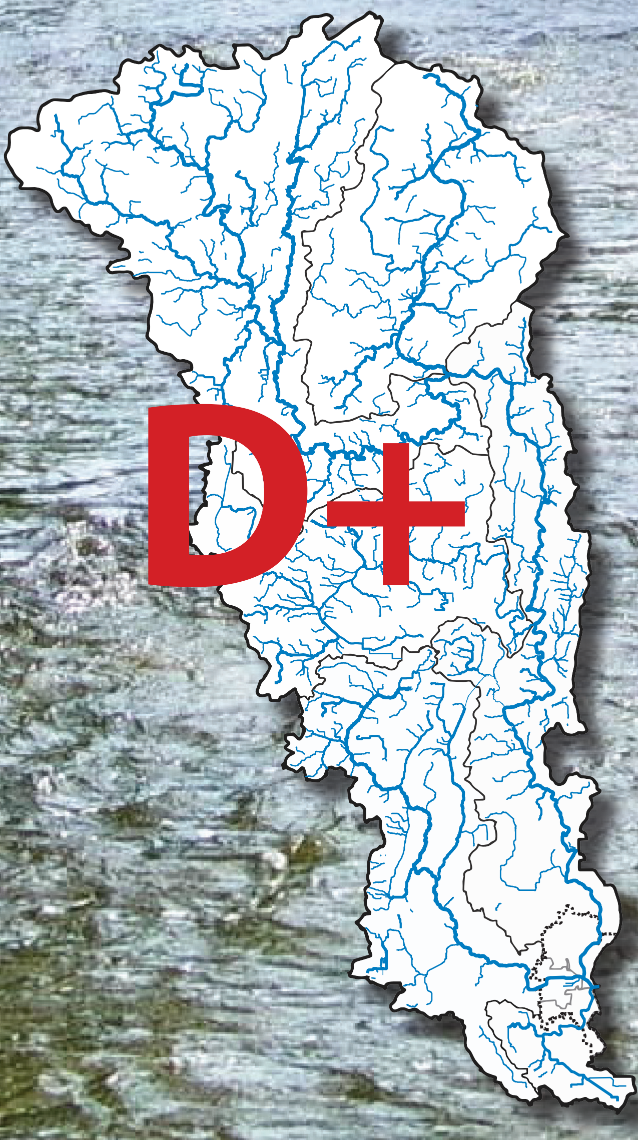
milwaukee RIVERKEEPER®

2016 Milwaukee River Basin Report Card

REPORT CARD



Introduction

Dear Friend of the River,

Welcome to our Seventh Annual Milwaukee River Basin Report Card. This year's Report Card summarizes the 2016 water quality of the Milwaukee River Basin, a 882.3 square mile area housed within Milwaukee, Waukesha, Washington, Ozaukee, Fond du Lac, Sheboygan, and Dodge Counties that includes the Milwaukee, Menomonee, and Kinnickinnic River Watersheds. Together, these Watersheds contain approximately 500 miles of perennial streams, over 400 miles of intermittent streams, 35 miles of Lake Michigan shoreline, 57 named lakes, and over 1.3 million people.

This year the Milwaukee River Basin received a grade of D+, its lowest grade since 2011. However, individual grades for each Watershed within the Milwaukee River Basin varied widely. To interpret these differences, our Report Card analyzes data results in the Menomonee and Kinnickinnic River Watersheds, the Milwaukee River Watershed and its four subwatersheds (the East and West Branch of the Milwaukee River, the South Branch of the Milwaukee River, Cedar Creek, and the North Branch of the Milwaukee River), and within the original geographical boundaries of the Milwaukee River Estuary.

To grade water quality, we compiled and averaged available data from our dedicated Milwaukee Riverkeeper (MRK) volunteer water monitors, as well as data from the Milwaukee Metropolitan Sewerage District (MMSD) and the Wisconsin Department of Natural Resources (WDNR). Our Report Card provides a snapshot of the health of the river at subwatershed, watershed, and basin levels. We measure basic water quality parameters such as dissolved oxygen, temperature, turbidity, pH, and macroinvertebrates (aquatic organisms), as well as several other pollutants of concern. In addition to our water quality grades, we highlighted the results from many of our other monitoring initiatives. These include our road salt, emerging contaminant, aesthetics, and stormwater monitoring programs.

As always, we would like to express a very special thank you to our volunteer water monitors. Without their tireless efforts, we would not have nearly the amount of data available to analyze and would know much less about the health of the Milwaukee River Basin. Our rivers are a better place thanks to their hard work!

If you are interested in participating in one of our many water monitoring programs email or call Milwaukee Riverkeeper, today!

Sincerely,

Zac Driscoll,
Water Quality Specialist

Cheryl Nenn,
Riverkeeper

Joe Fitzgerald,
Water Quality Intern

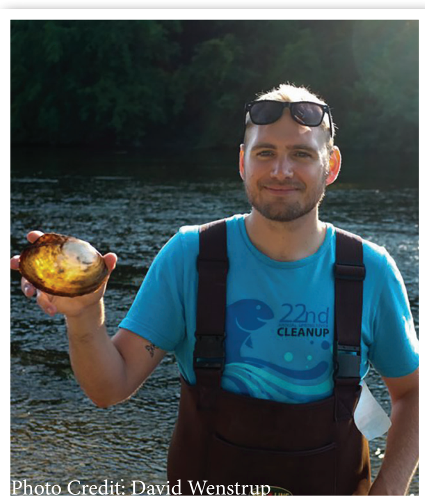
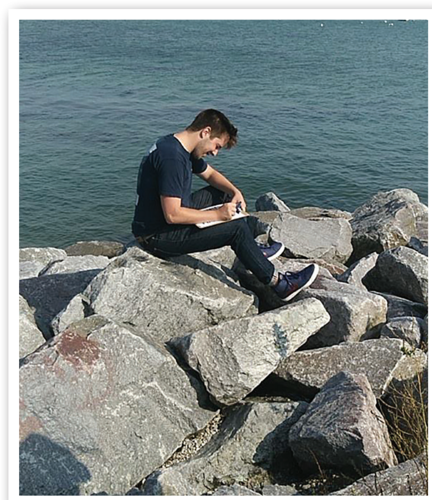


Photo Credit: David Wenstrup



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Welcome to the Milwaukee River Basin!

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What's new about our 2016 Report Card?

By publishing a yearly report on the health of the Milwaukee River Basin, we hope to provide a metric that explains how water quality changes in the Basin over time. To do this, we strive to keep our program as consistent as possible between years. However, because much of our data is collected by volunteers, fluctuations in our volunteer base can affect the number and location of our sampling sites. Likewise, the expansion of our monitoring programs and updates to our data analysis techniques can also influence our grades. To put this year's Report Card in perspective with previous years and to help better interpret this year's grade, we explain some of the major changes to the 2016 analysis below.

The addition of specific conductivity monitoring to our summer water quality monitoring program in 2016 has been an eye-opening expansion. Though MMSD had monitored this parameter in past years, adding this parameter to our program not only increased the amount of data to analyze, but also provided data from areas that MMSD does not monitor. Since specific conductivity typically scores a failing grade each year, including this parameter in watersheds where it was not monitored in the past has likely contributed to lower watershed grades in those areas, as well as to a lower overall Milwaukee River Basin grade.

A second major change to this year's Report Card grading is the separation of the Milwaukee Estuary from its associated watersheds. The Milwaukee Estuary is located in downtown Milwaukee, and is made up of the most downstream sections of the Milwaukee, Menomonee, and Kinnickinnic River Watersheds. The Estuary is much deeper and more influenced by Lake Michigan than its contributing watersheds. As a result, the Estuary typically has different, and usually better, water quality than the river segments directly upstream. Analyzing the Milwaukee Estuary separately should more accurately illustrate water quality in the Milwaukee, Menomonee, and Kinnickinnic Rivers. For example, the Kinnickinnic River Watershed previously included several Estuary monitoring locations, which likely "inflated" its grade. Separating these watersheds helps highlight specific water quality concerns in this area. Although this approach doesn't affect the overall Basin grade, it does have a major impact on the grades of specific watersheds, as seen in subsequent articles.

The final change to this year's Report Card grading was an alteration to dissolved oxygen and temperature grading protocols. Specifically, in accordance with the State of Wisconsin's water quality standards, streams with a cold water fishery designation were graded to a higher dissolved oxygen and temperature standard. Though there are only a few of these streams included within our analysis, fish and wildlife living in cold water systems require better water quality and these rivers are held to higher standards.

