



Water Quality Monitoring for Devils Tower National Monument

2019 Data Report

Natural Resource Data Series NPS/DETO/NRDS—2022/1363





ON THIS PAGE

Upstream view of the Belle Fourche River and PVC pipe for sonde from the gage station at Devils Tower National Monument, Wyoming, in 2019.

ON THE COVER

Photograph of Downstream view of gage at Belle Fourche River at Devils Tower National Monument, WY, 2019.
Photograph courtesy of USGS at Station 06427850.

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2019 Data Report

Natural Resource Data Series NPS/DETO/NRDS—2022/1363

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible and technically accurate.

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Abstract

The Northern Great Plains Inventory and Monitoring Network (NGPN) began monitoring water quality in the Belle Fourche River at Devils Tower National Monument (DETO) in 2013, with the assistance of the U.S. Geological Survey (USGS). This report summarizes the third sampling season in 2019 for streamflow, water temperature, dissolved oxygen, specific conductance, and pH. The sampling was conducted during the ice-free season from April 9, 2019 to November 5, 2019. NGPN's collaboration with USGS supported real-time and archived access to this data through the USGS National Water Information System Website, [BELLE FOURCHE RIVER AT DEVILS TOWER, WY - USGS Water Data for the Nation](#), where it remains available to the public.

2019 was a cool and wet year. The mean stage height of 3.06 ft on the Belle Fourche River was greater than the peak in 2016. There was considerable seasonal variation in all water quality measures, but the values were generally good. A summary of our results can be found in Descriptive Statistics Summary tables for the ice-free season (Table 3) and for each month (Table 4). No exceedances of any state water quality standards occurred in 2019. The Belle Fourche River at Devils Tower is currently impaired for fecal coliform which impacts the recreation use of the river. There is a total maximum daily load (TMDL) plan in place to restore water quality.

Acknowledgements

We would like to acknowledge Wyoming-Montana Water Science Center USGS staff including Ray Woodruff and crew for collecting the water quality data; DETO park staff; Isabel Ashton for providing the R code; Stephanie Rockwood, Isabel Ashton, and Theresa Schaffner for providing much of the background information and template for this report. Thanks to Myles Cramer for reviewing this report.

Introduction

Devils Tower National Monument (DETO) was established in 1906 as the first National Monument in the United States, with a mission to preserve the Tower and the surrounding 1347 acres (545 ha) of ponderosa pine forests, mixed-grass prairies, and riparian corridor along the Belle Fourche River. Although there are several springs in the Monument, the Belle Fourche River is the major hydrologic feature of the park (NPS 1997). The Belle Fourche River is about 290 miles (470 km) long from the headwaters in northeastern Wyoming to its confluence with the Cheyenne River approximately 50 miles ENE of Rapid City, South Dakota (Figure 1). Northeastern Wyoming is a dry region; on average it receives 17 inches of precipitation annually, with two-thirds of that precipitation occurring as rain in the spring and summer.

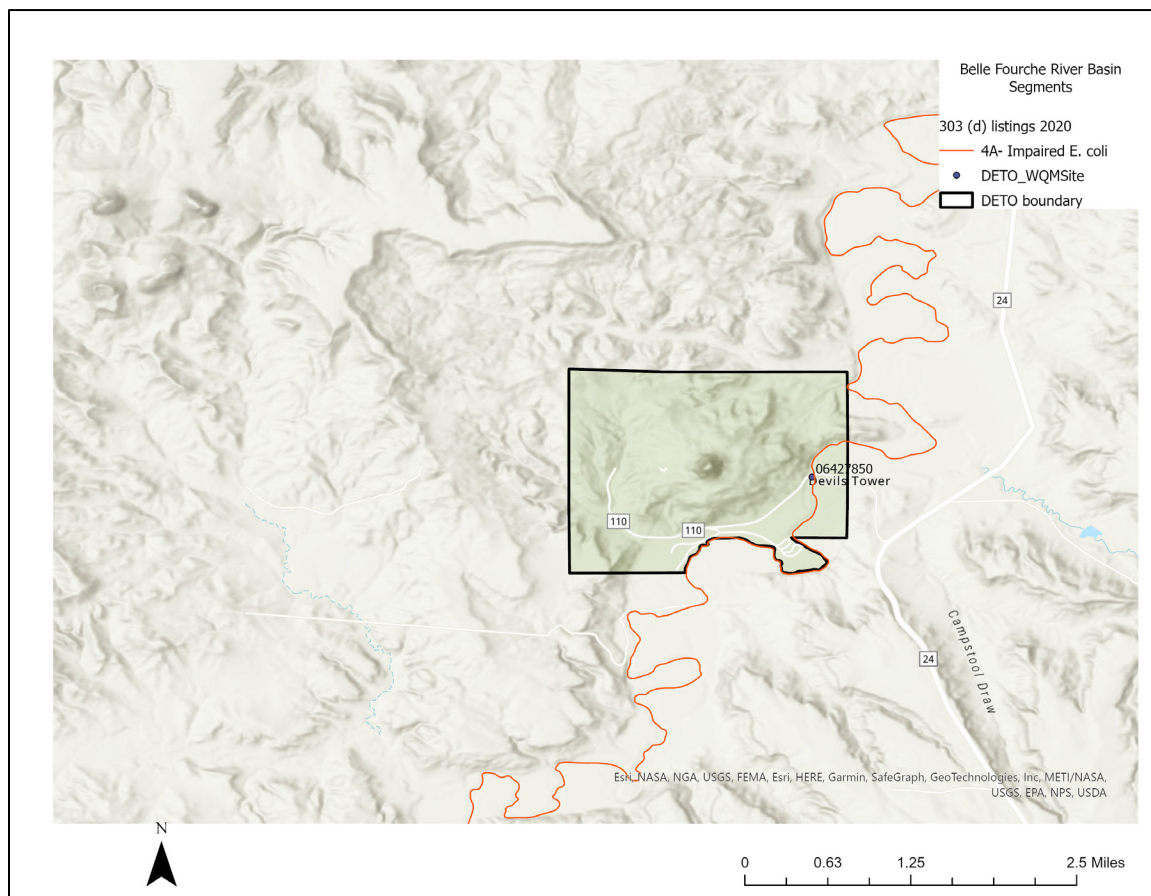


Figure 1. Map of the Devils Tower National Monument and the Belle Fourche River in Wyoming. The river reach that runs through the monument, highlighted in red, is listed as impaired under 303(d) criteria for fecal coliform bacteria.

Approximately 2 miles (3.6 km) of the Belle Fourche River runs through DETO as the river flows northeast toward South Dakota. In this area, river flow tends to peak between March and June, while annual low flows occur in November and December. River flow seasonality has been limited since 1952 by the construction of the Keyhole Reservoir and dam upstream of DETO. This reduced the

floods that cottonwood seedlings relied on for germination and establishment (Martin 1995). The river has become deeply incised, creating areas along the river where the water table is now 1.7–2.2 m deep and typical riparian vegetation, such as willows, are largely absent, having been replaced by grassland (Anderson 2013).

Primary land uses in the region include livestock grazing, hay production, mineral extraction, and oil and gas production (WYDEQ 2020). The Belle Fourche River is designated as a Class 2AB warm water fishery, defined as a water known to support game fish populations or spawning and nursery areas at least seasonally and where a game fishery and drinking water use is attainable (WYDEQ 2018b). Several stretches of the river are listed as impaired waterways under section 303(d) of the Clean Water Act, including the 60.7-mile stretch running through DETO, from Arch Creek to Sourdough Creek, AUID= WYBF101202010904_00. This reach is impaired for fecal coliform bacteria (WYDEQ 2020). The Belle Fourche River reach running through Devils Tower is in the 17a Black Hills Foothills Level IV Ecoregion (Chapman et al 2003). It is best described as a ponderosa pine woodland and grassland savanna with 15–20 inches of precipitation annually. Livestock grazing, ranching, recreation, and wildlife habitat are described as the primary land uses with some gypsum and copper mining in the area (Chapman 2003).

Water quality monitoring at DETO in the 1970s found fecal coliform bacteria levels above state thresholds on several occasions in 1974 and 1975 (NPS 1997). Bacteria is a widespread problem in the Belle Fourche River. All three of the assessed Wyoming reaches are impaired for bacteria, and five out of five reaches of the Belle Fourche in South Dakota are nonsupporting for bacteria as well (SD DANR 2020). Use determinations have only been completed on 2% of the surface water in the Belle Fourche Watershed in Wyoming (WY DEQ 2020). Nonpoint source pollution is the determined cause of bacterial impairments (Tetra Tech Inc 2013). Livestock, possibly failing septic systems, and other wildlife are likely suspects for contributing to high bacteria loads (Tetra Tech Inc 2013). The human population is very sparse around Devils Tower with only an estimated 300 households living along the reach and a total population of 7,181 in Crook's County (2020 census). The 2017 NASS livestock census indicates Crook County supports 67,640 cattle and calves and 12,214 sheep and lambs. Bacteria data collection in the Belle Fourche River is sparse as well and further sampling has not been done after the total maximum daily load (TMDL) was published in 2013. The river was sampled above and below the town of Hulett, WY and found no significant increase below the town. As with many bacterial impairments, concentrations increase after high flows (TetraTech 2013) and loads should be reduced at these high flows to meet the TMDL. Grazing land management, riparian buffers, and alternative watering systems are recommended to reduce bacteria loads. For more details and current impairment information visit the [Wyoming Department of Environmental Quality website](#).

The Northern Great Plains Inventory & Monitoring Network (NGPN) began monitoring water quality at DETO in 2013 to better understand current conditions and changes over time in the Belle Fourche River (Ashton et al. 2020). The monitoring is conducted at the gaging station at Devils Tower National Monument, WY (Monitoring Location 06427850; 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 repeats water quality monitoring at DETO every three years, (Wilson et al. 2014), conducting in-depth analysis of status and trends after three to five cycles of sampling. This report summarizes data from the third season of water quality sampling in 2019.

