Priority Watershed Water Quality Evaluation for the Pine River Watershed, Waushara County, Wisconsin

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EGAD #3200-2020-02

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Purpose

This project evaluated water quality improvements made in the Pine River Watershed from Best Management Practices installed in the watershed from 1996 through 2002 as part of the Pine River/Willow Creek Priority Watershed Project. This project determined if the goals of the Priority Watershed Project to protect and improve the watershed water quality were met by collecting fish, aquatic macroinvertebrate, habitat, temperature, dissolved oxygen, and inorganic chemistry information throughout the watershed. The monitoring in this project supports the efforts of partners to write and implement a USEPA-approved Nine Key Element Plan (9KE) to reduce sediment and nutrients reaching waterbodies within the Pine River Watershed in the future.

Methods

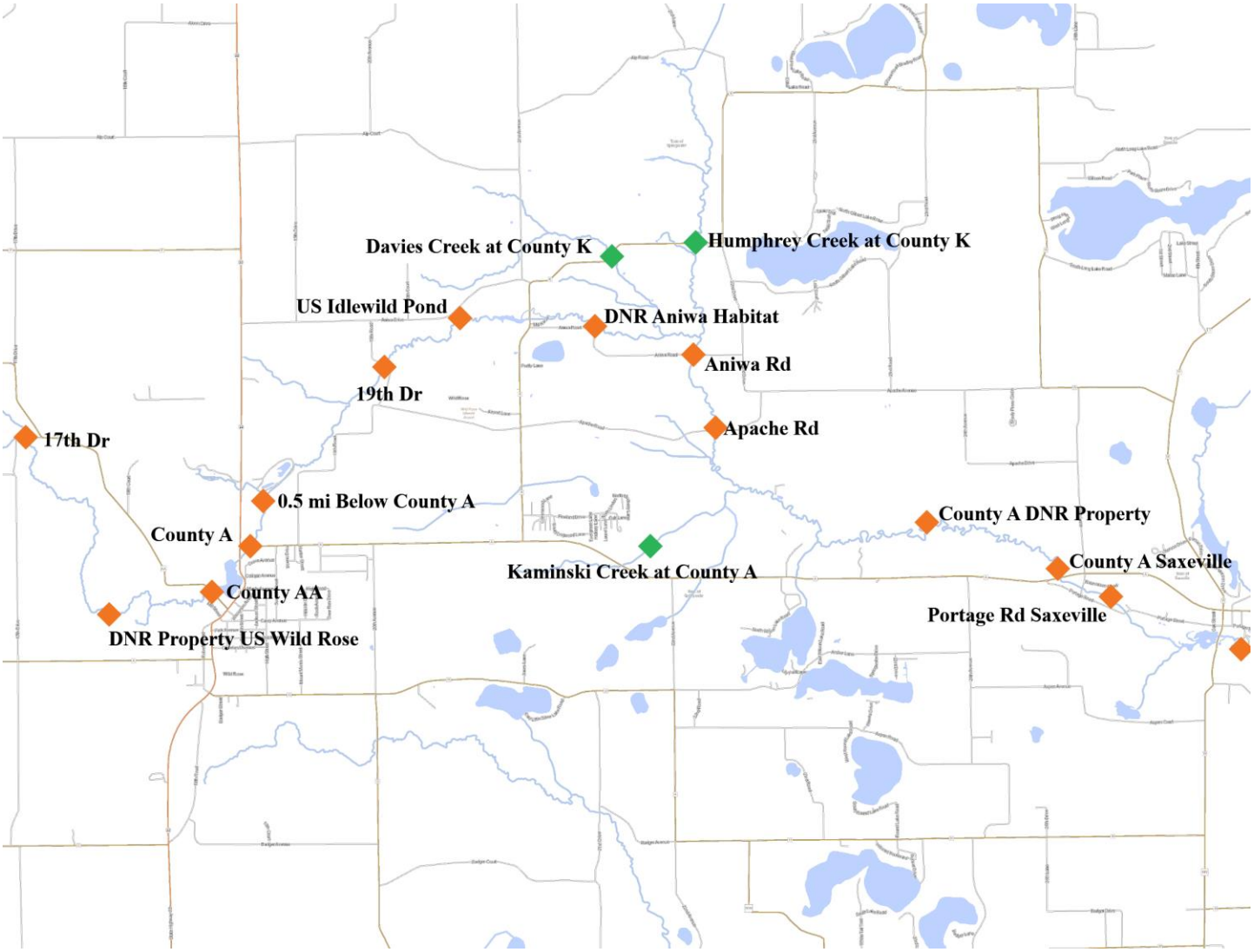
During the growing season of 2018, Total Phosphorus (TP) samples were collected at 11 locations once per month from May through October (Table 1, Map 1-2). Neither baseflow nor storm or snowmelt event sampling were targeted during this monthly monitoring, following the protocol of Wisconsin Consolidated Assessment and Listing Methodology (WisCALM 2018). In addition to the monthly TP samples, TP, Total Dissolved Phosphorus (TDP), Dissolved Nitrate + Nitrite as Nitrogen (NO_3+NO_2 as N), Ammonia (NH3), Total Suspended Solids (TSS), and Biological Oxygen Demand (BOD) samples were collected during 2 rain or snowmelt events between March and June 2018 at 11 locations in Table 1. Thirdly, winter baseflow NO_3+NO_2 as N samples were collected in March 2019 at 20 locations listed in Table 2 when the ground was frozen and as little influence from surface runoff inputs were expected (Map 1-2). All samples were collected using the standard WDNR grab sampling method for a total of 104 samples (WDNR 2015). All nutrient samples were shipped to Wisconsin State (WISLOH) for analysis. The WISLOH entered all sample analysis data into the WDNR Surface Water Integrated Monitoring System (SWIMS) database.

SWIMS Station ID	Site Name	Surface Water WBIC
703070	Pine River at 17th Drive	247800
703106	Pine River at DNR Property US Wild Rose	247800
10016425	Pine River at County A Saxeville	247800
703107	Pine River at 26th Road	247800
703063	Pine River at 28th Ct	247800
10032735	Pine River at Hwy 49	247800
10050462	Pine River at Farm Bridge	247800
10022011	Davies Creek at County K	250800
10007897	Humphrey Creek at County K	250500
10020683	Carpenter Creek at County NN	248800
10049901	Mud Creek at County H	247900

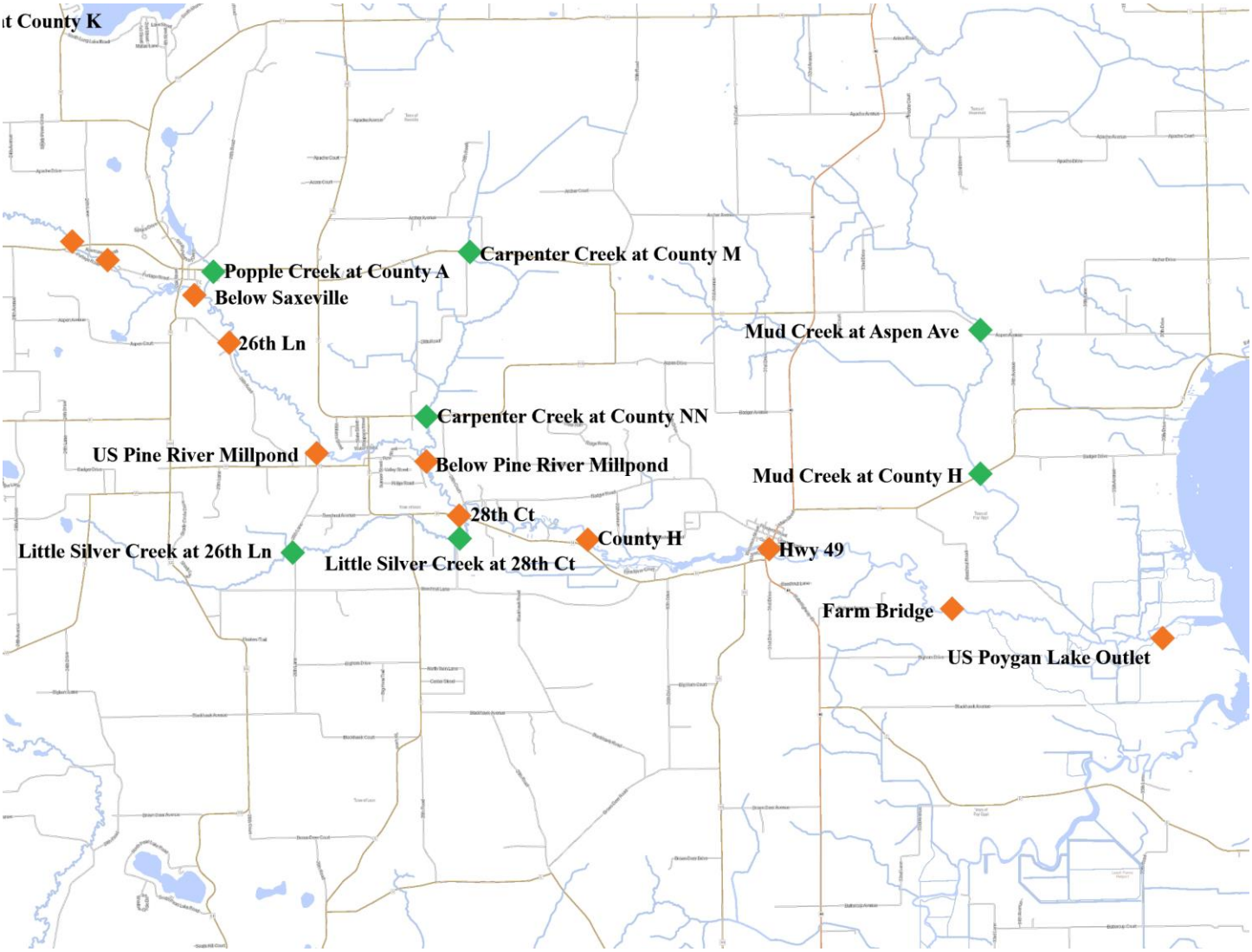
Table 1: Growing Season and Event Inorganic Chemistry Monitoring Sites Sampled in the Pine River Watershed in 2018.

SWIMS Station ID	Site Name	Surface Water WBIC
703070	Pine River at 17th Drive	247800
703106	Pine River at DNR Property US Wild Rose	247800
703047	Pine River- Above Hwy A	247800
703073	Pine River at 19th Drive	247800
10007883	Pine River at Apache Road	247800
10016425	Pine River at County A Saxeville	247800
10034803	Pine River Below Saxeville Dam	247800
703107	Pine River at 26th Road	247800
10051490	Pine River DS Pine River Millpond	247800
10039602	Pine River US Poy Sippi Millpond	247800
10032735	Pine River at Hwy 49	247800
10022011	Davies Creek at County K	250800
10007897	Humphrey Creek at County K	250500
703082	Kaminski Creek at County A	250100
10048955	Popple Creek at Cth A	249200
10020685	Carpenter Creek at County M	248800
10020683	Carpenter Creek at County NN	248800
10007905	Little Silver Creek at 26th Ln	248600
10015814	Little Silver Creek at 28th Court	248600
10049901	Mud Creek at County H	247900

Table 2: Winter Baseflow NO_3+NO_2 as N Monitoring Sites Sampled in the Pine River Watershed in March 2019.



Map 1: Western Pine River Watershed Sample Locations. (Orange locations indicate Pine River monitoring sites, green locations indicate tributary monitoring sites).



Map 1: Western Pine River Watershed Sample Locations. (Orange locations indicate Pine River monitoring sites, green locations indicate tributary monitoring sites).

In October 2019, twenty-five locations were sampled for aquatic macroinvertebrates (Table 3, Map 1-2). All sites were sampled using the WDNR *Guidelines for the Standard Collection of Macroinvertebrate Samples from Wadable Streams v2.0* (WDNR 2017). A D-shaped kicknet with 600 micron mesh was used at all sites by standing upstream from the net and placing it firmly on the stream bed while digging into the substrate with the heel or toe to free the macroinvertebrates from the substrate. Riffles were targeted at each of the sites, but if none were present then, available gravel, overhanging vegetation, woody debris, or other vegetation would be sampled. For a representative sample of the aquatic macroinvertebrate community, a minimum of 100 aquatic macroinvertebrates collected in each sample was targeted. The aquatic macroinvertebrates were preserved in a 70-80% ethanol solution inside quart "Mason" jars. If necessary, multiple "Mason" jars were used per sample depending upon how much sediment and organic material was collected with the aquatic macroinvertebrates. Within the next 24 hours, the samples were re-preserved with another 70-80% ethanol solution. Samples were taken to the UWSP Aquatic Biomonitoring Laboratory (ABL) for lowest possible taxonomic identification. Staff at the ABL entered the data into the SWIMS database in 2019.

SWIMS Station ID	Site Name	Surface Water WBIC
703070	Pine River at 17th Drive	247800
703106	Pine River at DNR Property US Wild Rose	247800
703071	Pine River at CTH AA	247800
703047	Pine River- Above Hwy A	247800
703049	Pine River .5 mi below A	247800
703073	Pine River at 19th Drive	247800
10050198	Pine River US Idlewild Millpond	247800
10049174	Pine River-Aniwa Habitat Site	247800
10037927	Pine River at Aniwa Road	247800
10007883	Pine River at Apache Road	247800
10022005	Pine River CTH A DNR Property	247800
10016425	Pine River at County A Saxeville	247800
10029791	Pine River Portage Road Saxeville	247800
10034803	Pine River Below Saxeville Dam	247800
703107	Pine River at 26th Road	247800
10007978	Pine River US Pine River Millpond	247800
703063	Pine River at 28th Ct	247800
10032735	Pine River at Hwy 49	247800
10050462	Pine River at Farm Bridge	247800
10007897	Humphrey Creek at County K	250500
10048955	Popple Creek at Cth A	249200
10020685	Carpenter Creek at County M	248800
10020683	Carpenter Creek at County NN	248800
10007905	Little Silver Creek at 26th Ln	248600
10049901	Mud Creek at County H	247900

Table 3: Aquatic Macroinvertebrate Monitoring Locations Sampled in the Pine River Watershed in 2018.

Between July and September 2018, wadable fish surveys were conducted at 20 sites (Table 4, Map 1-2). The 20 wadable fish surveys were conducted following the WDNR *Guidelines for Assessing Fish Communities of Wadable Streams in Wisconsin v2.0* (WDNR 2018). All 20 wadable sites were surveyed in July through September 2018 during the guidance-recommended summer time survey period. Water chemistry data was recorded at each wadable site prior to conducting the fish survey. The wadable fish survey stations were a minimum of 35 times the mean stream width (overall minimum of 100 meters, overall maximum of 400 meters). An otter sled stream shocker with a 4000 Peak Watt generator was used for 16 of the 20 wadable sites with appropriate stream width and/or depth. A 12 Volt, 18 Amp Hour battery-powered backpack shocker was used for 4 of the 20 sites based upon the streams' smaller width and depth. Catch per effort sampling procedures were used for this project (no particular species was targeted, all captured). A single upstream pass was made using 0.125-inch mesh nets to collect the fish. At the end of the station, captured fish were identified and counted and all game fish were measured for length. Once all data was collected, the fish were returned to the creek. In addition to the wadable fish surveys, a non-wadable fish survey was conducted near the outlet of the Pine River to Lake Poygan (Table 4). The fish survey at the mouth of the Pine River was conducted following the *Guidelines for Assessing Fish Communities of Non-Wadeable Rivers in Wisconsin v2*.0 (WDNR 2019). The non-wadable fish survey protocol requires a flat-bottom, mini-boom boat with a single anode 3-4 meters off the front. The survey is conducted by moving the boat downstream from a starting point and proceeding 1600 meters (1 mile) to an endpoint. One person at the front of the boat, using a net of 3/8" bar mesh, attempts to capture all fish seen. Netted fish are placed in a holding tank until weight, length, and species can be determined. Processed fish are then returned to the river. Fish survey data was entered into the WDNR Fisheries and Habitat Management Database (FHMD) by WDNR Water Resources staff (except non-wadable).

