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Natural Resource Stewardship and Science

Water Quality Monitoring for Knife River Indian Villages National Historic Site

2019 Data Report

Natural Resource Data Series NPS/KNRI/NRDS—2022/1382

ON THIS PAGE
Upstream from USGS Gaging Station 06340590 on the Knife River in July 2019 at Knife River Indian Villages National Historic Site, North Dakota.
Photograph by USGS, station 06340590.

ON THE COVER
Downstream from USGS Gaging Station 06340590 on the Knife River in August 2019 at Knife River Indian Villages National Historic Site, North Dakota.
Photograph by USGS, station 06340590.

Water Quality Monitoring for
Knife River Indian Villages National Historic Site

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Abstract

The Northern Great Plains Inventory and Monitoring Network (NGPN) began monitoring water quality in the Knife River at Knife River Indian Villages National Historic Site (KNRI) in 2013, with the assistance of the U.S. Geological Survey (USGS). This report summarizes the data collected during the 2019 ice-free season (April 18 through October 31) for streamflow, water temperature, dissolved oxygen, specific conductance, and pH. This was the third season of continuous monitoring.

2019 began as moderately dry year until discharge on the Knife River peaked at 1,900 cubic feet per second in September following unusually heavy precipitation. There was considerable seasonal variation in all water quality measures. A summary of our results can be found in Descriptive Statistics Summary tables for the ice-free season (Table 2) and for each month (Table 3). Notably, water temperature exceeded state standards (Table 1) in summer months although these exceedances made up less than 1% of all records. Additionally, dissolved oxygen was observed below state standards twice on the same day in June, but Knife River still met the dissolved oxygen standard due to the brief nature of this deficiency.

NGPN's collaboration with USGS supported real-time and archived access to this data through the USGS National Water Information System Website KNIFE RIVER NR STANTON, ND - USGS Water Data for the Nation, where it remains available to the public.

Introduction

Knife River Indian Villages National Historic Site (KNRI) was established in 1974 with a mission to commemorate the culture and history of the Northern Great Plains Indian peoples and to preserve, study, and interpret the historic and archeological resources of the site. Native people have called Knife River home for up to 12,000 years. Village sites within KNRI including Big Hidatsa Village, Lower Hidatsa Village, and Awatixa Village containing earthlodge dwellings which were clustered along the Knife River's rich floodplains. The floodplains produced abundant crops such as squash, corn, and beans (NPS 2018) and the river facilitated trade. The Mandan, Hidatsa, and Arikara tribes displaced from the immediate vicinity of the park consider KNRI a living homeland (NPS 2013). KNRI sits on 1,758 acres of upland mixed-grass prairie and riparian forests, at the confluence of the Knife and the Missouri River. The Knife River originates in the Badlands of west-central North Dakota and flows about 200 miles (193 km) until it reaches the Missouri River (Figure 1). KNRI is in a semi-arid region that averaged 19 inches of precipitation annually from 1995-2015, but extreme variation in temperature and precipitation is common in this region.

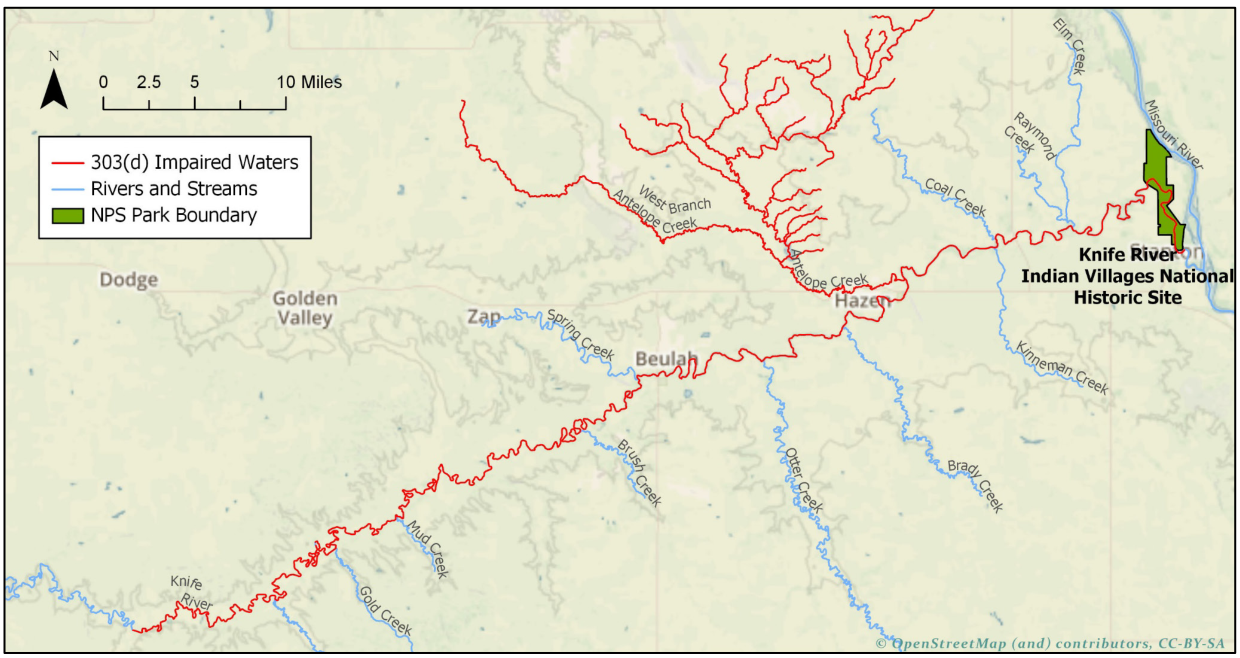


Figure 1. Map of the Knife River Indian Villages National Historic Site and the Knife River in North Dakota. The stretch of the river running through the site, ND-10130201-002-S_00 is listed as impaired under 2018 303(d) criteria (indicated in red) for *E. coli* bacteria.

About 3 miles of the Knife River flows through the park, and many of the archeological sites are on or close to the banks of the river (National Park Service 2013). In this area, river flow tends to peak between March and May, while annual low flows occur in November and December (NPS 1997). The river within the park is impacted by Garrison Dam just ten miles upstream on the Missouri River, which can cause the Knife River to back up when high amounts of water are released from the dam (Ellis 2005, Rust 2006, NPS 2013).

The Knife River is designated as a Class II water in North Dakota. Class II waters are similar to Class I waters which are defined as "water suitable for propagation or protection, or both, of resident fish species and other aquatic biota and for swimming, boating and other water recreation". Class II waters may require additional treatment to meet drinking water requirements (NDDEQ 2021). The stretch of the Knife River that runs through KNRI, ND-10130201-002-S_00, is listed as an impaired waterway under section 303(d) of the Clean Water Act and is listed for *Escherichia coli* (ND Department of Health 2019). Fecal coliform concentrations were found to be as high as 2419 cfu / 100 ml in 2011, which is almost ten times the maximum concentration for recreation (Tronstad 2013). The source of the *E. coli* and fecal coliform is not known, but livestock feeding operations, agriculture, and failing septic systems are likely contributors to bacteria impairments in North Dakota. For more details and current impairment information visit the North Dakota Department of Environmental Quality website and How's My Waterway - Community (epa.gov) . Bacteria counts collected by NDDEQ were not taken in the park, but there was some sampling approximately 13 km upstream from 06340590, from the same reach, ND-10130201-002-S_00, available from Water Quality Data Home. Three of 5 geomeans of bacteria counts at that station, 21NDHDWQ_WQX-380088, violated the water quality standard in 2021.

The Knife River is characterized by a having a high sediment load (Tronstad 2013) with sandy substrate (Rust 2006). In one study, the Knife River was found to transport 1,690 tons of sand per day and 270 tons of clay and silt (Berkas 1995). Saturation of banks due to melting ice, heavy precipitation, abrasion from ice jams as well as the backwater effect from the dam contributes to bank instability and erosion (Ellis 2005). Mean bank erosion between 1965 and 2011 was estimated to be between .9 and 4.9 ft/year in cross-sections throughout the park (Sexton 2012). Riverbank erosion is a continued threat to archeological resources in the park (National Park Service 2013, Nadeau et al 2014).