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

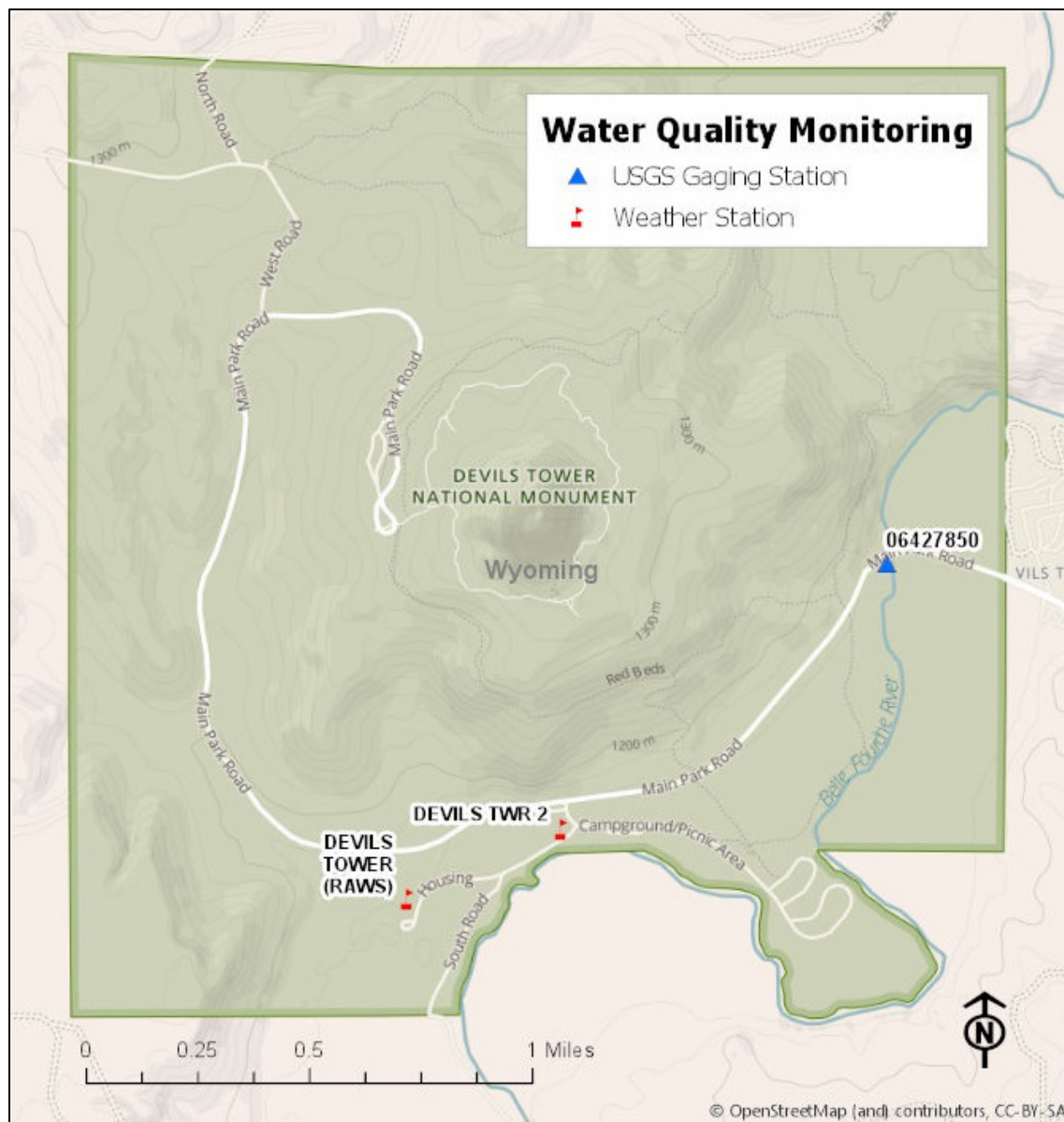


Figure 2. Map of Devils Tower National Monument and water quality monitoring location (blue triangle) and nearby weather stations (red flags). Climate data in this report is taken from the DEVILS TWR 2 weather station.

Table 1. Water quality parameters measured as part of the Northern Great Plains Inventory & Monitoring Water Quality Program and associated state standards (WYDEQ 2018a). These standards are not enforceable in periods of low flow, as defined by the minimum seven consecutive day flow which has the probability of occurring once in ten years (WYDEQ 2018a).

Water Quality Parameter	Description	WY state standards applicable to warm water fisheries designations
Water temperature (°C)	Water temperature is affected by solar radiation, air temperature, rainfall, flow dynamics, physiography of the waterbody, stream shading, land use/cover, and land development in the watershed. Water temperature monitoring indicates response to daily and annual climatic variations and may track short-term drought or long-term climate changes. Water temperature can indicate changes in water use, source, and flow dynamics. Aquatic organisms are dependent on specific temperature ranges for their optimum health and survival.	Pollution attributable to the activities of man shall not change ambient water temperatures to levels which result in harmful acute or chronic effects to aquatic life, or which would not fully support existing and designated uses. When ambient temperatures are above 15.6°C, pollution attributable to the activities of man shall not result in an increase of more than 2.2°C. The maximum allowable stream temperature will be the maximum natural daily stream temperature plus the allowable change, provided that this temperature is not lethal to existing fish life and under no circumstance shall pollution attributable to the activities of man result in a temperature that exceeds 30°C.
Dissolved Oxygen (mg/L)	The DO level, a measure of the amount of oxygen in the water column, is considered an important indicator of a waterbody's ability to support aquatic life. The DO in rivers and streams typically declines as temperature increases and as flow decreases; DO also responds to photosynthesis, resulting in natural variation during the day and additional natural variation through the season. The DO in water can vary over extended periods of time due to changes in the landscape or climate.	Minimum criteria include: • 30-day mean of 5.5 mg/L • 7-day mean of 6.0 mg/L • 7-day mean minimum of 4.0 mg/L • 1-day minimum of 5.0 mg/L
Specific Conductance (µS/cm)	Specific conductance, a measured concentration of the water's ability to conduct electricity, typically is proportional to the dissolved major ions in the water such as calcium, magnesium, sodium, and sulfate. A change in specific conductance indicates a change in the concentration(s) of major ions. Small changes in specific conductance are common through the day and through the seasons.	No criteria

Table 1 (continued). Water quality parameters measured as part of the Northern Great Plains Inventory & Monitoring Water Quality Program and associated state standards (WYDEQ 2018a). These standards are not enforceable in periods of low flow, as defined by the minimum seven consecutive day flow which has the probability of occurring once in ten years (WYDEQ 2018a).

Water Quality Parameter	Description	WY state standards applicable to warm water fisheries designations
pH	The pH is a measure of the hydrogen ion concentration in a solution. The pH in surface waters typically ranges from 6.5 to 8.5. pH may be influenced by watershed vegetation, hydrology, geology, and soils. Different organisms flourish within different ranges of pH.	Pollution attributable to the activities of man shall not be present in amounts which will cause the pH to be less than 6.5 or greater than 9.0 standard units. Pollution attributable to the activities of man shall not change the pH to levels which result in harmful acute or chronic effects to aquatic life, directly or in conjunction with other chemical constituents, or which would not fully support existing and designated uses.

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 06427850) inside the park at 3840 ft. elevation. Water quality and stage height are measured every 15 minutes throughout the ice-free season. Monitoring at DETO began in 2013 and was repeated in 2016, 2019, and will be repeated every three years thereafter. Program funding currently limits monitoring to a cycle of one year of monitoring, followed by two years without.

In 2019, NGPN partnered with the USGS Wyoming-Montana Water Science Center to have USGS staff collect water quality and streamflow data at DETO. The USGS deployed a continuous, multi-parameter sonde at the gage on April 9, 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).



Figure 3. A researcher deploys a sonde device to measure water quality on the Belle Fourche River at Devils Tower, WY. The United States Geological Survey Belle Fourche River gaging station (06427850) is set up for real-time data transmission via satellite. Photographs courtesy of NPS.

Table 2. Field journal for 2019 Water Quality Sampling at Devils Tower National Monument.

Date	Notes
April 9, 2019	Instrument installed.
April 25, 2019	Gage values deleted April 10 th due to minor fouling.
May 2, 2019	Sonde out of water between April 25 th and May 2 nd , values deleted. Cross section completed. Gage visited again May 6 th . DO drift correction applied May 2–6 th .
June 5, 2019	Peak stage recorded 7.11 ft on May 29 th . Fouling correction applied May 21 st –June 5 th . SC values deleted. Cross section.
July 9, 2019	Gage data deleted June 30. SC data deleted June 9 th . Data deleted July 7–9 th due to heavy fouling. Cross section.
August 6, 2019	Fouling correction applied July 9–Aug. 6 th . Cross section.
August 29, 2019	DCP malfunctioned August 5, 6, and 10 th —no data logged. SC data deleted on Aug. 29 th . Fouling correction applied. Cross section.
September 19, 2019	Cross-section. pH values Aug. 1–Sept 19 th rated fair. SC values deleted from Sept. 19 th .
November 5, 2019	DCP malfunctioned Sept 19 th –23 rd , October 28–30 th and Nov. 1–5 th – no data logged or transmitted. Sonde removed from water. Cross-section completed.

Satellite telemetry transmitted the water data to the Water Science Center in near real-time (<https://waterdata.usgs.gov/monitoring-location/06427850/>). 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 with 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 (Table 2). Calibration included pre- and post-calibration checks to quantify fouling errors and equipment drift—data critical to the correction and grading of the final data. On November 5, 2019, the USGS removed the multi-parameter sonde from the Belle Fourche River.

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 January of 2022 from the USGS, and used AQUARIUS Workstation by Aquatic Informatics (<http://aquaticinformatics.com/>) and R (R Core Team 2019) 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 there were missing data due to instrument error, means were generated by excluding the missing values and the maximum and minimum were left blank. Means were not calculated for days where all time steps were missing (i.e. the instrument didn't collect any data that day). Discharge data were not available for this site (only stage height), so a nearby stream gauge on the Belle Fourche River at the Wyoming and South Dakota border was used as a proxy (USGS ID number 06428500).

