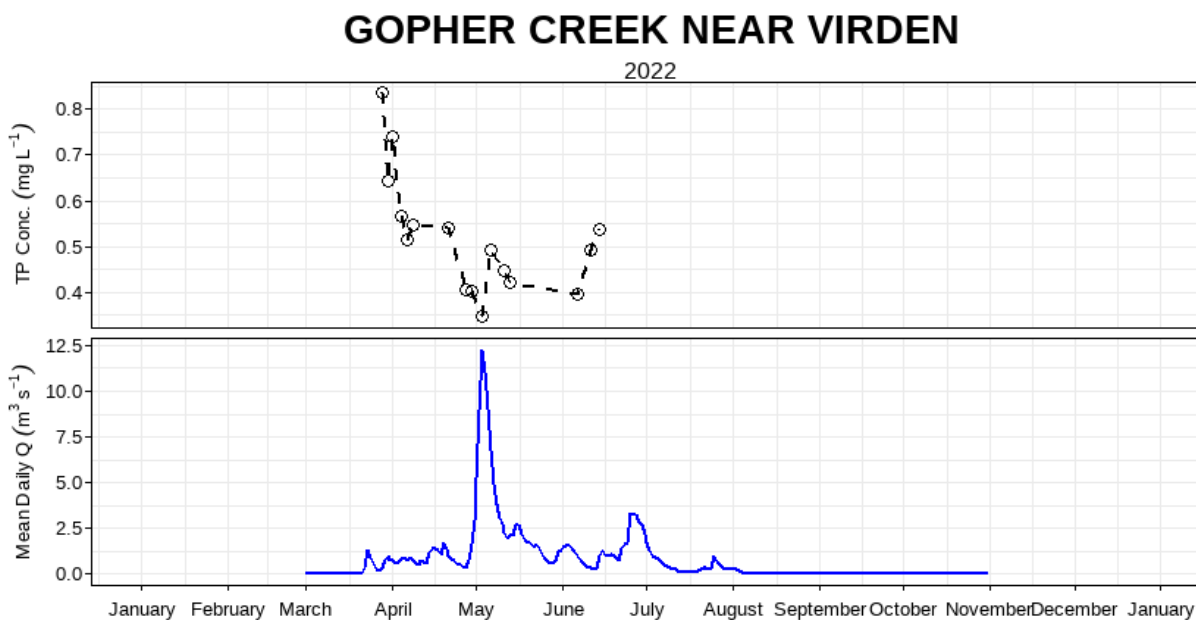


Figure 6: Mean daily discharge (m³ s⁻¹) and total phosphorus concentration (mg L⁻¹) over the 2022 sampling season at Gopher Creek near Virden (05MG003).

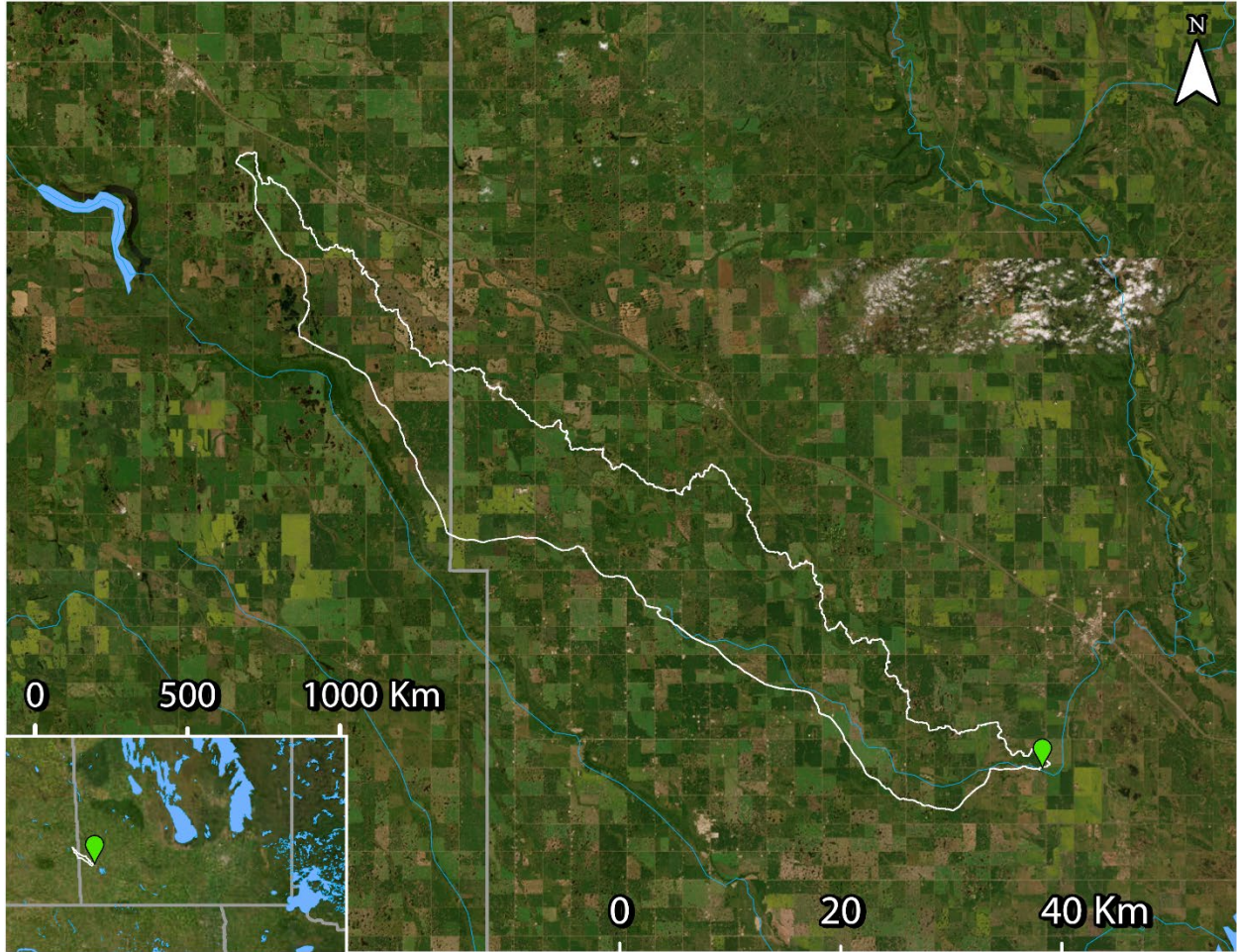


Figure 7: WSC station 05MG003 (green) and drainage area polygon (white - source: WSC). LWCBMN samples directly at the WSC station.

Little Saskatchewan River near Horod

Little Saskatchewan River flows south into the Assiniboine River. This sampling site is located at Water Survey of Canada flow meter 05MF024, just south of Riding Mountain Provincial Park. It is the most northern Little Saskatchewan River site. The sampling effort provided excellent coverage to calculate TP loads and exports.

Table 5: Indices of discharge and phosphorus from the gross drainage area of Little Saskatchewan River near Horod (05MF024) in 2022.

Gross drainage area:	667.97 km ²
Peak discharge:	42.43 m ³ s ⁻¹ (2022-05-12)
Peak TP concentration:	0.067 mg/L (2022-05-07)
% of water load in spring:	54.77%
% of TP load in spring:	55.69%
Water load:	0.12 km ³ y ⁻¹
TP load:	2.71 tonnes P y ⁻¹
Water export:	177.53 mm y ⁻¹
TP export:	0.041 P ha ⁻¹ y ⁻¹

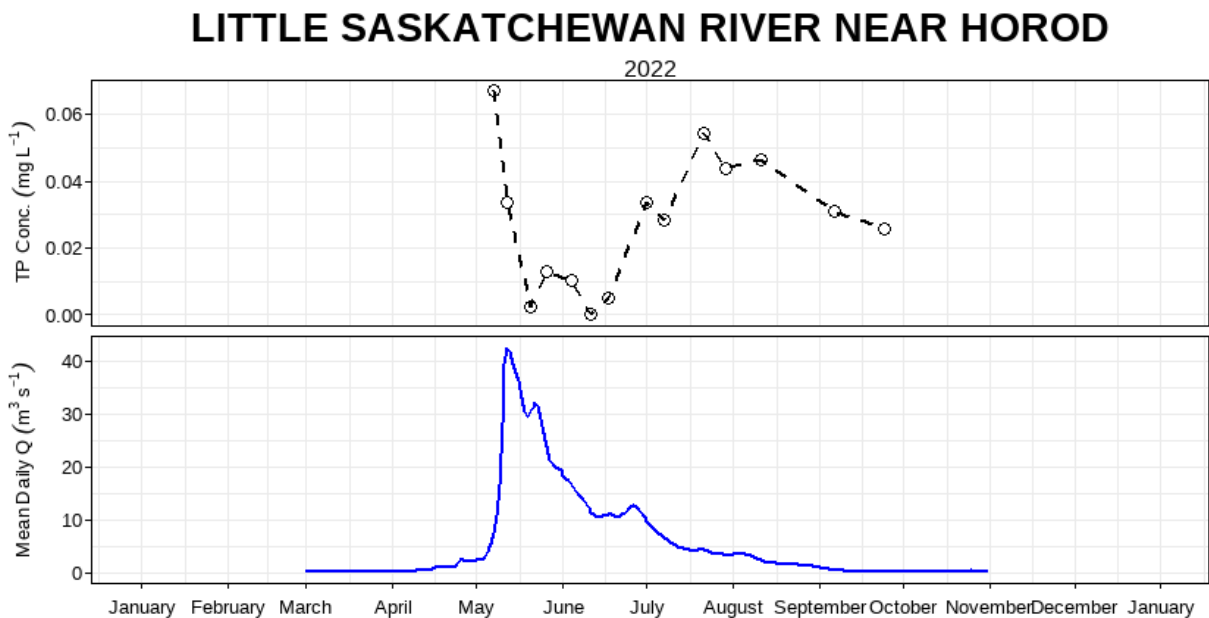


Figure 8: Mean daily discharge (m³ s⁻¹) and total phosphorus concentration (mg L⁻¹) over the 2022 sampling season at Little Saskatchewan River near Horod (05MF024).