SWIMS Station ID	Site Name	Surface Water WBIC
703070	Pine River at 17th Drive	247800
703071	Pine River at CTH AA	247800
703047	Pine River- Above Hwy A	247800
703073	Pine River at 19th Drive	247800
10037927	Pine River at Aniwa Road	247800
10007883	Pine River at Apache Road	247800
10022005	Pine River CTH A DNR Property	247800
10016425	Pine River at County A Saxeville	247800
10034803	Pine River Below Saxeville	247800
703107	Pine River at 26th Road	247800
10051490	Pine River Downstream Pine River Millpond	247800
N/A	Pine River Above Lake Poygan Confluence	247800
10022011	Davies Creek at County K	250800
10007897	Humphrey Creek at County K	250500
703082	Kaminski Creek at Cty A	250100
10048955	Popple Creek at Cth A	249200
10020685	Carpenter Creek at County M	248800
10020683	Carpenter Creek at County NN	248800
10007905	Little Silver Creek at 26th Ln	248600
10007907	Little Silver Creek at 28th Ct	248600
10044266	Mud Creek at Aspen Ave	247900

Table 4: Wadable Fish Survey Locations Sampled in the Pine River Watershed between July and September 2018.

Quantitative habitat surveys were conducted at 13 locations in the Pine River Watershed between August and November 2018 (Table 5, Map 1-2). All sites were surveyed following the WDNR *Guidelines for Evaluating Habitat of Wadable Streams* (WDNR 2002). Each quantitative habitat survey station length was 35 times the mean stream width of the survey station. Following the determination of station length, the station was divided into 12 transects. At each transect, substrate, sedimentation, erosion, water depth, and riparian land use data were collected. WDNR Water Resources staff entered the quantitative habitat data into the FHMD.

SWIMS Station ID	Site Name	Surface Water WBIC
703070	Pine River at 17th Drive	247800
703071	Pine River at CTH AA	247800
703073	Pine River at 19th Drive	247800
10007883	Pine River at Apache Road	247800
10016425	Pine River at County A	247800
10022011	Davies Creek at County K	250800
10007897	Humphrey Creek at County K	250500
703082	Kaminski Creek at Cty A	250100
10048955	Popple Creek at Cth A	249200
10020685	Carpenter Creek at County M	248800
10020683	Carpenter Creek at County NN	248800
10007905	Little Silver Creek at 26th Ln	248600
10007907	Little Silver Creek at 28th Ct	248600

Table 5: Quantitative Habitat Survey Locations in the Pine River Watershed Conducted in 2018.

Onset Hobo Pendant thermistors were deployed to collect in-stream temperature data from June through September 2018 at 21 locations in the Pine River Watershed (Table 6, Map 1-2). The temperature monitoring equipment in Carpenter Creek at County NN malfunctioned in 2018, so equipment was redeployed in 2019 (Table 15). The thermistor from the Pine River below Saxeville was lost in 2018, so equipment was redeployed in 2019 as well (Table 15). Temperature measurements were taken once per hour at each location from June through September. Temperature measurements were taken with an Onset Hobo Pendant thermistor attached to a fence post driven into the stream bed of the creek or river. The thermistor was attached to the fence post in such a manner as to suspend the thermistor in the water column low enough to stay under water in low flow conditions and high enough to not get buried in bottom substrate (~ 6 inches above the bottom). The thermistor was placed in a shaded location when possible. Temperature data were uploaded into the SWIMS database by WDNR Water Resources staff.

SWIMS Station ID	Site Name	Surface Water WBIC
703070	Pine River at 17th Drive	247800
703106	Pine River at DNR Property US Wild Rose	247800
703073	Pine River at 19th Drive	247800
10007883	Pine River at Apache Road	247800
10016425	Pine River at County A	247800
10034803	Pine River Below Saxeville	247800
703107	Pine River at 26th Road	247800
10051490	Pine River Downstream Pine River Millpond	247800
703063	Pine River at 28th Ct	247800
10039602	Pine River Upstream Poy Sippi Millpond	247800
10032735	Pine River at Hwy 49	247800
10050462	Pine River at Farm Bridge	247800
10022011	Davies Creek at County K	250800
10007897	Humphrey Creek at County K	250500
703082	Kaminski Creek at Cty A	250100
10048955	Popple Creek at Cth A	249200
10020685	Carpenter Creek at County M	248800
10020683	Carpenter Creek at County NN	248800
10007905	Little Silver Creek at 26th Ln	248600
10015814	Little Silver Creek at 28th Ct	248600
10049901	Mud Creek at County H	247900

Table 6: Temperature Monitoring Locations in the Pine River Watershed Sampled from June through September 2018.

Between July and September 2018, a continuous dissolved oxygen (DO) meter was deployed in the Pine River at 2 locations and 3 other streams (Table 7, Map 1-2). The DO meter recorded DO concentration (mg/L) and DO% Saturation, along with temperature, pH, and conductivity, every hour for a 5-day period beginning at midnight the first day.

SWIMS Station ID	Site Name	Surface Water WBIC
10016425	Pine River at County A Saxeville	247800
703063	Pine River at 28th Ct	247800
10022011	Davies Creek at County K	250800
10007897	Humphrey Creek at County K	250500
10020683	Carpenter Creek at County NN	248800

Table 7: Dissolved Oxygen Meter 5-Day Deployment Locations

Results

The 2018 TP sample analysis results in the Pine River Watershed ranged from 0.0147 mg/L in the Pine River at the DNR Property upstream of Wild Rose in September to 0.305 mg/L in Mud Creek at County H in June (Table 8-9, Chart 1-2). The TP sample analysis results in the Pine River mainstem ranged from 0.0147 mg/L in the DNR Property upstream of Wild Rose in September to 0.179 mg/L at 17th Drive in June (Table 8, Chart 1). All 7 locations in the Pine River mainstem had an average TP concentration below the Wisconsin Administrative Code ch. NR 102.06(3)(b) water quality criteria (WQC) for creeks and rivers at 0.075 mg/L. The average TP concentrations for the 7 mainstem sites in this project ranged from 0.0267 mg/L at the DNR Property upstream of Wild Rose to 0.0702 mg/L at 17th Drive (Table 8, Chart 1). The 4 tributaries to the Pine River had TP concentrations ranging from 0.0155 mg/L in Davies Creek at County K in May to 0.305 mg/L in

Mud Creek at County H in June (Table 9, Chart 2). The average TP concentration in the tributaries ranged from 0.0394 in Davies Creek to 0.1656 in Mud Creek in 2018 (Table 9, Chart 2). Davies and Humphrey Creeks had an average TP concentration below the WQC, while Carpenter and Mud Creeks averaged above. Carpenter and Mud Creeks were sampled in May, June, August and October 2018 for TP.

	Pine at 17th Drive	Pine at DNR Property US Wild Rose	Pine at County A Saxeville	Pine at 26th Road	Pine at 28th Court	Pine at Hwy 49	Pine at Farm Bridge
May	0.0437	0.0156	0.0375	0.0346	0.0446	0.0454	0.0510
June	0.179	0.0706	0.0685	0.0923	0.0818	0.113	0.112
July	0.0660	0.0154	0.0255	0.0238	0.0351	0.0475	0.0440
Aug.	0.0651	0.0152	0.0210	0.0242	0.0347	0.0422	0.0354
Sept.	0.0475	0.0147	0.0264	0.0289	0.0432	0.0446	0.0522
Oct.	0.0198	0.0287	0.0250	0.0275	0.0275	0.0161	0.0165
Avg.	0.0702	0.0267	0.034	0.0386	0.0445	0.0515	0.0519

Table 8: Total Phosphorus Concentrations and Averages (mg/L) of Samples Collected in the Pine River Mainstem in 2018 Upstream (left) to Downstream (right).

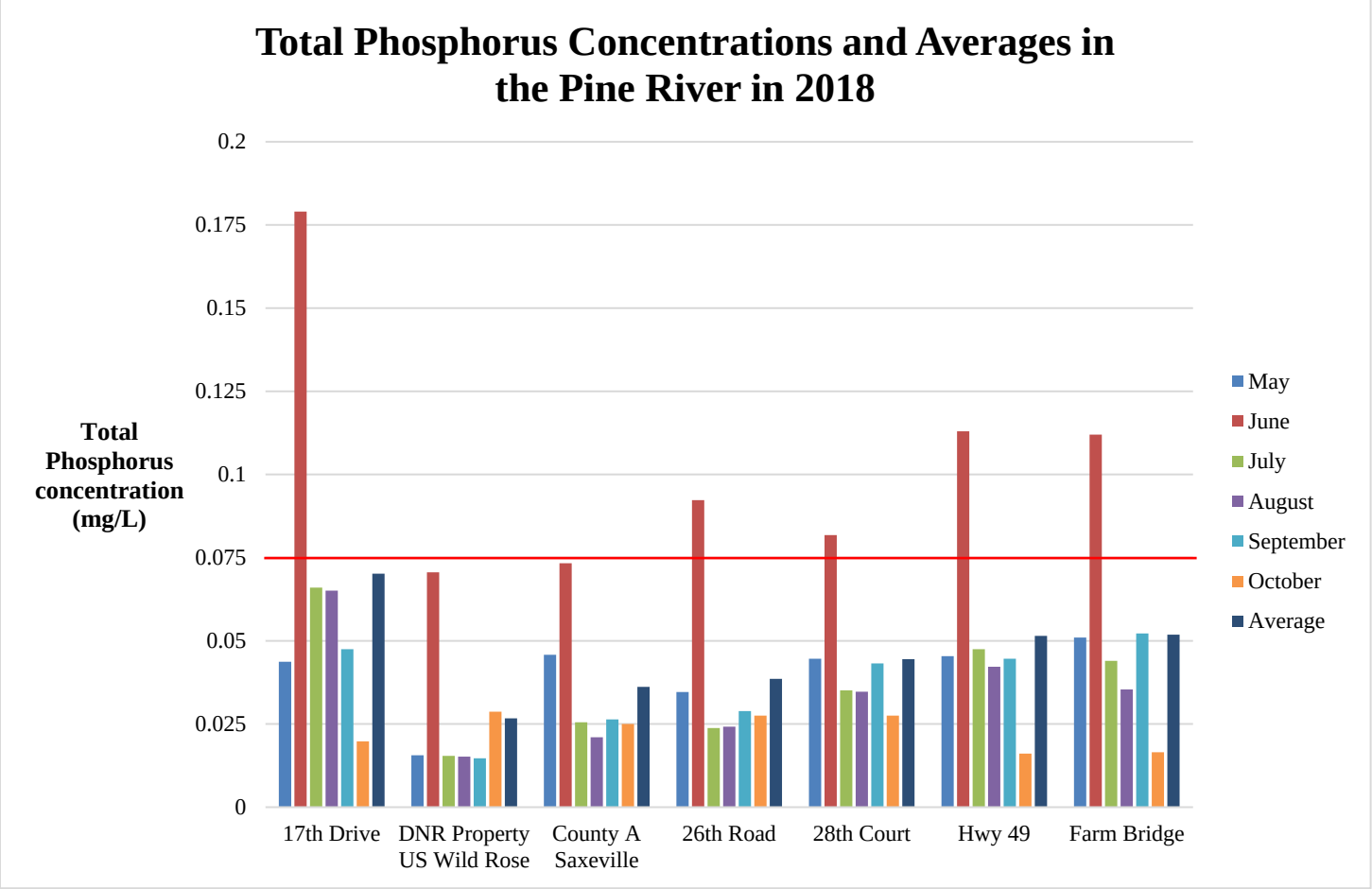


Chart 1: Total Phosphorus Concentrations and Averages of Samples Collected in the Pine River Mainstem in 2018 (with 0.075 mg/L WQC red line) Upstream (left) to Downstream (Right).

	Davies Creek at County K	Humphrey Creek at County K	Carpenter Creek at County NN	Mud Creek at County H
May	0.0155	0.0535	0.0913	0.175
June	0.133	0.160	0.209	0.305
July	0.0301	0.0384	N/A	N/A
Aug.	0.0194	0.0309	0.0184	0.157
Sept.	0.0162	0.0362	N/A	N/A
Oct.	0.0221	0.0351	0.0355	0.0254
Avg.	0.0394	0.059	0.0886	0.1656

Table 9: Total Phosphorus Concentrations and Averages (mg/L) of Samples Collected in Tributaries to the Pine River in 2018.

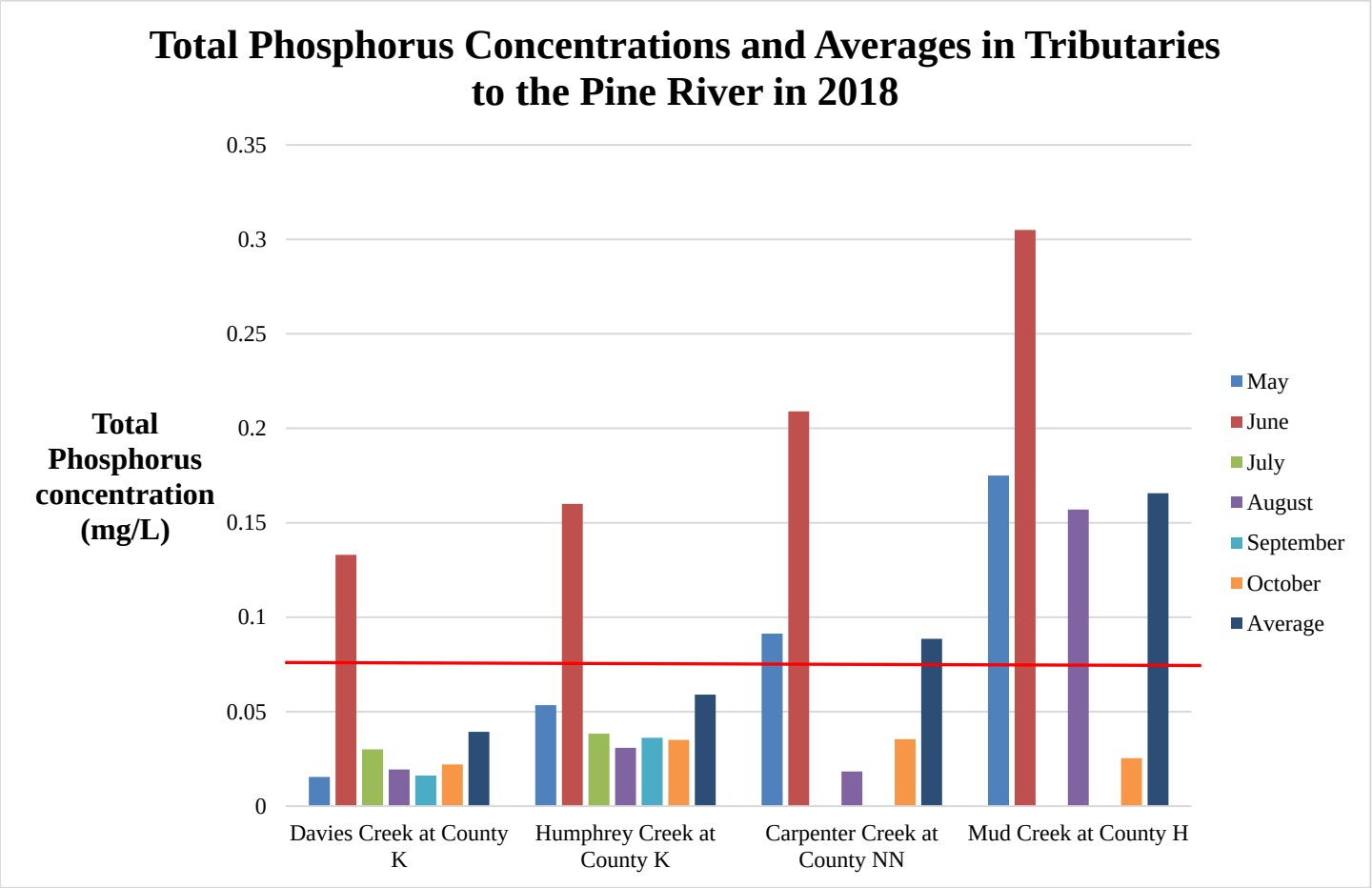


Chart 2: Total Phosphorus Concentrations and Averages of Samples Collected in the Pine River Mainstem in 2018 (with 0.075 mg/L WQC red line).