2016 Milwaukee River Basin Grades

A comparison of data collected in the Milwaukee, Menomonee, and Kinnickinnic River Watersheds to Milwaukee Riverkeeper's water quality goals has resulted in an overall grade of D+ for the Milwaukee River Basin in 2016. This year's grades reveal unique water quality concerns in each watershed and subwatershed of the Milwaukee River Basin. However, most of the Milwaukee River Basin struggles to meet standards for phosphorus, specific conductivity, and bacteria (where it was monitored). In general, water quality concerns in the Milwaukee River Basin seem to be largely due to each river's relationship with its surrounding land use.

Milwaukee Riverkeeper grades are based on an analysis of water quality data collected throughout the year and submitted to the WDNR Surface Water Integrated Monitoring System (SWIMS) database. Parameter grades are based on the percentage of data points that met our targets relating to aquatic ecosystem health. Grades are assigned on a typical percentage scale (see below). Overall watershed and subwatershed grades are computed by averaging their respective individual parameter grades. The overall Milwaukee River Basin grade is determined by averaging overall grades for the three major watersheds (Milwaukee, Menomonee, and Kinnickinnic). Data used in this year's analysis was collected by Milwaukee Riverkeeper volunteers and staff, MMSD, WDNR, Ozaukee County Parks and Planning Department's Fish Passage Program, and the Urban Ecology Center.

It is important to note that issues such as legacy contaminants, emerging pollutants, and stream conditions are not factored into our grading system. These factors may pose challenges to meeting our goals. For example, legacy pollutants such as polychlorinated biphenyls (PCBs), heavy metals, and petroleum products can also impair stream health, but monitoring for these contaminants is extremely expensive. Likewise, the geographic distribution of our sampling sites puts some limitations on the statistical strength of our comparisons between different areas of the Basin.

A

All water quality indicators meet desired targets **90 - 100%** of the time. Streams or river segments have "good" water quality, which are capable of supporting fish and other aquatic life.

B

Most water quality indicators meet desired targets roughly **80 - 89%** of the time. Quality of these streams and river segments tend to be good. Most areas are capable of supporting fish and other aquatic life.

C

There is a mix of healthy and unhealthy water quality indicators or indicators are only meeting water quality targets **70 - 79%** of the time. Water quality of these waters tends to be fair, as well as have fair conditions for fish and most aquatic life.

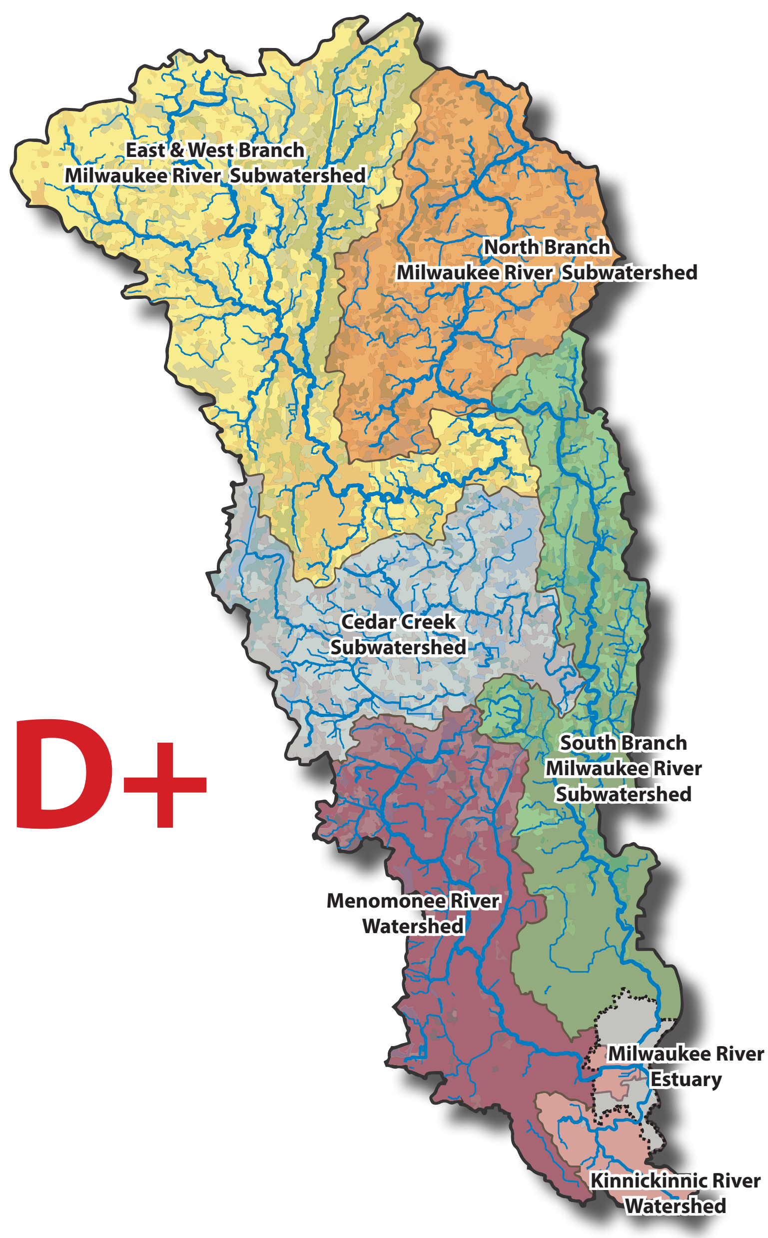
D

Few water quality indicators meet desired targets or only meet water quality targets **60 - 69%** of the time. Water quality and wildlife habitat of these waters tend to be poor.

F

Very few water quality indicators meet desired targets or meet water quality targets **below 60%** of the time. Quality of these streams and river segments are very poor and most often lead to poor conditions for fish and aquatic life.

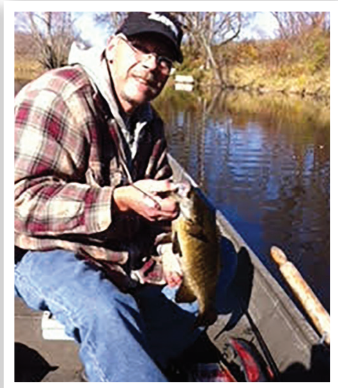
D+



Volunteer Spotlight!

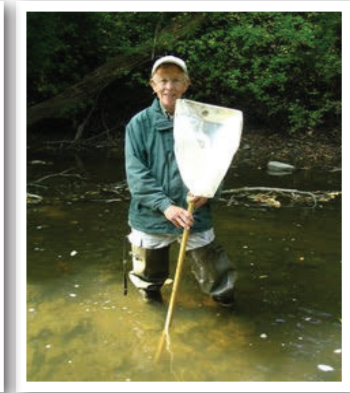
Every month during the summer, our water quality monitors make their way to river stations throughout the Milwaukee River Basin. This amazing group of individuals brave the elements so that we can gain a better understanding of the health of our rivers. Here is your chance to get to know some of our outstanding monitors in this year's volunteer spotlight!

Mike Henning



Russ Henning

Doug Day



Norm Gunder

How many years have you been a water quality monitor?

Russ & Mike: We have been water quality monitors for three years.

Doug: Four years.

Norm: I have been a water quality monitor for five years.

What got you interested in being a water quality monitor?

Russ & Mike: One day while we were fishing, we met a gentleman by the name of Jim Gennrich who was monitoring the river and we struck up a conversation with him. We became very interested in what he was doing and since we fish quite a bit, he suggested that we might become monitors ourselves. Since we wanted to learn more about the ecosystem and how we could make a positive impact for future generations, we decided to become monitors.

Doug: Monitoring is a nice fit for me in so many ways. It speaks to my love of water, interest in environment issues, and the need for engagement. Unlike some others in Milwaukee Riverkeeper, I don't have a science background and calibrating our meters was a little intimidating at first. Now, it has become second nature.

Norm: I became interested in monitoring water quality after taking a "Testing the Waters" workshop at Riveredge Nature Center in the late 1980's. Later I helped teach a science program for a few summers where middle school students gathered macroinvertebrates and sampled water quality. I hope the students enjoyed the program as much as I did. When I saw the opportunity to start monitoring waters in the Milwaukee area I didn't hesitate to sign up.

What is your favorite part about being a water quality monitor?

Russ & Mike: We like to see how the river changes throughout the year along with the changes brought to it by the varying animals and insects that inhabit and visit the river. It's also interesting to see how the weather and environment cause the river to change.

Doug: Returning month after month to the same spot on the Menomonee and experiencing the river's seasonal changes.

Norm: The bugs! There is something relaxing and almost magical about being in a river or stream--whether it is monitoring, fishing, canoeing or kayaking. My monitoring partner, Doug, is a great person to work with also.

Do you have any interesting stories of something that happened to you while conducting river monitoring?