Climate data were downloaded from the Devils Tower 2 (482466) National Weather Service Cooperator Observer Program station. The data were accessed and graphed using the web-based tool [Climate Analyzer](#).

Results

The water quality monitoring season (ice-free) on the Belle Fourche River at DETO lasted from April 9, 2019 to November 5, 2019. The discharge of the Belle Fourche River peaked in late May but was generally high during the monitoring period (Figure 4). The maximum recorded gage height was on May 29, 2019 at 7.11 ft and the minimum recorded gage height was recorded on November 2, 2019 at 1.53 ft (Appendix A). Peak stage height in 2019 was over 7 feet and peak discharge was close to 2,500 cubic ft per second, whereas 2016 had much lower flow (Ashton et al. 2020) compared to the 2019 and 2013 seasons. 2019 was warmer and wetter than average when compared to 1981–2010 (precipitation was ~122% of average and 117% of the 1991–2020 average). Average minimum and maximum temperatures were 3–7 degrees warmer than the 1981–2010 average (Figure 5) with cooler temperatures during the growing season and warmer temperatures in the winter. During the 2019 water year, it rained and snowed 21.46 inches with total monthly precipitation peaking in July (Figure 5).

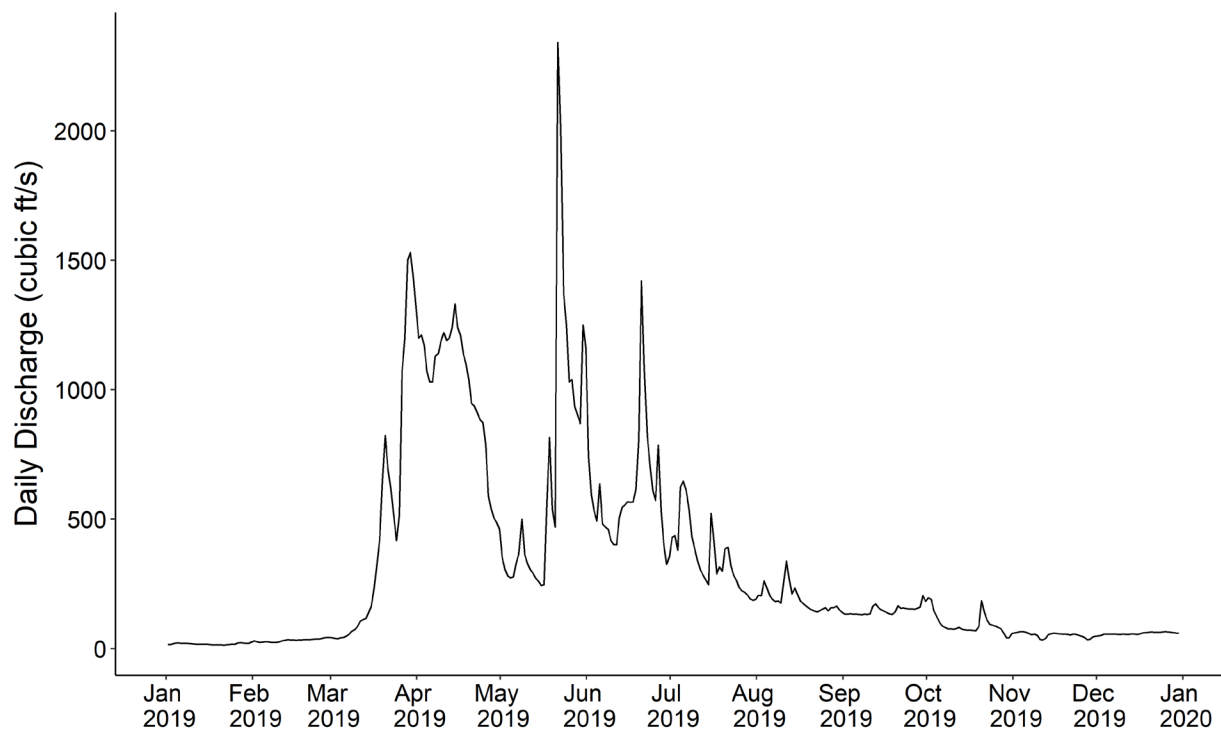
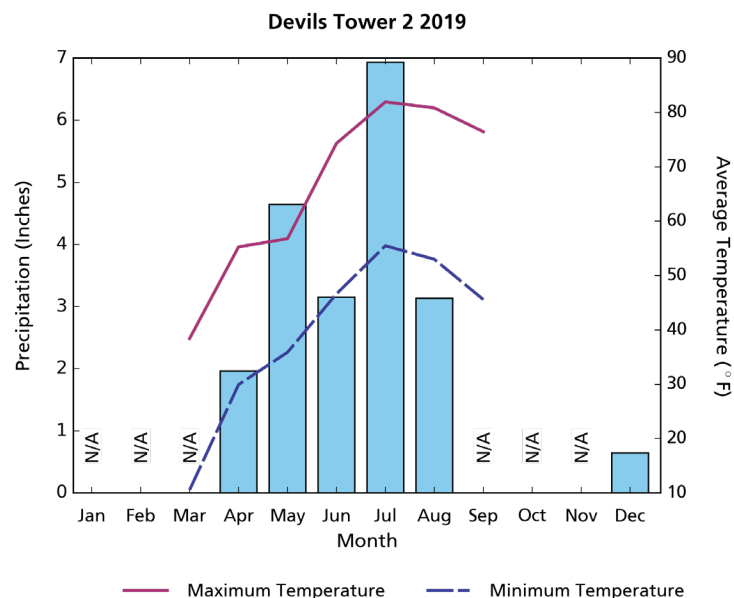


Figure 4. Daily mean discharge (black line) in 2019 on the Belle Fourche River at the Wyoming – South Dakota border, USGS Gaging Station 06428500.



Devils Tower 2 - 2019 - Departure from 1981 - 2010 Avgs.

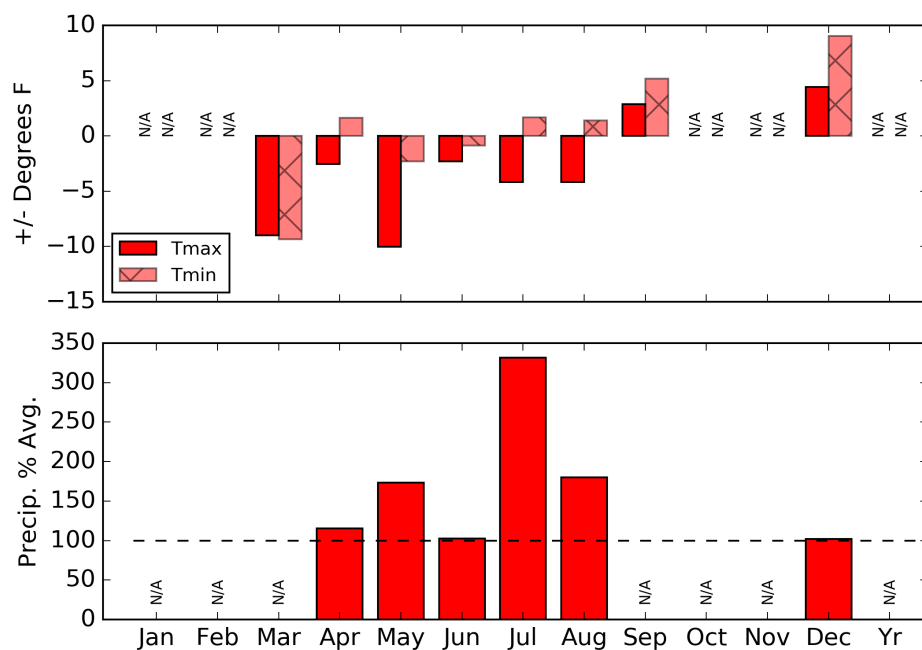


Figure 5. The top panel shows total monthly precipitation (light blue bars), average monthly minimum temperature (dashed blue line), and average monthly maximum temperature (solid red line) for 2019 in Devils Tower National Monument. The bottom panel shows monthly departures from 1981–2010 average temperature and precipitation for 2019 in Devils Tower National Monument. Climate data are from Devils Tower 2 Station (482466). The data were accessed and graphed using the web-based tool Climate Analyzer.

During the ice-free season at DETO, we collected over 18,000 water quality measurements in the Belle Fourche River (Table 3). We found mean water temperature of 14.64°C, dissolved oxygen concentrations of 9.2 mg/L, specific conductance of 1464 $\mu\text{S}/\text{cm}$, and pH of 8.2 (Table 3). There

was, however, variation across months in all parameters (Table 4). Mean water temperature in April was 5.4°C and increased to a mean of close to 21.8°C in July before declining back to 6.8°C in October (Table 4, Figure 6). Maximum water temperature never exceeded the Wyoming water quality standard of 30°C (Table 1).

Table 3. Summary of descriptive statistics for water temperature, dissolved oxygen, specific conductance, and pH measured for the ice-free sampling period on the Belle Fourche River at Devils Tower National Monument from April 9, 2019 through November 5, 2019. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 30.0°C; dissolved oxygen $\geq$ 5.0 mg/L and pH range is <6.5 or >9.0).

Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (μ S/cm)	pH
Mean	14.64	9.18	1464.36	8.19
Standard Deviation	6.48	1.69	187.17	0.15
Median	15.4	9	1450	8.2
Minimum	-0.1	5.6	862	7.6
Maximum	26.6	14.2	1900	8.6
Number of Points	18691	18485	18448	16657
Standard	<30°C	> 5 mg/L	NA	6.5–9.0
Number of Points below or above standard	0 (above)	0 (below)	NA	0 (above)
				0 (below)
% Exceedance	0%	0%	NA	0%

Table 4. Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period at Devils Tower National Monument on the Belle Fourche River from April 9, 2019 through November 5, 2019. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 30.0°C; dissolved oxygen $\geq$ 5.0 mg/L and pH range is <6.5 or >9.0).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (μ S/cm)	pH
April 9–April 30, 2019	Number of measurements	1970	1961	1949	1927
	Mean	5.4	11.78	1678.79	8.22
	Standard Deviation	1.63	1.44	119.26	0.06
	Median	5.4	12	1670	8.2
	Minimum	1.4	9	1320	8.1
	Maximum	8.4	14.2	1860	8.4
	% Exceedance	0	0	NA	0

Table 4 (continued). Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period at Devils Tower National Monument on the Belle Fourche River from April 9, 2019 through November 5, 2019. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 30.0°C; dissolved oxygen $\geq$ 5.0 mg/L and pH range is <6.5 or >9.0).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (μ S/cm)	pH
May, 2019	Number of measurements	2832	2832	2836	2450
	Mean	10.83	9.88	1439.04	8.15
	Standard Deviation	3.27	1.05	175.14	0.14
	Median	10.4	10	1520	8.1
	Minimum	4.9	7.8	862	7.8
	Maximum	18.9	12.8	1720	8.5
	% Exceedance	0	0	NA	0
June, 2019	Number of measurements	2874	2874	2854	2873
	Mean	16.29	8.59	1295.75	8.21
	Standard Deviation	2.88	0.75	106.49	0.09
	Median	15.4	8.6	1310	8.2
	Minimum	10.4	6.3	1100	8
	Maximum	24.9	10.8	1450	8.5
	% Exceedance	0	0	NA	0
July, 2019	Number of measurements	2975	2775	2901	2879
	Mean	21.87	7.45	1339.05	8.09
	Standard Deviation	1.74	0.94	98.81	0.13
	Median	21.8	7.2	1370	8.1
	Minimum	17.8	5.7	1020	7.7
	Maximum	26.6	10.3	1460	8.4
	% Exceedance	0	0	NA	0
August, 2019	Number of measurements	2832	2832	2834	1316
	Mean	20.77	8.32	1422.82	8.04
	Standard Deviation	1.75	1.51	72.57	0.29
	Median	20.8	8	1450	8
	Minimum	15.9	5.6	1070	7.6
	Maximum	24.8	12	1520	8.6
	% Exceedance	0	0	NA	0

Table 4 (continued). Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period at Devils Tower National Monument on the Belle Fourche River from April 9, 2019 through November 5, 2019. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 30.0°C; dissolved oxygen ≥ 5.0 mg/L and pH range is <6.5 or >9.0).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity ($\mu\text{S}/\text{cm}$)	pH
September, 2019	Number of measurements	2486	2489	2486	2490
	Mean	17.34	8.49	1443.72	8.31
	Standard Deviation	2.64	0.74	48.47	0.11
	Median	17.3	8.4	1470	8.3
	Minimum	12.1	7	1320	8
	Maximum	23.6	10.6	1500	8.6
	% Exceedance	0	0	NA	0
October, 2019	Number of measurements	2722	2722	2588	2722
	Mean	6.81	10.49	1722.34	8.26
	Standard Deviation	3.05	0.9	144.29	0.06
	Median	6.7	10.5	1770	8.3
	Minimum	-0.1	8.5	1320	8.1
	Maximum	13.3	12.5	1900	8.4
	% Exceedance	0	0	NA	0

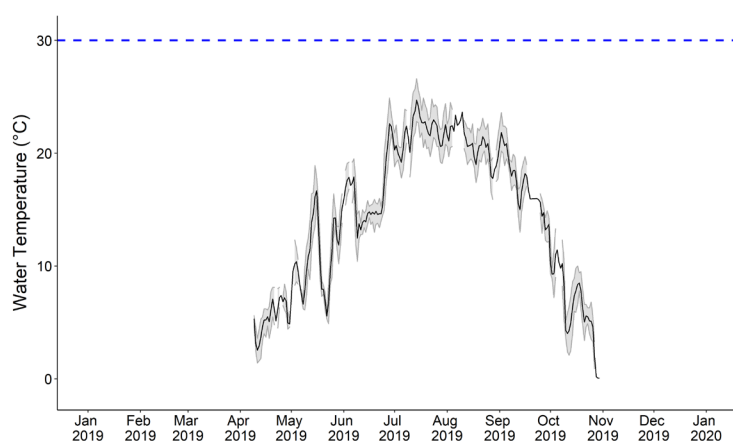


Figure 6. Daily mean water temperature (black line) collected on the Belle Fourche River at Devils Tower National Monument in 2019. The sonde was in the water from April 9, 2019 through November 5, 2019. The gray ribbon shows the daily maximum and minimum water temperature for the same period. The dashed blue line indicates one of the Wyoming 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 7). The highest mean dissolved oxygen concentrations were in the spring and fall, averaging greater than 10 mg/ L in April and October. Despite the variability, dissolved oxygen never dipped below state standards in 2019.

Specific conductance of the Belle Fourche River was highly variable throughout the year, ranging from 862 to 1900 uS/cm (Table 3, Figure 8), but showed a less predictable seasonal pattern than temperature or dissolved oxygen concentrations. The pH of the Belle Fourche River ranged between 7.6 and 8.6 (Figure 9), and it was never outside the range of the Wyoming state standards of 6.5–9.

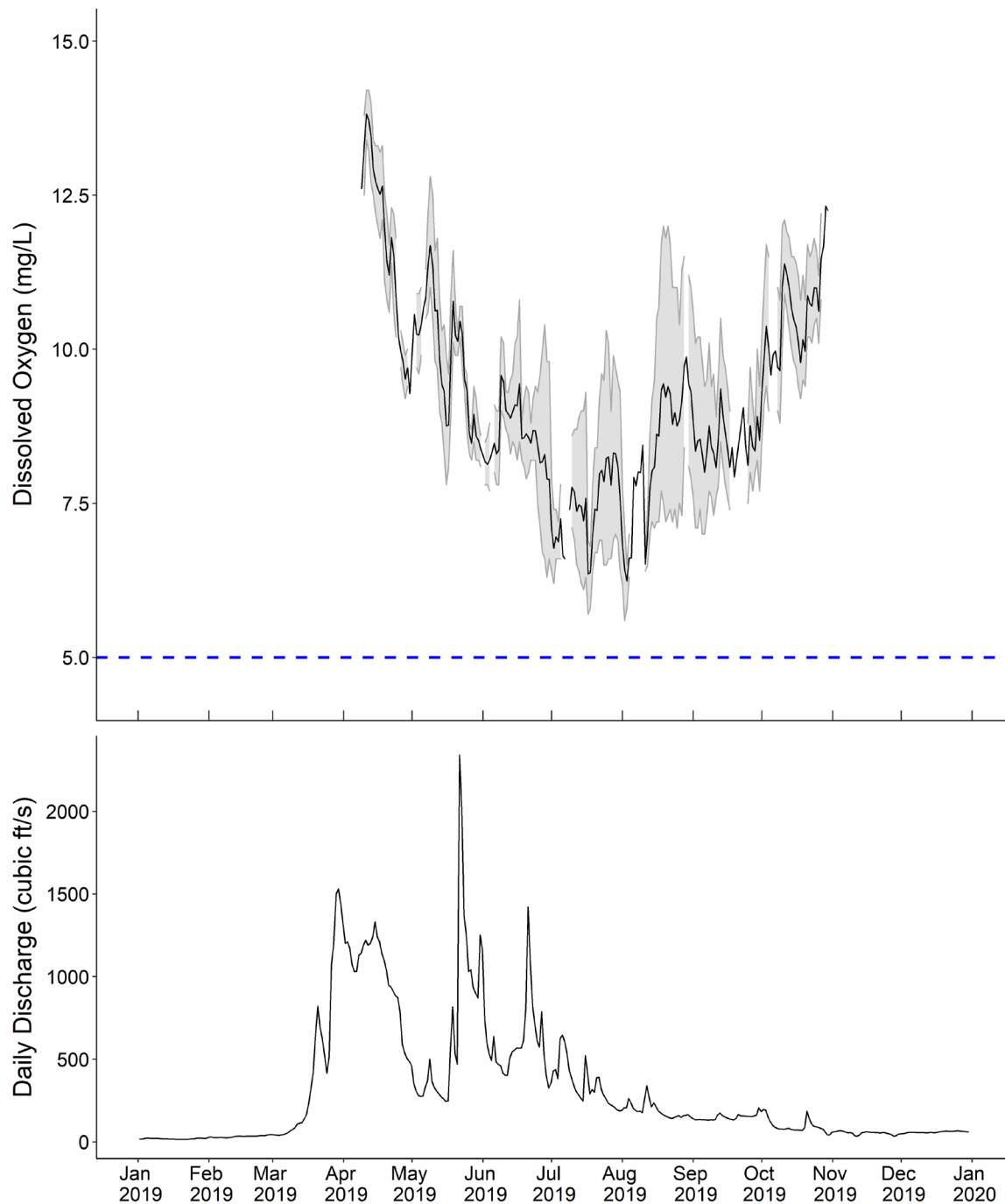


Figure 7. Daily mean dissolved oxygen concentrations (top) of the Belle Fourche River at Devils Tower National Monument in 2019 and daily discharge (bottom) of the Belle Fourche River at the Wyoming and South Dakota border. The gray ribbon shows the daily maximum and minimum dissolved oxygen for the same period. The dashed blue line indicates one of the Wyoming 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.