In late Winter 2018 to Spring 2019, snowmelt and rain events were targeted for nutrients, suspended solids, and biological oxygen demand monitoring in the Pine River Watershed (Photo 1). Nine locations were sampled during 2 significant snowmelt and/or rain events (Table 1 & 10, Chart 3-4)). Event samples were analyzed for TP, TDP, TSS, NH3, NO_3+NO_2 as N, and BOD. The tributaries to the Pine River demonstrated higher concentrations of nutrients, TSS, and BOD than observed in the mainstem (Table 10, Chart 3-4).

Runoff Event	Event 1 TP	Event 2 TP	Event 1 TDP	Event 2 TDP	Event 1 NH3	Event 2 NH3	Event 1 NOx	Event 2 NOx	Event 1 TSS	Event 2 TSS	Event 1 5-Day BOD	Event 2 5-Day BOD

Monitoring Location												
Pine River at DNR Property US Wild Rose	0.0426	0.0706	0.0229	0.0545	0.0270	0.0244	1.92	1.08	6.86	10.1	ND	ND
Pine River at County A Saxeville	0.0830	0.0685	0.0319	0.0465	0.0587	0.0291	1.41	0.731	58.3	9.21	2.65	ND
Pine River at 26th Road	0.0485	0.0591	0.0219	0.0263	0.0641	0.0338	2.24	1.53	16.0	33.6	2.54	ND
Pine River at 28th Court	0.0443	0.0551	0.0217	0.0285	0.0714	0.0432	2.08	1.54	8.67	15.6	2.49	ND
Pine River at Hwy 49	0.0416	0.0566	0.0225	0.0261	0.0699	0.0477	2.0	1.39	ND	14.3	2.33	ND
Pine River at Farm Bridge	0.0486	0.0597	0.0245	0.0293	0.0672	0.0497	2.03	1.4	ND	15.9	2.47	2.03
Humphrey Creek at County K	0.0963	0.160	0.0527	0.108	0.318	0.0791	2.49	1.59	20.0	18.0	3.26	2.13
Carpenter Creek at County NN	0.116	0.0876	0.0609	0.05	0.245	0.107	1.11	0.954	32.5	22.0	6.84	2.78
Mud Creek at County H	0.667	0.245	0.406	0.166	0.999	0.258	0.938	1.23	153.0	32.0	20.7	4.12

Table 10: Snowmelt and Rain Runoff Event Monitoring in the Pine River Watershed in 2018.

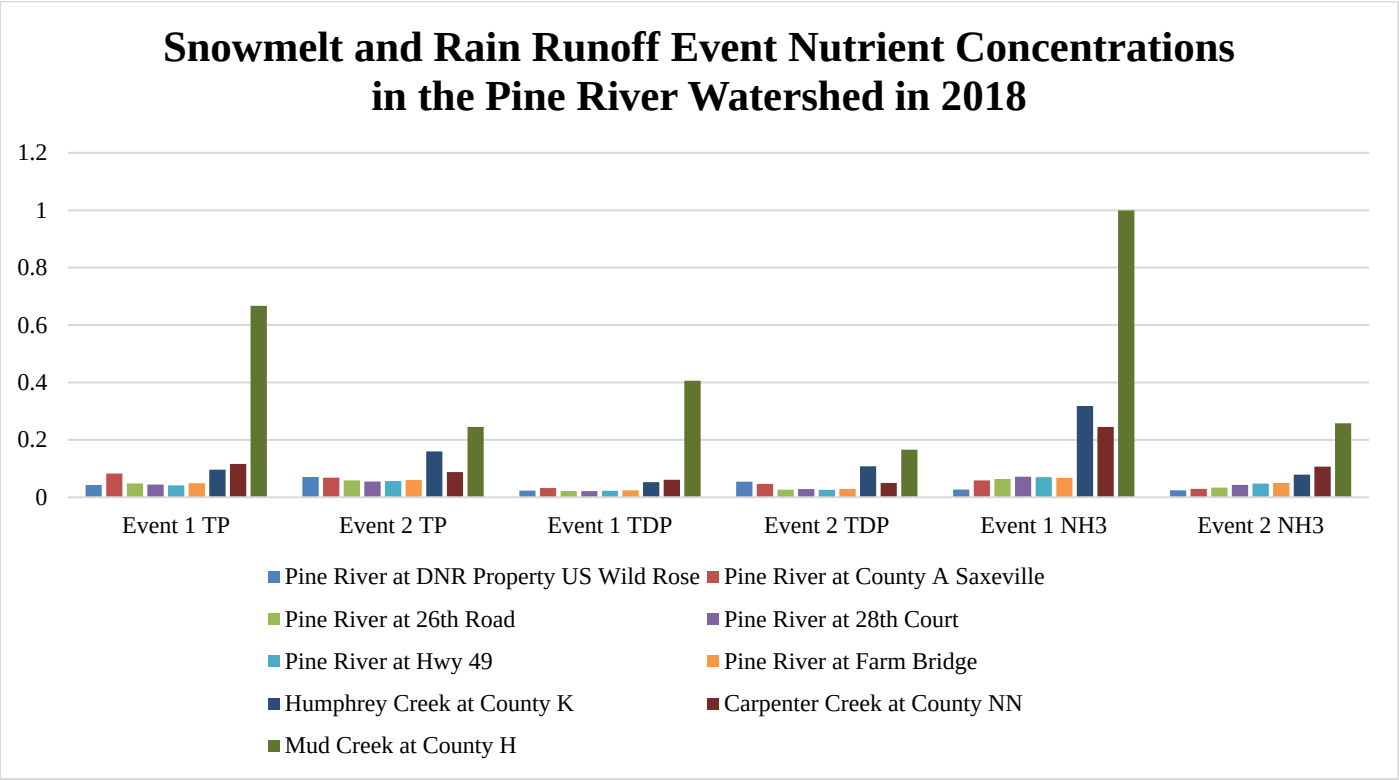


Chart 3: Snowmelt and Rain Runoff Event TP, TDP, and NH3 Concentrations in the Pine River Watershed in 2018.

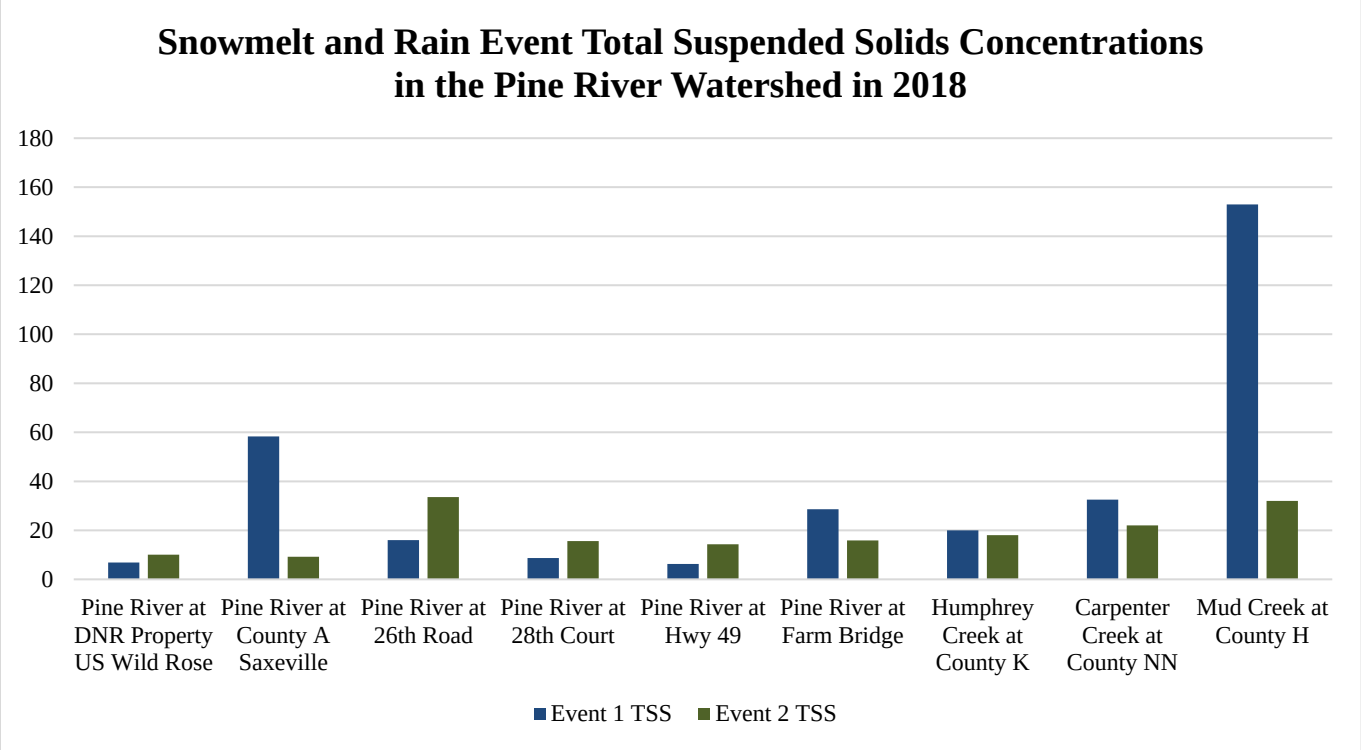


Chart 4: Snowmelt and Rain Runoff Event TSS Concentrations in the Pine River Watershed in 2018.

Photo 1: Mud Creek at County H during Spring Rain Event. Photo taken by D. Bolha on March 27th, 2019.

In March 2019, winter baseflow NO3+NO2 as N samples were collected in the Pine River Watershed at 20 locations. The NO_3+NO_2 as N concentrations ranged from 0.829 mg/L in Popple Creek at County A to 6.0 mg/L in Humphrey Creek at County K (Table 11, Chart 5). The highest concentration in the Pine River mainstem was 3.58 mg/L at Apache Road, while the lowest was ~2.5 miles upstream at 19th Road (2.29 mg/L). The highest NO_3+NO_2 as N concentrations were observed in Davies and Humphrey Creeks (Table 11, Chart 5), which likely had an influence on the higher concentration in the Pine River at Apache Road.

Location	Winter NO3 + NO2 as N
Pine River at 17th Drive	3.2
Pine River at DNR Property US Wild Rose	2.97
Pine River at Above Hwy A	3.1
Pine River at 19th Drive	2.29
Pine River at Apache Road	3.58
Pine River at County A Saxeville	2.75
Pine River at Below Saxeville Dam	2.79
Pine River at 26th Road	2.61
Pine River at DS Pine River Millpond	2.75
Pine River at US Poy Sippi Millpond	2.78
Pine River at Hwy 49	2.49
Davies Creek at County K	4.6
Humphrey Creek at County K	6
Kaminski Creek at County A	1.91
Popple Creek at Cth A	0.829
Carpenter Creek at County M	1.39
Carpenter Creek at County NN	2.23
Little Silver Creek at 26th Ln	2.01
Little Silver Creek at 28th Court	2.84
Mud Creek at County H	1.62

Table 11: Winter Baseflow NO_3+NO_2 as N Concentrations in the Pine River Watershed in 2018.

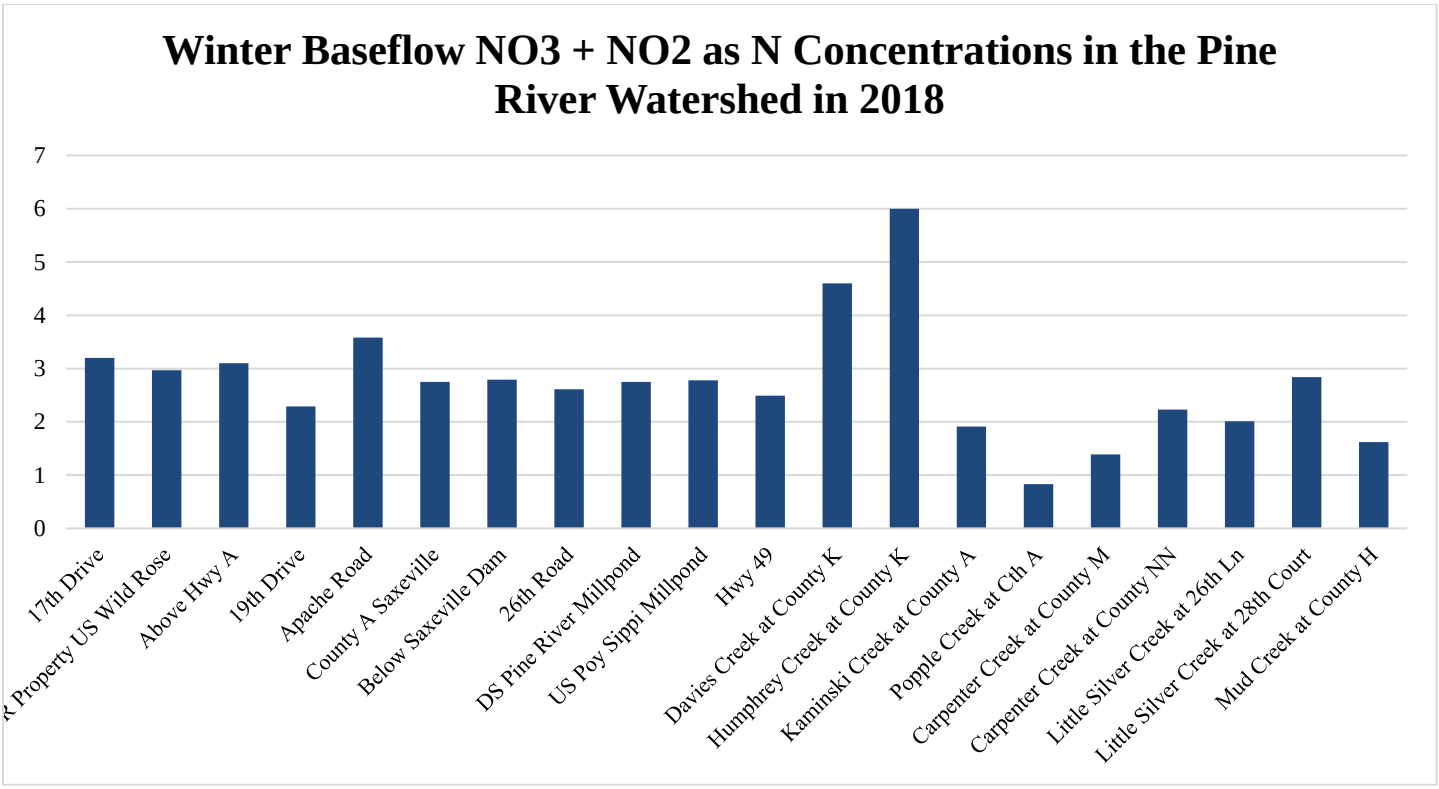


Chart 5: Winter Baseflow NO_3+NO_2 as N Concentrations (mg/L) in the Pine River Watershed in 2018.

Aquatic macroinvertebrate communities were sampled at 25 locations October 2018. Some aquatic macroinvertebrate species are tolerant of environmental degradation, while some species are moderately tolerant, and some others are intolerant. Based upon the representative macroinvertebrate sample collected and their associated tolerance to environmental degradation, an Index of Biotic Integrity (MIBI) was calculated to indicate the water quality condition of the stream or river (Table 12, Chart 6-7). In general, the higher the MIBI score, the better the water quality rating for a wadable stream in Wisconsin. The MIBI scores in the Pine River Watershed ranged from 3.47 in Carpenter Creek at County M to 9.60 in the Pine River near Apache Rd (Table 12, Chart 6-7). The water quality condition categories based upon the macroinvertebrate community for the 25 sites ranged from Fair to Excellent. The Pine River mainstem samples demonstrated a macroinvertebrate community indicating no apparent to likely substantial impact from environmental degradation. The 6 tributary macroinvertebrate communities indicated no apparent (Excellent) to substantial impact likely from environmental degradation to water quality (Fair). Ten of the 25 locations indicate a Condition Category of Excellent, while 7 indicate a Condition Category of Good (Table 12, Chart 6-7). The remaining 8 locations indicate a water quality Condition Category of Fair based upon the macroinvertebrates collected, while no communities indicate Poor water quality condition.