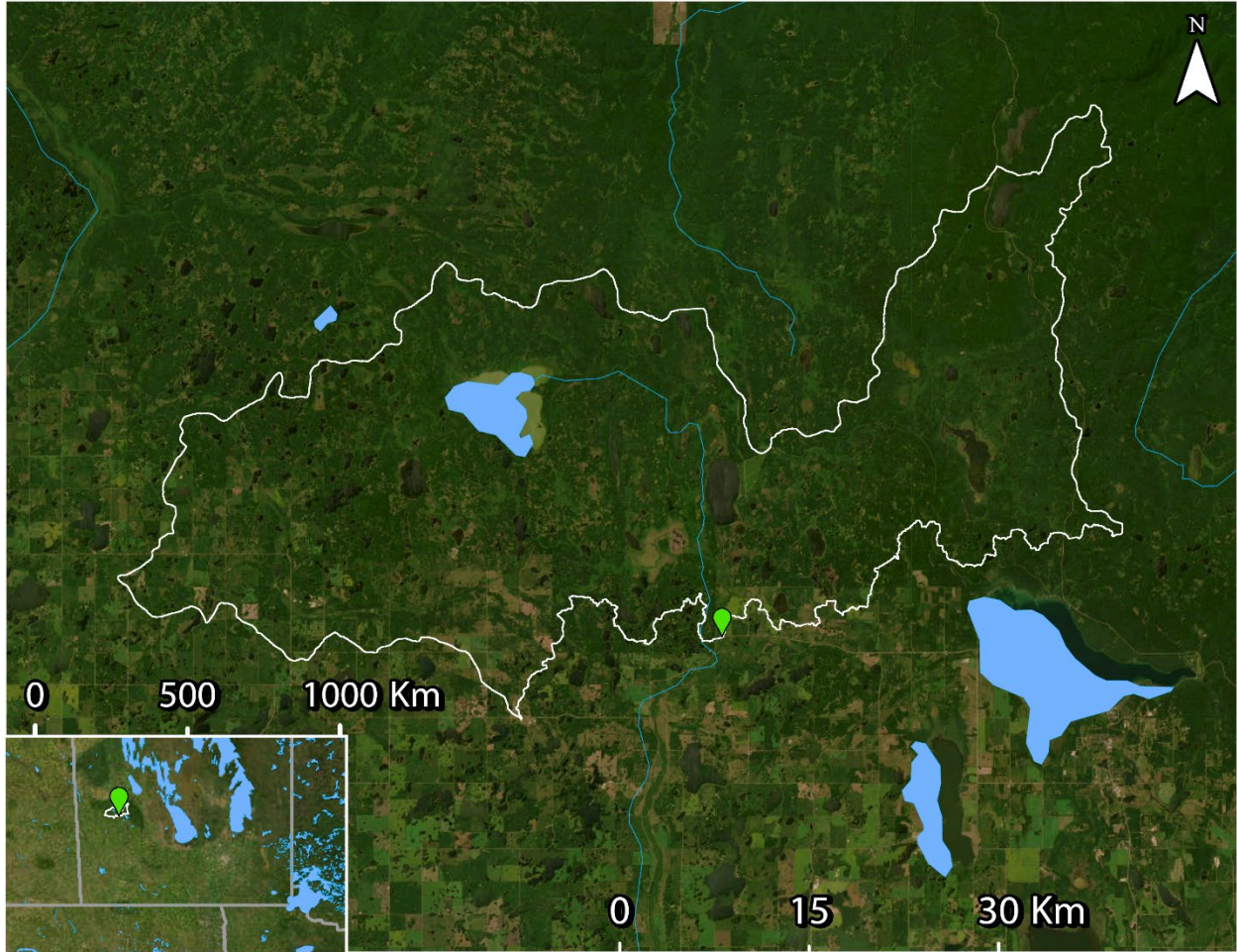


Figure 9: WSC station 05MF024 (green) and drainage area polygon (white – source: WSC). LWCBMN samples directly at the WSC station.

Little Saskatchewan River near Minnedosa

Little Saskatchewan River flows south into the Assiniboine River. This sampling site is located at Water Survey of Canada flow meter 05MF001, roughly 25 km northwest of Brandon, MB. The sampling effort provided excellent coverage to calculate TP loads and exports.

Table 6: Indices of discharge and phosphorus from the incremental drainage area of Little Saskatchewan River near Minnedosa (05MF001). See Supplemental Table 1 for gross calculations.

Incremental drainage area:	1944.62 km ²
Peak discharge:	130.97 m ³ s ⁻¹ (2022-05-16)
Peak TP concentration:	0.39 mg/L (2022-05-05)
% of water load in spring:	46.55%
% of TP load in spring:	59.48%
¹Incremental water load:	0.32 km ³ y ⁻¹
¹Incremental TP load:	85.29 tonnes P y ⁻¹
²Incremental water export:	162.25 mm y ⁻¹
²Incremental TP export:	0.44 kg P ha ⁻¹ y ⁻¹

LITTLE SASKATCHEWAN RIVER NEAR MINNEDOSA

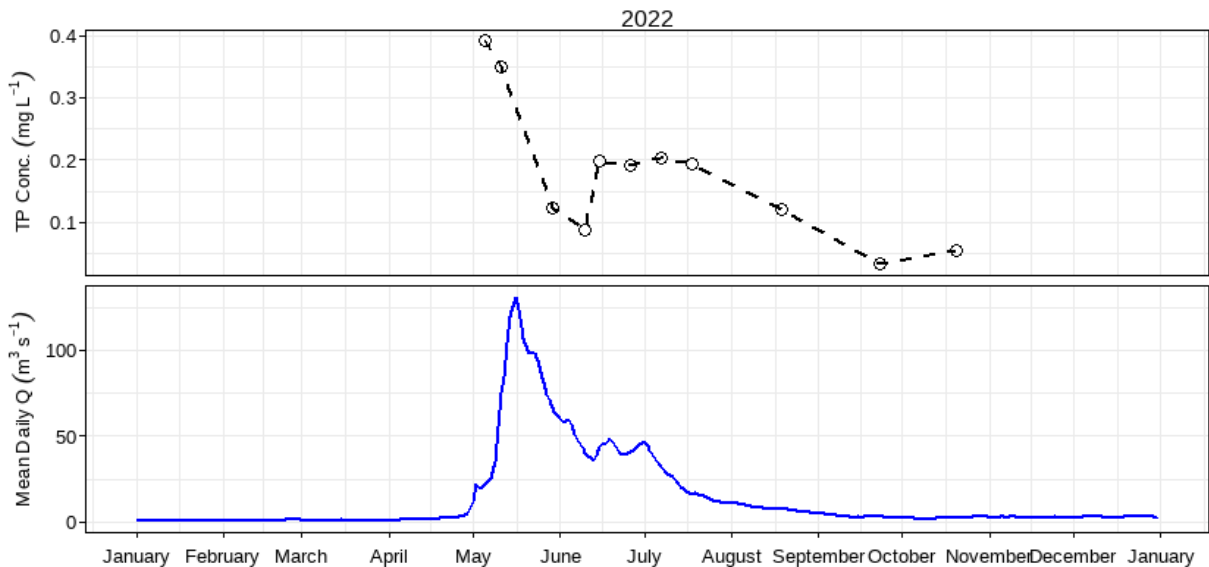


Figure 10: Mean daily discharge (m³ s⁻¹) and total phosphorus concentration (mg L⁻¹) over the 2022 sampling season at Little Saskatchewan River near Minnedosa (05MF001).

¹ Incremental values are calculated by subtracting gross “Little Saskatchewan River near Horod” values from gross “Little Saskatchewan River near Minnedosa” values.

² Incremental exports are calculated by dividing incremental loads by incremental drainage areas.