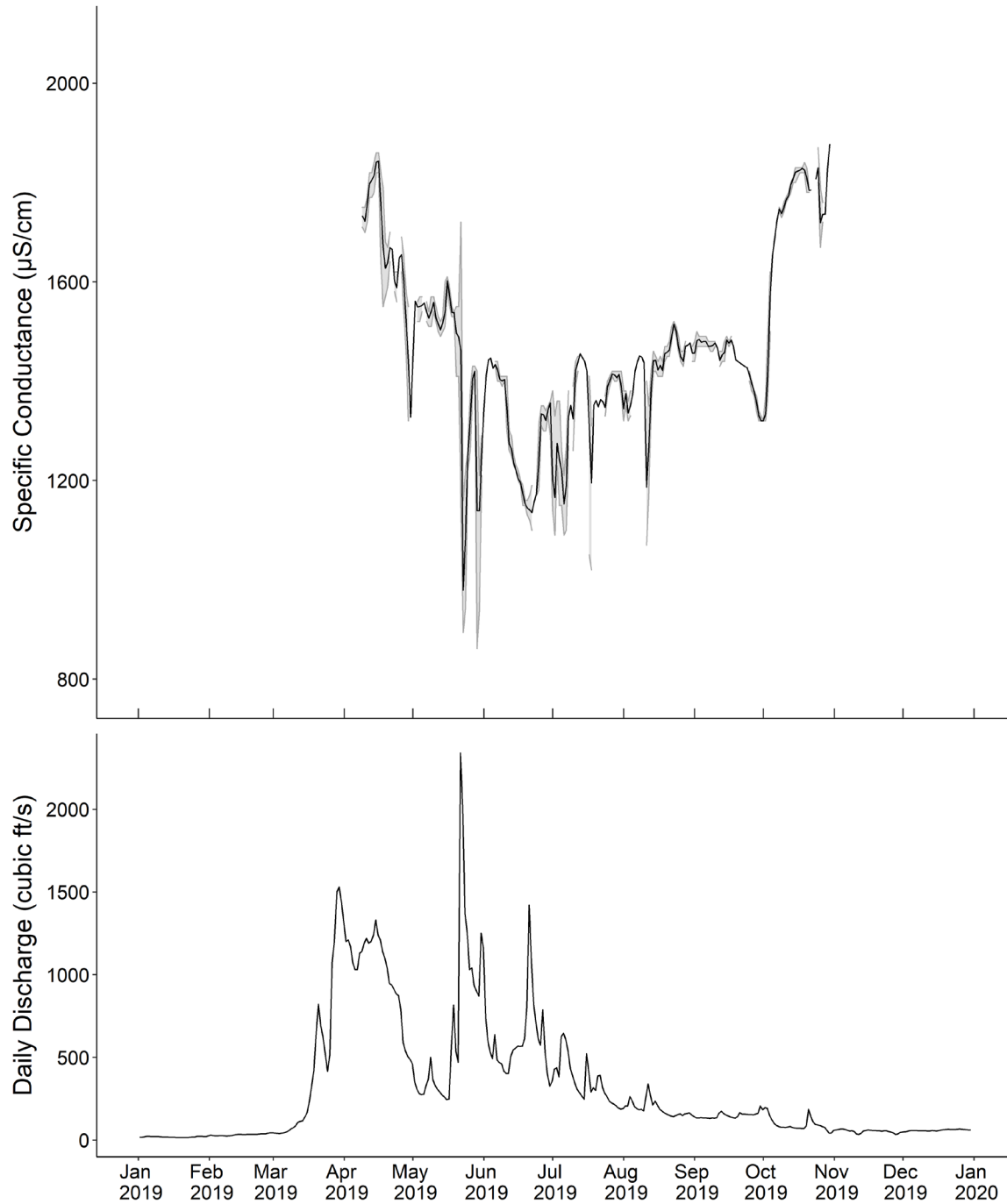


Figure 8. Daily mean specific conductance (top) of the Belle Fourche River at Devils Tower National Monument in 2019 and daily discharge (bottom) of the Belle Fourche River at the Wyoming and South Dakota border. The gray ribbon shows the daily maximum and minimum specific conductivity for the same period. The periods where the instrument did not collect data are indicated by gaps in the record.

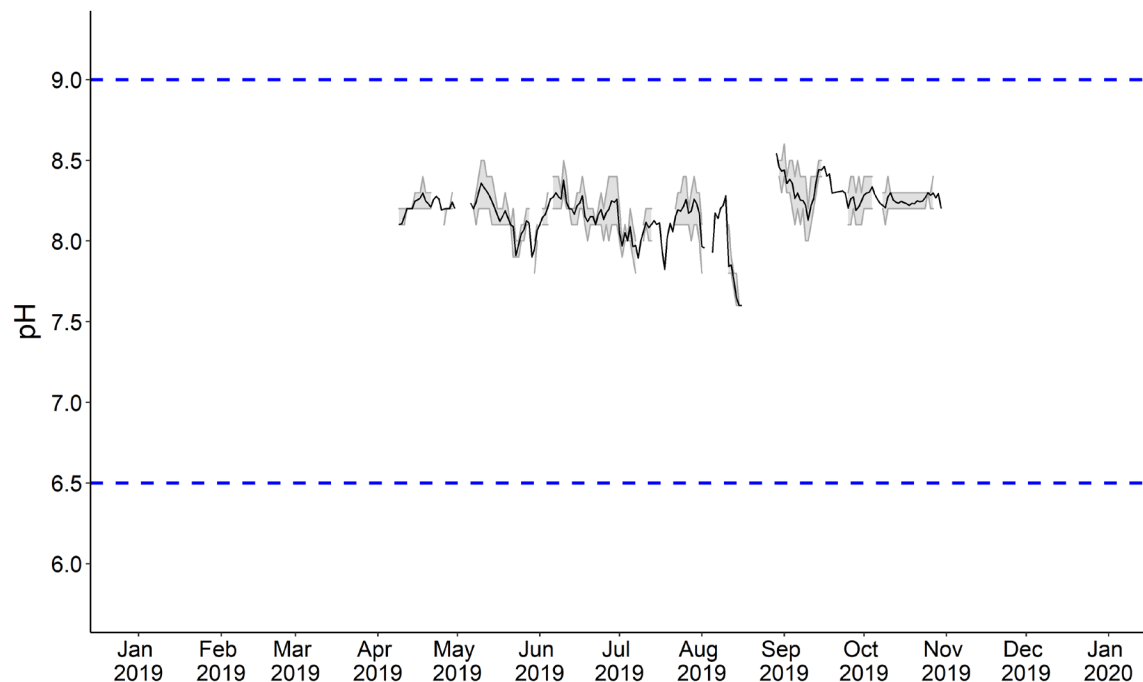


Figure 9. Daily mean pH (black line) of the Belle Fourche River at Devils Tower National Monument in 2019. Measurements were taken from April 9, 2019 through November 5, 2019. The gray ribbon shows the daily maximum and minimum pH for the same period. The dashed blue lines indicate the Wyoming state 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 Data Report is intended to provide a basic review of data collected during the 2019 water quality monitoring season at Devils Tower National Monument. 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 [BELLE FOURCHE RIVER AT DEVILS TOWER, WY - USGS Water Data for the Nation](#).

Literature Cited

- Anderson, J. M. 2013. The decline of a riparian gallery forest in Devils Tower, Wyoming: causation and management techniques for restoration. Montana State University, Bozeman, Montana.
- Ashton I, Rockwood S, Mills J, Thornbrugh DJ. 2020. Water quality monitoring for Devils Tower National Monument: 2013 data report. Natural Resource Data Series. NPS/DETO/NRDS—2020/1259. National Park Service. Fort Collins, Colorado
- Ashton IW and Rockwood S. 2020. Water quality monitoring for Devils Tower National Monument: 2016 data report. Natural Resource Data Series. NPS/DETO/NRDS—2020/1256. National Park Service. Fort Collins, Colorado
- Chapman, S.S., S.A. Bryce, J.M. Omernik, D.G. Despain, J. ZumBerg, and M. Conrad. 2002. Ecoregions of Wyoming. (color poster with map, descriptive text, summary tables, and photographs). U.S. Geological Survey (map scale 1:1,400,000). Reston, Virginia. [Ecoregion Download Files by State - Region 8 | US EPA](#) Accessed April 29, 2022.
- Martin, M. 1995. Assessment of specific riparian conditions in Devils Tower National Monument, Wyoming. National Park Service. Water Resources Division.
- National Agricultural Statistics Service. 2017 Census of Agriculture Crook County Profile. https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Wyoming/cp56011.pdf. Accessed 5/2/2022.
- NPS. 1997. Baseline water quality data inventory and analysis: Devils Tower National Monument. National Park Service. Water Resources Division. Fort Collins, CO. Technical Report NPS/NRWRD/NRTR-97/118.
- R Core Team. 2019. R: A language and environment for statistical computing. version 3.6.1. <http://www.R-project.org>. Vienna, Austria.
- SD DANR 2020. The 2020 Water Quality Report for Surface Water Quality Assessment. [Integrated Reports \(sd.gov\)](#)
- Tetra Tech Inc. 2013. Belle Fourche River watershed TMDLs for pathogens, ammonia, and chloride Final report prepared for Wyoming Department of Environmental Quality. http://deq.state.wy.us/wqd/watershed/Program%20Documents/TMDL-Carry%20Over%20to%20New%20Site/2.%20Completed%20Projects/Belle_Fourche_Final%20Draft%2008_23_13.pdf.
- Wagner, R. J., R. W. Boulger, C. J. Oblinger, and B. A. Smith. 2006. Guidelines and standard procedures for continuous water-quality monitors: station operation, record computation, and data reporting. . United States Geological Survey Techniques and methods 1-D3. <https://pubs.usgs.gov/tm/2006/tm1D3/>.