SWIMS Station ID	Stream Name and Location	Macroinvertebrate IBI Score	Condition Category
703070	Pine River at 17th Drive	7.67	Excellent
703106	Pine River at DNR Property US Wild Rose	9.06	Excellent
703071	Pine River at CTH AA	4.60	Fair
703047	Pine River- Above Hwy A	3.83	Fair
703049	Pine River .5 mi below A	5.87	Good
703073	Pine River at 19th Drive	4.39	Fair
10050198	Pine River US Idlewild Millpond	4.96	Fair
10049174	Pine River-Aniwa Habitat Site	5.98	Good
10037927	Pine River at Aniwa Road	8.38	Excellent
10007883	Pine River at Apache Road	9.60	Excellent
10022005	Pine River CTH A DNR Property	9.60	Excellent
10016425	Pine River at County A Saxeville	9.06	Excellent
10029791	Pine River Portage Road Saxeville	8.97	Excellent
10034803	Pine River Below Saxeville Dam	7.23	Good
703107	Pine River at 26th Road	6.99	Good
10007978	Pine River US of Pine River Millpond	9.40	Excellent
703063	Pine River at 28th Ct	8.56	Excellent
10032735	Pine River at Hwy 49	4.89	Fair
10050462	Pine River at Farm Bridge	6.40	Good
10007897	Humphrey Creek at County K	8.45	Excellent
10048955	Popple Creek at Cth A	5.85	Good
10020685	Carpenter Creek at County M	3.47	Fair
10020683	Carpenter Creek at County NN	3.56	Fair
10007905	Little Silver Creek at 26th Ln	7.11	Good
10049901	Mud Creek at County H	4.90	Fair

Table 12: Aquatic Macroinvertebrate Index of Biotic Integrity Scores and Water Quality Condition Category in the Pine River Watershed in 2018.

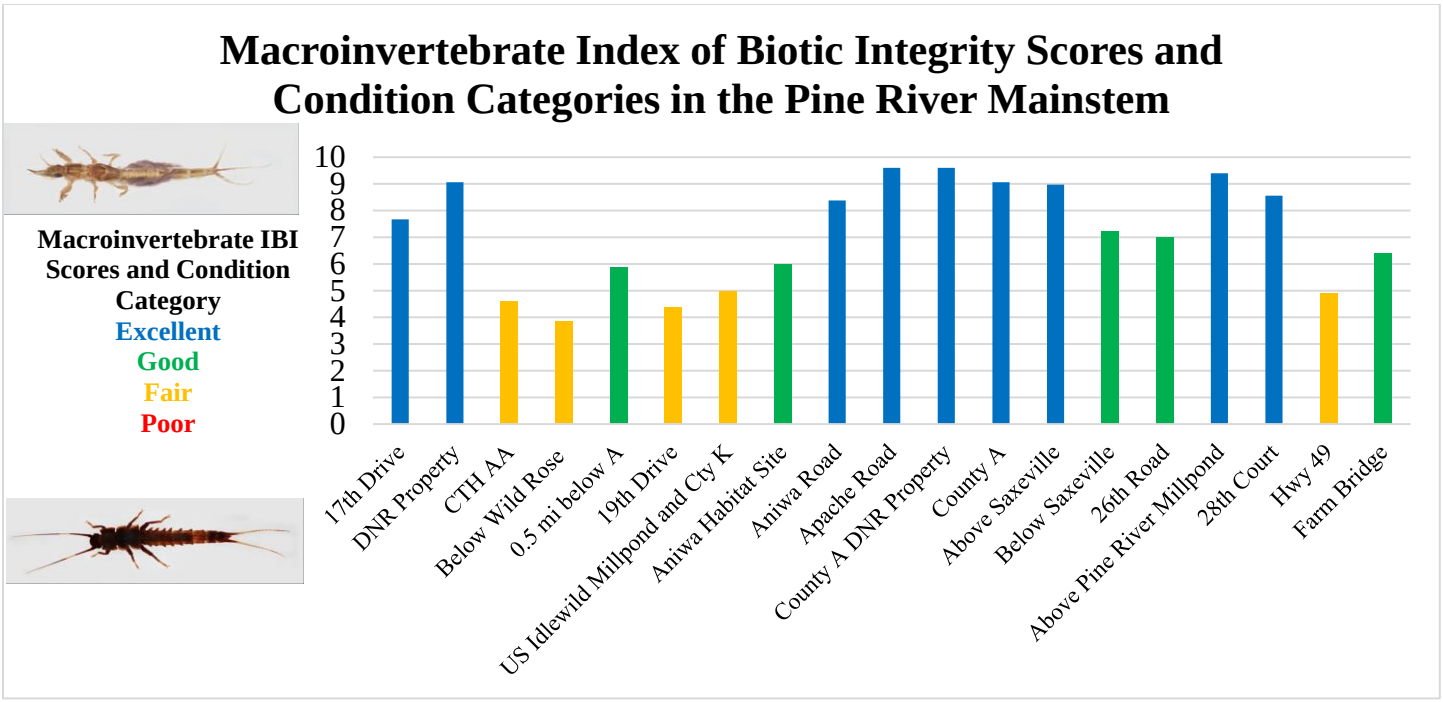


Chart 6: Macroinvertebrate Index of Biotic Integrity Scores and Water Quality Condition Category in the Pine River Mainstem Upstream (left) to Downstream (right) in 2018.

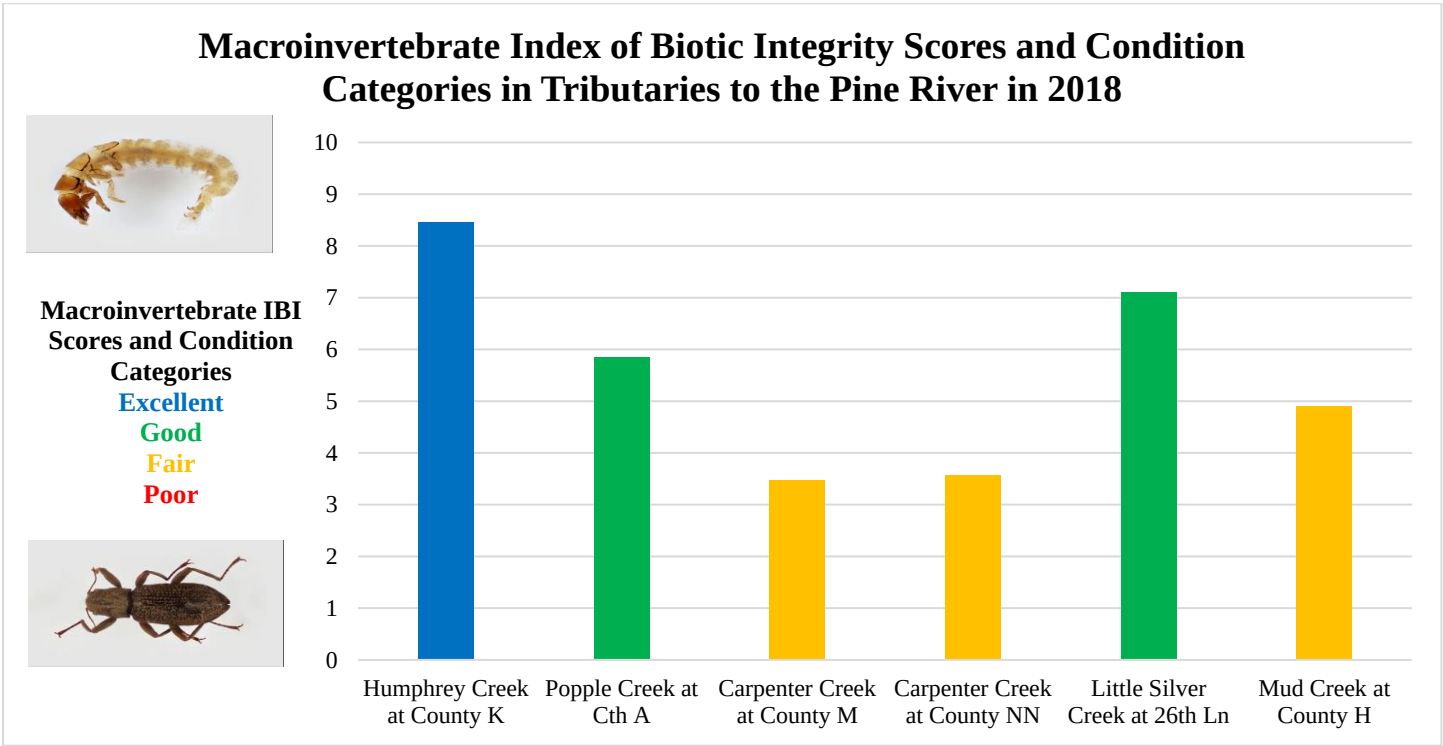


Chart 7: Macroinvertebrate Index of Biotic Integrity Scores and Water Quality Condition Category in the Pine River Tributaries in 2018.

Between July and September 2018, 21 locations were surveyed for representative fish communities (Photos 2-3). Some fish species are tolerant of environmental degradation, while some species are moderately tolerant, and some others are intolerant. Based upon the representative fish collected during the survey and their associated tolerance to environmental degradation, an Index of Biotic Integrity (FIBI) was calculated to indicate the water quality of each creek or river (Table 13, Chart 8-9). The FIBI scores ranged from 50 in Carpenter and Mud Creeks to 100 in the Pine River and Davies and Kaminski Creeks (Table 13, Chart 8-9). The Condition Category for the 21 sites ranged from Fair to Excellent. All 12 fish surveys in the Pine River mainstem indicate

a Condition Category of Good to Excellent, with the FIBI scores ranging from 60 to 100. Davies and Kaminski Creeks demonstrated a Condition Category of Excellent (Table 13, Chart 9). Four of the tributaries to the Pine River had a Condition Category of Good while the remaining 3 sites had a Condition Category of Fair based upon the fish surveys (Table 13, Chart 9).

Each fish community surveyed was used to verify or update the modeled Natural Community for that stream segment. Each of the streams' Natural Community was verified or changed based upon the fish caught in the survey (and any historical known surveys in that stream segment). Verifying or changing the modeled Natural Community was important since the Natural Community determines which FIBI was used to determine the water quality of that stream segment. The results of the calculated FIBI displayed in Table 13 and Chart 8-9 are based upon the verified or changed Natural Community.

SWIMS Station ID	Site Name	Fish IBI Score	Condition Category	Natural Community
703070	Pine River at 17th Drive	60	Good	Coldwater
703071	Pine River at CTH AA	80	Good	Coldwater
703047	Pine River- Above Hwy A	80	Good	Coldwater

703073	Pine River at 19th Drive	60	Good	Coldwater
10037927	Pine River at Aniwa Road	100	Excellent	Cold Transitional Mainstem
10007883	Pine River at Apache Road	100	Excellent	Cold Transitional Mainstem
10022005	Pine River at CTH A DNR Property	80	Excellent	Cold Transitional Mainstem
10016425	Pine River at County A Saxeville	100	Excellent	Cold TransitionalMainstem
10034803	Pine River Below Saxeville	100	Excellent	Cold Transitional Mainstem
703107	Pine River at 26th Road	100	Excellent	Cold TransitionalMainstem
10051490	Pine River DS Pine River Millpond	100	Excellent	Cold Transitional Mainstem
N/A	Pine River Above Lake Poygan Confluence	95	Excellent	Large River
10022011	Davies Creek at County K	90	Excellent	Coldwater
10007897	Humphrey Creek at County K	70	Good	Cold Transitional Headwater
703082	Kaminski Creek at Cty A	100	Excellent	Coldwater
10048955	Popple Creek at Cth A	60	Fair	Warm Headwater
10007904	Carpenter Creek at County M	60	Fair	Warm Transitional Headwater
10007901	Carpenter Creek at County NN	50	Good	Warm Transitional Mainstem
10007905	Little Silver Creek at 26th Lane	70	Good	Cold Transitional Headwater
10007907	Little Silver Creek at 28th Court	80	Good	Coldwater
10049901	Mud Creek at Aspen Avenue	50	Fair	Warm Transitional Headwater

Table 13: Fish Survey Results in the Pine River Watershed Conducted in July through September 2018.

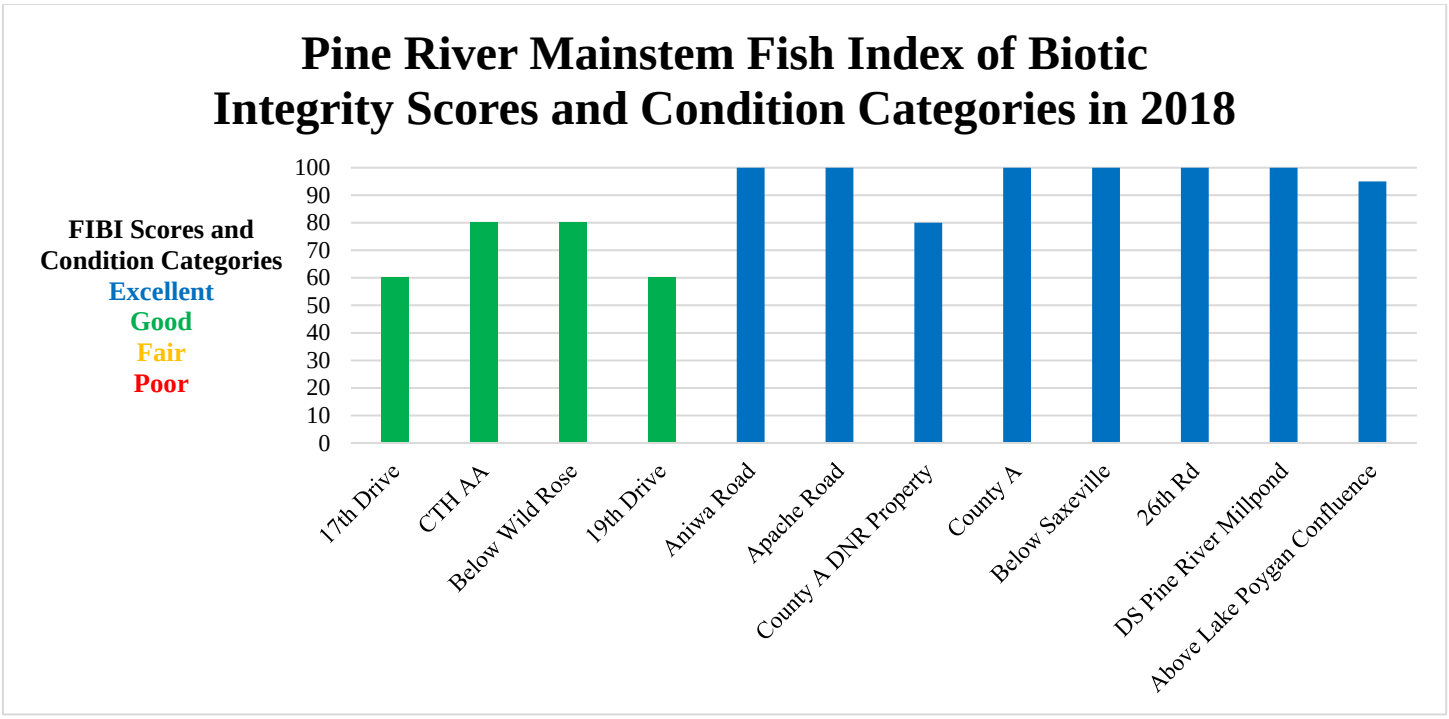


Chart 8: Fish Index of Biotic Integrity Scores and Condition Categories in the Pine River Mainstem in 2018.