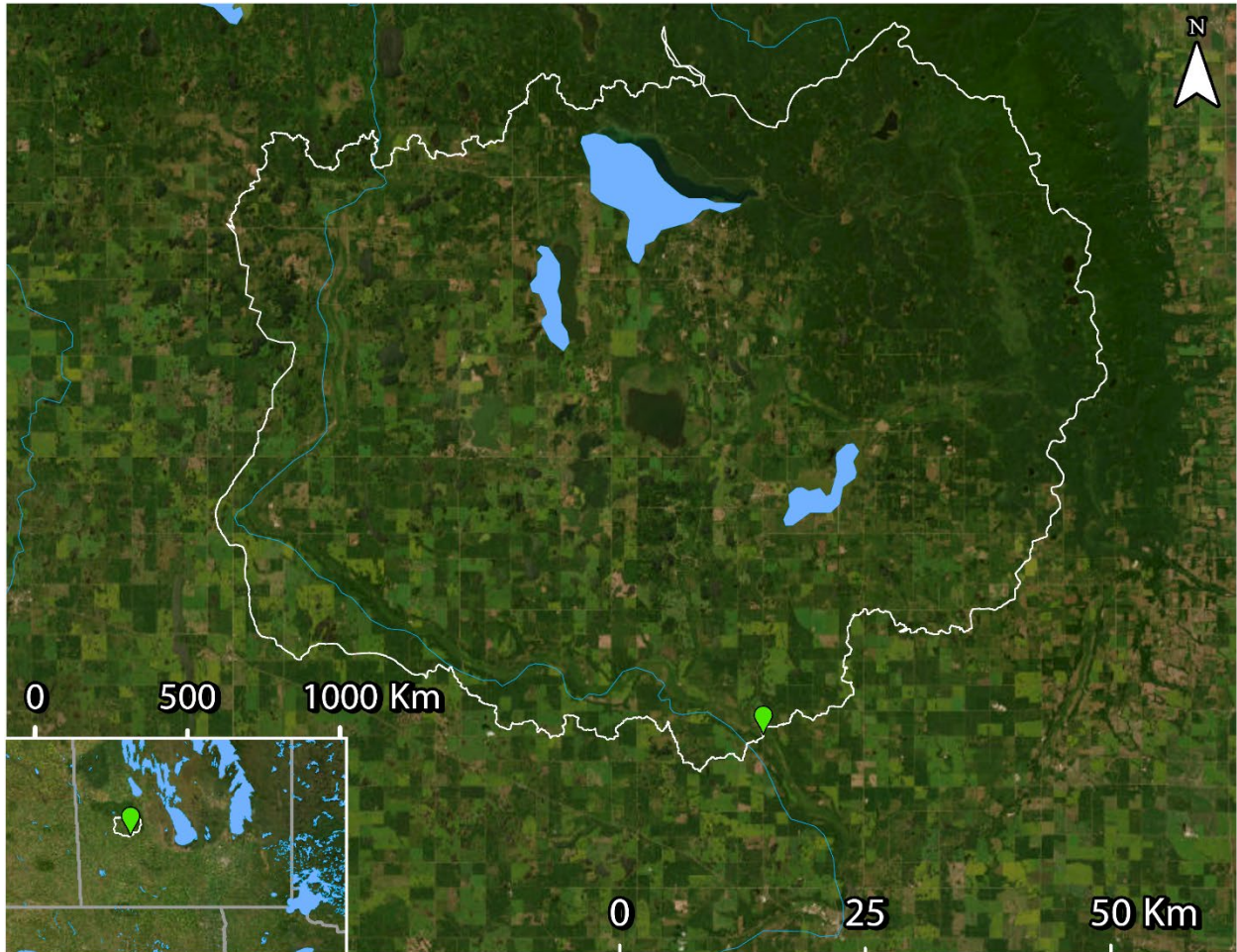


Figure 11: WSC station 05MF001 (green), and incremental drainage area polygon (white - source: WSC). See Supplemental Figure 1 for upstream drainage areas used to calculate incremental area. LWCBMN samples directly at the WSC station.

Little Saskatchewan River near Rivers

Little Saskatchewan River flows south into the Assiniboine River. This sampling site is located at Water Survey of Canada flow meter 05MF018, roughly 25 km northwest of Brandon, MB. The sampling effort provided excellent coverage to calculate TP loads and exports.

Table 7: Indices of discharge and phosphorus from the incremental drainage area of Little Saskatchewan River near Rivers (05MF018). See Supplemental Table 2 for gross calculations.

Incremental drainage area:	1277.36 km ²
Peak discharge:	136.61 m ³ s ⁻¹ (2022-05-17)
Peak TP concentration:	0.46 mg/L (2022-06-17)
% of water load in spring:	46.78%
% of TP load in spring:	41.08%
¹Incremental water load:	0.098 km ³ y ⁻¹
¹Incremental TP load:	26.10 tonnes P y ⁻¹
²Incremental water export:	77.11 mm y ⁻¹
²Incremental TP export:	0.20 kg P ha ⁻¹ y ⁻¹

LITTLE SASKATCHEWAN RIVER NEAR RIVERS



Figure 12: Mean daily discharge (m³ s⁻¹) and total phosphorus concentration (mg L⁻¹) over the 2022 sampling season at Little Saskatchewan River near Rivers (05MF018).

¹ Incremental values are calculated by subtracting “Little Saskatchewan River near Minnedosa” from gross “Little Saskatchewan River near Rivers” values.

² Incremental exports are calculated by dividing incremental loads by incremental drainage areas.

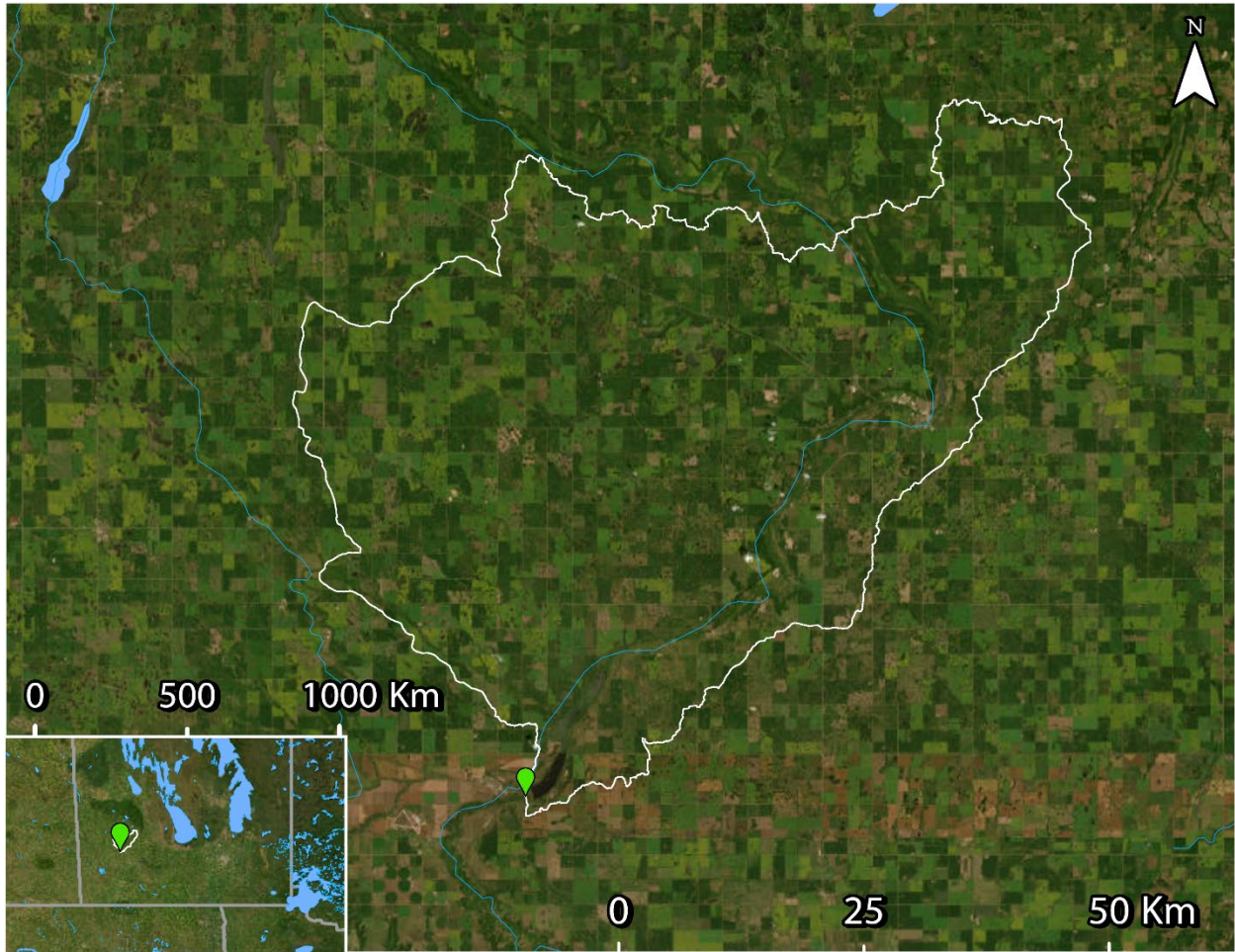


Figure 13: WSC station 05MF018 (green), and incremental drainage area polygon (white - source: WSC). See Supplemental Figure 2 for upstream drainage areas used to calculate incremental area. LWCBMN samples directly at the WSC station.

Birdtail River near Birtle

Birdtail River flows south-southwest into the Assiniboine River. This sampling site is located at Water Survey of Canada flow meter 05ME003, located about 14 km north-northeast of Birtle, MB. The sampling effort provided excellent coverage to calculate TP loads and exports.