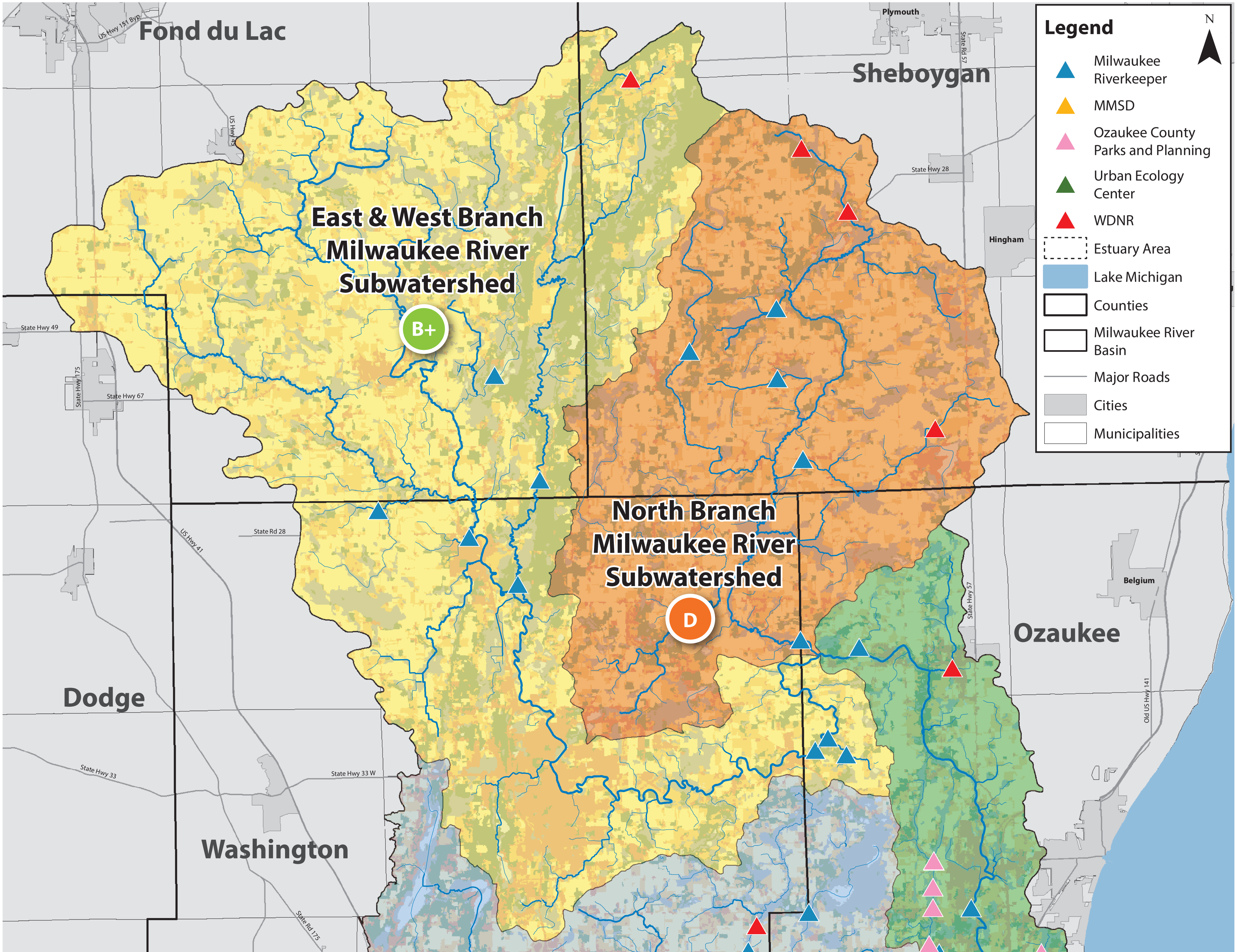
Russ & Mike: Sometimes when we are testing, we come across a blue heron that likes to stand pretty close to us. He seems to be looking for a free meal that he doesn't have to work so hard at getting as he's letting us do all the work.

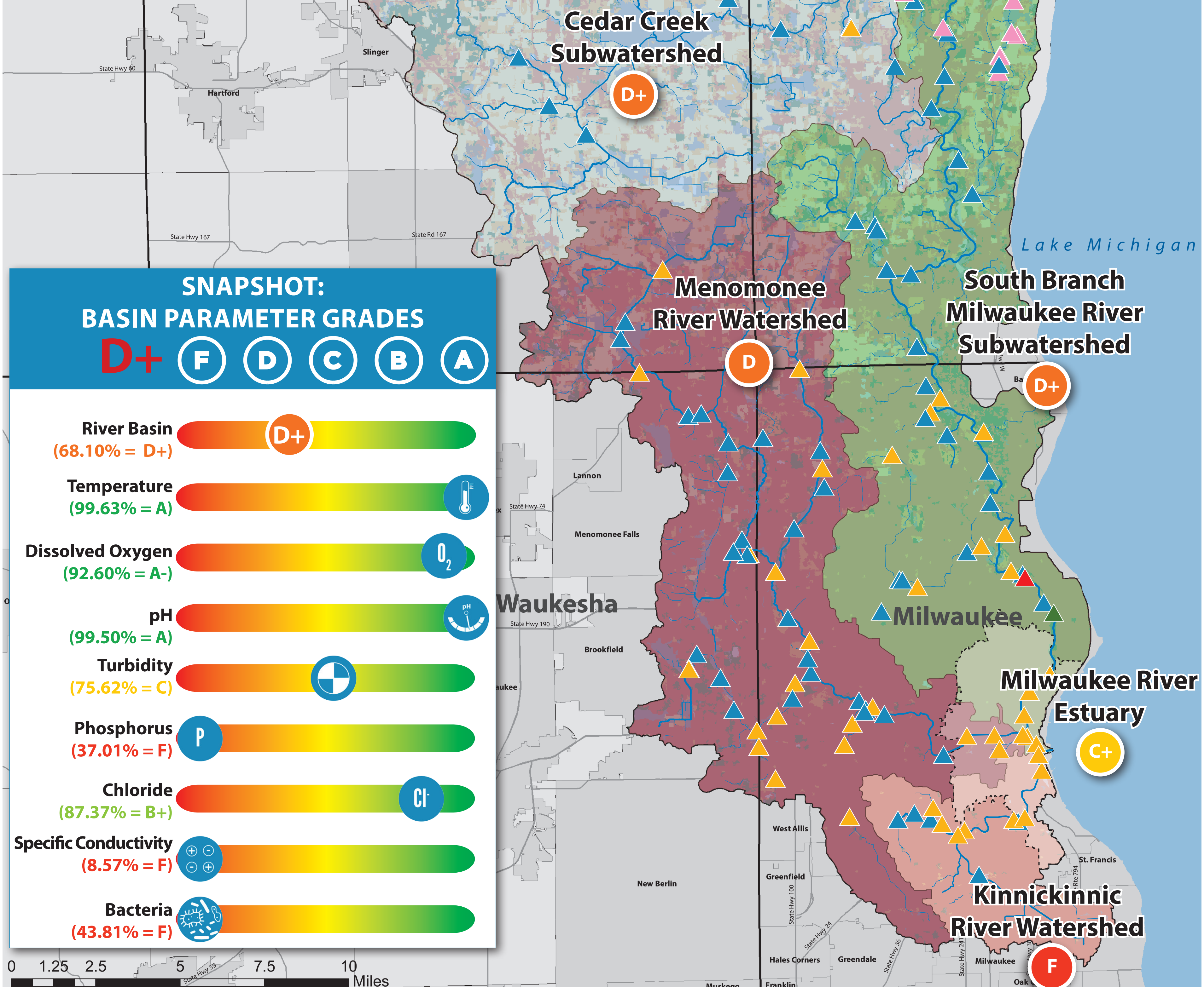
Another time we were startled when we were launching our boat and a deer lost it's footing and rolled down the hill behind us. He got up, looked at us, and went on his way.

Doug: I never expected there would be so much wildlife a short distance from North Ave and the Menomonee Parkway! Not just the deer and the ducks but also, one time, a feeding otter and, another, a flapping Coho struggling to escape our shallow riffles in its upstream run.

Norm: On my first water monitoring experience as a Milwaukee Riverkeeper volunteer I carefully checked the depth of Mole Creek. After stepping into the creek I sank down in the silt. Way down. For a moment I was not certain if I would be able to free myself. It was an inauspicious start to the volunteer experience.