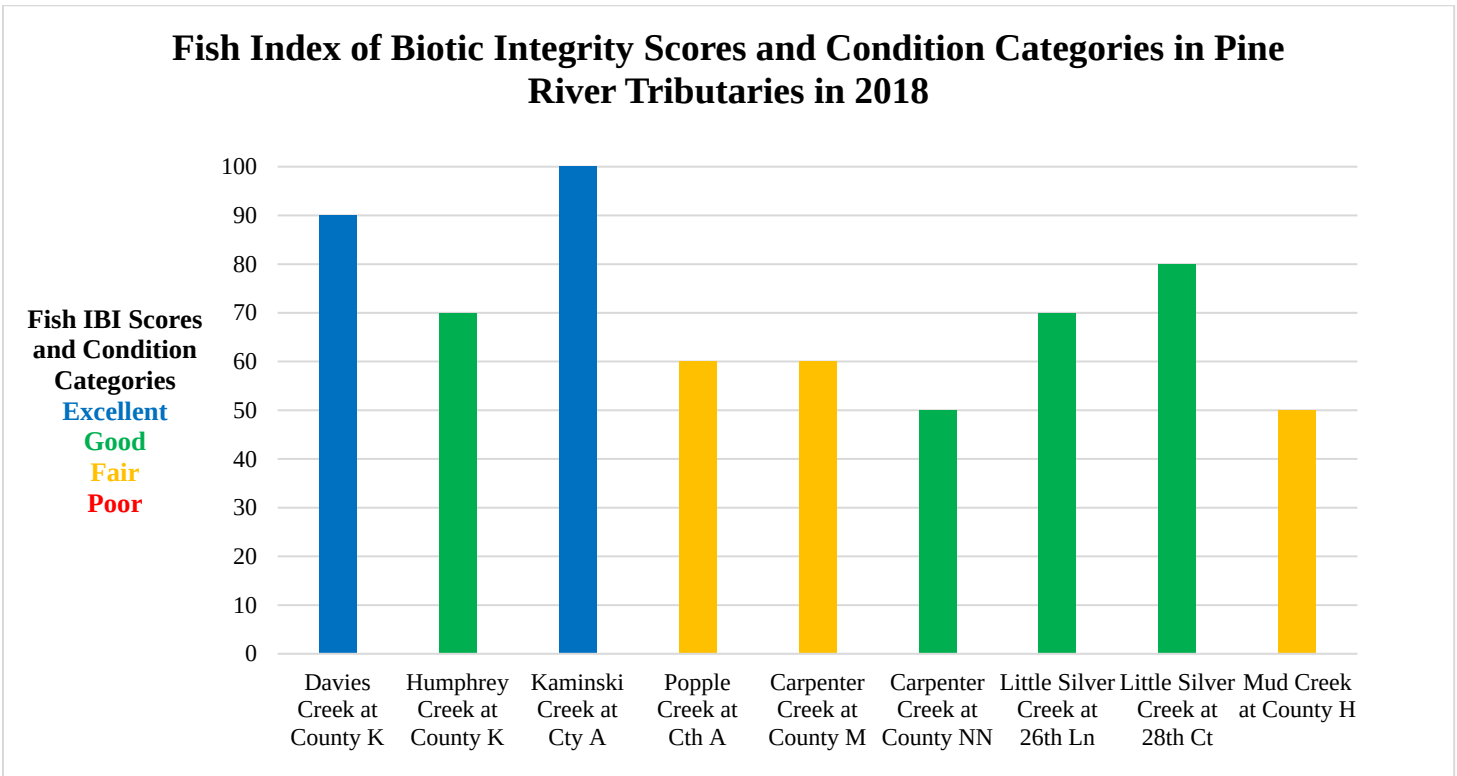


Chart 9: Fish Index of Biotic Integrity Scores and Condition Categories in the Pine River Tributaries in 2018.


Photo 2-3: Fish Collected during the Fish Index of Biotic Integrity Surveys in the Pine River Watershed in 2018. Photos taken by D. Bolha on August 17th, 2018.

Between September and November 2018, quantitative habitat surveys were conducted at 13 locations in the Pine River Watershed (Table 14, Map 1-2). Quantitative habitat assessments evaluate a representative stream reach (35 X Mean Stream Width) for the quantity and quality of habitat for game fish and compare the habitat to reference streams in Wisconsin. Based upon the assessment data collected during the 2018 surveys, a habitat rating was calculated for the 13 locations (Table 14, Chart 10). The quantitative habitat scores ranged from 53 in the Pine River at County AA to 73 in the Pine River and Little Silver Creek (Table 14, Chart 10). All 13 locations had habitat in the Good condition category.

SWIMS Station ID	Stream Name and Site Location	Quantitative Habitat Score	Condition Category
703070	Pine River at 17th Drive	70	Good
703071	Pine River at CTH AA	53	Good
703073	Pine River at 19th Drive	70	Good
10007883	Pine River at Apache Road	73	Good
10016425	Pine River at County A Saxeville	73	Good
10022011	Davies Creek at County K	60	Good
10007897	Humphrey Creek at County K	65	Good
703082	Kaminski Creek at Cty A	50	Good
10048955	Popple Creek at Cth A	68	Good
10007904	Carpenter Creek at County M	60	Good
10007901	Carpenter Creek at County NN	55	Good
10007905	Little Silver Creek at 26th Ln	70	Good
10007907	Little Silver Creek at 28th Ct	73	Good

Table 14: Quantitative Habitat Survey Scores and Condition Categories for the Pine River Watershed in 2018.

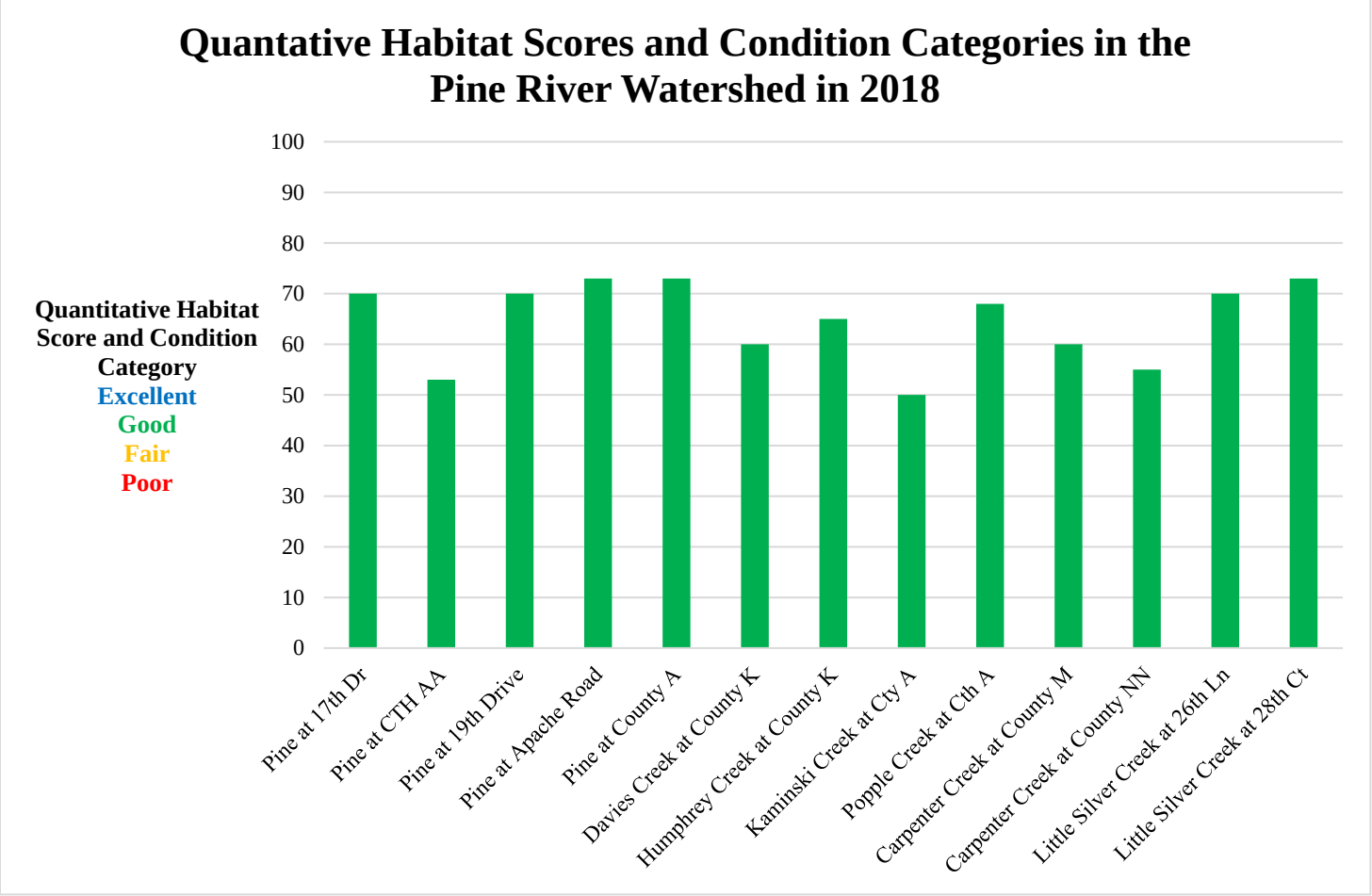


Chart 10: Quantitative Habitat Survey Scores and Condition Categories for the Pine River Watershed in 2018.

Water temperature data was collected from June through September 2018 at 21 locations in the Pine River Watershed (Table 6, Map 1-2). Carpenter Creek at County NN and Pine River below the Saxeville Dam were monitored in July through September 2019 due to equipment malfunction or loss. The temperatures ranged from 44.7F in Kaminski Creek at County A on 9/28/2018 to 90.3F in Mud Creek at County F on 6/30/2018. The average monthly temperatures ranged from 54.1F in Kaminski Creek in September to 74.9F in Mud Creek at County H in July (Table 15, Chart 11-12). The average monthly temperatures were reported for complete months only. The Maximum Daily Averages (MDM) ranged from 65.1F in the Pine River at 19th Drive to 81.7F in Mud Creek at Count H (Table 15, Chart 11-12). The Pine River mainstem monthly averages and MDM generally increased as the water flowed downstream.

Location	June Average (F)	July Average (F)	August Average (F)	Sept. Average (F)	Maximum Daily Average (F)

Pine River at 17th Drive	61.4	61.7	61.2	57.4	70.0
Pine River at DNR Property US Wild Rose	56.4	56.1	56.2	54.3	67.7
Pine River at 19th Drive	59.0	60.7	59.7	56.4	65.1
Pine River at Apache Road	60.8	62.9	61.5	57.3	68.0
Pine River at County A Saxeville	62.6	64.6	62.9	58.7	70.0
Pine River Below Saxeville	NA	67.1	62.8	59.6	70.8
Pine River at 26th Road	65.2	67.7	65.3	60.0	73.8
Pine River DS Pine River Millpond	65.8	68.6	66.1	60.6	74.6
Pine River at 28th Court	65.4	68.0	65.7	60.3	74.0
Pine River US Poy Sippi Millpond	65.3	68.0	65.8	60.5	73.8
Pine River at Hwy 49	67.9	71.7	68.7	62.1	77.6
Pine River at Farm Bridge	68.2	72.3	69.2	62.3	78.3
Davies Cr at County K	55.9	57.3	57.2	54.8	66.3
Humphrey Cr at County K	62.1	63.7	62.1	57.5	69.5
Kaminski Cr at County A	56.9	57.7	57.3	54.1	66.1
Popple Cr at County A	68.7	70.7	70.0	64.4	75.1
Carpenter Cr at County M	65.7	64.5	62.0	59.8	74.7
Carpenter Cr at County NN	NA	66.7	61.0	59.6	70.3
Little Silver Cr at 26th Lane	61.1	61.8	61.4	57.8	69.2
Little Silver Cr at 28th Court	59.9	60.7	60.5	57.1	68.9
Mud Cr at County H	68.5	74.9	71.4	63.2	81.7

Table 15: Monthly Average and Maximum Daily Average Temperatures in the Pine River Watershed in 2018.

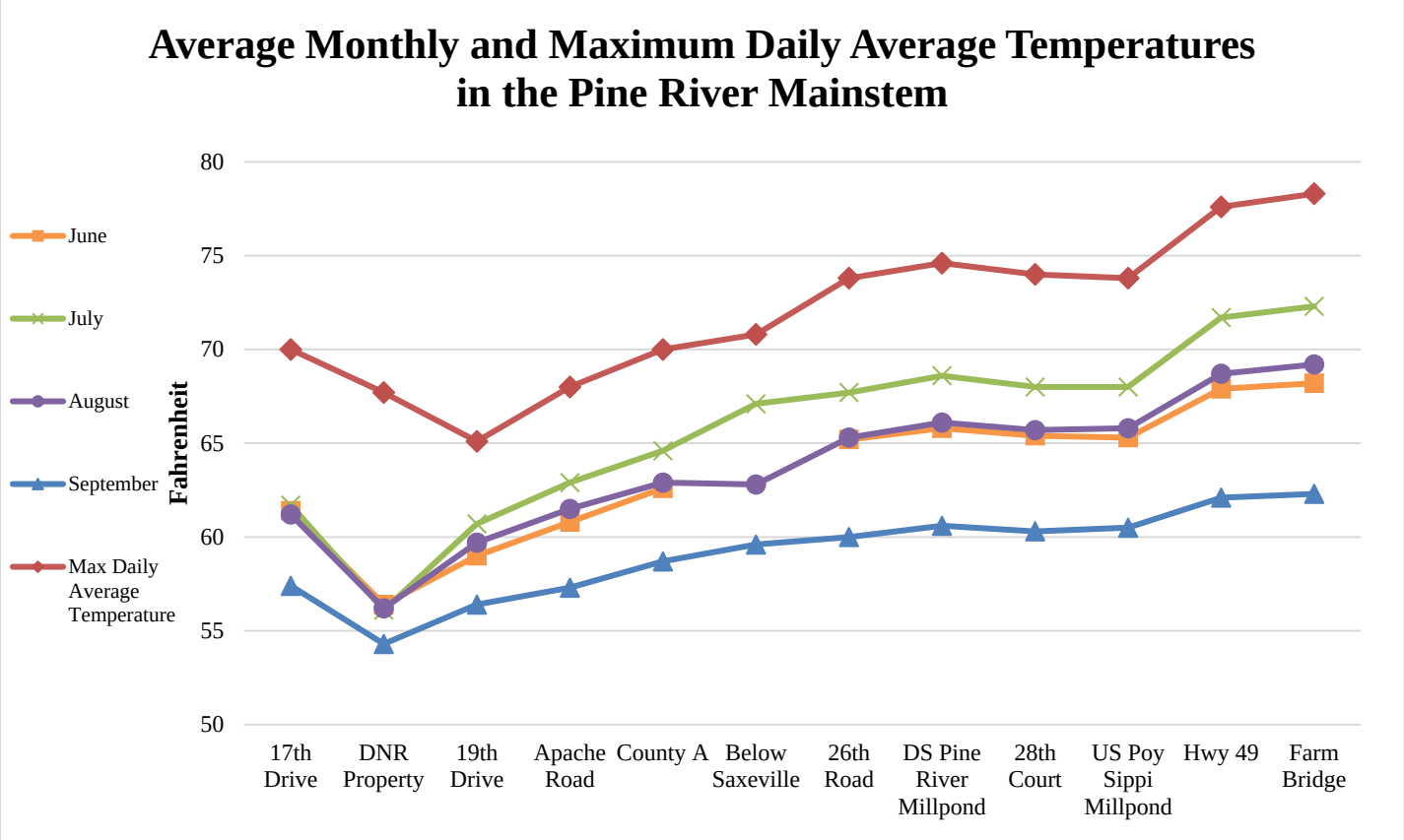


Chart 11: Monthly Average and Maximum Daily Average Temperatures in the Pine River Mainstem in 2018 Upstream (left) to Downstream (right).