Table 8: Indices of discharge and phosphorus from the gross drainage area of Birdtail River near Birtle (05ME003) in 2022.

Gross drainage area:	1090.43 km ²
Peak discharge:	69.15 m ³ s ⁻¹ (2022-05-10)
Peak TP concentration:	0.44 mg/L (2022-05-03)
% of water load in spring:	63.12%
% of TP load in spring:	67.45%
Water load:	0.18 km ³ y ⁻¹
TP load:	38.54 tonnes P y ⁻¹
Water export:	161.63 mm y ⁻¹
TP export:	0.35 kg P ha ⁻¹ y ⁻¹

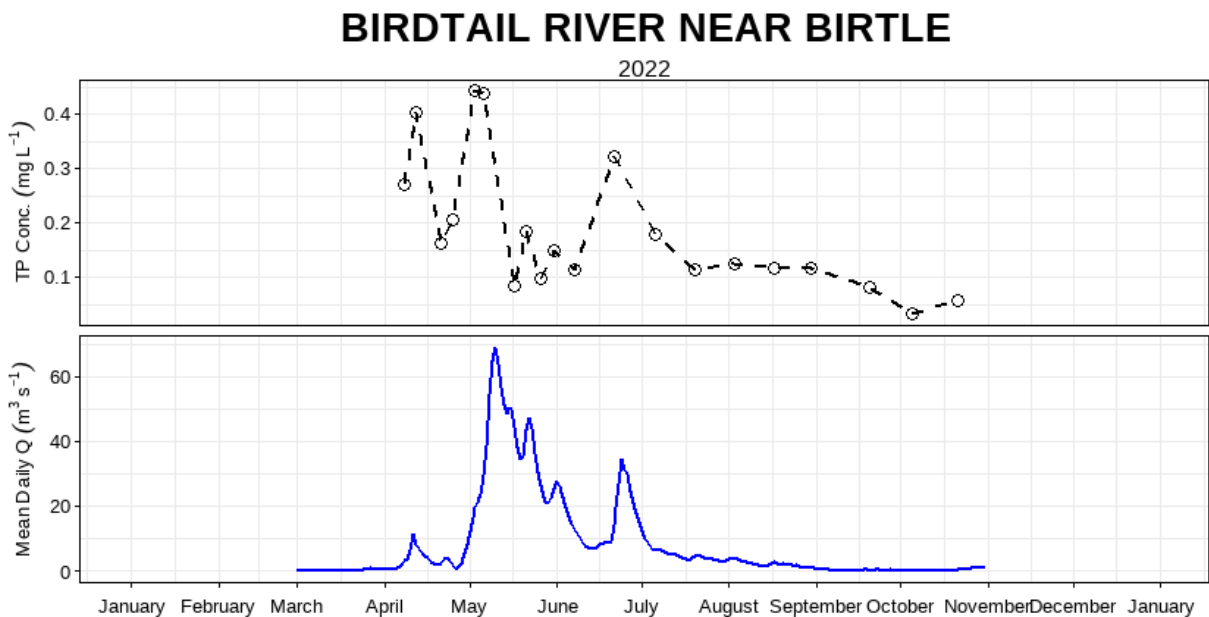


Figure 14: Mean daily discharge (m³ s⁻¹) and total phosphorus concentration (mg L⁻¹) over the 2022 sampling season at Birdtail River near Birtle (05ME003).

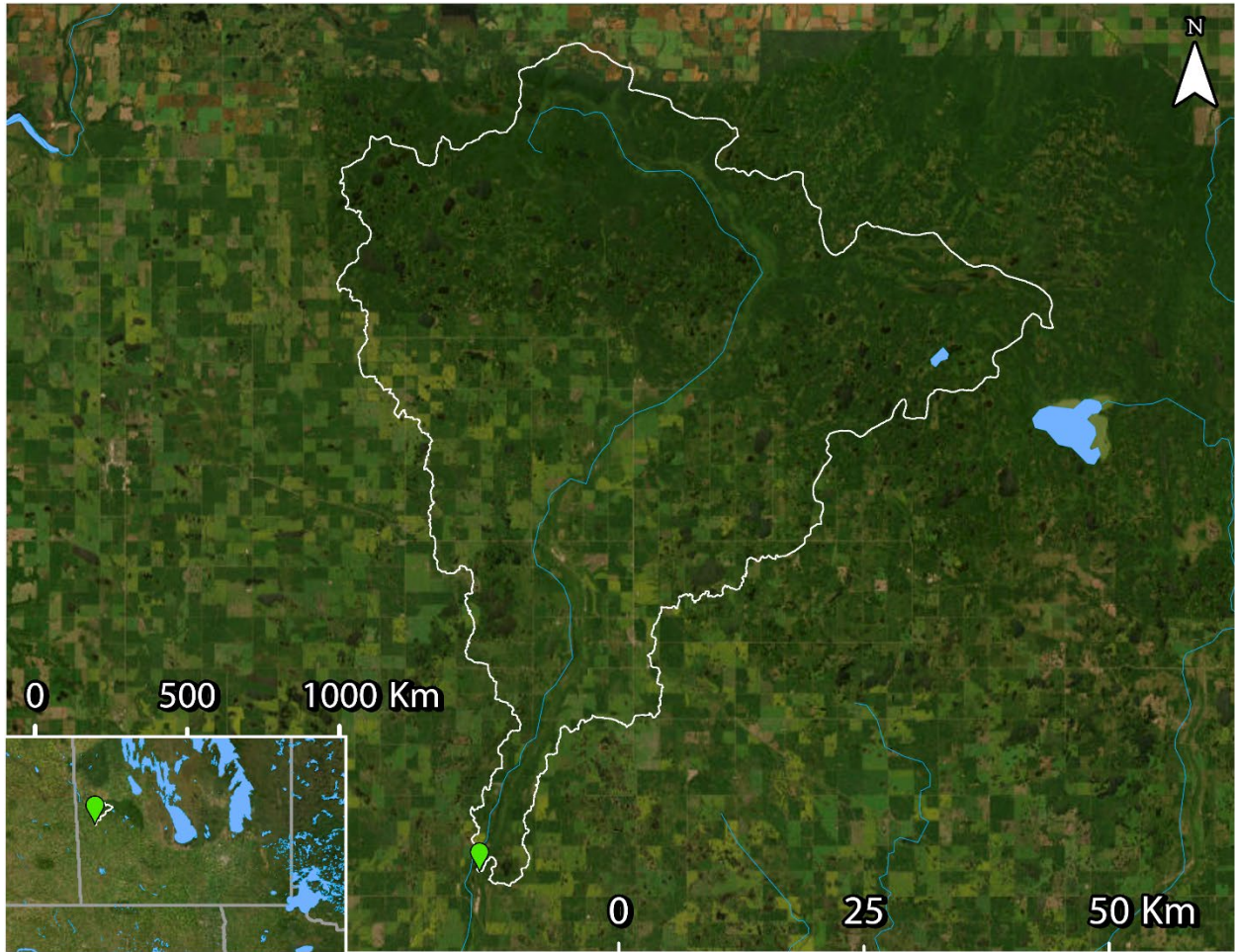


Figure 15: WSC station 05ME003 (green) and drainage area polygon (white – source: WSC). LWCBMN samples directly at the WSC station.

Assiniboine River near Miniota

This is the midstream sampling site along the Assiniboine River for this region. The majority of the drainage area is located in Saskatchewan. This sampling site is located at Water Survey of Canada flow meter 05ME006, near Miniota, MB. The sampling effort provided excellent coverage to calculate TP loads and exports.

Table 9: Indices of discharge and phosphorus from the incremental drainage area of Assiniboine River near Miniota (05ME006). See Supplemental Table 3 for gross calculations.

Incremental drainage area:	82959.6 km ²
Peak discharge:	216.95 m ³ s ⁻¹ (2022-05-13)
Peak TP concentration:	0.63 mg/L (2022-04-22)
% of water load in spring:	56.26%
% of TP load in spring:	65.18%
¹Incremental water load:	1.42 km ³ y ⁻¹
¹Incremental TP load:	473.35 tonnes P y ⁻¹
²Incremental water export:	17.11 mm y ⁻¹
²Incremental TP export:	0.057 kg P ha ⁻¹ y ⁻¹