The Northern Great Plains Inventory & Monitoring Network (NGPN) began monitoring water quality at KNRI in 2013 to better understand current conditions and changes over time in the Knife River (Ashton and Rockwood 2020a and b). The monitoring is conducted at the gaging station at Knife River Indian Villages National Historic Site, ND (Monitoring Location 06340590; Figure 2) in collaboration with the United States Geological Survey (USGS). The objective is to determine the status and long-term trends of core water quality parameters during the ice-free season. NGPN plans to repeat water quality monitoring at KNRI every three years, with the first cycle having been completed in 2013 (Wilson et al. 2014) then again in 2016, 2019 and 2022. NGPN will conduct an in-depth analysis of the status and trends of the Knife River after three to five cycles of sampling.

NGPN's core water quality parameters include streamflow, dissolved oxygen, pH, specific conductivity, and water temperature (Table 1; Wilson et al. 2014). These parameters are measured every 15 minutes throughout the ice-free season (typically March to November), and results are made available in real-time on the USGS National Water Information System Website.

Figure 2. Map of Knife River Indian Villages National Historic Site and water quality monitoring location (blue triangle) and nearby weather station (red flag). Climate data in this report is taken from the Knife River RAWS weather station.

Table 1. Water quality parameters measured as part of the Northern Great Plains Inventory & Monitoring Water Quality Program and associated state standards for North Dakota class II waters (NDDEQ 2019).

Water Quality Parameter	Description	ND state standards applicable to warm water fisheries designations
Water temperature (°C)	Water temperature is affected by solar radiation, air temperature, rainfall, flow dynamics, stream shading, in-stream bed material and reflectance and land use/cover in the watershed.	• 29.44°C • The maximum increase shall not be greater than five degrees Fahrenheit (2.78°C) above natural background conditions.
Dissolved Oxygen (mg/L)	Dissolved oxygen level is a measure of the amount of oxygen in the water column and an important indicator of a water body's ability to support aquatic life.	• 5 mg/L as a daily minimum • up to 10% of representative samples collected during any 3-year period may be less than this value, provided that lethal conditions are avoided.
Specific Conductance (µS/cm)	Specific conductivity is a measure of the water's ability to conduct electricity. Specific conductivity is typically proportional to the dissolved major ions in the water such as calcium, magnesium, sodium, and sulfate.	No criteria
pH	The pH of the stream is a measure of the hydrogen ion concentration in the water. Different organisms flourish within different ranges of pH.	• 6.0 - 9.0 • up to 10% of representative samples collected during any 3-year period may exceed this range, provided that lethal conditions are avoided.

Methods

The NGPN Water Quality Monitoring Protocol (Wilson et al. 2014) sets out the methods used for sampling water quality and streamflow. The general approach is briefly described below. For more detail, please see Wilson et al. 2014 (available at https://www.nps.gov/im/ngpn/water-quality.htm).

Data Collection

Water quality data are collected at a real-time USGS stream gage (ID number 06340590) inside the park at around 1,640 ft elevation. Water quality and streamflow are measured every 15 minutes throughout the ice-free season. Monitoring at KNRI was conducted in 2013, 2016, and 2019; and will continue to be repeated every three years. Program funding currently limits monitoring to a cycle of one year of monitoring, followed by two years without monitoring.

In 2019, NGPN continued to partner with the USGS North Dakota Water Science Center to have USGS staff collect water quality and streamflow data at KNRI. The USGS deployed a continuous, multi-parameter sonde along the left bank downstream of the bridge along the Knife River on April 18, 2019 (Figure 3) and visited the gaging station every 3–4 weeks for equipment maintenance (Table 2). This instrument recorded dissolved oxygen, pH, specific conductivity, and water temperature every 15 minutes, while the gage simultaneously measured stream stage (or gage height) and discharge, a measure of streamflow.

Figure 3. A sonde device is used to measure water quality on the Knife River in 2019 at Knife River Indian Villages National Historic Site (left panel). This sonde is coated in sediment. The United States Geological Survey Knife River gaging station (06340590) is set up for real-time data transmission via satellite (right panel). Photographs courtesy of NPS.

Table 2. Field journal for 2019 water quality sampling at Knife River Indian Villages National Historic Site.

Date	Notes
April 18, 2019	Installed gage equipment and water quality (WQ) monitor, ~ 12 pm. Ran levels to wire weight gage (WWG), collected cross section.
May 30, 2019	Calibrated probe, WQ monitor, buried probe cable. Did not have an RS232 cable to connect to the SATLINK 3 so unable to collect DCP info. Monitor buried 5/24-5/30, some parameters affected.
July 2, 2019	Routine WQ monitor and sonde calibration. Reset hg @ 1235. Recalibration on specific conductance (SC). No HWM (high water mark) seen.
July 25, 2019	Serviced monitor, gage good, cross section collected.
August 14, 2019	Serviced monitor – no calibration check forgot calibrants. Monitor was heavy fouling due to biomass. Gage good, no reset.
September 20, 2019	Tried to service monitor, could not reach too deep, just used field meter to check monitor readings. Gage good.
October 31, 2019	Monitor buried 9/23 to 10/4, parameters affected. Tried to service meter and remove equipment for the year, but river iced over and could not retrieve the meter. Found the line going to meter buried in sand and could not locate meter fence post before ice became unsafe and depths 4ft.

Satellite telemetry transmitted the water data to the Water Science Center in near real-time (https://waterdata.usgs.gov/monitoring-location/06340590/). The USGS staff reviewed the real-time data daily to verify the accurate transfer of provisional field data and to identify sensor malfunctions or erroneous data. Access to the real-time data allowed them to recognize problems recording equipment malfunction, sedimentation, electrical disruption, debris, or vandalism. If disruptions occurred, the USGS staff scheduled additional site visits to minimize the loss of data.

During each site visit, USGS staff conducted a site inspection and a side-by-side comparison with the in-the-water sonde and an independent field sonde. They serviced and calibrated the sensors as needed if possible. Calibration included pre- and post-calibration checks to quantify fouling errors and equipment drift, which is data critical to the correction and grading of the final data. On August 14, 2019, calibration checks could not be completed when the calibrants were forgotten in the office. On subsequent visits on September 20, 2019 and October 31, 2019, the sonde could not be reached due to high water preventing access, so service and calibration could not be completed. The multi-parameter sonde was unable to be retrieved during the final field visit (Table 2).

Quality assurance and quality control was conducted by USGS staff following established USGS guidelines (Wagner et al. 2006). NGPN received the final corrected (approved) data in December of 2021 from the USGS and used AQUARIUS Workstation by Aquatic Informatics (http://aquaticinformatics.com/) and R (R Core Team 2022) to store and analyze water data. Water year reports are provided by USGS, and the text can be found in Appendix A. Figures were generated in R, and daily mean values were calculated from 15-minute interval data. In the case where data values were missing due to instrument error, the means were generated by excluding the missing values; the daily maximum and minimum were left blank for these days. Means were not calculated

for days where all time steps were missing (i.e. the instrument didn't collect any data that day). We calculated the proportion of records that exceeded North Dakota environmental regulatory thresholds (Table 1).

Climate data were downloaded from the RAWS Knife River Climate Station. The data were accessed and graphed using the web-based tool Climate Analyzer.

Results

The water quality monitoring season (ice-free) on the Knife River at KNRI lasted from April 18, 2019 to October 31, 2019. The discharge of the Knife River was generally low through spring and summer. Discharge peaked at 1900 cfs in September 2019 and remained elevated through the end of the monitoring season (Figure 4). This peak coincided with an exceptionally rainy September that is visible in Figure 5 and Figure 6. Discharge was less than 150 cubic feet per second from June 3 to September 13, 2019; and the minimum discharge occurred on September 3 with a recorded value of only 38.7 cubic feet per second.