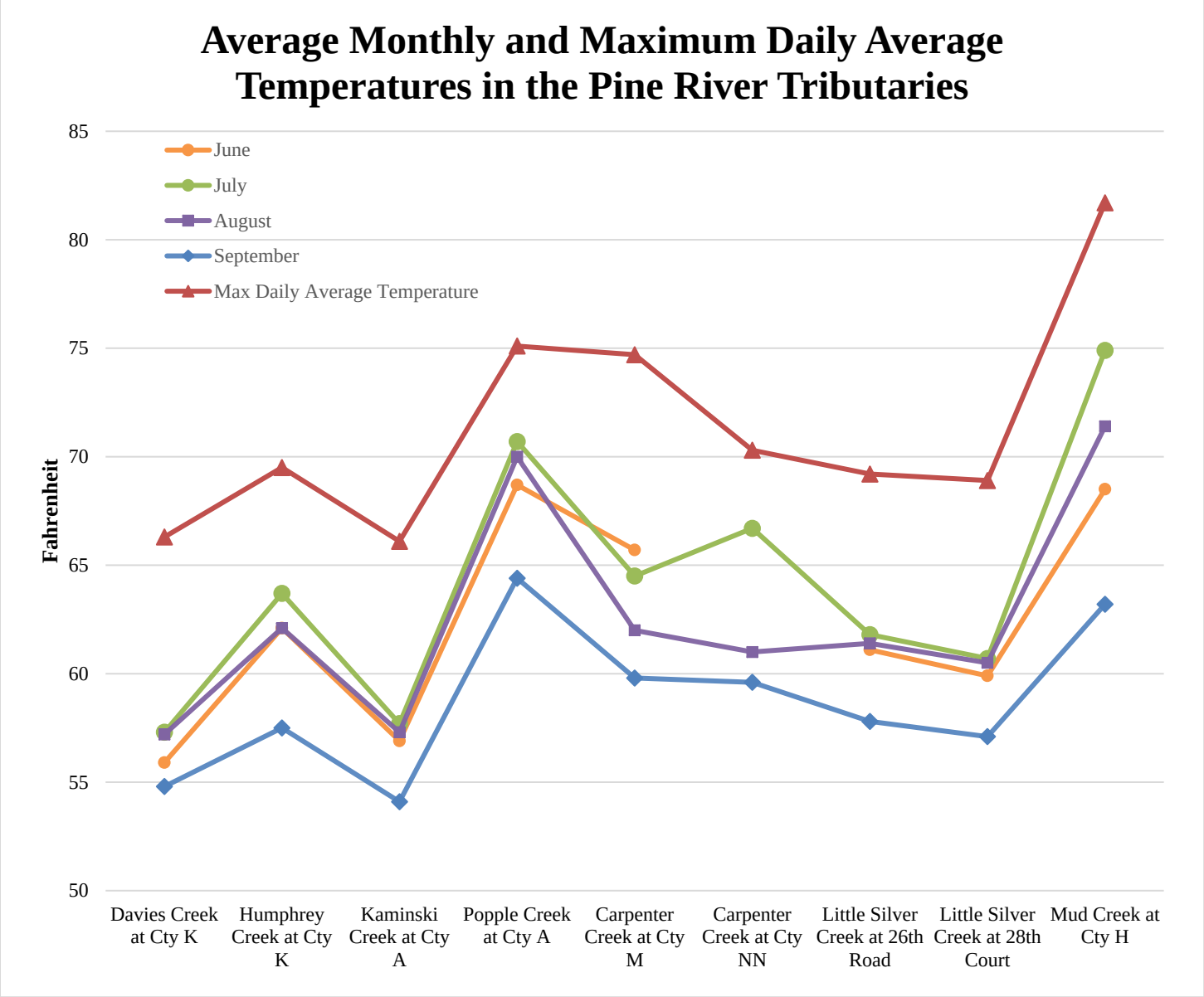


Chart 12: Monthly Average and Maximum Daily Average Temperatures in the Pine River Tributaries in 2018.

Continuous water chemistry meters were deployed in 5 locations in 2018 for a 5-day period collecting hourly instream DO and Temperature information (Photo 4). The Pine River mainstem was monitored at 2 locations, County A near Saxeville and at 28th Court. Additionally, Davies, Humphrey, and Carpenter Creeks were monitored for a 5-day period. The 2018 DO concentrations were above the Wisconsin Administrative Code ch. NR 102 water quality criteria for coldwater streams during the non-salmonid spawning period of 6.0 mg/L. The average DO concentrations ranged from 7.5 mg/L in Carpenter Creek at County NN to 9.5 mg/L in Davies Creek at County K (Table 16, Chart 13). The Pine River at County A near Saxeville had the largest diurnal fluctuation, ranging from 8.0 mg/L to 11.9 mg/L. Carpenter Creek had the lowest diurnal fluctuation, remaining between 7.0 mg/L and 8.0 mg/L during the 5-day deployment period.

Location	Deployment Dates	Temperature Max (F)	Temperature Min (F)	Average Temperature (F)	DO Max (mg/L)	DO Min (mg/L)	Average DO (mg/L)	DO% Saturation Max	DO% Saturation Min	Average DO% Saturation

Pine River at County A Saxeville	8/18/18-8/22/18	64.4	57.0	61.3	11.9	8	9.3	127.2	84	97.4
Pine River at 28th Court	7/21/18-7/25/18	70.7	63.5	66.9	8.5	6.4	7.6	97.4	71.1	86
Davies Creek at County K	8/4/18-8/8/18	62.6	53.1	56.8	10.4	8.5	9.5	105	84.8	94
Humphrey Creek at County K	9/8/18-9/12/18	64.0	51.1	56.8	9.4	7.9	8.5	97.8	76.1	83.6
Carpenter Creek at County NN	7/13/18-7/17/18	69.3	59.5	64.6	8.1	7.1	7.5	84.7	78.7	80.1

Table 16: 5-Day Water Chemistry Meter Deployment Results in the Pine River Watershed in 2018.

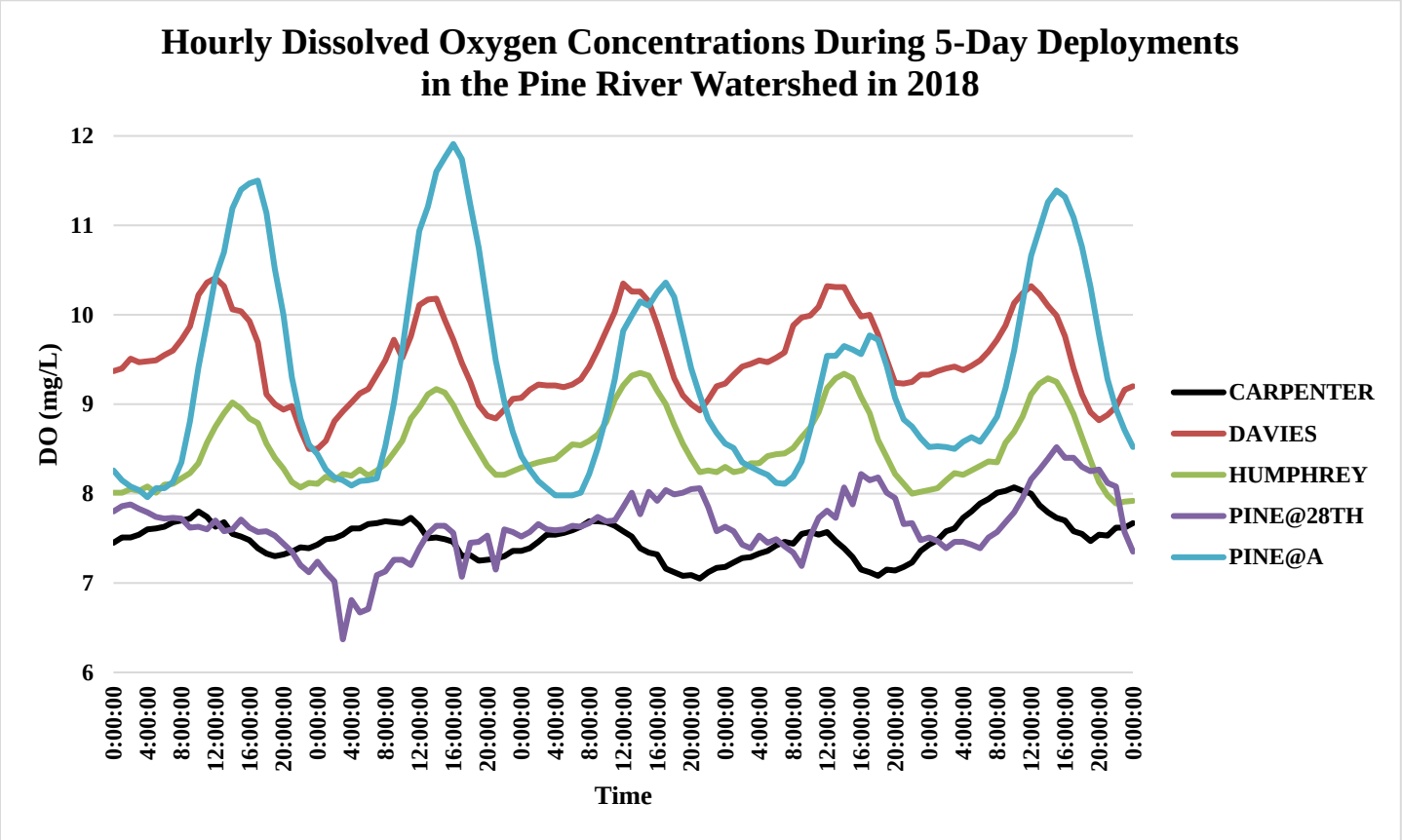


Chart 13: 5-Day Dissolved Oxygen Meter Deployment Results in the Pine River Watershed in 2018.

Photo 4: Continuous Dissolved Oxygen and Temperature Meter Deployment at Davies Creek at County K in 2018. Photo taken by D. Bolha on August 3rd, 2018.

Discussion

The purpose of this project was to evaluate water quality improvements made in the Pine River Watershed from Best Management Practices installed in the watershed from 1996 through 2002 and determine if the water quality goals of the Pine River/Willow Creek Priority Watershed Project were met in the Pine River sub-watershed (49.2% of Pine River/Willow Creek HUC 10 Watershed). The Pine River portion of the Pine River/Willow Creek HUC 10 watershed is divided into 4 HUC 12 sub-watersheds, Upper Pine (14,880 acres), Middle Pine (15,792 acres), Carpenter Creek (19,370 acres), and Lower Pine/Poygan (26,675 acres). The overall goal for the Priority Watershed Project was to restore, enhance, and protect the water quality of the surface waters of the sub-watersheds to ultimately improve the water quality of the Pine River. Nutrient and suspended solids samples, aquatic biological community evaluations, and habitat assessments were conducted to determine the water quality of the Pine River Watershed. The nutrient, aquatic macroinvertebrate, and fish monitoring in this project demonstrated that the water quality in the Pine River Watershed is between fair and excellent condition. The nutrient monitoring in 2018 indicate reductions in event concentrations and winter baseflow NO3+NO2 as N levels. The aquatic macroinvertebrate monitoring indicates improvements in water quality throughout the Pine River Watershed. The 2018 fish surveys indicate a mixture of water quality protections and declines.

The Pine River drains a 120 square-mile watershed before discharging into Lake Poygan near Poy Sippi, Wisconsin. The Pine River Watershed is located almost entirely within Waushara County (<1% in Southern Waupaca County). The Pine River headwaters are located northwest of Wild Rose and flows downstream from west to east roughly 36 miles until its confluence with Lake Poygan (Map 1-2). There are 377.5 named and unnamed stream miles in the watershed. The watershed is primarily forested (34.4%) with 27.8% in agricultural land use, while 19.2% is considered wetland. Typically, as increases in agricultural land use occur, there is a correlating increase in TP and TN concentrations in creeks in the watersheds in Wisconsin. Water clarity decreases and chlorophyll a concentration (which is an indication of algae populations) increases as TP and TDP increases. Water clarity and chlorophyll a concentration are indicators of water quality in Wisconsin lakes and rivers (WisCALM 2018).

Between 1995 and 1996, biological, physical and chemistry monitoring was conducted by the WDNR to summarize the existing conditions of the Pine River Watershed prior to the implementation of the Priority Watershed Project. In late 1996, the *Pine River and Willow Creek Priority Watershed Comprehensive Fishery Appraisal Report* was prepared by WDNR Fisheries staff Al Niebur and Carrie Hitchcock-Esch (WDNR 1996). In addition, water quality monitoring was conducted between 1995 and 1996 by WDNR Water Resources staff throughout the Pine River/Willow Creek/Poygan South Watershed to target which sub-watersheds have the greatest need for Best Management Practices (BMPs) to reduce non-point sediment and nutrients from reaching the Pine River and Lake Poygan. In February 1997, a *Pine/Willow/Poygan South Priority Watershed Surface Water Resource Appraisal Report* was prepared by WDNR Water Resources staff Mary Gansberg (WDNR 1997). A comparison of the 1995-1996 data to the data that was collected in 2018 can provide some indication of water quality changes over time as a result of the Priority Watershed Project.

During the Priority Watershed Appraisal Report monitoring period in 1995 and 1996, the Pine River and Carpenter Creek were monitored during an August 1995 rain event for BOD, NH3, NO3+NO2 as N, TP, and TSS (WDNR 1997). The rain event monitoring at the Pine River at 28th Court and Carpenter Creek at County NN in 2018 can be compared to the August 1995 results. The event TP and NH3 levels in the Pine River and Carpenter Creek decreased in the samples from 1995 to 2018 (Table 17). The TSS and BOD decreased in the Pine River while an increase was observed in Carpenter Creek. The NO3+NO2 as N in the event sampling increased in the Pine River and Carpenter Creek (Table 17).

Location	Event Year	TP	NH3	NO3+NO2 as N	TSS	BOD
Pine River at 28th Court	1995	0.096	0.160	0.883	18.0	2.5
Pine River at 28th Court	2018	0.050	0.0573	1.81	12.1	2.25
Carpenter Creek at County NN	1995	0.175	0.256	0.403	ND	3.5
Carpenter Creek at County NN	2018	0.102	0.176	1.032	27.3	4.81

Table 17: Historical Event Inorganic Chemistry Comparison to 2018 Event Inorganic Chemistry in the Pine River Watershed.

In February 1996, winter baseflow samples were collected in the Pine River and 2 tributaries for NO3+NO2 as N concentrations. In March 2018, winter baseflow sampling was conducted at 20 locations, including the 5 locations sampled in February 1996 (Table 18, Chart 14). Winter baseflow sampling for NO3+NO2 as N can indicate the levels in the contributing groundwater. The Pine River baseflow samples were either similar in value or were lower in concentrations. This may be an indication that the NO3+NO2 as N levels in the contributing groundwater have decreased. Kaminski Creek at County A increased from 1996 at 1.55 mg/L to 1.91 mg/L in 2018 (23%). The headwaters of Carpenter Creek at County M decreased from 2.24 mg/L NO3+NO2 as N in 1996 to 1.39 mg/L in 2018 (-38%) (Table 18, Chart 14).

Location	1996 NO3+NO2 as N (mg/L)	2019 NO3+NO2 as N (mg/L)

Pine River at 17th Dr	3.69	3.2
Pine River at DNR Property US Wild Rose	3.09	2.97
Pine River at 19th Dr	2.23	2.29
Kaminski Creek at County A	1.55	1.91
Carpenter Creek at County M	2.24	1.39

Table 18: Historical and Current Winter Baseflow NO3 + NO2 as N Concentrations in the Pine River Watershed.