Milwaukee River Basin Map




Cedar Creek Subwatershed
D+
Menomonee River Watershed
D
South Branch Milwaukee River Subwatershed
D+
Milwaukee River Estuary
C+
Kinnickinnic River Watershed
F
Lake Michigan
Milwaukee
Waukesha
Slinger
Hartford
Lannon
Menomonee Falls
Brookfield
New Berlin
West Allis
Greenfield
Hales Corners
Greendale
Franklin
Muskego
St. Francis
State Hwy 60
State Hwy 167
State Rd 167
State Hwy 74
State Hwy 190
State Hwy 100
State Hwy 24
State Hwy 36
State Hwy 241
State Hwy 59
Rte 794
SNAPSHOT:
BASIN PARAMETER GRADES
D+ F D C B A
River Basin (68.10% = D+)
Temperature (99.63% = A)
Dissolved Oxygen (92.60% = A-)
pH (99.50% = A)
Turbidity (75.62% = C)
Phosphorus (37.01% = F)
Chloride (87.37% = B+)
Specific Conductivity (8.57% = F)
Bacteria (43.81% = F)
0 1.25 2.5 5 7.5 10 Miles

How We Grade Our Water Quality Parameters

	Water Temperature	Dissolved Oxygen	pH	Turbidity
Description	Each aquatic organism's survival is limited by its tolerance to changes in water temperature. As a result, temperature ranges can be used to classify aquatic ecosystems where drastic changes in water temperature can have significant impacts on biodiversity.	Dissolved oxygen is a measure of the amount of oxygen dissolved in a volume of water. The amount of oxygen found in our rivers depends on atmospheric exchange (generally influenced by a streams velocity and substrate), and on water temperature. Oxygen is essential for every organism's survival in some concentration. Therefore, not only is dissolved oxygen an important water chemistry parameter, it also limits habitat.	pH measures acidity, or the number of hydrogen ions (H+) present in the water. Measurements range from 0 (most acidic) to 14 (most basic). Sudden changes in the pH of a waterbody can have drastic impacts on the survival of organisms that live there. Extended changes to pH can impact the function of that system.	Water clarity or turbidity is an important ecological parameter, an indicator of many water quality issues, and a defining characteristic of stream habitat for many aquatic organisms. Turbidity measurements quantify the degree that light is scattered by particles suspended in water, therefore measurements of turbidity will use different units depending on the methods and equipment being used.
Existing Standard	**Maximum Temperature** **Warm Water Sport Fisheries:** 31.7 C **Cold Water Trout Fisheries:** 22 C	**Warm Water Sport Fisheries:** 5 mg/L **Cold Water Fisheries:** 6 mg/L **Limited Aquatic Life:** 2 mg/L	pH must be within the range of 6.0 - 9.0, and cannot shift more than 0.5 units from the estimated seasonal maximum or minimum.	None
MRK Grade Standard	**Maximum Temperature** **Warm Water Sport Fisheries**: 31.7 C **Cold Water Trout Fisheries:** 22 C	**Warm Water Fisheries:** 5 mg/L **Cold Water Fisheries:** 6 mg/L	pH must be between 6.0 - 9.0.	≥ 54.7 cm in a 120 cm transparency tube (<10 NTU) is ideal for aquatic life. MMSD uses sensors to test turbidity, so a target of <10 FNU was used for their data.
Why the MRK Standard	Milwaukee Riverkeeper believes that all waterways within the Milwaukee River Basin are capable of meeting existing biological uses for fish and aquatic life in warm water or cold water fisheries. Variance standards are not protective of aquatic life, so we did not assess streams to those standards.	Milwaukee Riverkeeper believes that all streams in the Milwaukee River Basin are capable of supporting existing WDNR standards for warm water sport and cold water fisheries. Limited Aquatic Life and variance standards are not protective of aquatic life, so we did not assess streams to those standards.	Streams in the Milwaukee River Basin typically have a nearly neutral acidity (around 7), tending to err on the more basic side of the scale. In order to assure that acidity is not impacting local aquatic ecosystems, Milwaukee Riverkeeper grades within the range recommended by the WDNR.	Milwaukee Riverkeeper's standards for turbidity are based off of recommendations from WDNR. Since our report card grade is based on data gathered from a variety of sources, sometimes utilizing different methods, our grading must be adaptive. Our standard for turbidity is based off of existing state guidance, and accepted conversions between NTUs and FNUs.
How We Monitor	Monthly measurements taken at each monitoring site are compared to temperature standards for warm or cold water fisheries depending on the classification of the stream at which they were taken.	Dissolved oxygen measurements are taken using a dissolved oxygen Hach test kit, a YSI 550 dissolved oxygen probe, or other WDNR approved meters calibrated before entering the field.	pH measurements are taken monthly at each site using either an Oakton Acorn 5 or 5+ pH sensor.	Milwaukee Riverkeeper volunteers take monthly measurements of water clarity or transparency using a 120 cm transparency tube, those measurements are converted into NTU. MMSD procedures utilize electronic meters at each site that measure turbidity in FNU because of their specific light source.

	Phosphorus	**Chloride**	**Specific Conductivity**	**Bacteria**
Description	Phosphorus (measured as Total Phosphorus) is recognized as a limiting nutrient for plant and algae growth in freshwater systems. It is generally low to absent in natural systems. Phosphorus can enter our waterways naturally from leaf litter and sediment, but when found in high levels, it is more commonly associated with anthropogenic sources like fertilizers, soaps, anti-corrosion inhibitors, and industrial discharge.	Freshwater organisms must maintain a higher salt concentration than the water surrounding them. When there are extreme levels of chloride surpassing the tolerance of native organisms, mortality can increase, limiting the diversity of aquatic systems. Aside from reducing the habitat available to aquatic organisms, chloride concentrations can also influence abiotic processes in rivers and lakes.	Specific conductivity is a measure of the ability of water to pass an electrical current. Measurements of specific conductivity are impacted by the presence of charged particles, both positive (cations) and negative (anions). Specific conductivity is naturally tied to the geology of streams, but it can also be impacted by discharges of charged particles into streams (e.g. chloride, phosphate, nitrate, heavy metals, etc.).	Bacteria concentrations can impact the health of aquatic systems as well as the health of communities that interact with those systems. Regulatory agencies have strict guidelines for bacteria based on human health impacts. High bacteria levels can be a sign of agricultural runoff, failing septic, or illicit discharges of sewage. New methods of testing for bacteria can better distinguish between animal and human sources.
Existing Standard	The Wisconsin State Standard for phosphorus is 0.075 mg/L in streams, and 0.1 mg/L in larger rivers specifically designated in state rule NR 125.	**Chronic Toxicity:** over 395 mg/L over a four day period; **Acute Toxicity:** 757 mg/L or greater twice in one season.	**United State Environmental Protection Agency (US EPA) guidance:** 150-500 μS/cm	Wisconsin Recreational Use Standards state that fecal coliform should never exceed 200 CFU/100 mL in waterways. Designated variance rivers are not to exceed 1000 CFU/100 mL. US EPA established an *E. coli* standard of 235 CFU/100 mL for beaches.
MRK Grade Standard	Milwaukee Riverkeeper adheres to the Wisconsin State Standard for phosphorus, 0.075 mg/L in streams and 0.1 mg/L in rivers specifically designated in state rule NR 125.	Samples are graded based on their ability to pass standards for both chronic and acute toxicity.	150-500 μS/cm	Fecal coliform should never exceed 200 CFU/100 mL; *E. coli* should never exceed 235 CFU/100 mL.
Why the MRK Standard	Low levels of phosphorus should be achievable in all sections of the Milwaukee River Basin. Adhering our grading standard to State water quality standards allows our monitoring to be utilized as evidence of impaired waterways and helps us to gage our progress on pollution reduction and restoration efforts.	For purposes of this Report Card, we do not grade chloride based on the duration of measured chloride concentrations, but rather based on exceedance of chronic and acute targets. We do analyze concentrations and duration for proposed impaired waters listing. Milwaukee Riverkeeper believes it is critical for streams to remain below chronic and acute standards for any duration of time.	Inland freshwater studies conducted by the US EPA suggest that this range is healthy for systems supporting mixed fisheries (US EPA 2009). This range is difficult to meet for most of our urban streams.	Milwaukee Riverkeeper believes that achieving Wisconsin Recreational Use Standards in our rivers should be a goal across the Milwaukee River Basin.
How We Monitor	A subset of Milwaukee Riverkeeper volunteers collect samples monthly that are sent to the Wisconsin State Lab of Hygiene for analysis. Phosphorus measurements from the WDNR SWIMS database and MMSD's routine surface water monitoring are collated and analyzed.	Chloride samples are taken at sites throughout the Milwaukee River Basin and sent to the Wisconsin State Lab of Hygiene for analysis. Chloride samples taken by Milwaukee Riverkeeper volunteers for winter sampling in 2016/2017 were not included in this years grading.	Conductivity measurements are taken using a ECTestr meter calibrated before entering the field.	Samples taken for bacteria are analyzed based on the number of colony forming units (CFU's) present in a 100 mL sample. Grades in this year's report card were calculated using Wisconsin Recreational Standards. The number of samples exceeding standards for fecal coliform and *E. coli* were combined and graded together compared to the total number of samples taken.