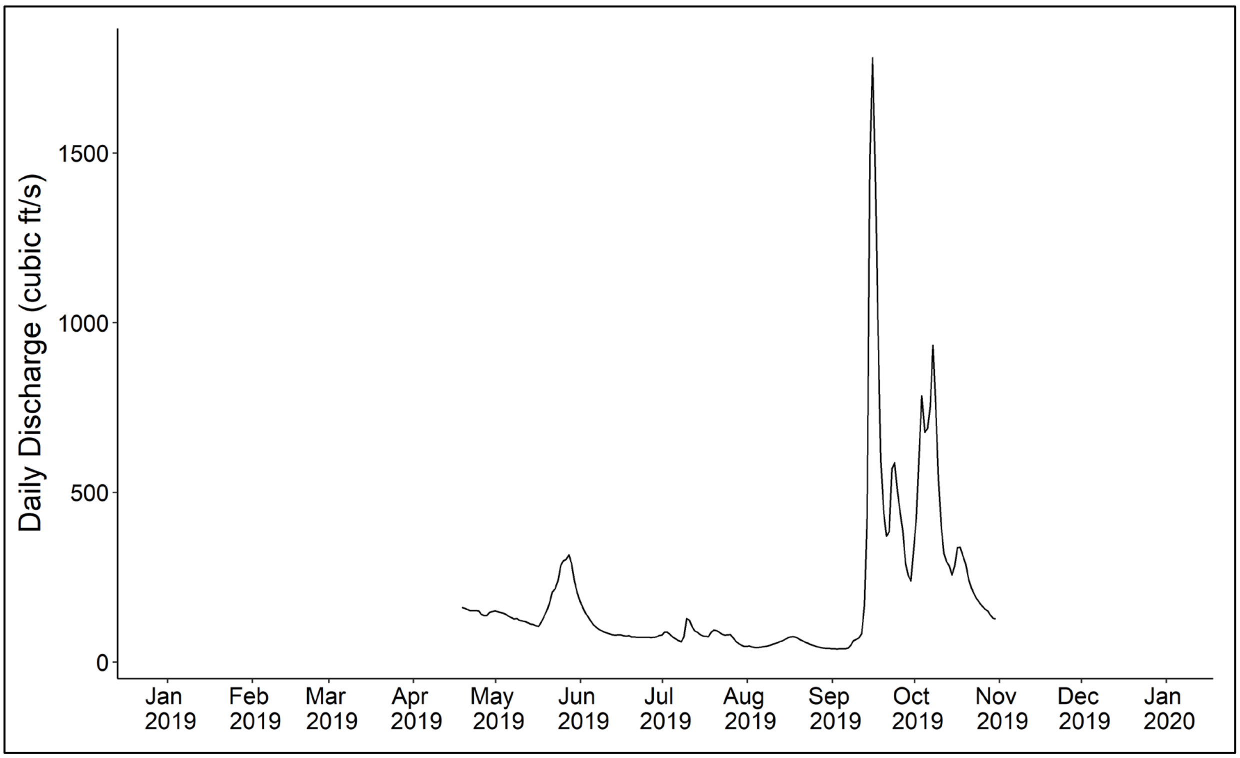


Figure 4. Daily mean discharge (black line) in 2019 on the Knife River at Knife River Indian Villages National Historic Site, USGS Gaging Station 06340590.

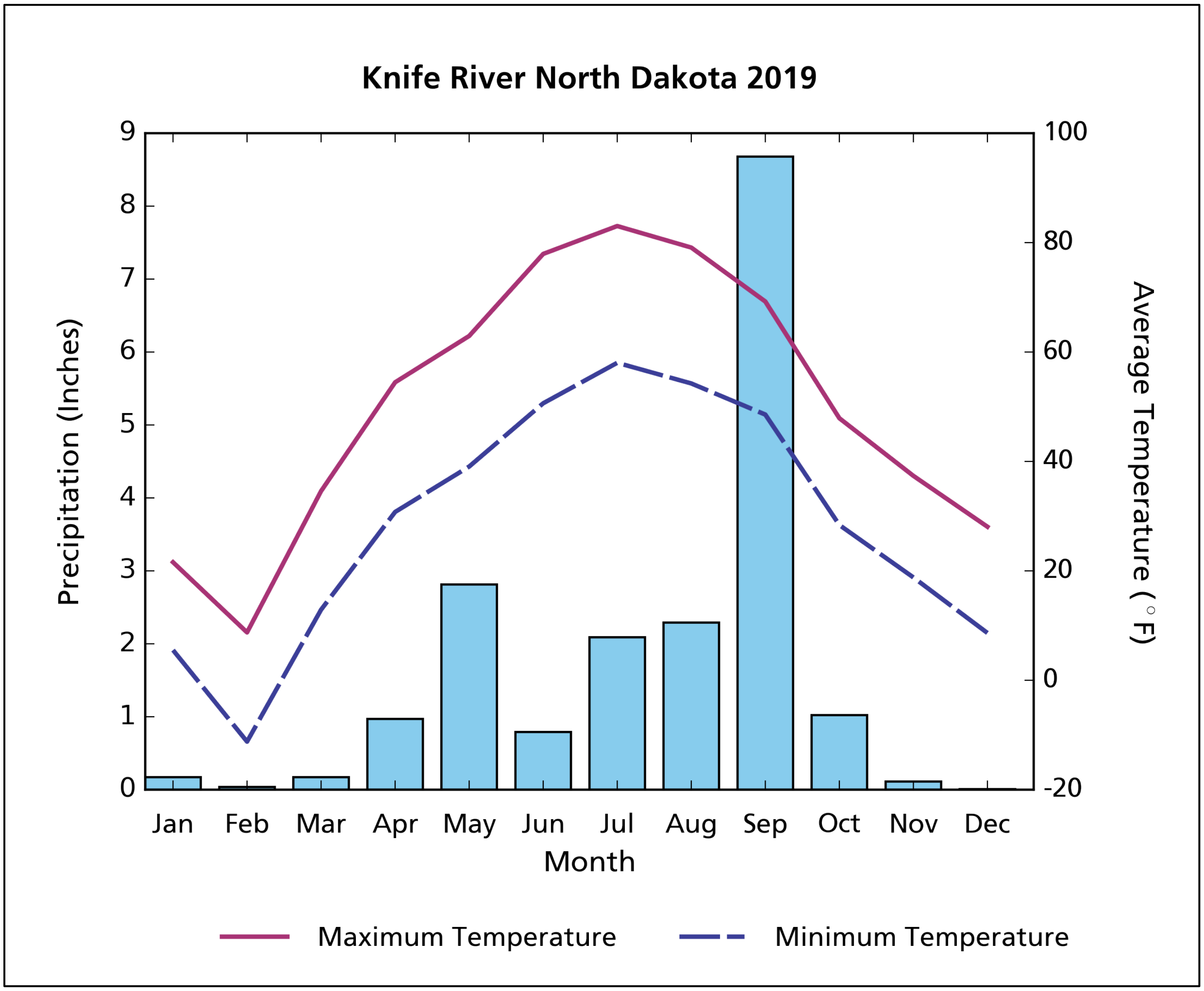
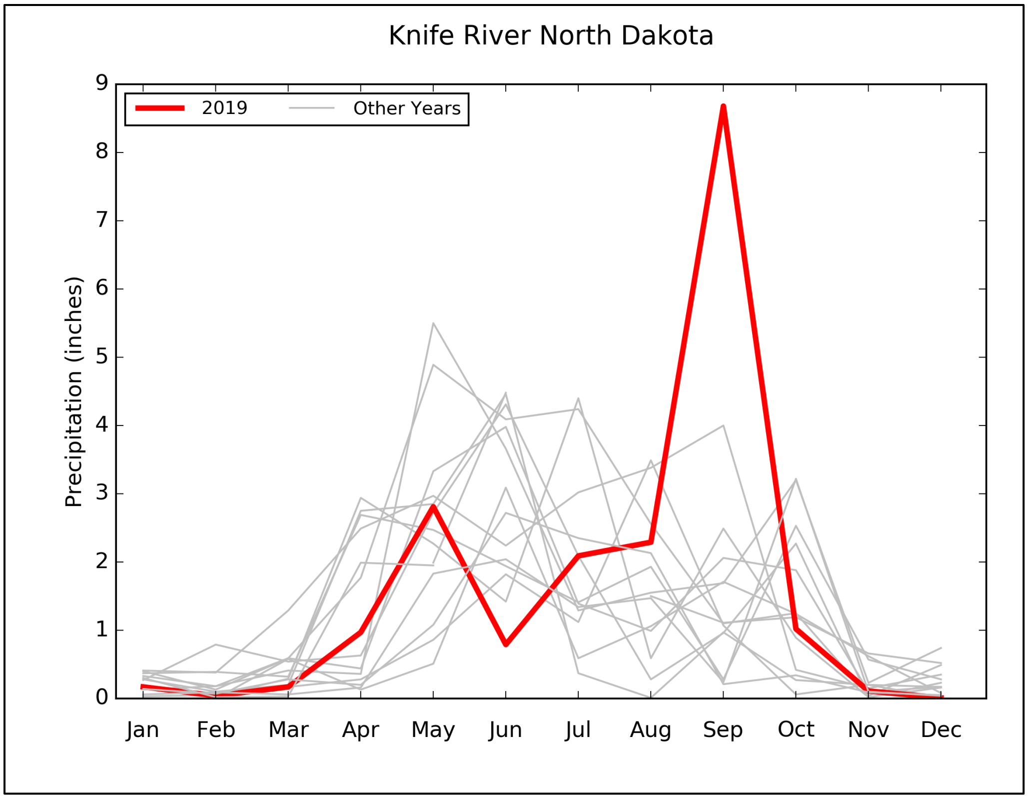


Figure 5. The left panel shows the total monthly precipitation (blue bars), average monthly minimum temperature (dashed blue line) and average monthly maximum temperature (solid red line) for the 2019 calendar year in Knife River Indian Villages National Historic Site. Climate data are from Knife River RAWS climate station. The data were accessed and graphed using the web-based tool Climate Analyzer.