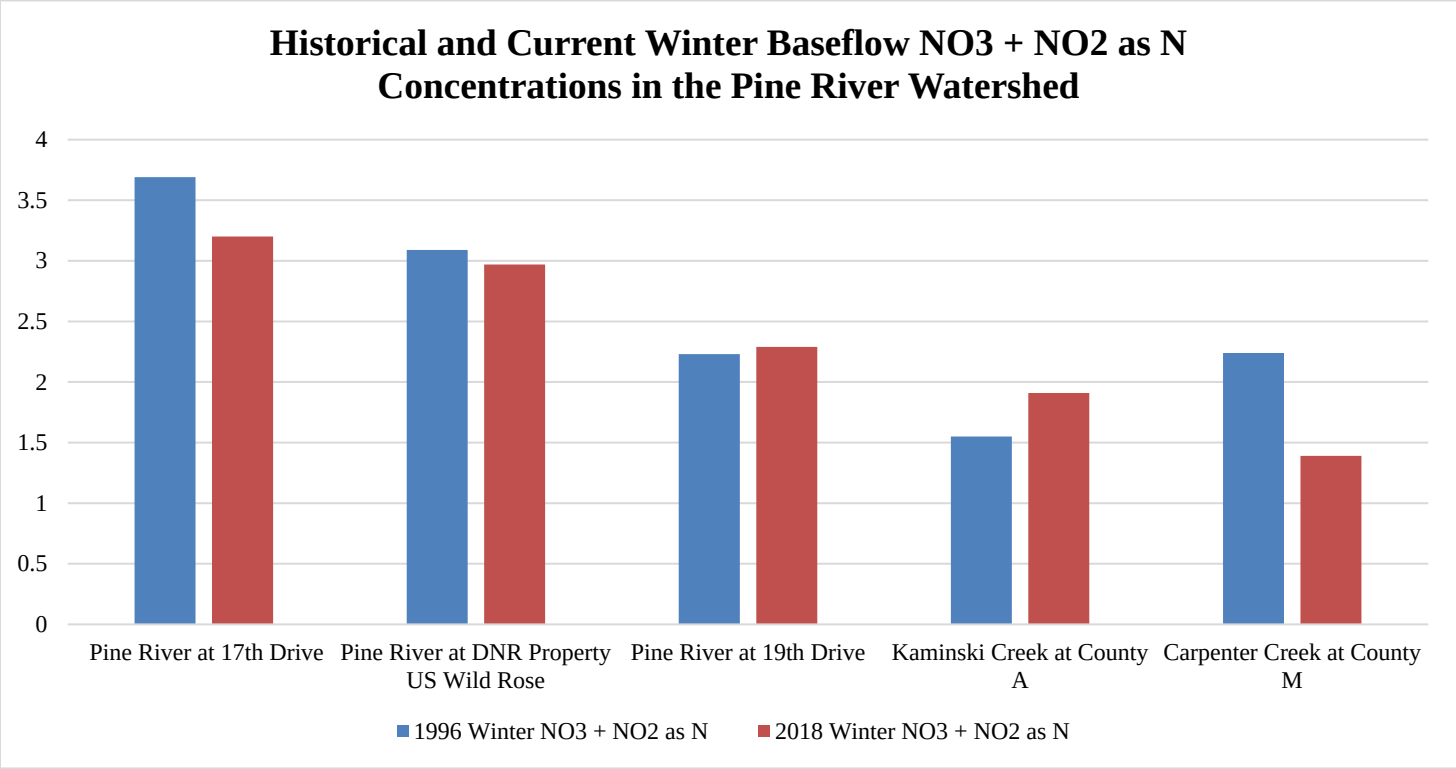


Chart 14: Historical and Current Winter Baseflow NO3 + NO2 as N Concentrations in the Pine River Watershed.

In the early stages of the Priority Watershed Project, aquatic macroinvertebrate surveys were conducted at 7 locations in the Pine River Watershed (WDNR 1997). In the 1997 *Surface Water Appraisal Report*, the macroinvertebrate index of biotic integrity (HBI) was calculated using William Hilsenhoff's *An Improved Biotic Index of Organic Stream Pollution* (Hilsenhoff 1987). The HBI was calculated for the 2018 samples as well (Table 19). The WDNR MIBI protocol was followed during the surveys; thus, the MIBI scores from the early stages of the Priority Watershed Project can be compared with the MIBI surveys conducted in 2018. The MIBI was built to reflect structural changes in macroinvertebrate assemblages in response to local and watershed-level disturbance, riparian condition and local habitat quality. Both the HBI and MIBI provide an indication of the water quality of the stream sampled but look at it a little differently so both are listed in Table 19 for comparison. The 7 sites' MIBI scores increased, with 5 of 7 increasing significantly (+≥1), which is indication that water quality has improved. Percent EPT is the percent Ephemeroptera, Plecoptera, Tricoptera genera out of the total number genera in a sample. These insect orders are generally known to be intolerant of pollution. The EPT% was calculated for the Historical and current samples (Table 19). The Pine River downstream of Wild Rose (19th Drive) showed a depressed MIBI and EPT% in 1995 and 2018 which indicates some watershed and/or habitat disturbance is impacting the macroinvertebrate community. In addition, the excessive aquatic plant growth in the Pine River downstream of the Wild Rose Millpond suggests a significant source of nutrients which likely contributes to the Fair MIBI scores in 1996 and 2018 (Table 19, Chart 15).

Location	1995 HBI Score	2018 HBI Score	1995 HBI Condition Category	2018 HBI Condition Category	1995 MIBI Score	2018 MIBI Score	1995 MIBI Condition Category	2018 MIBI Condition Category	1995 %EPT Genera	2018 %EPT Genera
Pine River at DNR Property US Wild Rose	1.56 in 2000	1.93	Excellent	Excellent	8.18 in 2000	9.06	Excellent	Excellent	80%	67%
Pine River at 19th Drive	5.50 in 1998	4.67	Good	Good	3.78 in 1998	4.39	Fair	Fair	18%	17%
Pine River at County K/Aniwa Habitat Site	4.24	4.81	Very Good	Good	4.60	5.98	Fair	Good	32%	31%
Pine River at County A Saxeville	1.89	3.40	Excellent	Excellent	6.43	9.06	Good	Excellent	47%	52%
Pine River at 28th Court	3.49	4.14	Excellent	Good	6.64	8.56	Good	Excellent	44%	41%
Humphrey Creek at County K	3.55	4.85	Very Good	Good	5.66	8.45	Good	Excellent	58%	24%
Little Silver Creek at 28th Court	2.61	3.94 in 2012	Excellent	Good	6.27	8.10 in 2012	Good	Excellent	62%	46%

Table 19: Comparison of Historical Macroinvertebrate Communities to the 2018 Macroinvertebrate Communities in the Pine River Watershed.

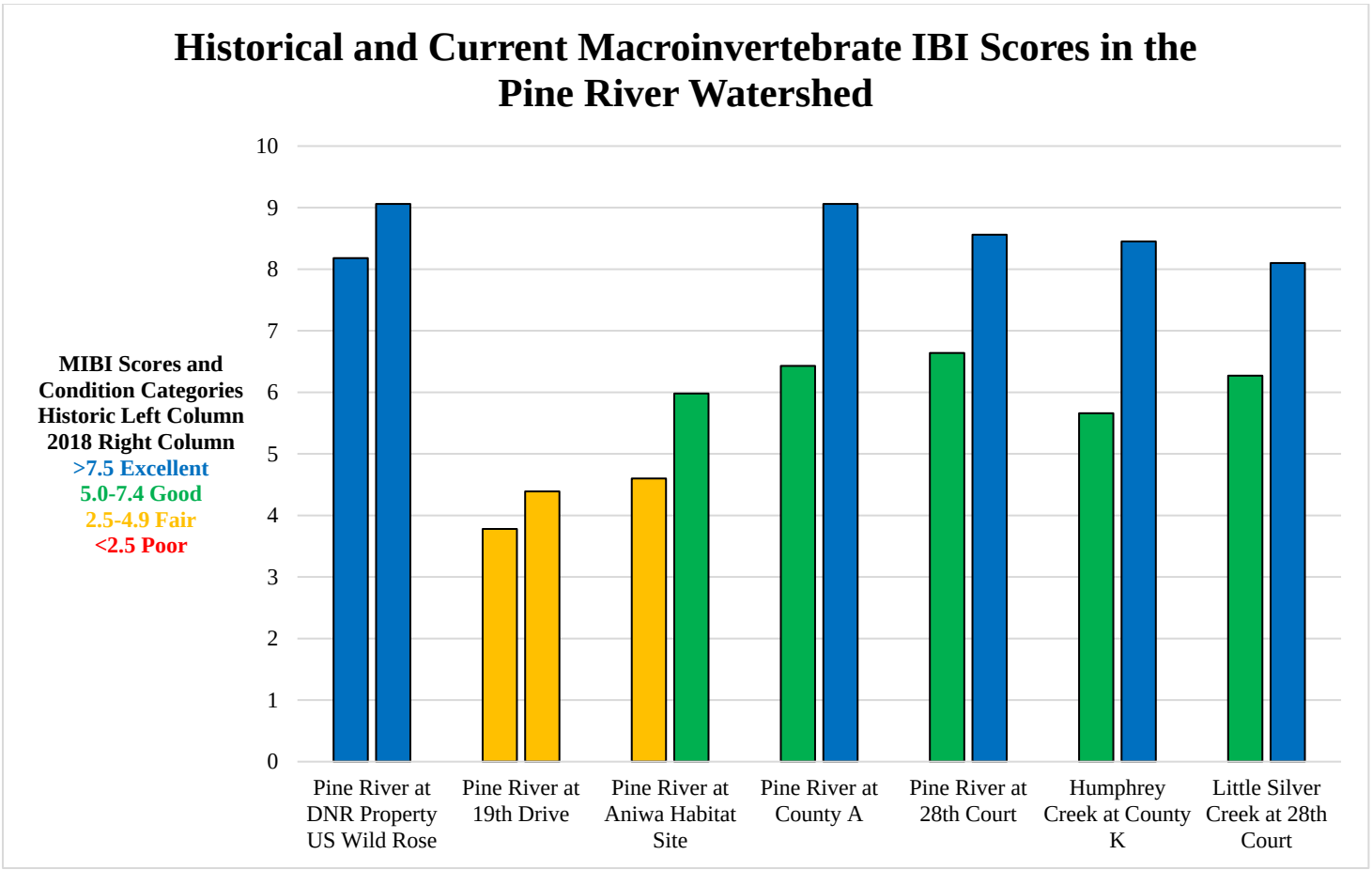


Chart 15: Comparison of Historical MIBI (Left Column) Scores to 2018 MIBI (Right Column) Scores in the Pine River Watershed.

Between May and July 1996, fish surveys were conducted at 15 locations in the Pine River Watershed (WDNR 1997). FIBI protocol was followed during the surveys; thus, the FIBI scores from 1996 can be compared with the FIBI scores from 2018 as part of this project. At the time of the *Comprehensive Fishery Appraisal* (WDNR 1996), Wisconsin had developed a Coldwater Index of Biotic Integrity (Lyons 1996) and a Warmwater Index of Biotic Integrity (Lyons 1992). The Coldwater IBI was calculated for all surveys in the Pine River Watershed (Lyons 1996). The goals of the Priority Watershed Project were based upon changes in the Coldwater IBI. The Coldwater IBI scores were calculated for each of the surveys in 2018 (Table 20) to determine if the goals of the Priority Watershed Project were met. In 1996, the Coldwater IBI scores and Condition Categories in the Pine River Watershed ranged from 30 to 100 and Fair to Excellent, respectively. The 2018 Coldwater IBI scores and Condition Categories ranged from 10 to 100 and Poor to Excellent, respectively. The Pine River at 17th Road and 19th Drive maintained their Coldwater IBI of 60 in the Condition Category of Good (Table 20, Chart 16). Kaminski and Davies Creeks improved to or maintained their Excellent Coldwater IBI Condition Category (Table 20, Chart 16). The Pine River at County A DNR Property dropped from Fair Condition in 1996 to Poor Condition in 2018. The Coldwater IBI at County A DNR Property was heavily influenced by the number of thermal and degradation tolerant White Suckers, Creek Chubs, and the Golden Shiner captured. The Carpenter Creek Coldwater IBI Condition Category dropped from Fair in 1996 to Poor in 2018. Some of the goals of the Priority Watershed were met by maintaining the good to excellent Coldwater IBI scores. However, some water quality goals were not met such as the goal of Carpenter Creek Coldwater IBI increase to 60.

Site	1996 Coldwater IBI	2018 Coldwater IBI	1996 Condition Category	2018 Condition Category

Pine River at 17th Drive	60	60	Good	Good
Pine River at 19th Drive	60	60	Good	Good
Pine River at Apache Road	50	50	Fair	Fair
Pine River at County A DNR Property	30	20	Fair	Poor
Pine River at 26th Rd	30	50	Fair	Fair
Davies Creek at County K	80	90	Good	Excellent
Humphrey Creek at County K	60	50	Good	Fair
Kaminski Creek at County A	100	100	Excellent	Excellent
Carpenter Creek at County NN	30	10	Fair	Poor
Carpenter Creek at County M	50	10	Fair	Poor
Little Silver Creek at 26th Lane	60	50	Good	Fair
Little Silver Creek at 28th Court	60	80	Good	Good

Table 20: Comparison of Historical Coldwater FIBI (Left Column) Scores to 2018 Coldwater FIBI (Right Column) Scores in the Pine River Watershed.

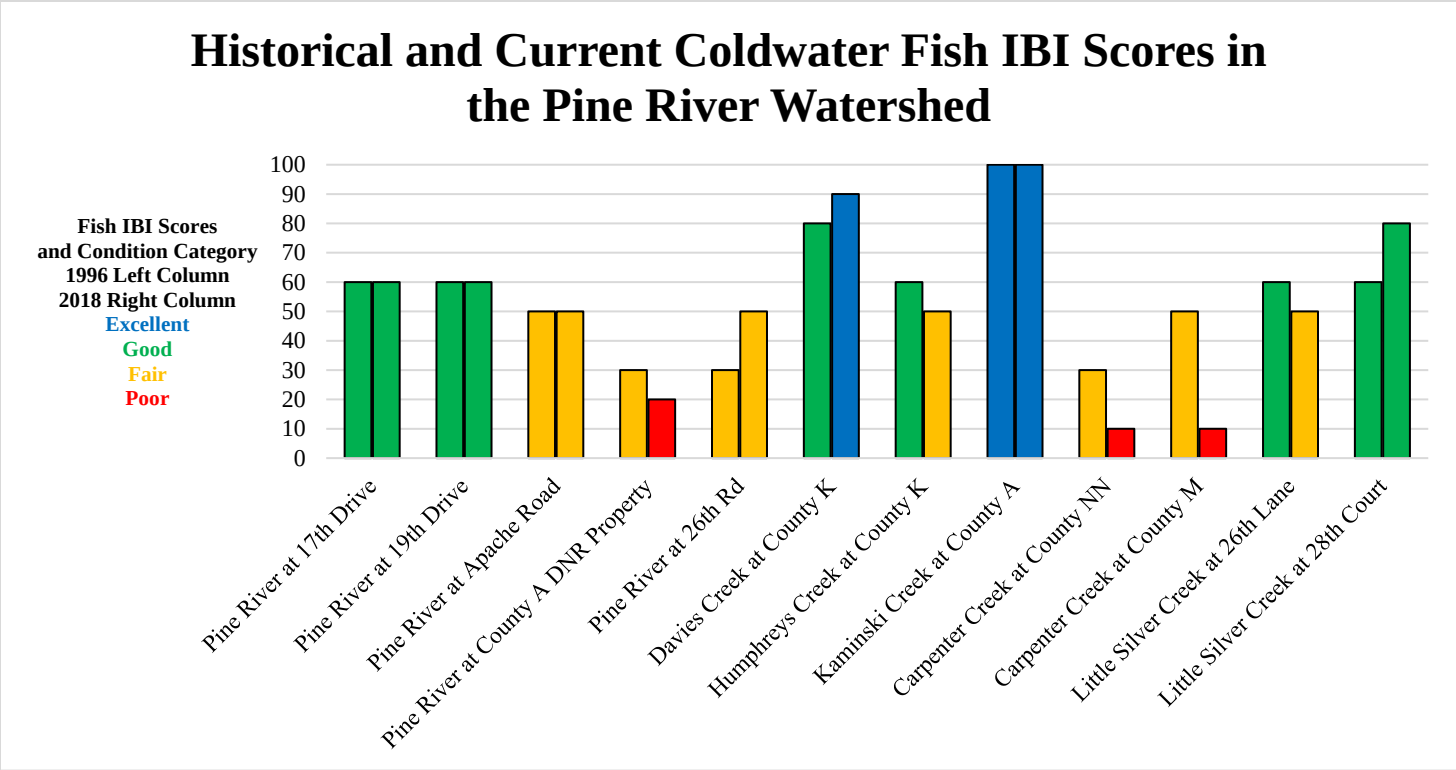


Chart 16: Comparison of Historical Coldwater FIBI (Left Column) Scores to 2018 Coldwater FIBI (Right Column) Scores in the Pine River Watershed.