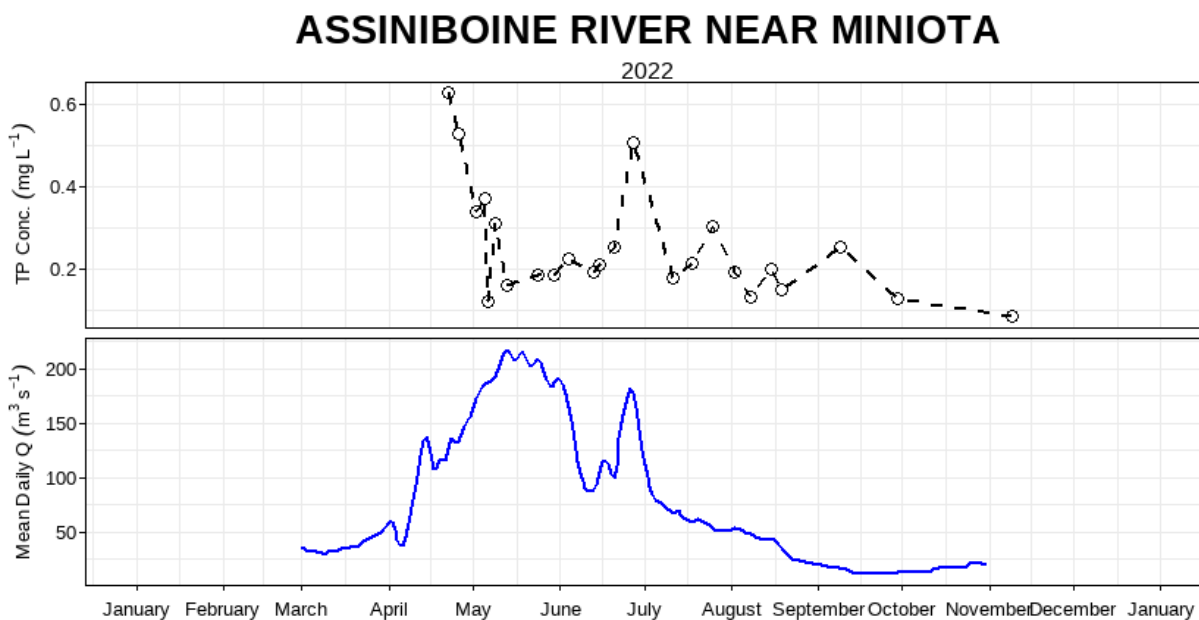


Figure 16: Mean daily discharge (m³ s⁻¹) and total phosphorus concentration (mg L⁻¹) over the 2022 sampling season at Assiniboine River near Miniota (05ME006).

¹ Incremental values are calculated by subtracting “Birdtail River near Birtle” from gross “Assiniboine River near Miniota” values.

² Incremental exports are calculated by dividing incremental loads by incremental drainage areas.

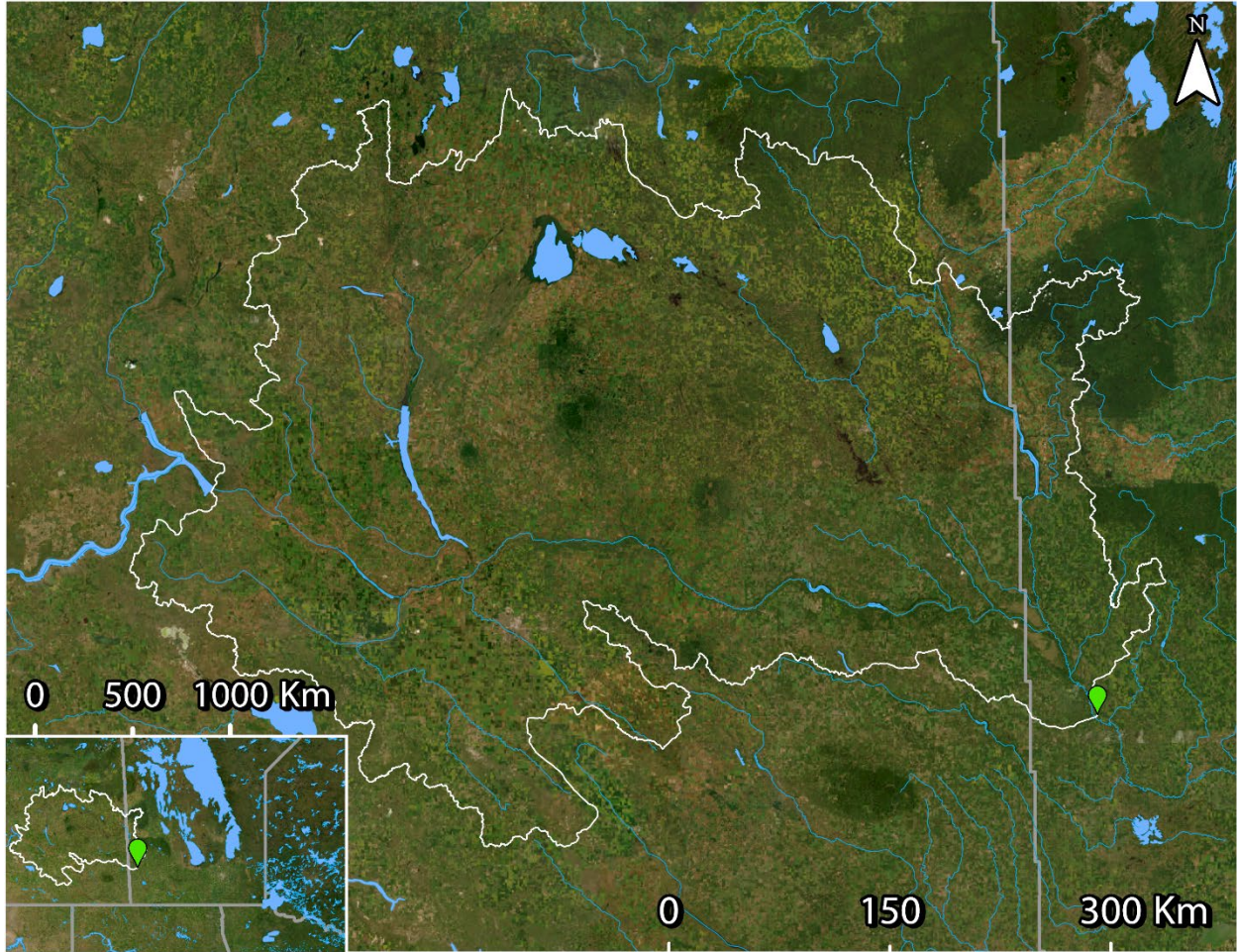


Figure 17: WSC station 05ME006 (green), and incremental drainage area polygon (white - source: WSC). See Supplemental Figure 3 for upstream drainage areas used to calculate incremental area. LWCBMN samples directly at the WSC station.

Assiniboine River near Brandon

This sampling is located along the Assiniboine River near Brandon MB. This sampling site is located at Water Survey of Canada station 05MH001, in the northern part of Brandon, MB. The sampling effort provided excellent coverage to calculate TP loads and exports.

Table 10: Indices of discharge and phosphorus from the incremental drainage area of Assiniboine River near Brandon (05MH001). See Supplemental Table 4 for gross calculations.

Incremental drainage area:	5057.73 km ²
Peak discharge:	397.41 m ³ s ⁻¹ (2022-05-20)
Peak TP concentration:	0.48 mg/L (2022-04-27)
% of water load in spring:	47.90%
% of TP load in spring:	51.60%
¹Incremental water load:	0.37 km ³ y ⁻¹
¹Incremental TP load:	107.09 tonnes P y ⁻¹
²Incremental water export:	73.78 mm y ⁻¹
²Incremental TP export:	0.21 kg P ha ⁻¹ y ⁻¹

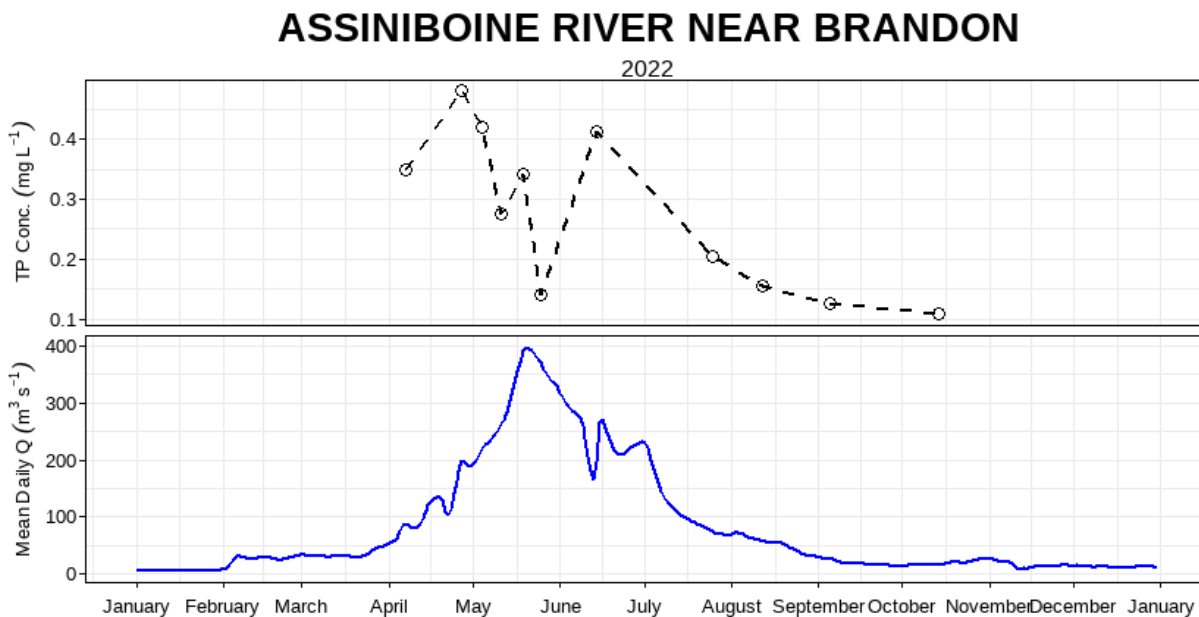


Figure 18: Mean daily discharge (m³ s⁻¹) and total phosphorus concentration (mg L⁻¹) over the 2022 sampling season at Assiniboine River near Brandon (05MH001).