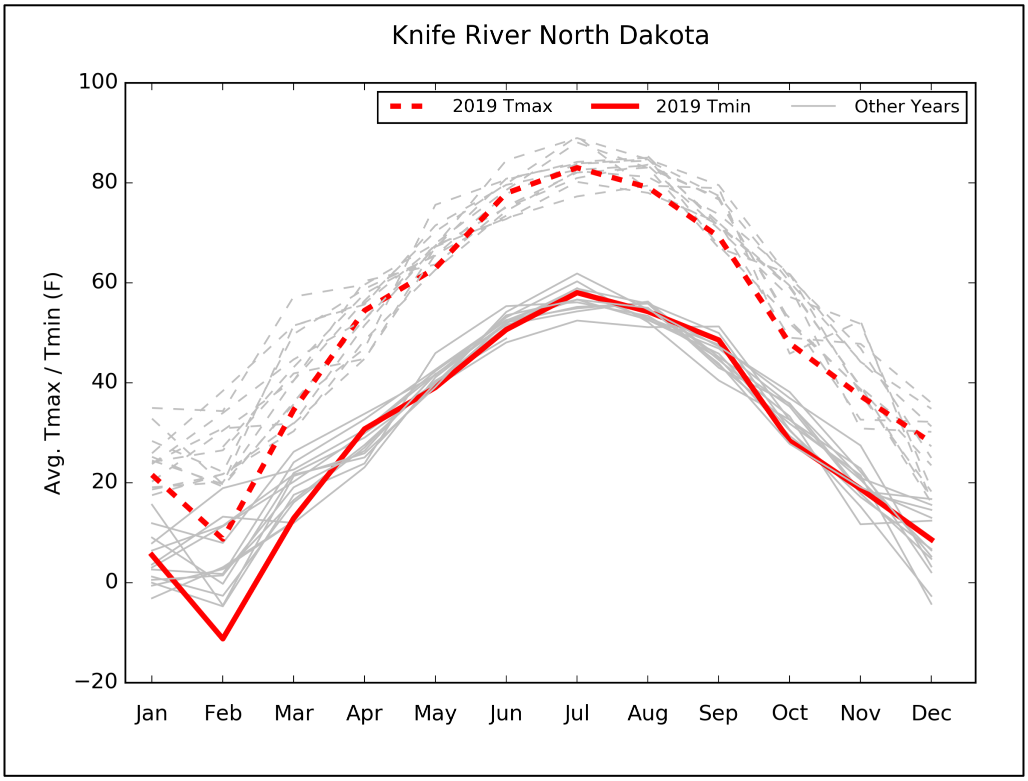


Figure 6. A comparison of 2019 precipitation (top) and temperature (bottom) in Knife River Indian Villages National Historic Site compared to the period of record. Climate data are from Knife River RAWS climate station. The data were accessed and graphed using the web-based tool [Climate Analyzer.](#)

During the ice-free season at KNRI, we collected over 18,500 water quality measurements in the Knife River, although some sensors on the multi-parameter sonde experienced intermittent errors and data were not recorded (Table 3). This monitoring period had a mean water temperature of 16.8°C, a mean dissolved oxygen concentration of 9.08 mg/L, a mean specific conductance of 1,849 µS/cm, and a mean pH of 8.46 (Table 3). There was, however, variation across months in all parameters (Table 4). Mean water temperature in late April was nearly 11°C and increased to a mean of 24.6°C in July before declining down to 5.45°C in October (Table 4, Figure 7). Maximum water temperature exceeded the North Dakota water quality standard of 29.44°C 159 times, with observations in July and August (Table 4).

Table 3. Summary of descriptive statistics for water temperature, dissolved oxygen, specific conductance, and pH measured for the ice-free sampling period at Knife River Indian Villages National Historic Site in the Knife River from April 18 to October 31, 2019. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 29.4°C; dissolved oxygen ≥ 5.0 mg/L and pH range is <6.0 or >9.0).

Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm)	pH
Mean	16.8	9.08	1,848.98	8.46
Standard Deviation	7.08	1.62	328.12	0.12
Median	17.8	8.8	1,890	8.5
Minimum	-0.1	4.9	943	7.9
Maximum	32.4	13.8	2,730	8.7
Number of Points	18,818	16,688	14,484	17,744
Number of Points below or above standard	159 (above)	2 (below)	NA	0
% Exceedance	0.84%	0.01%	NA	0%

Table 4. Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period at Knife River Indian Villages National Historic Site in the Knife River from April 18 to October 31, 2019. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 29.4°C; dissolved oxygen ≥ 5.0 mg/L and pH range is <6.0 or >9.0).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (µS/cm)	pH
April 18-30, 2019	Number of measurements	1,199	1,199	1,199	1,199
	Mean	10.97	10.64	1,579.35	8.39
	Standard Deviation	3.02	0.8	60.63	0.03
	Median	11.6	10.5	1,590	8.4
	Minimum	5.1	9.3	1,460	8.3
	Maximum	16.1	12.3	1,680	8.4
	% Exceedance	0%	0%	–	0%
May, 2019	Number of measurements	2,968	2,239	2,307	2,944
	Mean	13.47	10.14	1,908.01	8.43
	Standard Deviation	3.59	0.94	202.48	0.06
	Median	13	10.3	1,880	8.4
	Minimum	5.1	7.4	1,670	8.3
	Maximum	22.2	12.1	2,730	8.6
	% Exceedance	0%	0%	–	0%
June, 2019	Number of measurements	2,880	2,730	2,880	2,880
	Mean	21.26	7.78	2,175.64	8.43
	Standard Deviation	3.12	0.96	215.54	0.05
	Median	21.2	7.7	2,110	8.4
	Minimum	14.4	4.9	1,890	8.3
	Maximum	29.1	10.1	2,720	8.5
	% Exceedance	0%	0.07%	–	0%
July, 2019	Number of measurements	2,966	2,960	2,966	2,966
	Mean	24.6	8.39	1,995.97	8.5
	Standard Deviation	2.64	1.02	227.15	0.06
	Median	24.4	8.3	2,030	8.5
	Minimum	19.1	6.5	1,330	8.3
	Maximum	32.4	13	2,330	8.7
	% Exceedance	3.91%	0%	–	0%

Table 4 (continued). Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period at Knife River Indian Villages National Historic Site in the Knife River from April 18 to October 31, 2019. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 29.4°C; dissolved oxygen ≥ 5.0 mg/L and pH range is <6.0 or >9.0).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (µS/cm)	pH
August, 2019	Number of measurements	2,975	2,971	2,975	2,976
	Mean	21.81	8.34	1,821.01	8.53
	Standard Deviation	3.22	0.85	136.04	0.08
	Median	21.7	8.4	1,790	8.6
	Minimum	13.4	6.4	1,590	8.4
	Maximum	30.7	10.3	2,130	8.7
	% Exceedance	1.45%	0%	–	0%
September, 2019	Number of measurements	2,878	2,152	2,157	2,167
	Mean	16.63	8.17	1,336.06	8.36
	Standard Deviation	2.74	0.92	195.21	0.23
	Median	16.4	8.3	1,370	8.5
	Minimum	11.1	5.9	943	7.9
	Maximum	25.9	9.7	1,670	8.6
	% Exceedance	0%	0%	–	0%
October 1-31, 2019	Number of measurements	2,948	2,433	0	2,608
	Mean	5.45	11.31	NA	8.5
	Standard Deviation	2.96	1.38	NA	0.07
	Median	5.3	11.4	NA	8.5
	Minimum	-0.1	8.2	NA	8.3
	Maximum	11.1	13.8	NA	8.6
	% Exceedance	0%	0%	–	0%