In 2012, the WDNR developed 2 fish-based indexes of biotic integrity for Coolwater fish communities in those transitional stream sections between the traditional Coldwater and Warmwater streams (Lyons 2012). Just as in 2018 (Table 13, Chart 8-9), the 1996 FIBI surveys were used to verify the Natural Community of the river or creek. The 1996 FIBI scores and Condition Categories in Table 19 were based upon the verified Natural Community. None of the Natural Communities verified or changed in 2018 were changed based upon the 1996 FIBI surveys. Twelve of the 15 locations surveyed in 1996 were close enough for comparison to the 2018 surveys (Table 21, Chart 17). Based upon their verified Natural Communities, the FIBI scores and condition categories were very similar when comparing 1996 to 2018. The 5 Pine River mainstem surveys maintained the same FIBI score and Condition Category. This may be an indication that the mainstem of the river will take a bit longer to reflect water quality improvements due to watershed practice implementation. Davies Creek at County K and Carpenter Creek at County NN increased from Good to Excellent. Humphrey Creek at County

K, Carpenter Creek at County M, and Little Silver Creek at 26th Ln decreased in score but maintained their Good Condition Category (Table 21, Chart 17). Precipitation in Waupaca, Wisconsin in 2018 (41.3" rainfall) was greater than average (33.5" rainfall). The increased velocity in the mainstem of the river may have encouraged fish to seek refuge in the slower moving tributaries which in turn would have skewed some of the tributary FIBI scores higher. More monitoring during an average precipitation level year may be necessary to verify these scores.

Site	1996 FIBI	2018 FIBI	1996 Condition Category	2018 Condition Category	Verified or Updated Natural Community
Pine River at 17th Drive	60	60	Good	Good	Coldwater
Pine River at 19th Drive	60	60	Good	Good	Coldwater
Pine River at Apache Road	100	100	Excellent	Excellent	Cold Transitional Mainstem
Pine River at County A DNR Property	90	90	Excellent	Excellent	Cold Transitional Mainstem
Pine River at 26th Rd	100	100	Excellent	Excellent	Cold Transitional Mainstem
Davies Creek at County K	80	90	Good	Excellent	Coldwater
Humphrey Creek at County K	80	70	Good	Good	Cold Transitional Headwater
Kaminski Creek at County A	100	100	Excellent	Excellent	Coldwater
Carpenter Creek at County M	90	60	Good	Good	Warm Transitional Headwater
Carpenter Creek at County NN	90	100	Good	Excellent	Warm Transitional Mainstem
Little Silver Creek at 26th Lane	90	70	Good	Good	Cold Transitional Headwater
Little Silver Creek at 28th Court	60	80	Good	Good	Coldwater

Table 21: Historical and Current Fish Index of Biotic Integrity Scores and Condition Categories in the Lower Little Wolf River.

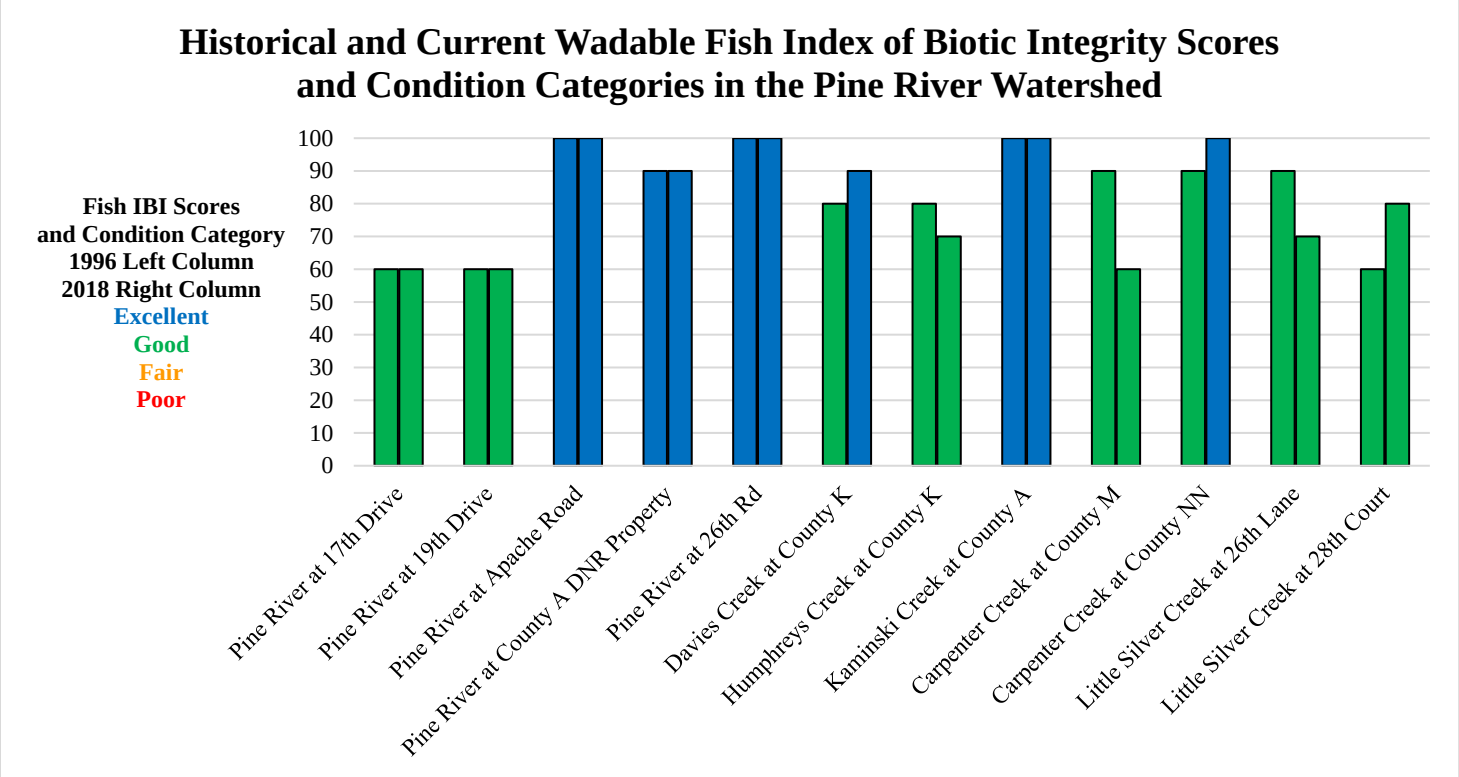


Chart 17: Historical and Current Fish Index of Biotic Integrity Scores and Condition Categories in the Pine River Watershed.

Stream aquatic life habitat conditions were evaluated throughout the Pine River Watershed in the summer of 1995 and 1996 using the *Stream Classification Guidelines for Wisconsin* (Ball 1982). A matrix was used to numerically rank physical habitat characteristics that may limit the quantity and quality of aquatic life. As the score decreases, the habitat rating for aquatic life gets better. In 2018, Ball's habitat condition assessment was conducted to compare the habitat quantity and quality of the Pine River Watershed after implementation of the Priority Watershed project. None of the Condition Categories of the habitat assessments changed from the mid-1990s to 2018 (Table 22, Chart 18). The condition categories in the Pine River Watershed ranged from Fair to Good according to the Ball assessment protocol. Although no Condition Category changes were observed, there were slight numerical changes in the scores at some of the locations (Table 22, Chart 18).

Site	1995-1996 Ball Habitat Score	2018 Ball Habitat Score	Condition Category	Condition Category

Pine River at 17th Drive	122	119	Good	Good
Pine River at County AA	146	134	Fair	Fair
Pine River at Apache Road	122	85	Good	Good
Pine River at County A Saxeville	86	88	Good	Good
Pine River at 28th Court	71	N/A	Good	N/A
Pine River at Hwy 49	86	N/A	Good	N/A
Davies Creek at County K	106	117	Good	Good
Humphrey Creek at County K	116	97	Good	Good
Kaminski Creek at Cty A	152	155	Fair	Fair
Popple Creek at Cth A	165	139	Fair	Fair
Carpenter Creek at County M	180	153	Fair	Fair
Carpenter Creek at County NN	131	168	Fair	Fair
Little Silver Creek at 26th Ln	N/A	99	N/A	Good
Little Silver Creek at 28th Ct	125	118	Good	Good
Mud Creek at County H	173	N/A	Fair	N/A

Table 22: Historical and Current Aquatic Life Habitat Assessment Ratings and Condition Categories in the Pine River Watershed.

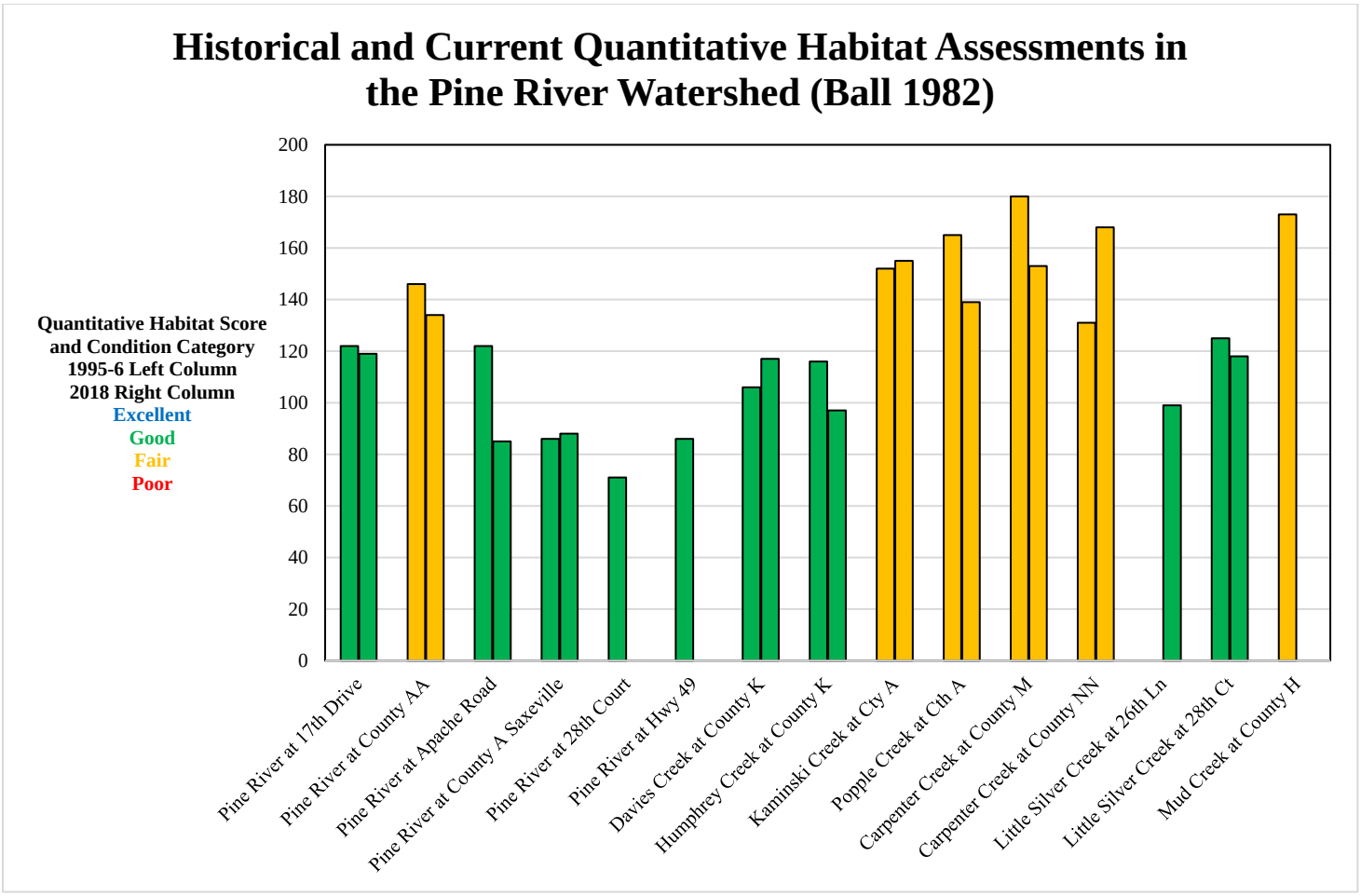


Chart 18: Historical and Current Aquatic Life Habitat Assessment Ratings and Condition Categories in the Pine River Watershed.

In 1995, low dissolved oxygen (DO) was identified as having a negative impact on the water quality of streams in the Pine River Watershed. Continuous DO and temperature meters were placed in 3 streams and at 2 locations in the Pine River mainstem (Table 16, Chart 13). The DO and temperature meters were deployed for at least 5 days. In 2018, DO and temperature meters were deployed at the same locations in Table 16 for a period of 5 days, beginning at midnight the first day. The Pine River from its headwaters downstream to Poy Sippi and Humphrey, Carpenter, and Davies Creeks are listed as trout waters in Wisconsin. Wisconsin Administrative Code ch. NR 102 established the minimum DO water quality standard for trout waters at 6 mg/L (7 mg/L during spawning time). Between 1995 and 1996, the DO in the Pine River ranged from 6.8 mg/L to 14 mg/L, never dipping below the minimum of 6 mg/L. Davies, Humphrey, and Carpenter Creeks were below the minimum DO at least for a short period of time in 1996 (WDNR 1997). In 2018, the DO fluctuated less and was generally higher than the DO measurements in 1995 and 1996. In addition, the 2018 DO levels in Davies, Humphrey, and Carpenter Creeks stayed above the WQC minimum of 6.0 mg/L (Table 16, Chart 13). This may be an indication of lower amounts of organic loads using up oxygen are being delivered to the Pine River and its tributaries. The higher water levels in 2018 may have had some effect on the DO levels. Redeploying DO meters in the Pine River Watershed during average precipitation year may be necessary.

Conclusions

The water quality monitoring in 2018 demonstrated some water quality improvements, protection, and declines since the implementation of the Priority Watershed Project of the late 1990s and early 2000s. The mainstem of the Pine River maintained its good to excellent fish communities and indicated a reduction in baseflow NO_3+NO_2 as N. An increase in the macroinvertebrate communities was observed at all locations sampled in 2018 compared to those sampled in 1996 indicates water quality improvements. The DO meter deployments in 2018 indicate no levels below the minimum for trout waters at 6.0 mg/L. Conversely, Carpenter and Mud Creeks are not meeting their potential uses, demonstrate high nutrients, and sedimentation limits available fish and aquatic macroinvertebrate habitat. Sedimentation limits available fish and aquatic macroinvertebrate habitat in Humphrey Creek as well. There is abundant aquatic macrophyte growth in the Pine River downstream of the Wild Rose Millpond which indicates a significant source of nutrients. The Fair MIBI at 19th Drive may reflect the effects of the nutrients and abundant aquatic macrophyte growth impacts on the water quality in the river. The need for watershed improvements remains throughout portions of the Pine River Watershed.

In the *Nonpoint Source Control Plan for the Pine River/Willow Creek Priority Project*, Saxeville Dam on the Pine River is indicated as a trout migration barrier (WDNR 1998). The Poy Sippi Dam is a fish and freshwater mussel migration barrier as well. The millpond dams in the Pine River Watershed continue to have thermal and biological impacts on the Pine River. Drawdowns of the millponds in the Pine River Watershed may impact the water quality of the Pine River (Photo 5). Efforts to coordinate future drawdown timing and duration with dam owners, resource agencies, municipalities, and riparian land owners should be made.

Photo 5: Drawdown of the Pine River Millpond in 2019 for Spillway Maintenance. Photo taken by D. Bolha on October 15th, 2019.

Carpenter Creek is on the US EPA Clean Water Act Section 303d List of Impaired Waters. Carpenter Creek was added to the list due to habitat degradation from sedimentation in 2002. The sediment reduction goals (27% or 471 tons sediment reduction reaching the creek annually) of the 2004 Total Maximum Daily Load (TMDL) have not been met. For the health of Carpenter Creek and its removal from the CWA 303d list, best management practices to reduce the sediments reaching the creek should be implemented.

Some of the land use characteristics observed during the 2018 monitoring project that can have a negative impact to the water quality of the Pine River and its tributaries were limited buffer protection along the stream corridors, eroding streambanks, cropland erosion, wetland drainage and ditching, perched culverts, aquatic invasive species, and sedimentation of fish and aquatic life habitat (Photo 6-9). There are more opportunities to install practices to lower the nutrients and sediment reaching the Pine River. The water quality in the Pine River Watershed is generally in good to excellent condition, so protecting it is critical for this unique resource.

Photo 6-7: Native Virile Crayfish (left) and Non-native Invasive Rusty Crayfish (right) Captured in the Pine River. Photo taken by D. Bolha on August 17th, 2018.

Photo 8: Unnamed Tributary to Carpenter Creek at 28th Road. Photo taken by D. Bolha on February 15th, 2018.

Photo 9: Perched Culvert on Kaminski Creek at County A. Photo taken by D. Bolha on February 15th, 2018.

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