Macroinvertebrates

In 2016, Milwaukee Riverkeeper volunteers collected macroinvertebrate data from 30 monitoring sites on 72 different occasions, the WDNR monitored one site twice, and the Urban Ecology Center monitored one location in Hubbard Park on seven separate occasions. Measurements of the health of macroinvertebrate communities can be an outstanding way to reveal the long term health of aquatic ecosystems. Although, a stream's aquatic community may not be able to define exact environmental problems, it does give us a sense of when a stream ecosystem is healthy or undergoing changes or stress. Milwaukee Riverkeeper volunteers monitor macroinvertebrate communities using a biotic index method recommended by the WDNR's Water Action Volunteers Program. This index assesses the health of streams by monitoring the presence/absence of specific organisms with known tolerance to pollutants and dissolved oxygen levels. Based on the type of organisms that are found (tolerant, semi-tolerant, semi-sensitive, and sensitive to pollution), sites are assigned a grade ranging from 0-4. Using this scale, a grade below 1 means that no organisms were present, 1-2 represents a stream with poor community health, 2.1-2.5 indicates a stream with fair community health, 2.6-3.5 means a stream has good community health, and any values 3.6 and above are representative of excellent community health.

The Milwaukee River Basin's average macroinvertebrate score was fairly healthy, sitting around 2.37. Each watershed within the basin had a varying range of grades, and a unique overall average biotic index score (Figure 1). Within each watershed, despite specific anomalies, there seemed to be a spatial trend in scores where sites in the upper reaches of each stream generally had higher biotic index scores than those in lower reaches. That being said, aside from the Kinnickinnic River Watershed, which was assessed to have a poor biological community, and the East and West Branch of the Milwaukee River, which was measured to have an excellent biological community, the remaining watersheds in the Milwaukee River Basin all scored as a fairly healthy biological community.

	Number of Measured Sites	Number of Measurements	Average Biotic Index Score
Cedar Creek Subwatershed	2	5	2.48
East & West Branch Milwaukee River Subwatershed	4	5	2.71
Kinnickinnic River Watershed	2	4	1.81
Menomonee River Watershed	8	25	2.41
Milwaukee River South Branch Subwatershed	16	42	2.36

Figure 1. A table summarizing the results of macroinvertebrate monitoring during the 2016 water quality monitoring season. A lower biotic index score can indicate a less healthy river.

A breakdown of our macroinvertebrate monitoring revealed which organisms appear most frequently throughout the Milwaukee River Basin and each of its watersheds (Figure 2). Throughout the Basin, the most frequently observed organisms were mayflies, closely followed by both damselflies and crayfish. However, observations of each organism varied between each watershed. For example, other than damselflies, we almost exclusively observed organisms that exist in poor water quality in the Kinnickinnic River. The East and West Branch of the Milwaukee River, which received the highest overall biotic index score, contained mostly critters that thrive in good or excellent water quality. These critters included caddisfly larvae most frequently, but also stonefly and dobson fly larvae.

Macroinvertebrates Found in the Milwaukee River Basin in 2016

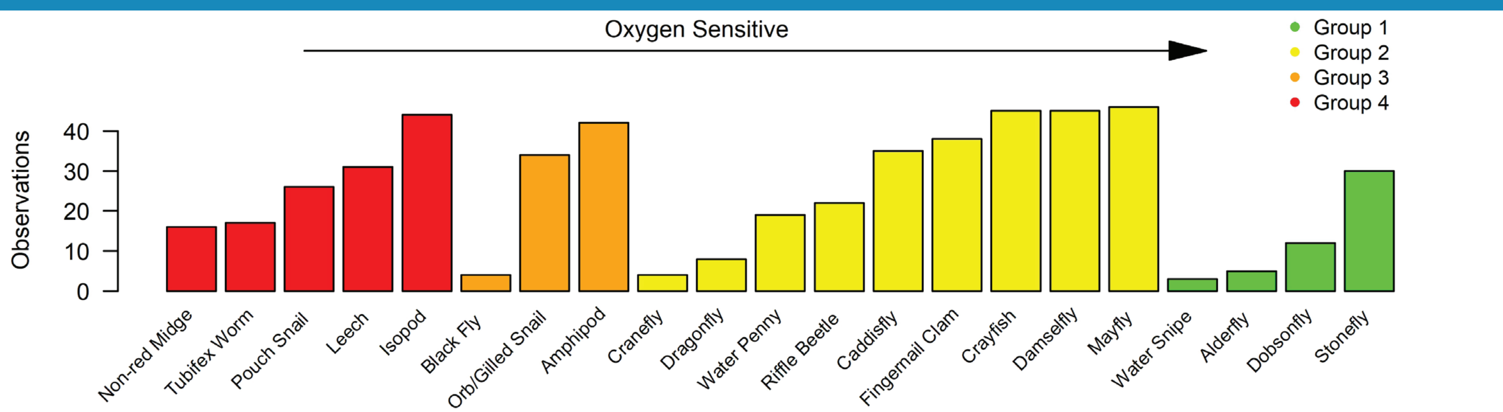


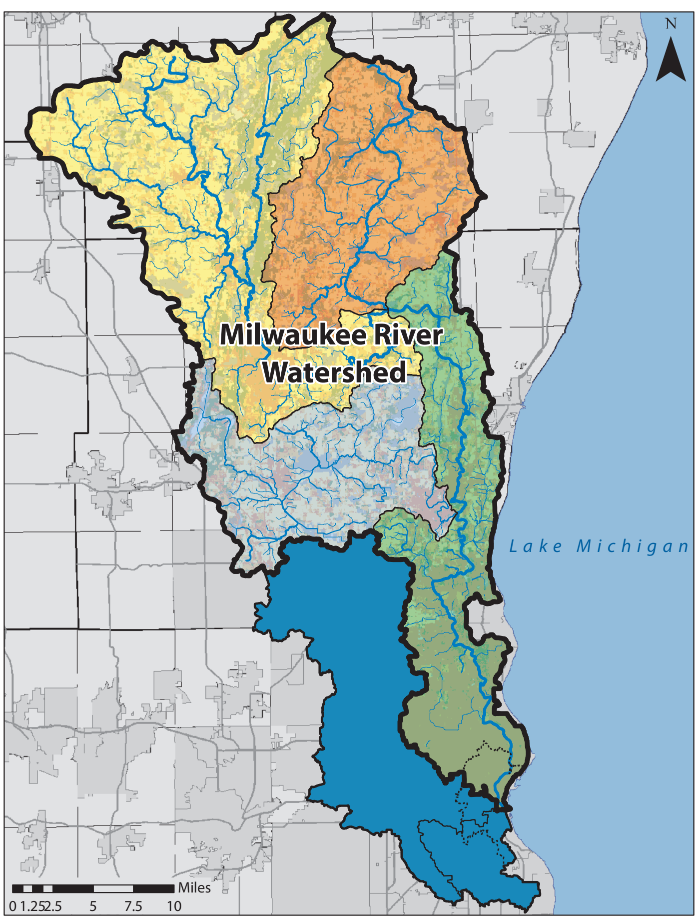
Figure 2. A bar chart displaying the total number of observations of each organism found during the 2016 macroinvertebrate monitoring season. Bar color refers to each organism's classification within the WDNR biotic index, where organisms in group four are pollution tolerant while organisms in group one require very good water quality.