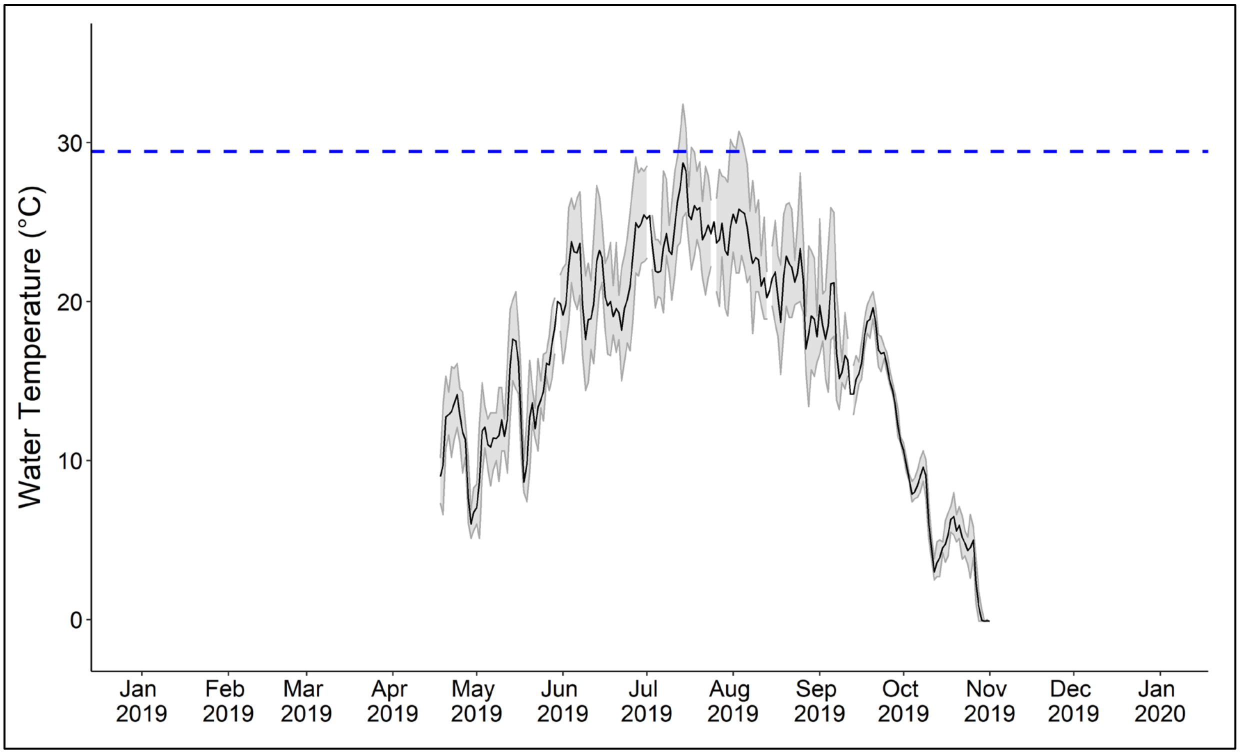


Figure 7. Daily mean water temperature (black line) collected on the Knife River at Knife River Indian Villages National Historic Site in 2019. The sonde was in the water and recording data from April 18 through October 31, 2019. The gray ribbon shows the daily maximum and minimum water temperature for the same period. The dashed blue line indicates one of the North Dakota state water quality standards (see Table 1 for more details). The periods where the instrument did not collect data are indicated by gaps in the record.

Dissolved oxygen also displayed seasonal variation (Table 3, Figure 8). The highest mean dissolved oxygen concentrations were in the spring and fall, averaging greater than 10 mg/L in April, May, and October. Dissolved oxygen was recorded below North Dakota's state water quality criterion of 5 mg/L twice on June 19, 2019 (Table 1). Both observations were at 4.9 mg/L, and no additional observations were below 5 mg/L for the remainder of the season. 16,688 dissolved oxygen measurements were taken, so these two deficient observations are well below the 10% exception specified in the North Dakota water quality standards (Table 1), so the data that were recorded does not suggest that Knife River was in violation of the dissolved oxygen standards.

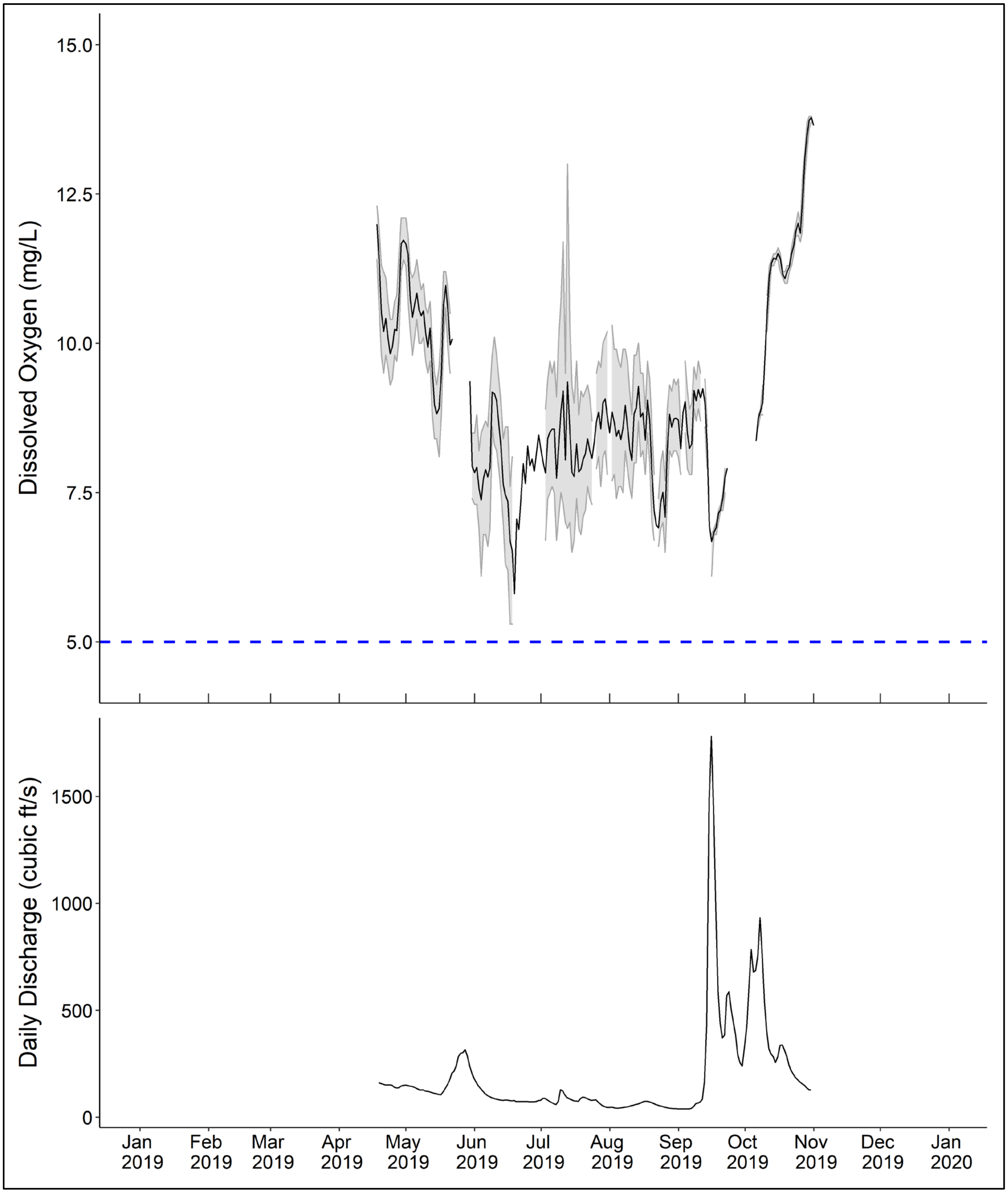


Figure 8. Daily mean dissolved oxygen concentrations (top) and daily discharge (bottom) of the Knife River in 2019 at Knife River Indian Villages National Historic Site. Measurements were taken from April 18 to October 31, 2019. The gray ribbon shows the daily maximum and minimum dissolved oxygen for the same period. The dashed blue line indicates one of the North Dakota state water quality standards (see Table 1 for more details). The periods where the instrument did not collect data are indicated by gaps in the record.