¹ Incremental values are calculated by subtracting “Arrow River near Arrow River”, “Assiniboine River near Miniota”, “Gopher Creek near Virden”, “Little Saskatchewan River near Rivers”, and from “Assiniboine River near Brandon” values.

² Incremental exports are calculated by dividing incremental loads by incremental drainage areas.

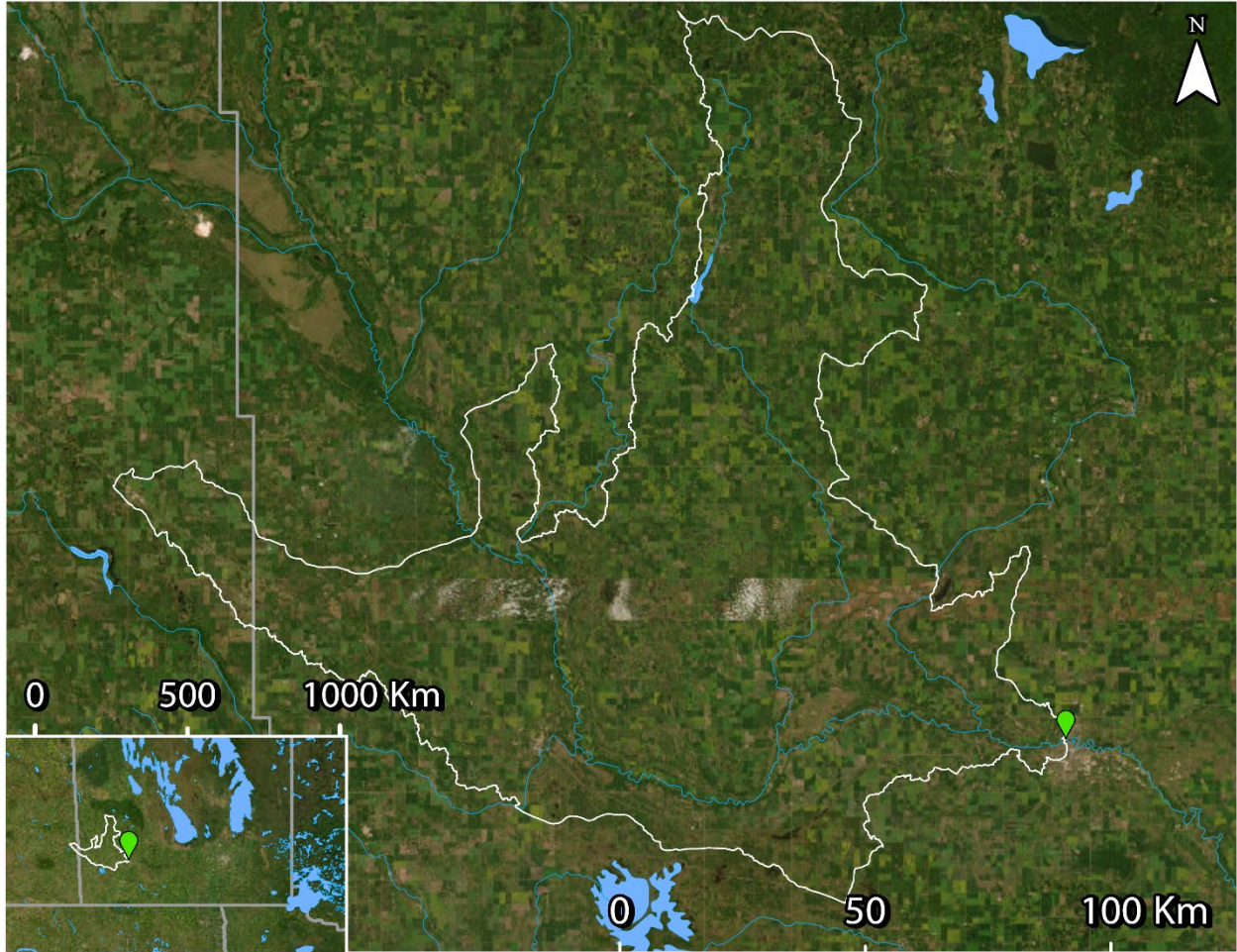


Figure 19: WSC station 05MH001 (green), and incremental drainage area polygon (white - source: WSC). See Supplemental Figure 4 for upstream drainage areas used to calculate incremental area. LWCBMN samples directly at the WSC station.

Sites without capacity for load/export calculation

Rolling River near Erickson

Rolling River flows south into the Little Saskatchewan River and then the Assiniboine River. This sampling site is located at Water Survey of Canada flow meter 05MF008, just east of Proven Lake and south of Riding Mountain Provincial Park. There were not enough samples to accurately calculate phosphorus loads/exports.

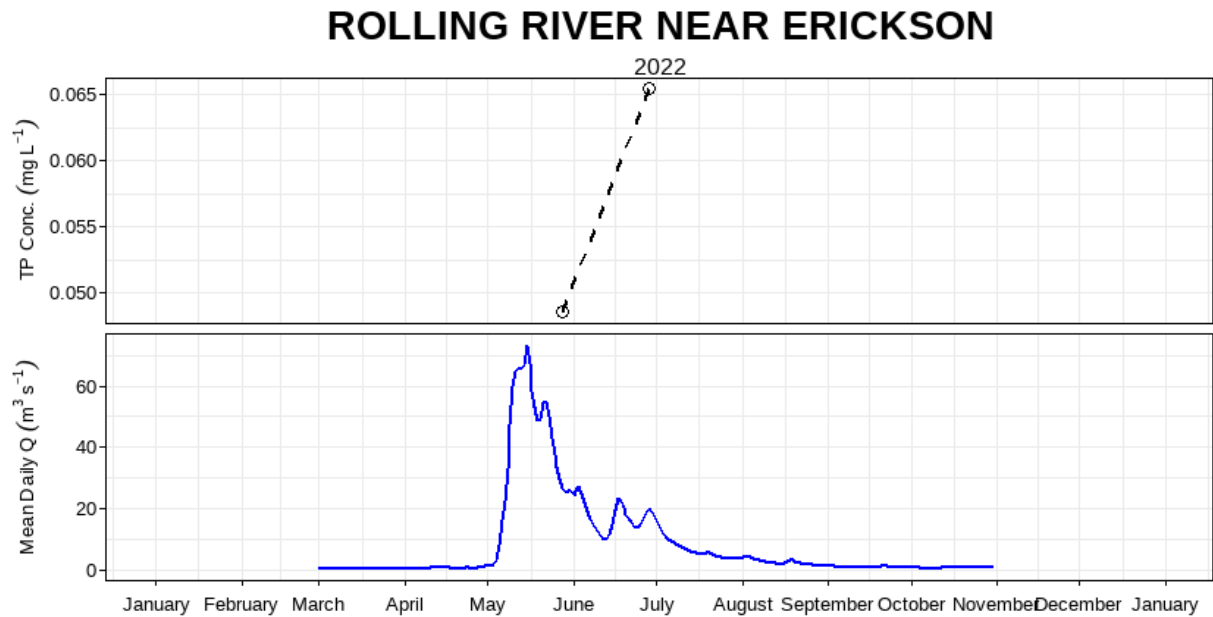


Figure 20: Mean daily discharge ($\text{m}^3 \text{s}^{-1}$) and total phosphorus concentration (mg L^{-1}) over the 2022 sampling season at Rolling River near Erickson (05MF008).

Assiniboine River at St. Lazare

The majority of the drainage area is located in Saskatchewan. This sampling site is located at Water Survey of Canada station 05ME011, southwest of St-Lazare, Man. This sampling site only measures primary water levels and therefore phosphorus loads and exports cannot be calculated.