Milwaukee River Watershed C

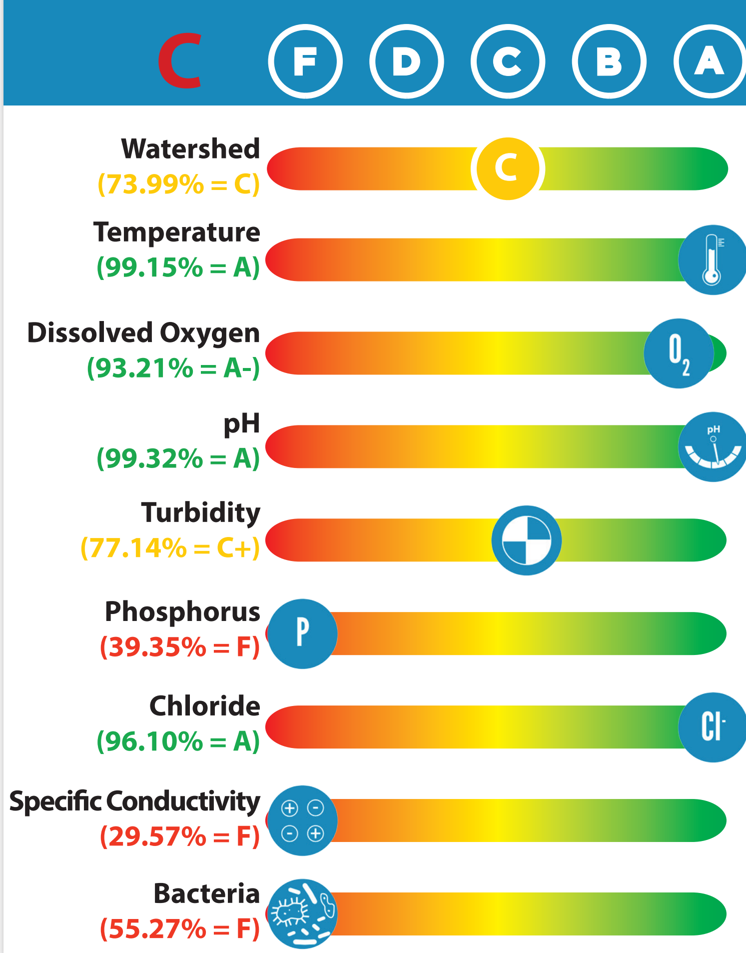
The Milwaukee River Watershed makes up an area of 700 square miles located north of the Kinnickinnic and Menomonee Rivers. The Watershed covers portions of Dodge, Fond du Lac, Milwaukee, Ozaukee, Sheboygan, and Washington Counties. Since the Watershed is so large, and its branches are distinctly unique, the Milwaukee River Watershed is commonly thought of as four connected subwatersheds: the East and West Branch Subwatershed, the North Branch Subwatershed, the Cedar Creek Subwatershed, and the South Branch Subwatershed. Between these branches, the Milwaukee River flows over 476 stream miles, originating in springs and wetlands surrounded by rural forested and agricultural land use in its upper reaches, and eventually meeting Lake Michigan at the City of Milwaukee Harbor. Land cover throughout the Milwaukee River Watershed is approximately 18% urban/developed, 34% agricultural, 17% grassland, 14% forested/barren, and 16% wetland habitat. However, each subwatershed consists of distinctively different land coverage.

In 2016, the Milwaukee River **Watershed** received an overall grade of C, scoring approximately 5% higher than the Milwaukee River **Basin** grade of D+, which includes the Menomonee and Kinnickinnic River Watersheds. Water quality throughout the Milwaukee River Watershed varies within each subwatershed, and at each site. Those differences, as well as the variables associated with our assessment of each subwatershed, will be addressed in individual articles. The Milwaukee River Watershed as a whole struggled to meet standards for bacteria, specific conductivity, and phosphorus. These parameters all received an F, ultimately bringing down the 2016 grade. Conversely, the Milwaukee River Watershed's overall grade was balanced out by several high scoring water quality parameters including temperature, dissolved oxygen, pH, and chloride. All of these parameters received a grade of an A- or above. However, although chloride received an A on average, we did observe very high levels during the winter of 2016 likely due to the application of road salt. This was especially true for smaller tributaries like Indian and Brown Deer Creek. The addition of unique standards for sites on designated warm and cold water streams illuminated concerns about water temperature in cold water streams of the Milwaukee River. While warm water streams met the standard 100% of the time, the few cold water streams in the Milwaukee River Basin only met the temperature standard 60% of the time, potentially posing a threat to cold water fisheries. This year's grades for the Milwaukee River Watershed are more or less consistent with the grades achieved in 2015 and 2014 when the Milwaukee River Watershed also received a grade of C. Specific grades for individual water quality parameters either rose (turbidity, specific conductivity, chloride, bacteria) or fell (dissolved oxygen, pH, water temperature, phosphorus). However, the total grade for the Watershed only dropped approximately 3% from last year.