Specific conductance of the Knife River was highly variable throughout the year (Table 3, Figure 9), but showed a less predictable seasonal pattern than temperature or dissolved oxygen concentrations. Values were quite high at times, though the range (943-2730 µS/cm) and median values (1890 µS/cm) were in line with the 2013 and 2016 data report which had median specific conductance values of 1890 µS/cm and 2170 µS/cm respectively and ranges of 761-2240 µS/cm and 1200-3780 µS/cm (Ashton 2020a and 2020b). Though North Dakota does not have a conductivity standard, values above 2,000 µS/cm are generally considered high though conductivity is very dependent on local geology and soil properties (Wilson et al 2014). The 2019 median specific conductance was above the median for large rivers at Northern Great Plains parks (Rust 2006). The pH of the Knife River stayed in a narrow range between 7.9 and 8.7 (Figure 10) and was never outside the range of the North Dakota state standards of 6.0 - 9.0.

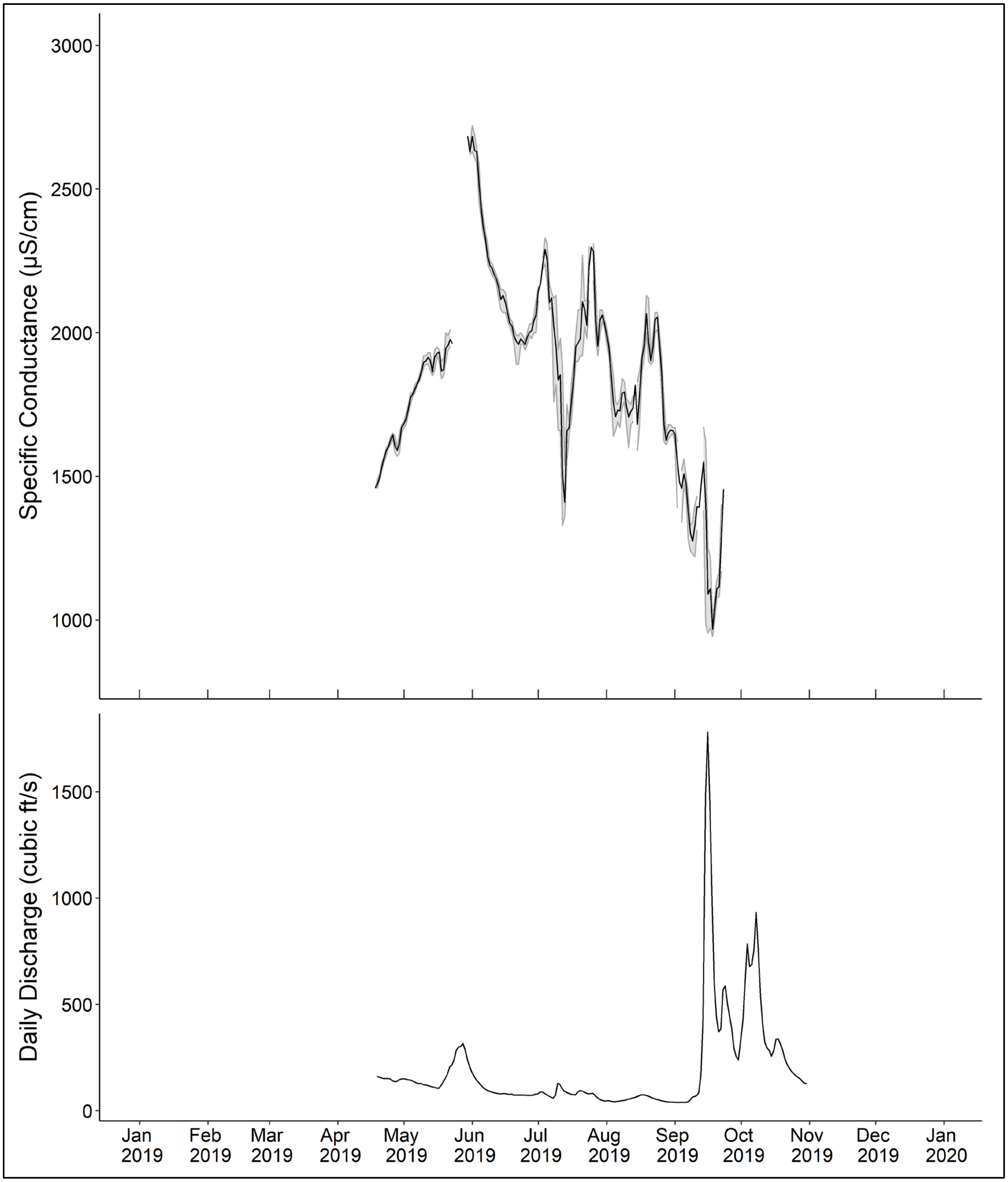


Figure 9. Daily mean specific conductance (top) and daily discharge (bottom) of the Knife River in 2019 at Knife River Indian Villages National Historic Site. Measurements were taken from April 18 to October 31, 2019. The gray ribbon shows the daily maximum and minimum specific conductivity for the same period. The periods where the instrument did not collect data are indicated by gaps in the record.

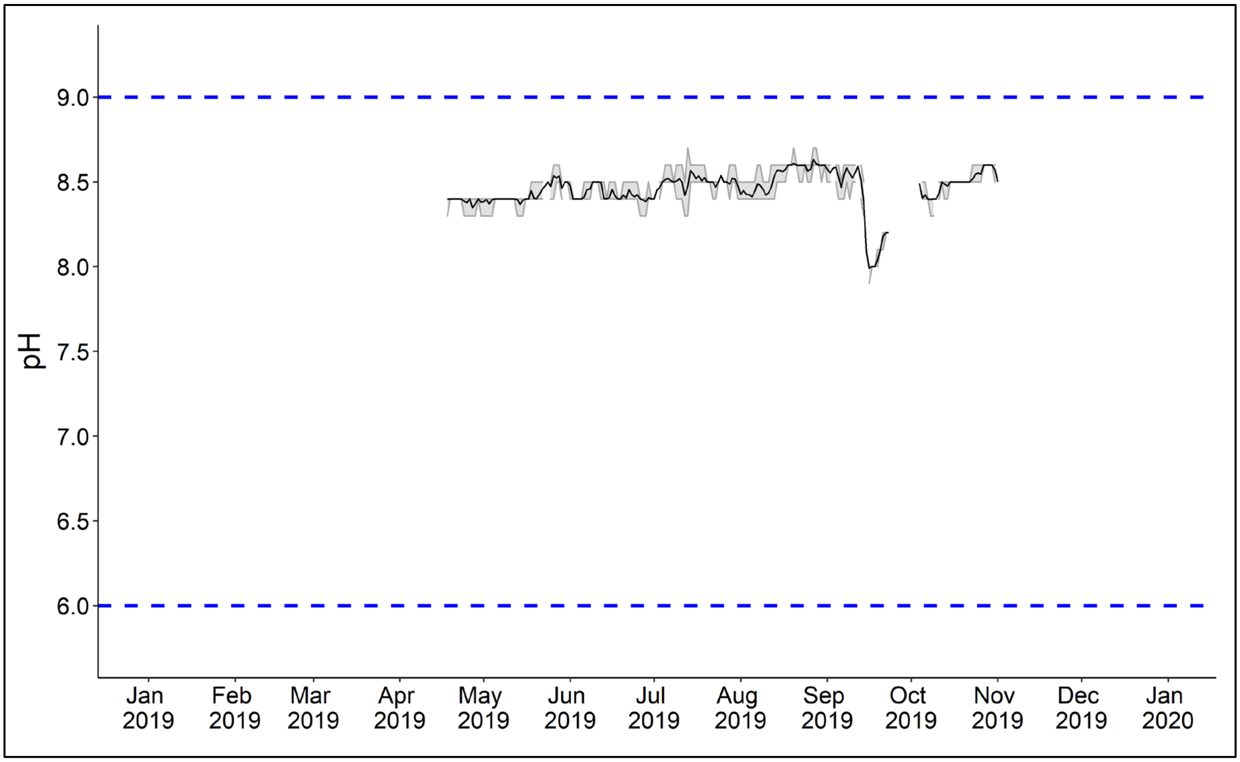


Figure 10. Daily mean pH (black line) of the Knife River at Knife River Indian Villages National Historic Site in 2019. Measurements were taken from April 18 to October 31, 2019. The gray ribbon shows the daily maximum and minimum pH for the same period. The dashed blue lines indicate the North Dakota state water quality standards (see Table 1 for more details). The periods where the instrument did not collect data are indicated by gaps in the record.