- Wilson, M. H., B. L. Rowe, R. A. Gitzen, S. K. Wilson, and K. J. Paintner-Green. 2014. Water quality monitoring protocol for wadeable streams and rivers in the Northern Great Network: Narrative version 1.0. Natural Resources Report NPS/NGPN/NRR—2014/868 National Park Service, Fort Collins, Colorado.
- WYDEQ. 2018a. Chapter 1. Wyoming surface water quality standards. Ref No: 020.0011.1.04242018. Wyoming Department of Environmental Quality <https://rules.wyo.gov/>.
- WYDEQ. 2018b. Wyoming's 2016/2018 Integrated 305(b) and 303(d) Report. Wyoming Department of Environmental Quality, Water Quality Division, Watershed Section Document #18-0111. <http://deq.wyoming.gov/wqd/water-quality-assessment/>.
- WYDEQ. 2020 Wyoming's 2020 Integrated 305(b) and 303(d) Report. Wyoming Department of Environmental Quality, Water Quality Division, Watershed Section. [Water Quality Assessment - Wyoming Department of Environmental Quality](#) Accessed 4/29/2022.
- US EPA How's My Waterway, Belle Fourche River, Assessment Id: WYBF101202010904_00. [How's My Waterway - Waterbody Report \(epa.gov\)](#) Accessed 4/29/22.

Appendix A. USGS Water Data Quality Report for Belle Fourche River, 2019.

06427850 BELLE FOURCHE RIVER AT DEVILS TOWER, WY

LOCATION—Lat 44°35'22", long 104°42'12" referenced to North American Datum of 1927, Crook County, WY, Hydrologic Unit 10120201,

WATER-QUALITY RECORDS

PERIOD OF RECORD—Water years 1968–1992.

PERIOD OF DAILY RECORD—March to November 2013, March to October 2016, April 2019 to current.

INSTRUMENTATION—Water-quality monitors for specific conductance, pH, water temperature and dissolved oxygen.

REMARKS—

SPECIFIC CONDUCTANCE

03-08-2016 TO 11-01-2016: records are excellent except records from May 16–24, June 24 to July 6, Aug. 12–24, and Oct. 22 to Nov. 1 are good.

pH

03-08-2016 TO 11-01-2016: records are excellent except records from Aug. 18–24 are good.

WATER TEMPERATURE

03-08-2016 TO 11-01-2016: records are excellent. Water-temperature records represent water temperature at sensor within 0.2°C.

DISSOLVED OXYGEN

03-08-2016 TO 11-01-2016: records are excellent except records from June 29, July 3–5, and Aug. 28–30, which are good; records from Aug. 31 to Sept. 7 and Sept 10, 13, are fair; and records from Sept. 8, 9, 11, 12, and Sept. 14 to Oct. 3, are poor.

Maximum and minimum recorded values in the EXTREMES paragraphs may have occurred during days of partial record and may not appear in the daily values tables.

EXTREMES FOR PERIOD OF DAILY RECORD - SPECIFIC CONDUCTANCE: Maximum recorded, 2,190 uS/cm, June 22, 2106; minimum recorded, 452 uS/cm, October 10, 2013. pH: Maximum recorded, 8.7 units, many days 2016; minimum recorded, 7.6 units, August 12 and September 6–8, 2013. WATER TEMPERATURE: Maximum recorded, 29.6°C, July 11, 2013, June 16, 19, 2016; minimum recorded –0.1°C, March 23–26, April 9, 10, and November 18, 2013. DISSOLVED OXYGEN: Maximum recorded, 13.8 mg/L, October 5, 2013; minimum recorded, 4.4 mg/L, August 13, 2013.

EXTREMES FOR CURRENT YEAR - SPECIFIC CONDUCTANCE: Maximum recorded, 2,080 uS/cm, April 6–8, 13, May 15, 16; minimum recorded, 452 uS/cm, October 10. pH: Maximum recorded, 8.4 units, September 10; minimum recorded, 7.6 units, August 12 and September 6–8. WATER TEMPERATURE: Maximum recorded, 16.7°C, October 1; minimum recorded –0.1°C, November 18. DISSOLVED OXYGEN: Maximum recorded, 13.8 mg/L, October 5; minimum recorded, 4.4 mg/L, August 13.

06427850 BELLE FOURCHE RIVER AT DEVILS TOWER, WY
Dissolved Oxygen Time Series

Analysis Period: 05/06/2019 to 11/05/2019

Analysis:

Record: May 6 to Nov. 5 the temperature record was complete and satisfactory with the following exceptions:

Aug. 5, 6, 10, Sept. 19 to 23, Oct. 28 to 30, and Nov. 1 to 5 when the DCP malfunctioned and no data were transmitted or logged.

Site characteristics: The channel is straight for 290 ft upstream and 240 ft downstream. The bed consists of silt and cobble. During the summer months algae can be prevalent. The banks consist of heavy grass at times and increase slightly in elevation. All flow will be in one channel.

Instrumentation: Sutron Satlink3 HDR DCP, Sutron Bubbler with an Acubar transducer, and YSI multi-parameter water-quality sensor are deployed to measure, log, and transmit the following data: stage, water temperature, specific conductance, pH, and dissolved oxygen. The DCP and one 12-volt batteries are housed in two small metal boxes. The boxes are attached to the bridge's concrete superstructure, located on the left, upstream side of the bridge. The pressure transducer and water-quality sensor cables are encased in 1 1/4-in vinyl pipe from the gage boxes to the riverbank. At the riverbank, the cables are transitioned into a 4-in PVC pipe to facilitate easy deployment of the water-quality sonde and the pressure transducer. A solar panel and YAGI antenna are mounted on a section of 2-in galvanized-steel pipe that is attached to the bridge adjacent to the gage boxes. The outside-gage reference is provided by a wire-weight gage deployed on the downstream-side bridge guard rail.

Sampling location: It is under the bridge on State Highway 110.

Field Visits: During the period of record inspections were completed May 6, June 5, July 9, Aug. 6, 29, Sept. 19, 23, and Nov. 5.

Deletions: Erroneous readings were often deleted while the sonde was serviced during site visits. Also, erroneous values were screened by either threshold suppression or manual deletion on many days.

Data were deleted July 7 to 9 due to heavy fouling.

Fouling Corrections: During the period of analysis fouling corrections ranged from -0.22% (-0.02mg/L) to 8.66% (0.59 mg/L).

June 5 a -0.1mg/L fouling correction was indicated. During the inspection June 5, readings were thought to have not completely stabilized. Therefore, fouling and drift corrections, which are normally applied in two sets, were combined into set 1. In order to maintain continuity of record during this period, the single set was applied with a total indicated correction of -0.46 mg/L . This

was based off unit values prior to and after cleaning and calibration. This correction was initiated upon a recession from a peak on May 21.

July 9 to Aug. 6 a 2.15% fouling correction was indicated and applied. No apparent peak could be attributed to the fouling and corrections were prorated by time between inspections.

Aug. 29 a 3.98% Fouling correction was indicated. This correction was applied as indicated and was again prorated by time between inspections.

Sept. 19 a minimal fouling correction (-0.22%) was indicated. This was well within published criteria and no fouling correction was applied.

Nov. 5 the DCP was found malfunctioning and no data were recorded. The indicated correction of -0.08% was not applied.

Calibration Drift Corrections: Drift corrections during the period of analysis ranged from -9.08% (-0.84mg/L) to 9.89% (0.74mg/L). Drift corrections were applied as indicated in Set 2 and were prorated by time between inspections.

Other Corrections: None.

Cross-section surveys: May 2. Cross-sectional surveys were completed May 6, June 5, July 9, Aug. 6, 29, Sept 19, and Nov. 5.

Vertical profiles: None.

Remarks: Records are good

Analysis for this period last updated 3/26/2020 5:42:41 PM by ejblajsz

Analyzed By: ejblajsz

Date: 03/26/2020

Approved By: rwoodruf

Date: 03/27/2020

Analysis Period: 04/09/2019 to 05/06/2019

Analysis:

Record: Apr. 19 to May 6, 2019

Site characteristics: The channel is straight for 290 ft upstream and 240 ft downstream. The bed consists of silt and cobble. During the summer months algae can be prevalent. The banks consist of heavy grass at times and increase slightly in elevation. All flow will be in one channel.

Instrumentation: Sutron Satlink3 HDR DCP, Sutron Bubbler with a Acubar transducer, and YSI multi-parameter water-quality sensor are deployed to measure, log, and transmit the following data: stage, water temperature, specific conductance, pH, and dissolved oxygen. The DCP and one 12-volt batteries are housed in two small metal boxes. The boxes are attached to the bridge's concrete superstructure, located on the left, upstream-side of the bridge. The pressure transducer and water-quality sensor cables are encased in 1 1/4-in vinyl pipe from the gage boxes to the river bank. At the river bank, the cables are transitioned into a 4-in PVC pipe to facilitate easy deployment of the water-quality sonde and the pressure transducer. A solar panel and YAGI antenna are mounted on a section of 2-in galvanized-steel pipe that is attached to the bridge adjacent to the gage boxes. The outside-gage reference is provided by a wire-weight gage deployed on the downstream-side bridge guard rail.

Sampling location: It is under the bridge on State Highway 110.

Field Visits: Gages were reactivated on Apr. 9 and visited on Apr. 25, May 2, and May 6.

Deletions: Record was deleted on Apr. 25 and Apr. 30 to May 2 when the sonde was out of the water and on May 6 when the sonde was being service.

Fouling Corrections: Fouling corrections indicated on Apr. 25 and May 2 were due to the sonde being out of the water. On May 6 a fouling correction of 0.22 mg/L was determined and applied back to a 0 on May 2.

Calibration Drift Corrections: A 0.36 mg/L drift correction was indicated on May 6 and it was prorated back to a 0 on May 2. Other drift corrections indicated were thought due to the sonde being out of the water.

Other Corrections: None.

Cross-section surveys: May 2.

Vertical profiles: None.

Remarks: Records are good.

Analysis for this period last updated 5/8/2019 11:53:39 AM by krwatson

Analyzed By: krwatson

Date: 05/08/2019

Approved By: rwoodruf
Date: 03/27/2020

06427850 BELLE FOURCHE RIVER AT DEVILS TOWER, WY

Stage Only

Analysis Period: 05/06/2019 to 11/05/2019

Analysis:

Gage Height or Elevation Record: May 6 to Nov. 5, 2019. Gage height record was complete and satisfactory and considered of good quality. However, Sept. 19–23 no data were transmitted or logged as the DCP malfunctioned.