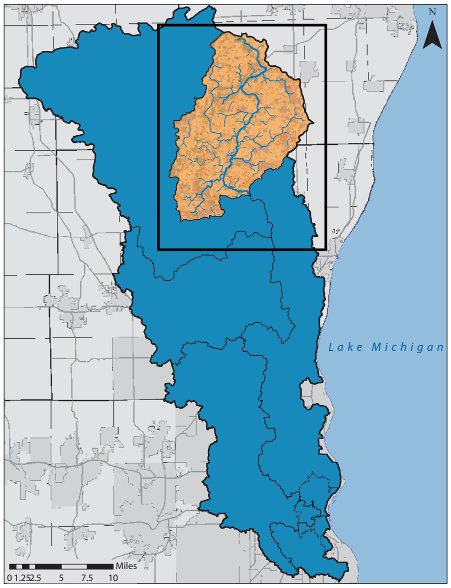
Milwaukee River Watershed

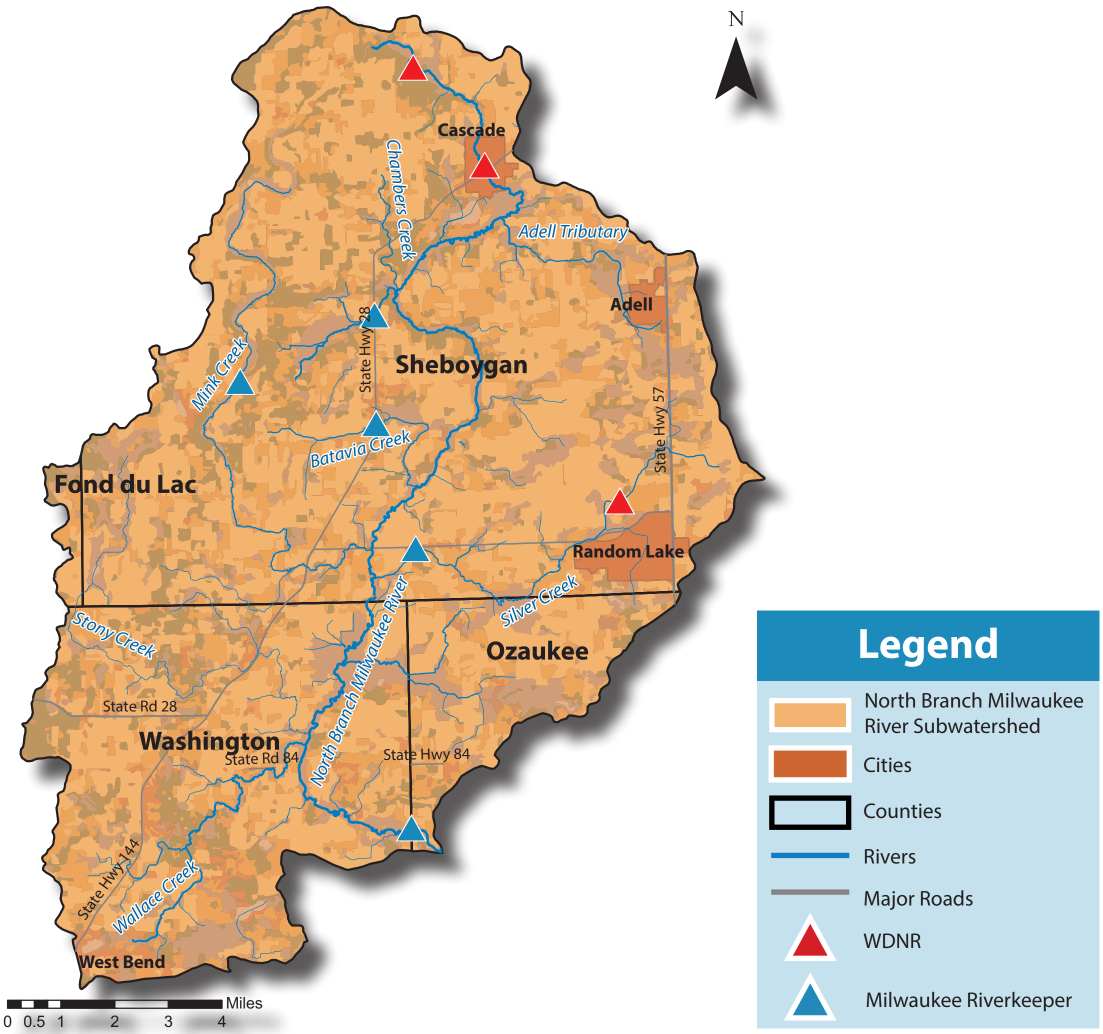


2016 Watershed Parameter Grades



North Branch Milwaukee River Subwatershed D





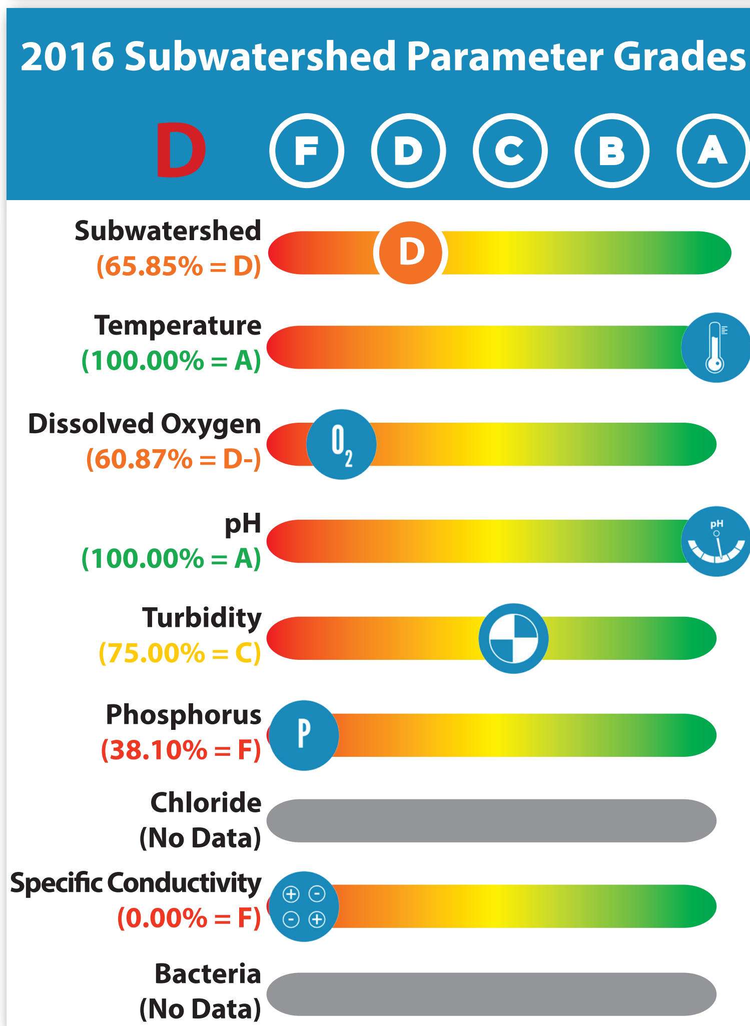
The Milwaukee River's North Branch Subwatershed covers an area of 149.7 square miles spread between four counties: Fond du Lac, Ozaukee, Sheboygan, and Washington. The North Branch Milwaukee River begins in the Nichols Creek State Wildlife Area in Sheboygan and flows 28 miles until it meets the main channel of the Milwaukee River in Ozaukee County. The seepages and springs in the 612 acres of the Nichols Creek State Wildlife Area are one of the originating sources of the Milwaukee River. The North Branch Subwatershed is primarily rural, its land cover is 45% agricultural, 15% wetland, 20% grasslands, and 14% forested. Urban land use in the Subwatershed makes up less than 5% of the total coverage. As a result, the North Branch of the Milwaukee River is made up of a network of small tributaries that meander through primarily natural or agricultural land. Approximately 60% of the 100 foot riparian area surrounding streams in the North Branch Subwatershed is classified as wetland, and only around 2% is listed as urban or developed (WDNR 2016). Conversely, the 100 foot riparian buffer of the Milwaukee River Estuary is almost exclusively classified as urban/developed land use, with only small pockets of forests making up about 1% of the land cover (WDNR 2016). Much of the lower Milwaukee River Watershed deals with balancing aquatic habitat flood management because of urban development, while habitat within tributaries of the North Branch Subwatershed is often limited by the lack of water contributing to streamflow (especially in late summer months). The land use characteristics and hydrology of the North Branch of the Milwaukee River make it unique from its southern counterparts.

In 2016, Milwaukee Riverkeeper volunteers monitored water quality at five sites throughout the Milwaukee River's North Branch a total of 24 times. WDNR staff monitored three sites on four separate occasions. Based on our collective monitoring results, this year's grade for the North Branch of the Milwaukee River is a D. This is a drastic drop from 2015 when the North Branch received a grade of B-, and it is different from both the overall Milwaukee River Watershed grade of C, and the Basin grade of D+. Though numerous water quality issues were identified in this year's monitoring, fewer data points were collected in the North Branch than last year, which poses a limitation to our understanding of the Subwatershed. The number of sites monitored by our volunteers decreased, highlighting just how variable water quality can be depending on the selection of sites monitored throughout a watershed. The loss of data from locations such as Nichols Creek, which historically had pristine water quality, impacted the overall lower grade. Streams in the northern reaches of the Milwaukee River are much smaller, some are ephemeral, and many generally have low flow that is heavily dependent on weather conditions. Changes to weather or even slight modifications of land use throughout the North Branch Watershed can cause water quality to change substantially.

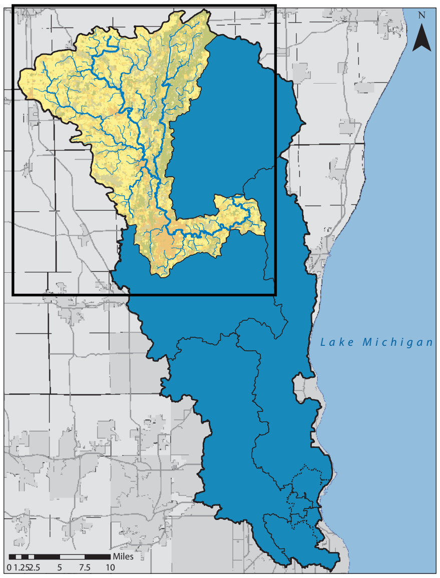
Another reason this year's grade for the North Branch Subwatershed declined was the addition of specific conductivity to our monitoring program, which has highlighted particular water quality concerns. In 2016, not a single data point in the North Branch Subwatershed met our water quality goals for specific conductivity, giving it the lowest grade for this parameter in the entire Milwaukee River Basin. Although concerning, without more information, it is difficult to pinpoint what is exactly causing the low grade for specific conductivity in this subwatershed. Specific conductivity is controlled by different dissolved ions or charged particles, and without knowing the concentration of each of these dissolved ions, it is not possible to know what is causing high specific conductivity levels. That being said, the relatively large percentage of agricultural land use in the North Branch Subwatershed provides some insight to develop a hypothesis. Phosphates, nitrates, and potassium are key components in fertilizer applied to farm fields. During rain events, fertilizer runs off into river systems, which likely increases the concentration of these nutrients, and consequently increases specific conductivity. Therefore, these particular ions might play a role in causing high specific conductivity levels on the North Branch Subwatershed. However, more analysis focused on identifying the composition of the ion concentrations in these streams is required to better understand what caused the low grade for specific conductivity in the North Branch Subwatershed.