Further Analysis

This report is intended to provide a basic review of the data collected during the 2019 water quality monitoring season at Knife River Indian Villages National Historic Site. All data included in this report is available upon request from the Northern Great Plains Inventory and Monitoring Network, as well as in the archives found on the USGS National Water Information System for site 06340590.

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Appendix A.

USGS Water Data Quality Report and Station Analysis for Knife River 06340590, 2019 and Station Analysis

06340590 Knife River NR Stanton, ND

Location: Lat 47°21'29", long 101°23'50" referenced to North American Datum of 1927, in SW 1/4 SW 1/4 sec.21, T.145 N., R.84 W., Mercer County, ND, Hydrologic Unit 10130201, on left bank, 10 ft downstream from county bridge, and 2.4 mi north of Stanton.

Drainage Area: Not determined.

Surface-Water Records

Period of Record, Daily Discharge: April to October 2013, March to November 2016, April to November 2019, April to November 2022 (discontinued).

Period of Record, Daily Gage Height: April to October 2013, March to November 2016, April to November 2019, April to November 2022 (discontinued).

Gage: Water stage recorder. Datum of gage is 1,640 ft above North American Vertical Datum of 1988, from topographic map.

Remarks: 10/01/15-09/30/16: Records good except for estimated daily discharges, which are poor.

Extremes for Water Year 2016: Maximum flow, 806 ft^3/s, April 3, peak stage, 11.13 ft; minimum daily flow, 40 ft^3/s, August 30 and 31.

Regulation: Slight regulation by Lake Ilo 81 mi upstream, capacity, 7,130 acre-ft.

Water-Quality Records

Period of Daily Record

Water Temperature: April to October 2013, March to November 2016, April 2019 to October 2019, April 2022 to November 2022 (Discontinued).

Specific Conductance: April to October 2013, March to November 2016, April 2019 to October 2019, April 2022 to November 2022 (Discontinued).

pH: April to October 2013, March to November 2016, April 2019 to October 2019, April 2022 to November 2022 (Discontinued).

Dissolved Oxygen: April to October 2013, March to November 2016, April 2019 to October 2019, April 2022 to November 2022 (Discontinued).

Instrumentation: Multiparameter water-quality monitor.

Remarks: None

Record Rated Water Temperature
Period April 4-October 16, 2013: Rated good: April 4-October 16.

Period March 11-November 3, 2016: Rated good: March 11-November 3.

Record Rated Specific Conductance
Period April 4-October 16, 2013: Rated good: April 4-May 20, June 10-October 16. Rated fair: May 21-June 9.

Period March 11-November 3, 2016: Rated good: March 11-April 28, May 14-July 15, July 26-November 3. Rated fair: April 29-May 9, July 16-23. Rated poor: May 10-13, July 24-25.

record Rated Ph
Period April 4-October 16, 2013: Rated good: April 4-October 16.

Period March 11-November 3, 2016: Rated good: March 11-November 3.

Record Rated Dissolved Oxygen
Period April 4-October 16, 2013: Rated good: April 29-October 16. Rated poor: April 4-28.

Period March 11-November 3, 2016: Rated good: March 11-November 3.

Extremes for Period - April 4-October 16, 2013
Water Temperature: Maximum recorded, 29.5°C, July 18; minimum recorded, 0.0°C, April 4, 15.

Specific Conductance: Maximum recorded, 2,340 microsiemens, July 15; minimum recorded, 761 microsiemens, April 6.

pH: Maximum recorded, 8.7 units, July 14; minimum recorded, 7.6 units, May 29.

Dissolved Oxygen: Maximum recorded, 12.4 milligrams per liter, April 9; minimum recorded, 4.8 milligrams per liter, September 11.

Extremes for Period - March 11-November 3, 2016
Water Temperature: Maximum recorded, 33.2°C, July 20; minimum recorded, -0.1°C, March 20.

Specific Conductance: Maximum recorded, 3,770 microsiemens, April 30; minimum recorded, 1,200 microsiemens, July 17.

pH: Maximum recorded, 8.7 units, October 5-7, 29-30, November 2-3; minimum recorded, 8.1 units, July 17-18, August 14-15.

Dissolved Oxygen: Maximum recorded, 14.0 milligrams per liter, March 18-20; minimum recorded, 5.6 milligrams per liter, July 31.

Extremes for Period of Daily Record
Water Temperature: Maximum recorded, 33.2°C, July 20, 2016; minimum recorded, -0.1°C, March 20, 2016.

Specific Conductance: Maximum recorded, 3,770 microsiemens, April 30, 2016; minimum recorded, 761 microsiemens, April 6, 2013.

pH: Maximum recorded, 8.7 units, many days; minimum recorded, 7.6 units, May 29, 2013.

Dissolved Oxygen: Maximum recorded, 14.0 milligrams per liter, March 18-20, 2016; minimum recorded, 4.8 milligrams per liter, September 11, 2013.

U.S. Department of Interior, U.S. Geological Survey

Suggested citation: U.S. Geological Survey, 2022, National Water Information System data available on the World Wide Web (USGS Water Data for the Nation), accessed [November 17, 2022), USGS 06340590 Knife River NR Stanton, ND.

Record: The monitor was ran at the station from 4/18/19 until 10/31/19 when the monitor data was stopped being of adequate quality. This was part of NPS project that every three years we run a monitor for the open water period. The monitor recorded water temperature, specific conductance, pH, and dissolved oxygen. The monitor provided a good record for the period up to the 8/14 visit. After this visit the monitor was unable to be retrieved from the river due to high water and the data is of poorer quality. The monitor provided a complete record with no missing data. Parts of the monitor did become buried in the sand from 5/24-5/30 and 9/23 to 10/4 affecting some of the parameters.

Site characteristics: The river is a muddy sand bottom channel with a rock/gravel riffle for control 200 ft downstream. The monitor is located on the downstream side of bridge were the river is around 60 ft wide. River is subject to very high flows that cause shifting sand across the channel redefining the channel bed.

Instrumentation: A YSI 6920 V2 with optical DO, SN: 10C101098, was used for the entire period. The monitor was strung through conduit and attached to a fence post near the left bank by the bridge.

Field Visits: The monitor was visited 7 times during the period on around a 4 week schedule. The monitor was cleaned during every visit and calibration checked every visit other than on 9/20/19 and 10/31/19 due to high water preventing access to the monitor. No calibration was done on 8/14/19 due to calibrants left in office. If the calibration check was outside of parameter criteria the monitor was recalibrated and this happened a few times during the period for SC, pH, and DO. These calibration corrections are noted in the calibration drift corrections.

<u>Deletions</u>

WT: No additional edits were needed on the WT data that caused any gaps. A couple of deletions were needed during visits to remove couple unit values that are not real. The unit values are in good condition for the period. Used a couple of force interpolations on 5/30 and 10/28 to removed gaps of around 3 hours, these gaps did not affect the max/min of the day.

SC: Unit values were in fairly good condition. A few periods of deletion were needed due to the monitor becoming buried in the sand (Table A-1).

Table A-1. Specific conductance corrections.

Start Time	End Time	Correction Type	Comments
2019-05-23 13:15:00	2019-05-30 10:15:00	Delete Region	Delete region, sensor buried in sand
2019-08-14 08:30:00	2019-08-14 08:30:00	Delete Region	Delete region, spike
2019-09-13 11:00:00	2019-09-13 11:00:00	Delete Region	Delete region, spike
2019-09-23 11:15:00	2019-11-01 17:45:00	Delete Region	Delete region, monitor buried in the sand until washed out

pH: Few spikes needed to be deleted during the period and periods when the monitor was buried in sand (Table A-2).

Table A-2. PH corrections.

Start Time	End Time	Correction Type	Comments
2019-05-23 17:00:00	2019-05-23 21:15:00	Delete Region	Delete region, affected
2019-05-24 02:00:00	2019-05-24 03:15:00	Delete Region	Delete region
2019-09-15 09:15:00	2019-09-15 09:15:00	Delete Region	Delete region
2019-09-15 09:45:00	2019-09-15 10:00:00	Delete Region	Delete region
2019-09-23 14:45:00	2019-10-04 11:30:00	Delete Region	Delete region, meter buried in sand until washed out

DO: Deletions and adjustable trims were used during the period to clean up spikes and painting data due to the sensor being affected by sediment load during higher flows. Some gaps in the data occurred due to these edits (Table A-3).