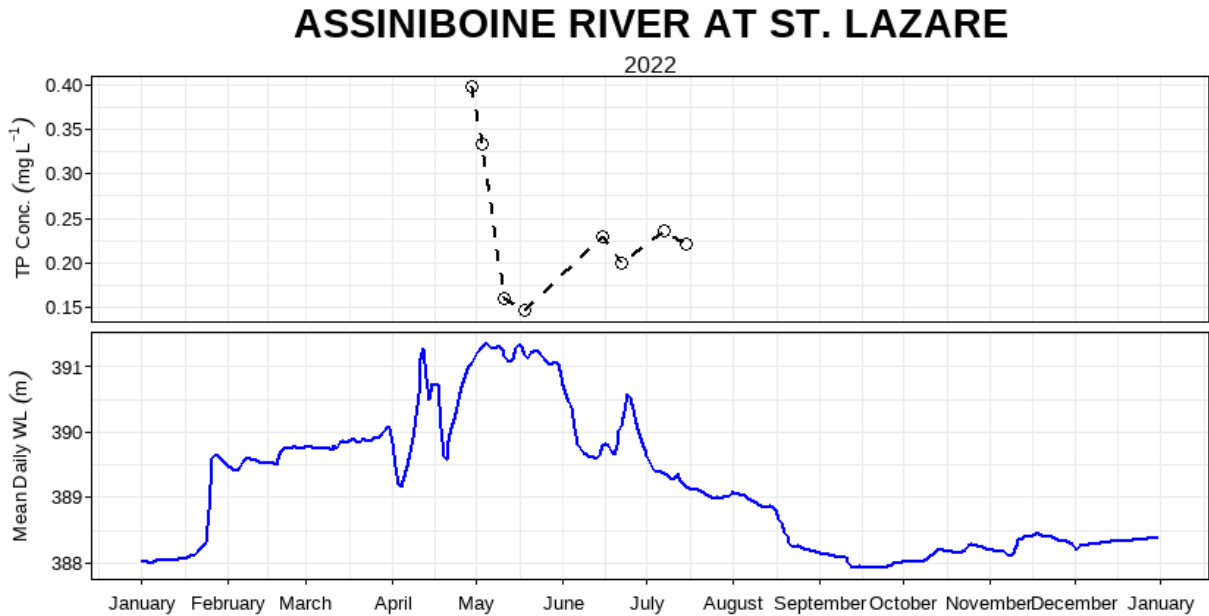


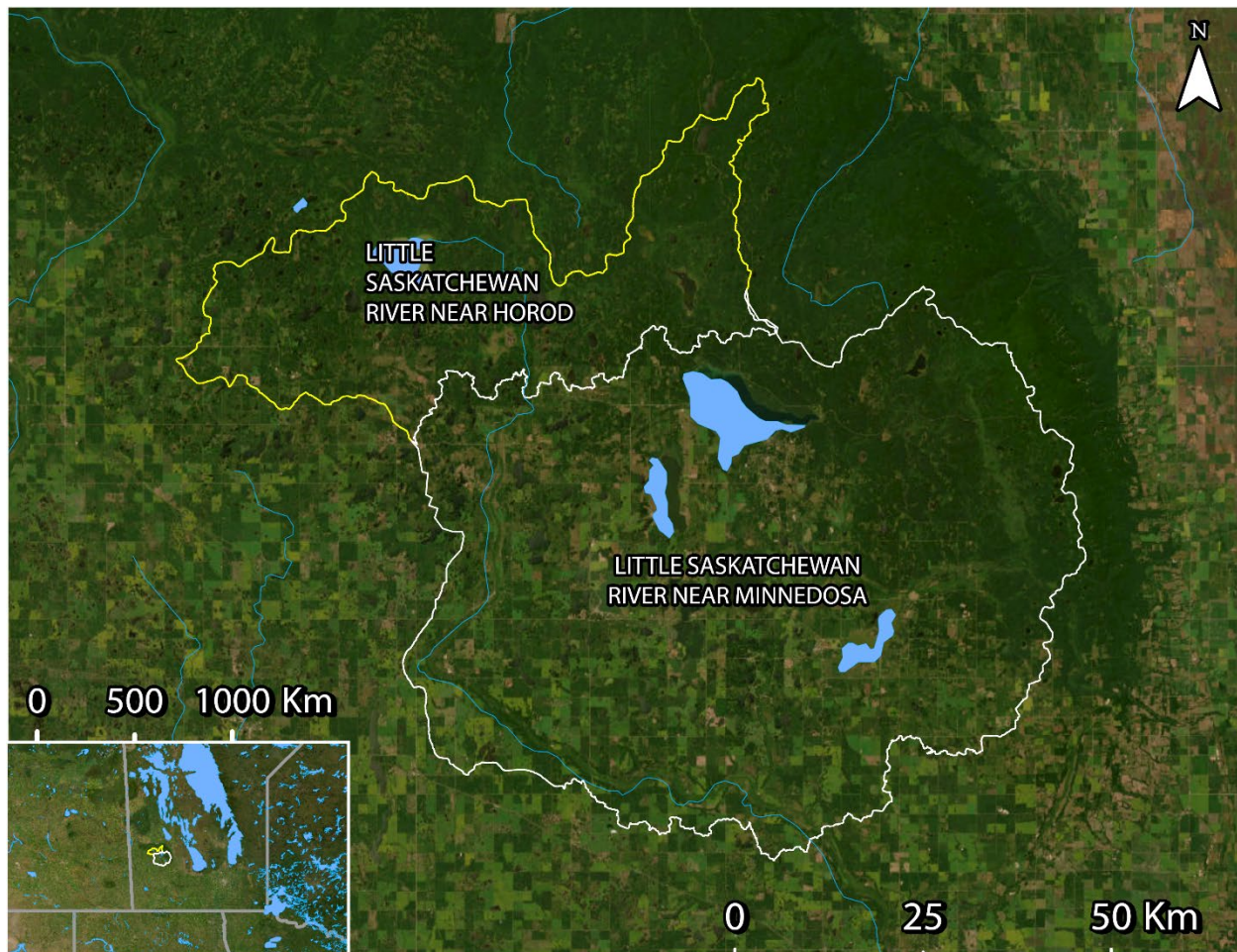
Figure 21: Mean daily water level (m) and total phosphorus concentration (mg L⁻¹) over the 2022 sampling season at Assiniboine River at St. Lazare (05ME011).

Incremental Calculations

Little Saskatchewan River near Minnedosa

Supplemental Table 1: Indices of discharge and phosphorus from the combined gross drainage area and stream discharge of Little Saskatchewan River near Minnedosa (05MF001).

Gross drainage area:	2615.39 km ²
Water load:	0.43 km ³ y ⁻¹
TP load:	88.00 tonnes P y ⁻¹
Water export:	165.98 mm y ⁻¹
TP export:	0.34 kg P ha ⁻¹ y ⁻¹

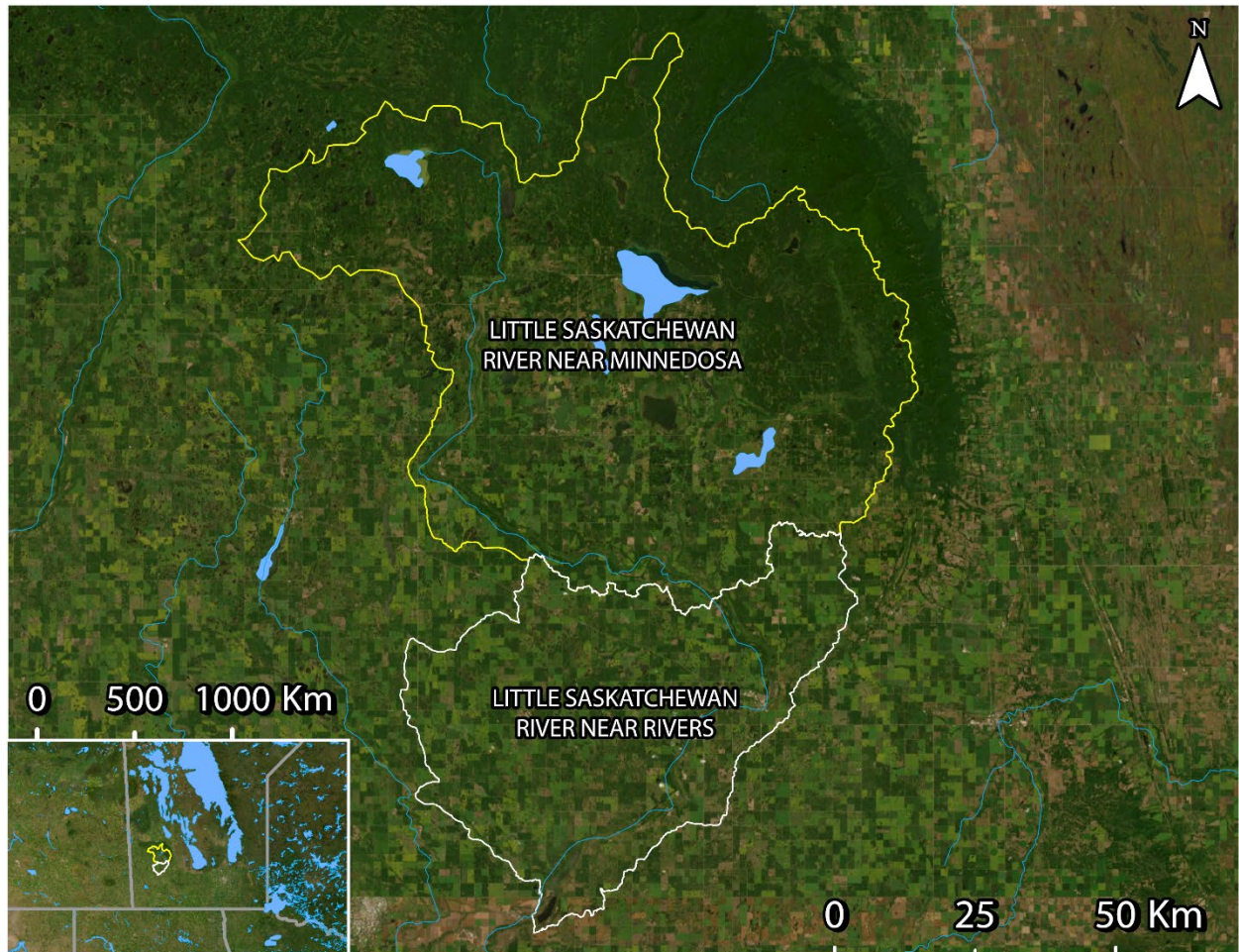


Supplemental Figure 1: Incremental drainage area in white and upstream drainage areas in yellow. Incremental values are calculated by subtracting gross “Little Saskatchewan River near Horod” values from gross “Little Saskatchewan River near Minnedosa” values.