Data were deleted Oct. 28 and 29 as the transducer was partially frozen in ice. Erroneous values were deleted June 30 and Sept 23.

Datum: No levels completed.

Backup Data: None needed.

Ice Affected: Gage-height data were affected by backwater from ice Oct. 28–31 and Nov. 1 and 2.

Edits: Data were deleted Oct. 28 and 29 as the transducer was partially frozen in ice. Erroneous values were deleted June 30 and Sept 23.

Gage-Height Corrections: During the period of analysis, corrections indicated to the OG ranged from +0.04 to −0.13. Corrections were generally prorated by time between inspections.

However, Nov. 5 a −0.13 ft correction was indicated. This was attributed to orifice movement associated with the onset of ice. Therefore, the previous correction (−0.06ft) was continued until just before ice affected data and was prorated across the ice period to −0.13 ft.

Other Corrections: None.

Peak Stage: A peak stage of 7.11 ft was recorded on May 29

Estimates: None.

Comments: Records good.

Analysis for this period last updated 2/21/2020 3:06:43 PM by ejblajsz

Analyzed By: ejblajsz

Date: 02/21/2020

Approved By: rwoodruf

Date: 02/25/2020

Analysis Period: 04/09/2019 to 05/06/2019

Analysis:

Gage Height or Elevation Record: Apr. 9 to May 6.

Datum: No levels completed.

Backup Data: None needed.

Ice Affected: None.

Edits: Record was deleted on Apr. 10 when minor fouling occurred and Apr. 30 to May 2, when the flow was below the orifice.

Gage-Height Corrections: A -0.01 ft correctio was indicated on May 6 and it was prorated back to 0.00 ft on May 2.

Other Corrections: None.

Peak Stage: 6.70 ft on Apr. 11.

Estimates: None.

Comments: Records good.

Analysis for this period last updated 2/25/2020 2:49:45 PM by rwoodruf

Analyzed By: krwatson

Date: 05/08/2019

Approved By: rwoodruf

Date: 02/25/2020

06427850 BELLE FOURCHE RIVER AT DEVILS TOWER, WY

pH Time Series

Analysis Period: 05/06/2019 to 11/05/2019

Analysis:

Record: May 6 to Nov. 5 the temperature record was complete and satisfactory with the following exceptions:

Aug. 5, 6, 10, Sept. 19 to 23, Oct. 28 to 30, and Nov. 1 to 5 when the DCP malfunctioned and no data were transmitted or logged.

Site characteristics: The channel is straight for 290 ft upstream and 240 ft downstream. The bed consists of silt and cobble. During the summer months algae can be prevalent. The banks consist of heavy grass at times and increase slightly in elevation. All flow will be in one channel.

Instrumentation: Sutron Satlink3 HDR DCP, Sutron Bubbler with an Acubar transducer, and YSI multi-parameter water-quality sensor are deployed to measure, log, and transmit the following data: stage, water temperature, specific conductance, pH, and dissolved oxygen. The DCP and one 12-volt batteries are housed in two small metal boxes. The boxes are attached to the bridge's concrete superstructure, located on the left, upstream side of the bridge. The pressure transducer and water-quality sensor cables are encased in 1 1/4-in vinyl pipe from the gage boxes to the riverbank. At the riverbank, the cables are transitioned into a 4-in PVC pipe to facilitate easy deployment of the water-quality sonde and the pressure transducer. A solar panel and YAGI antenna are mounted on a section of 2-in galvanized-steel pipe that is attached to the bridge adjacent to the gage boxes. The outside-gage reference is provided by a wire-weight gage deployed on the downstream-side bridge guard rail.

Sampling location: It is under the bridge on State Highway 110.

Field Visits: During the period of record inspections were completed May 6, June 5, July 9, Aug. 6, 29, Sept. 19, 23, and Nov. 5.

Deletions: During the period of analysis, erroneous values were often deleted when the sonde was serviced during inspections. Erroneous data were also deleted on many days associated with temporary fouling.

Data were deleted July 8, 9, Aug. 2 to 5, and Aug. 15 to 29 due to fouling greater than the published criteria of deletion (0.8 units).

Fouling Corrections: During the period of analysis, fouling corrections ranged from -0.05 to +1.49 units. May 6 to July 7 no fouling corrections were applied. Fouling indicated July 9 (+0.23 units) was initiated July 7 and prorated to the inspection. Data were deleted July 8 and 9, as data was suspect during much of the period of fouling.

Aug. 29 a 1.49-unit fouling correction was indicated. This correction was not applied as fouling was abrupt and appeared to appear Aug. 16. Data were deleted Aug. 16 to 29 due to this fouling.

Sept. 19 a 0.33-unit fouling correction was indicated prior to cleaning. No obvious event caused fouling. Therefore, the correction was prorated by time between inspections on Aug. 29 and Sept. 19.

Nov. 5 DCP was found malfunctioning. After it was repaired the a minimal-fouling correction (0.06 units) was indicated. No correction was applied Sept. 19 to Nov. 5.

Calibration Drift Corrections: The sonde was calibrated on all visits with exception of the visit on Sept. 23. No drift corrections were applied, as the sonde was found reading well within published criteria for drift correction.

Other Corrections: None.

Cross-section surveys: Cross-sectional surveys were completed May 6, June 5, July 9, Aug. 6, 29, Sept 19, and Nov. 5.

Vertical profiles: None.

Remarks: Records good except for those Aug. 1 to Sept. 19, which are fair.

Analysis for this period last updated 3/26/2020 3:24:19 PM by ejblajsz

Analyzed By: ejblajsz

Date: 03/26/2020

Approved By: rwoodruf

Date: 03/26/2020

Analysis Period: 04/09/2019 to 05/06/2019

Analysis:

Record: Apr. 19 to May 6, 2019

Site characteristics: The channel is straight for 290 ft upstream and 240 ft downstream. The bed consists of silt and cobble. During the summer months algae can be prevalent. The banks consist of heavy grass at times and increase slightly in elevation. All flow will be in one channel.

Instrumentation: Sutron Satlink3 HDR DCP, Sutron Bubbler with a Acubar transducer, and YSI multi-parameter water-quality sensor are deployed to measure, log, and transmit the following data: stage, water temperature, specific conductance, pH, and dissolved oxygen. The DCP and one 12-volt batteries are housed in two small metal boxes. The boxes are attached to the bridge's concrete superstructure, located on the left, upstream-side of the bridge. The pressure transducer and water-quality sensor cables are encased in 1 1/4-in vinyl pipe from the gage boxes to the river bank. At the river bank, the cables are transitioned into a 4-in PVC pipe to facilitate easy deployment of the water-quality sonde and the pressure transducer. A solar panel and YAGI antenna are mounted on a section of 2-in galvanized-steel pipe that is attached to the bridge adjacent to the gage boxes. The outside-gage reference is provided by a wire-weight gage deployed on the downstream-side bridge guard rail.

Sampling location: It is under the bridge on State Highway 110.

Field Visits: Gages were reactivated on Apr. 9 and visited on Apr. 25, May 2, and May 6.

Deletions: Record was deleted on Apr. 25 and Apr. 30 to May 2 when the sonde was out of the water and May 2–6 when the parameter on the DCP was not set correctly.

Fouling Corrections: Fouling corrections ranged from -0.01 to $+0.02$ units and were not applied as they are within acceptable limits except for Apr. 25 when the sonde was out of the water.

Calibration Drift Corrections: The sonde was calibrated on all visits and corrections ranged from -0.04 to $+0.06$ units and are within acceptable limits, so no correction was applied.

Other Corrections: None.

Cross-section surveys: May 2.

Vertical profiles: None.

Remarks: Records good.

Analysis for this period last updated 5/8/2019 11:45:35 AM by krwatson

Analyzed By: krwatson

Date: 05/08/2019

Approved By: rwoodruff

Date: 03/26/2020

06427850 BELLE FOURCHE RIVER AT DEVILS TOWER, WY

Specific Conductance Time Series

Analysis Period: 05/06/2019 to 11/05/2019

Analysis:

Record: May 6, 2019 to Nov. 5, 2019 the DCP provided a complete and satisfactory record of specific conductivity with the following exceptions:

The DCP malfunctioned and no data were transmitted or logged on April 30 to May 2, Aug. 5, 6, 10, Sept. 19 to 23, Oct. 28, 29, 30, and Nov. 1 to 5.

Site characteristics: The channel is straight for 290 ft upstream and 240 ft downstream. The bed consists of silt and cobble. During the summer months algae can be prevalent. The banks consist of heavy grass at times and increase slightly in elevation. All flow will be in one channel.

Instrumentation: Sutron Satlink3 HDR DCP, Sutron Bubbler with a Acubar transducer, and YSI multi-parameter water-quality sensor are deployed to measure, log, and transmit the following data: stage, water temperature, specific conductance, pH, and dissolved oxygen. The DCP and one 12-volt batteries are housed in two small metal boxes. The boxes are attached to the bridge's concrete superstructure, located on the left, upstream side of the bridge. The pressure transducer and water-quality sensor cables are encased in 1 1/4-in vinyl pipe from the gage boxes to the riverbank. At the riverbank, the cables are transitioned into a 4-in PVC pipe to facilitate easy deployment of the water-quality sonde and the pressure transducer. A solar panel and YAGI antenna are mounted on a section of 2-in galvanized-steel pipe that is attached to the bridge adjacent to the gage boxes. The outside-gage reference is provided by a wire-weight gage deployed on the downstream-side bridge guard rail.

Sampling location: It is under the bridge on State Highway 110.

Field Visits: Field visits, during the period record, were made on the following days: May 6, June 5, July 9, Aug. 6, 29, Sept. 19, 23, and Nov. 5.

Deletions: Record was deleted during the servicing of the specific conductance sonde on May 6, June 5, July 9, Aug. 29, and Sept. 19.