Table A-3. Dissolved oxygen (DO) corrections.

Start Time	End Time	Correction Type	Comments
2019-05-22 20:15:00	2019-05-30 10:15:00	Delete Region	Delete region, sensor buried in the sand
2019-06-19 21:45:00	2019-06-19 23:00:00	Delete Region	Delete region
2019-06-22 12:45:00	2019-06-22 19:15:00	Delete Region	Delete region, fouling of the sensor
2019-06-24 12:45:00	2019-06-25 02:30:00	Delete Region	Delete region, fouling of the sensor
2019-06-26 04:15:00	2019-06-26 15:45:00	Delete Region	Delete region, fouling of the sensor
2019-06-28 01:30:00	2019-07-02 08:00:00	Adjustable Trim	Removed fouling spikes.
2019-08-01 06:15:00	2019-08-01 06:15:00	Delete Region	Delete region
2019-08-22 05:45:00	2019-08-22 06:30:00	Delete Region	Delete region, spikes
2019-09-12 22:15:00	2019-09-12 22:15:00	Delete Region	Delete region, spike
2019-09-15 09:30:00	2019-09-15 11:00:00	Delete Region	Delete region, debris in sensor
2019-09-15 15:15:00	2019-09-15 16:30:00	Delete Region	Delete region
2019-09-23 13:30:00	2019-10-04 06:30:00	Delete Region	Delete region, monitor buried in sand until washed out

Fouling Corrections

WT: One correction was used from 5/18 (0,0) to 5/30 (0, 0.97) to prorated through the runoff event as the fouling correction was caused by the monitor becoming partially buried in the sand from high flows.

SC: Fouling corrections were needed between most visits during the period (Table A-4). After the August visit the monitor was not able to be reached due to high flows and the fouling correction started to get fairly large due to the monitor becoming partially buried. Then during the high flow the monitor became unburied and tracked very well but it had a large offset to the actual field values found. Reviewing the data at the end of the period, it appears that it is good data I just needs a large shift to be accurate. If you look at the data after the monitor was buried from 9/23-11/1, the data looked very similar to how it tracked before the burying and then you can see at the end of the data that's is deleted after Nov 1 that the monitor is definitely not working correctly. The data after 10/4 also jumps fairly high compared to the rest of the season but this matches what the SC does at this site after large runoff with the SC increasing. This must indicate that the river flushes the system when large runoff occurs that increases SC instead of diluting it which is normal. If we do not use this data it would result in a loss of over a months worth of data due to not being able to access the monitor.

Table A-4. Specific conductance fouling corrections.

Start Time	End Time	Correction Amount(s)	Comments
2019-05-30 10:40:00	2019-07-02 09:10:00	Start Shift Points: 0, 0; End Shift Points: 0, 0; 1e+05, 2000;	Adjusted automatic fouling correction as the fouling could not have been a negative correction as the act of cleaning should increase the SC readings. Adjusted correction to match with observed post visit readings.
2019-07-02 09:10:00	2019-07-25 08:40:00	Start Shift Points: 0, 0; End Shift Points: 0, 0; 1e+05, 7474.466;	Fouling correction between visits. Cleaned monitor.
2019-07-25 08:40:00	2019-08-14 08:35:00	Start Shift Points: 0, 0; End Shift Points: 0, 0; 1e+05, 6749.556;	Fouling correction between visits. Cleaned monitor.
2019-09-15 09:15:00	2019-09-20 08:30:00	Start Shift Points: 0, 0; 10000, 3200; End Shift Points: 0, 0; 10000, 3400;	Prorated through high flows as fouling occurs. Used field readings from 9/19 visit for correction.
2019-09-20 08:45:00	2019-09-23 11:00:00	Start Shift Points: 0, 0; 10000, 3400;	Continued until monitor becomes buried in sand.
2019-10-04 18:00:00	2019-10-31 23:45:00	Start Shift Points: 0, 0; 10000, 7450;	Used correction from 10/31 field reading to correct data after monitor becomes unburied in the sand. The monitor is likely still partially buried in sand causing the large correction but the data is tracking good and believe that it is still valid even though it is outside of criteria.

pH: No fouling corrections were needed for the period. All visits had correction within 0.1 units. A correction was used from 5/23 until 5/30 to correct the pH during the monitor being partially buried in sand. The correction was within 0.3 units.

DO: One fouling correction was needed during the period with the rest of the visits having corrections less than 0.2 mg/l/ (Table A-5).

Table A-5. Dissolved oxygen fouling correction.

Start Time	End Time	Correction Amount(s)	Comments
2019-05-30 12:30:00	2019-07-02 09:00:00	Start Shift Points: 0, 0; End Shift Points: 0, 1.58;	Fouling correction based on clean readings and post visit readings.

<u>Calibration Drift Corrections</u>

WT: No correction needed for the period.

SC: Minor drift correction seen during the period.

Table A-6. Specific conductance drift correction.

Start Time	End Time	Correction Amount(s)	Comments
2019-05-30 12:30:00	2019-07-02 09:10:00	Start Shift Points: 0, 0; End Shift Points: 0, 0; 1e+05, 3229.902;	Drift correction between visits of 3.2%. Recalibrated monitor before redeployment.
2019-07-02 09:10:00	2019-07-25 08:40:00	Start Shift Points: 0, 0; End Shift Points: 0, 0; 1e+05, -1043.893;	Minor drift correction between visits. Did not recalibrate monitor.
2019-07-25 08:45:00	2019-10-31 23:45:00	Start Shift Points: 0, 0; 10000, -100;	Continued drift correction found from last calibration check until the end of the period. Could not retrieve the monitor from river due to high flows.

pH: No drift corrections were used during the period. All calibration checks were within 0.2 units for the period.

DO: A few drift corrections were used during the period based on calibration checks done during field visits. (Table A-7).

Table A-7. Dissolved oxygen drift correction.

Start Time	End Time	Correction Amount(s)	Comments
2019-07-02 10:00:00	2019-07-25 08:45:00	Start Shift Points: 0, 0; End Shift Points: 0, 0.54;	Drift correction based on 7/25 visit, Recalibrated meter
2019-07-25 09:45:00	2019-10-31 23:45:00	Start Shift Points: 0, 0.54;	Calibration must not have taken as seen in recorded data. Continued correction based on calibration check.

Other Corrections: 5 point WT corrections with NIST thermistor: 41516584 on 4-11-19 (Table A-8).

Table A-8. Water temperature correction. [a, b]

NIST Reading	Instrument Reading	Correction
22.93	22.75	0.18
36.14	36.23	-0.09
6.54	6.55	-0.01
12.40	12.34	0.06
45.63	45.69	-0.06

[a] Average correction was .02, therefore the instrument was rated 'OK".

[b] A second 5-point check has not been done as of this date due to the monitor still in the river and unable to be retrieved.

Cross-section surveys: Cross section was collected from the bridge on 7/25/19. The cross section showed that the channel was well mixed for all four parameters and that the cross-sectional average is within criteria to the monitor readings. pH showed a slight discrepancy, but this was likely caused by the difference in the two meters calibrations for pH. This shows that the monitor placement represents the average of the channel and no correction was needed for the period. The data for the cross sections is located under the Field Visit folder for the visits and named as 06340590_20190725_Xsect.

<u>Comparisons</u>

WT: The water temperature compares well with the other nearby stations at 06336000 and 06349000.

SC: The SC compares well with the discharge at the station. An inverse relationship is seen with the SC to the discharge with all runoff events seeing the corresponding decrease in SC concentrations. The SC graph compares well with other nearby station 06336000 and 06349000.

pH: The pH compared well with the one other nearby station 06336000. The pH was fairly steady for most of the period.

DO: DO compares well with the other nearby station 06336000. Similar trends are seen between the two. The common diurnal pattern with seen throughout the period and compares well with air temperature from NDAWN station at Hazen 06340500.

Remarks: Daily values for all the parameters look good with no additional remarks needed. Updated SIMS station description by added new water quality section and added information about the monitoring.

NPS 468/187138, December 2022

National Park Service
U.S. Department of the Interior

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