Little Saskatchewan River near Rivers

Supplemental Table 2: Indices of discharge and phosphorus from the gross drainage area of Pembina River downstream of Little Saskatchewan River near Rivers (05MF018) in 2022.

Gross drainage area:	3892.75 km ²
Water load:	0.53 km ³ y ⁻¹
TP load:	114.10 tonnes P y ⁻¹
Water export:	136.82 mm y ⁻¹
TP export:	0.29 kg P ha ⁻¹ y ⁻¹



Supplemental Figure 2: Incremental drainage area in white and upstream drainage area in yellow. Incremental values are calculated by subtracting “Little Saskatchewan River near Minnedosa” from gross “Little Saskatchewan River near Rivers” values.

Assiniboine River near Miniota

Supplemental Table 3: Indices of discharge and phosphorus from the gross drainage area of Pembina River downstream of Assiniboine River near Miniota (05ME006) in 2022.

Gross drainage area:	84050 km ²
Water load:	1.60 km ³ y ⁻¹
TP load:	511.89 tonnes P y ⁻¹
Water export:	18.98 mm y ⁻¹
TP export:	0.061 kg P ha ⁻¹ y ⁻¹

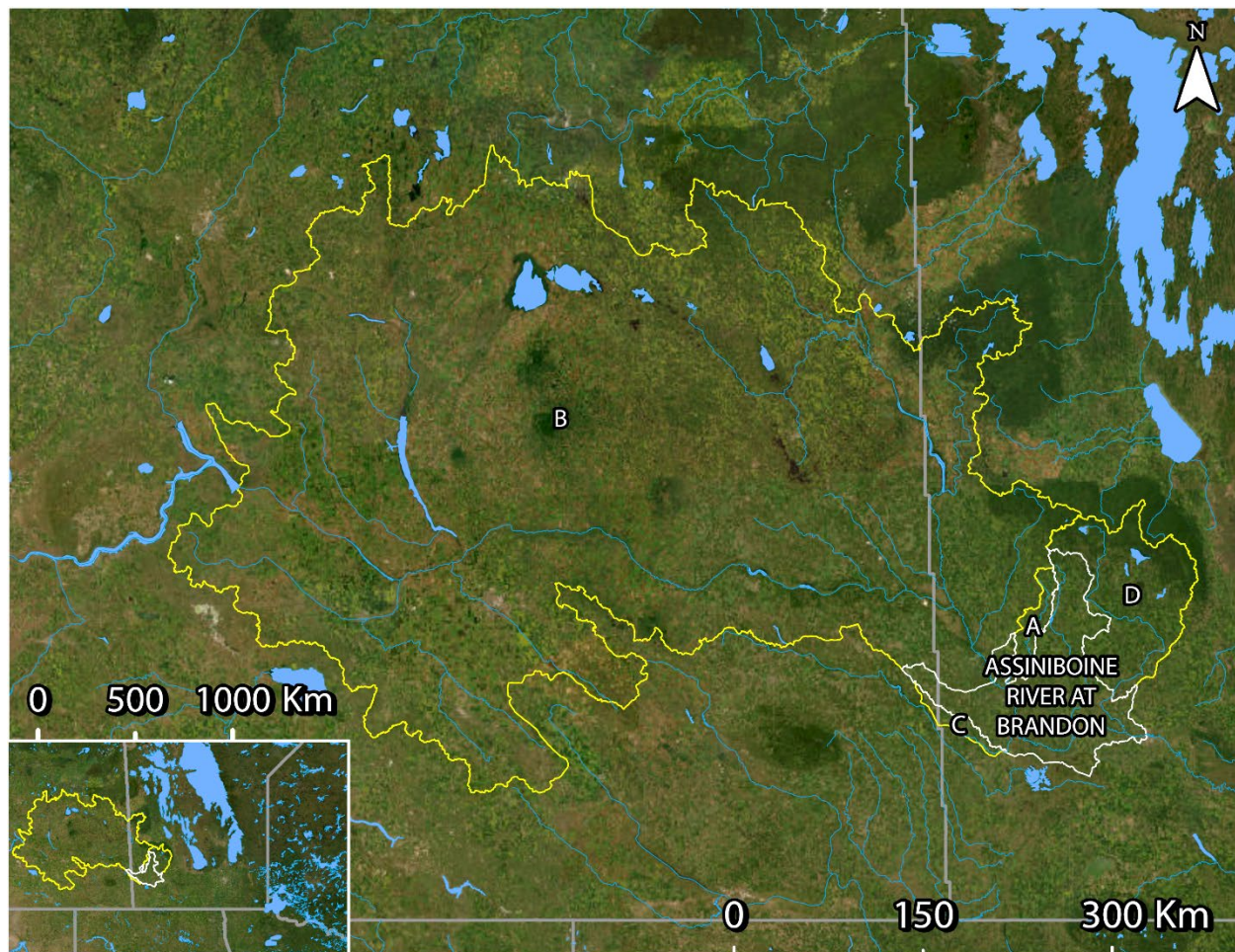


Supplemental Figure 3: Incremental drainage area in white and upstream drainage area in yellow. Incremental values are calculated by subtracting “Birdtail River near Birtle” from gross “Assiniboine River near Miniota” values.

Assiniboine River near Brandon

Supplemental Table 4: Indices of discharge and phosphorus from the gross drainage area of Pembina River downstream of Assiniboine River near Brandon (05MH001) in 2022.

Gross drainage area:	93866.7 km ²
Water load:	2.54 km ³ y ⁻¹
TP load:	756.07 tonnes P y ⁻¹
Water export:	27.08 mm y ⁻¹
TP export:	0.081 kg P ha ⁻¹ y ⁻¹



Supplemental Figure 4: Incremental drainage area in white and upstream drainage area in yellow. Incremental values are calculated by subtracting “Arrow River near Arrow River” (A), “Assiniboine River near Miniota” (B), “Gopher Creek near Virden” (C), “Little Saskatchewan River near Rivers” (D), and from “Assiniboine River near Brandon” values.

Map Sources

Drainage area polygons

Primarily, and whenever possible, drainage area polygons were taken from the Water Survey of Canada's (WSC) National Hydrometric Network Basin Polygons. Released on July 15, 2022, this prerelease version of the dataset contains drainage area polygons for over 7300 of the 7896 active and discontinued WSC stations. According to WSC, this dataset will continue to be updated as new polygons are added. For our analysis, we used drainage areas from this dataset.

Link: <https://catalogue.ec.gc.ca/geonetwork/srv/eng/catalog.search#/metadata/0c121878-ac23-46f5-95df-eb9960753375>

Secondarily, when no WSC drainage area polygons were available, or when it was necessary to enable accurate incremental calculations, we used drainage area polygons from the Total Gross Drainage Areas of the Agriculture and Agri-Food Canada (AAFC)'s Watersheds Project – 2013

Link: <https://open.canada.ca/data/en/dataset/67c8352d-d362-43dc-9255-21e2b0cf466c>

Due to the required use of drainage area polygons from two different datasets, some polygons may slightly overlap. Hotspot maps, as a result, have a few instances where a drainage area is visually cut off. However, most of these instances are very minor, and we display all watersheds in their full extent on each sampling site's individual section.

Map layers

Satellite imagery used in all maps is from the World Imagery map layer (Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community). World Imagery provides one meter or better satellite and aerial imagery in many parts of the world and lower resolution satellite imagery worldwide.

Lake and river map data used in all maps is from North America Environmental Atlas (Lakes, Rivers). The North American Environmental Atlas – Lakes & Rivers datasets display area hydrographic features (Lakes: major lakes and reservoirs; Rivers: major rivers, streams, and canals) of North America at a reference spatial scale of 1:1,000,000. Credits: Commission for Environmental Cooperation (CEC). 2023. "North American Atlas – Lakes and Rivers". Natural Resources Canada (NRCan), Instituto Nacional de Estadística y Geografía (INEGI), Comisión Nacional del Agua (CONAGUA), U.S. Geological Survey (USGS). Ed. 3.0, Vector digital data [1:1,000,000].

The **Lake Winnipeg Community-Based Monitoring Network** (LWCBMN) is a collaborative, long-term phosphorus monitoring program designed to identify localized phosphorus hotspots where action is required to improve Lake Winnipeg water quality. LWCBMN mobilizes citizen volunteers and watershed partners to collect water samples across Manitoba, generating robust water-quality data that is useful to community practitioners, academic researchers, government scientists and policy-makers alike. Focusing research, resources and action in phosphorus hotspots is necessary to reduce phosphorus loading to Lake Winnipeg.

LWCBMN is delivered in partnership with Manitoba's watershed districts, LWF's science advisors, volunteer citizen scientists and Dr. Nora Casson's laboratory at the University of Winnipeg. Thank you to all who make this network possible!

The **Lake Winnipeg Foundation** (LWF) advocates for change and coordinates action to improve the health of Lake Winnipeg. Combining the commitment of our grassroots membership and the expertise of our science advisors, LWF is nationally recognized for our unique capacity to link science and action. Our goal is to ensure policy and practices informed by evidence are implemented and enforced.

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