Spikes were deleted due to temporary fouling on many days. In most cases fouling was short lived and was associated with floating algae catching on the sonde pipe. Oct. 22 to 24 data were deleted due to fouling (likely due to slush ice). The fouling during this period was less than the published threshold of deletion. However, it was suspect when compared to surrounding data, and record were deleted.

Fouling Corrections: May 6 to Nov. 5 fouling corrections ranged from 0.19 to 14.2%.

May 6 a +0.19 ft fouling correction was indicated prior to cleaning. This was well within published criteria and no correction was applied. On June 5 a 6.5% fouling correction was indicated by unit values and applied. Fouling was initiated with a peak in stage that occurred May 22.

July 9 a 14.2% fouling correction was indicated and applied. Fouling was associated with a peak that occurred June 30. Fouling was subsequently prorated from June 30 to July 9.

Aug. 6 a 6.44% fouling correction was indicated. The DCP malfunctioned just prior to visit. It was assumed all fouling was present prior to DCP malfunction. The fouling was timed with a peak that occurred on July 17.

On Aug. 19 and Sept. 19 fouling corrections were relatively minor. Aug. 29 a 2.7% fouling correction was indicated. This was within published criteria of correction. However, to maintain continuity of record the correction was applied as indicated and was initiated with a peak. On Sept. 19 a 6.6% fouling correction was applied as indicated. As no significant peak occurred, the correction was prorated between inspections.

The DCP abruptly malfunctioned on Sept. 19 and no data were received. On Sept. 23 the DCP was repaired and sonde cleaned. On Nov. 5 a 5.87% fouling correction was indicated. However, the DCP malfunctioned prior to the inspection and no data were recorded after Oct. 30. Indicated fouling Nov. 5 was most likely due to slush on the sonde and was thought to occur in the period of record that was missing. Therefore, no fouling correction was applied Sept. 23 to Nov. 5.

Calibration Drift Corrections: The sonde calibration was checked during all inspections except for Sept. 23. Indicated-drift corrections were minor, ranging from -1.9% to 1.4%. All drift corrections were within published criteria for correction. However, June 5, Aug. 29, and Sept. 19 drift corrections were applied. Application of drift corrections were considered reasonable as the sonde was re-calibrated during each inspection.

Aug. 29 a -1.2% drift correction was indicated during inspection. However, to maintain continuity of record a -0.8% correction was applied.

Other Corrections: None.

Cross-section surveys: Cross-sectional surveys were completed May 6, June 5, July 9, Aug. 6, 29, Sept. 19 and Nov. 5.

Vertical profiles: None.

Remarks: Records are good except for those June 30 to July 9, which are fair.

Analysis for this period last updated 3/26/2020 12:36:44 PM by ejblajsz

Analyzed By: ejblajsz

Date: 03/26/2020

Approved By: rwoodruf

Date: 03/26/2020

Analysis Period: 04/09/2019 to 05/06/2019

Analysis:

Record: Apr. 19 to May 6, 2019

Site characteristics: The channel is straight for 290 ft upstream and 240 ft downstream. The bed consists of silt and cobble. During the summer months algae can be prevalent. The banks consist of heavy grass at times and increase slightly in elevation. All flow will be in one channel.

Instrumentation: Sutron Satlink3 HDR DCP, Sutron Bubbler with a Acubar transducer, and YSI multi-parameter water-quality sensor are deployed to measure, log, and transmit the following data: stage, water temperature, specific conductance, pH, and dissolved oxygen. The DCP and one 12-volt batteries are housed in two small metal boxes. The boxes are attached to the bridge's concrete superstructure, located on the left, upstream-side of the bridge. The pressure transducer and water-quality sensor cables are encased in 1 1/4-in vinyl pipe from the gage boxes to the river bank. At the river bank, the cables are transitioned into a 4-in PVC pipe to facilitate easy deployment of the water-quality sonde and the pressure transducer. A solar panel and YAGI antenna are mounted on a section of 2-in galvanized-steel pipe that is attached to the bridge adjacent to the gage boxes. The outside-gage reference is provided by a wire-weight gage deployed on the downstream-side bridge guard rail.

Sampling location: It is under the bridge on State Highway 110.

Field Visits: Gages were reactivated on Apr. 9 and visited on Apr. 25, May 2, and May 6.

Deletions: Record was deleted during the servicing of the specific conductance sonde on Apr. 9 and May 2, 6.

Fouling Corrections: All fouling corrections ranged from -0.19 to +0.19 percent and they were not applied except for Apr. 25 when the sonde was found out of the water.

Calibration Drift Corrections: The sonde calibration was checked on Apr. 25, May 2, 6 and no calibration was needed.

Other Corrections: None.

Cross-section surveys: May 2.

Vertical profiles: None.

Remarks: Records are good.

Analysis for this period last updated 5/8/2019 11:25:33 AM by krwatson

Analyzed By: krwatson

Date: 05/08/2019

Approved By: rwoodruff

Date: 03/26/2020

06427850 BELLE FOURCHE RIVER AT DEVILS TOWER, WY

Water Temperature Time Series

Analysis Period: 05/06/2019 to 11/05/2019

Analysis:

Record: May 6 to Nov. 5 the temperature record was complete and satisfactory with the following exceptions:

Aug. 5, 6, 10, Sept. 19 to 23, Oct. 28 to 30, and Nov. 1 to 5 when the DCP malfunctioned and no data were transmitted or logged.

Site characteristics: The channel is straight for 290 ft upstream and 240 ft downstream. The bed consists of silt and cobble. During the summer months algae can be prevalent. The banks consist of heavy grass at times and increase slightly in elevation. All flow will be in one channel.

Instrumentation: Sutron Satlink3 HDR DCP, Sutron Bubbler with an Acubar transducer, and YSI multi-parameter water-quality sensor are deployed to measure, log, and transmit the following data: stage, water temperature, specific conductance, pH, and dissolved oxygen. The DCP and one 12-volt batteries are housed in two small metal boxes. The boxes are attached to the bridge's concrete superstructure, located on the left, upstream side of the bridge. The pressure transducer and water-quality sensor cables are encased in 1 1/4-in vinyl pipe from the gage boxes to the riverbank. At the riverbank, the cables are transitioned into a 4-in PVC pipe to facilitate easy deployment of the water-quality sonde and the pressure transducer. A solar panel and YAGI antenna are mounted on a section of 2-in galvanized-steel pipe that is attached to the bridge adjacent to the gage boxes. The outside-gage reference is provided by a wire-weight gage deployed on the downstream-side bridge guard rail.

Sampling location: It is under the bridge on State Highway 110.

Field Visits: During the period of record inspections were completed May 6, June 5, July 9, Aug. 6, 29, Sept. 19, 23, and Nov. 5.

Deletions: Erroneous readings were often deleted while the sonde was serviced during site visits. Also, erroneous values were screened by either threshold suppression or manual deletion on many days. Temperature data recorded 0.0 for many of the erroneous deletions. This was thought to be a contributing factor when the DCP would malfunction. The Sonde seemed to lock up when this occurred.

Fouling Corrections: Indicated-fouling corrections during the period of analysis were minor ranging from -0.6 to +0.09. All fouling corrections were well within published criteria of correction and no fouling corrections were applied. On Nov. 5 a +0.6 C correction was indicated. This was not applied as the sonde was malfunctioning upon arrival, and slush was causing to be slightly unstable.

Calibration Drift Corrections: Temperature checks of the sonde were completed prior to install (March 25) and after removal for the season (Dec. 3). The thermistor was found reading within acceptable limits and no drift corrections were applied during the period of analysis.

Other Corrections: None.

Cross-section surveys: Cross-sectional surveys were completed May 6, June 5, July 9, Aug. 6, 29, Sept 19, and Nov. 5.

Vertical profiles: None.

Remarks: Records are good.

Analysis for this period last updated 3/26/2020 2:25:04 PM by ejblajsz

Analyzed By: ejblajsz

Date: 03/26/2020

Approved By: rwoodruf

Date: 03/26/2020

Analysis Period: 11/01/2016 to 05/06/2019

Analysis:

Record: Apr. 19 to May 6, 2019

Site characteristics: The channel is straight for 290 ft upstream and 240 ft downstream. The bed consists of silt and cobble. During the summer months algae can be prevalent. The banks consist of heavy grass at times and increase slightly in elevation. All flow will be in one channel.

Instrumentation: Sutron Satlink3 HDR DCP, Sutron Bubbler with a Acubar transducer, and YSI multi-parameter water-quality sensor are deployed to measure, log, and transmit the following data: stage, water temperature, specific conductance, pH, and dissolved oxygen. The DCP and one 12-volt batteries are housed in two small metal boxes. The boxes are attached to the bridge's concrete superstructure, located on the left, upstream-side of the bridge. The pressure transducer and water-quality sensor cables are encased in 1 1/4-in vinyl pipe from the gage boxes to the river bank. At the river bank, the cables are transitioned into a 4-in PVC pipe to facilitate easy deployment of the water-quality sonde and the pressure transducer. A solar panel and YAGI antenna are mounted on a section of 2-in galvanized-steel pipe that is attached to the bridge adjacent to the gage boxes. The outside-gage reference is provided by a wire-weight gage deployed on the downstream-side bridge guard rail.

Sampling location: It is under the bridge on State Highway 110.

Field Visits: Gages were reactivated on Apr. 9 and visited on Apr. 25, May 2, and May 6.

Deletions: Temperature data was deleted on Apr. 25 and Apr. 30 to May 2 when the sonde was out of the water.

Fouling Corrections: No fouling corrections applied.

Calibration Drift Corrections: No drift corrections applied.

Other Corrections: None.

Cross-section surveys: Cross section was completed on May 2.

Vertical profiles: None.

Remarks: Records are good.

Analysis for this period last updated 5/8/2019 11:17:15 AM by krwatson

Analyzed By: krwatson

Date: 05/08/2019

Approved By: rwoodruff

Date: 03/26/2020

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 109/184005, August 2022

National Park Service
U.S. Department of the Interior



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