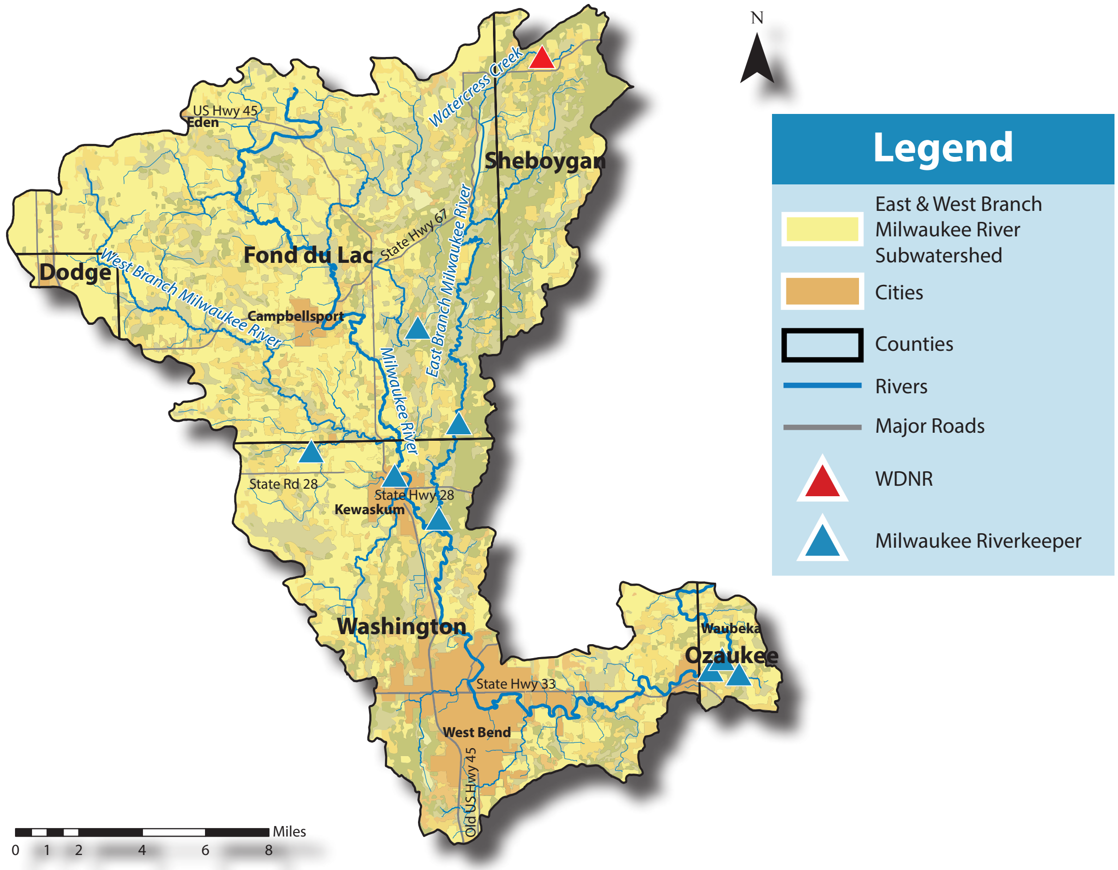
An additional parameter of concern in the North Branch Subwatershed is dissolved oxygen. Like previous years, the Subwatershed continued to have major issues with low dissolved oxygen concentrations, receiving a D- grade. This is in stark contrast to the high dissolved oxygen grades observed in all other watersheds throughout the Milwaukee River Basin. Particular streams that contributed to this low dissolved oxygen grade include Mink, Melius, and Batavia Creeks. Low oxygen concentrations were observed later in the season for both Mink and Melius Creeks, both reaching their minimum levels in September. Conversely, Batavia Creek's dissolved oxygen levels remained extremely low for the entire monitoring season, ranging from 0.22 – 3.1 mg/L. These low values are especially concerning since nearly all fish living in rivers typically need at least 5 mg/L of dissolved oxygen to survive. Though the major drivers for the low oxygen values are not entirely clear, there a few mechanisms that could help to explain them. Streams in the northern reaches of the Milwaukee River are much smaller, and generally have lower flow. Low flow can lead to stagnant water, which can result in reduced dissolved oxygen concentrations. Also, runoff from the agricultural land use surrounding these creeks is likely adding a large amount of nutrients, organic matter, and bacteria after rain events. When this happens, bacteria can reach high levels and consume a lot of dissolved oxygen while breaking down organic matter and nuisance plants and algae that often spring up when there are high levels of nutrients. This also can lead to low oxygen levels. Further monitoring of these creeks is needed to better understand what is driving the low dissolved oxygen concentrations.

Milwaukee Riverkeeper staff sample for specific conductivity and other water quality parameters in Batavia Creek during summer (top) and winter months (bottom).



East & West Branch Milwaukee River Watershed B+





The East and West Branch of the Milwaukee River Subwatershed makes up an area of 266 square miles that occupies portions of Dodge, Fond du Lac, Ozaukee, Sheboygan, and Washington Counties. The Milwaukee River's main channel (which runs between the West and East Branches) is the longest river in the Subwatershed, starting in a series of wetlands in Fond du Lac County and running 53 miles until it meets the North Branch of the Milwaukee River around Waubeka. The Milwaukee River East Branch finds its headwaters in Watercress Creek, one of the few trout streams in the Milwaukee River Basin. Unlike the Milwaukee River's main channel, and the West Branch of the Milwaukee River, the East Branch of the Milwaukee River is left more or less to its natural flows and meanders and runs through much of the Kettle Moraine State Forest. Much of the West Branch has been modified and/or channelized for agriculture, and the main channel of the Milwaukee River has also been considerably modified due to the presence of a series of dams and flow barriers that impact connectivity (WDNR 2001). The land usage in the 100 foot riparian corridor around streams in the East and West Branch Subwatershed is approximately 4% urban/developed, 19% agricultural, 13% forested/grassland, and 64% wetland. Land coverage throughout the entire area of the Subwatershed is 9% urban/developed, 36% agricultural, 35% forested/grassland, and 19% wetland (WDNR 2016).

In 2016, Milwaukee Riverkeeper volunteers monitored eight stations throughout the East and West Branch Subwatershed a total of 43 times, and WDNR staff monitored one site on one occasion. This year's grade for the Subwatershed stayed consistent with its 2015 grade receiving a B+, the highest overall subwatershed grade in the entire Milwaukee River Basin. The high grade in this Subwatershed is likely due to its low urban and agricultural land use, and high amounts of protected natural areas.

Though the grade for the Subwatershed remained consistent, we did observe slight changes to specific water quality parameters compared to last year's grades. Most notably was the drop in temperature from an A in 2015 to an A- in 2016. For this year's Report Card, our grading analysis used separate standards for streams with warm or cold water fisheries as designated by WDNR. Based on chemical and physical characteristics, streams designated as cold water fisheries have the potential to sustain sensitive populations of fish and wildlife, and therefore are held to higher water quality standards. Designated cold water streams are rare within the Milwaukee River Basin, and should not be held to the same standards as streams supporting warm water fisheries, since cold water streams require higher levels of dissolved oxygen and cooler temperatures to attain their designated status. The East and West Branch Subwatershed contains several cold water streams, including Auburn Lake Creek. On several occasions in 2016, temperature data recorded at Auburn Lake Creek did not meet standards for its cold water fisheries designation, bringing down the overall temperature grade for the Subwatershed (Figure 3). On a more positive note, Auburn Lake Creek did meet higher standards for dissolved oxygen that apply to cold water streams.

In 2016, Milwaukee Riverkeeper expanded our specific conductivity monitoring into the East and West Branch of the Milwaukee River. Specific conductivity data collected within this Subwatershed passed water quality goals 64.7 percent of the time resulting in a D letter grade. Though a D seems low, this was by far the highest grade received by any Subwatershed for specific conductivity. A river's specific conductivity is controlled by the concentration of ions dissolved within the water. Major dissolved ions that effect specific conductivity in streams include things like phosphate, nitrate, potassium, and chloride. Higher concentrations of these ions in a waterbody will result in higher specific conductivity measurements. Additionally, many of the ions mentioned above are typically associated with urban and agricultural runoff. The low urban and agricultural land use in this Subwatershed could be one reason that the East and West Branch of the Milwaukee River received a better grade than other Subwatersheds for specific conductivity. However, one important caveat to mention is that our volunteers only measured specific conductivity in this Subwatershed during the summer months. Our results from the entire Basin suggest that specific conductivity is the highest during the winter as a result of chloride inputs from road salt application. Increasing our winter road salt monitoring efforts into the East and West Subwatershed of the Milwaukee River could help us better understand if specific conductivity levels are also reaching high levels over the winter in this Subwatershed.

Sand County Foundation initiated a "Pay for Performance" pilot program in this Subwatershed, where the Foundation worked with farmers to minimize the nutrients running off of farms and into rivers, exchanging money for direct reductions in phosphorus and other nutrients due to sustainable agricultural practices. This approach may not be possible throughout the Milwaukee River Basin, but is a good first attempt to better understand how much it might cost to achieve our water quality goals in more rural watersheds dominated by agriculture. In addition, the Milwaukee River Watershed Conservation Partnership Program, funded by the Natural Resources Conservation Service (NRCS), has plans to expand into the East and West Branch Subwatershed (as well as the North Branch Subwateshed) in 2018. This program identifies agricultural properties discharging the most pollutants to area waterways and supplies targeted funds to pay for best management practices. These types of innovative programs are an encouraging step towards increasing action and community involvement to improve the health of our rivers.

Level I volunteer water quality monitors training at Riveredge Nature Center along the Milwaukee River.

2016 Temperature Data Observed at Auburn Lake Creek

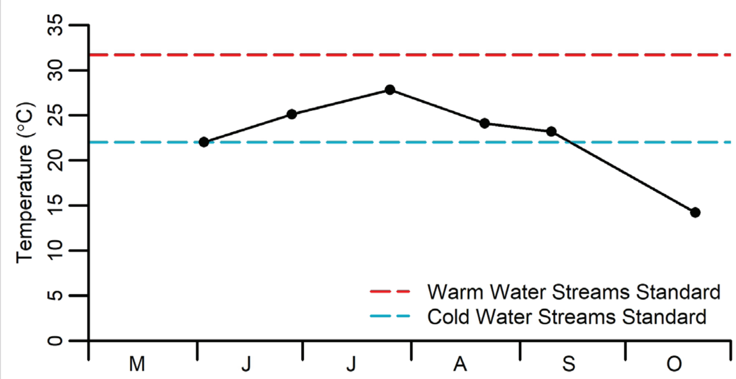
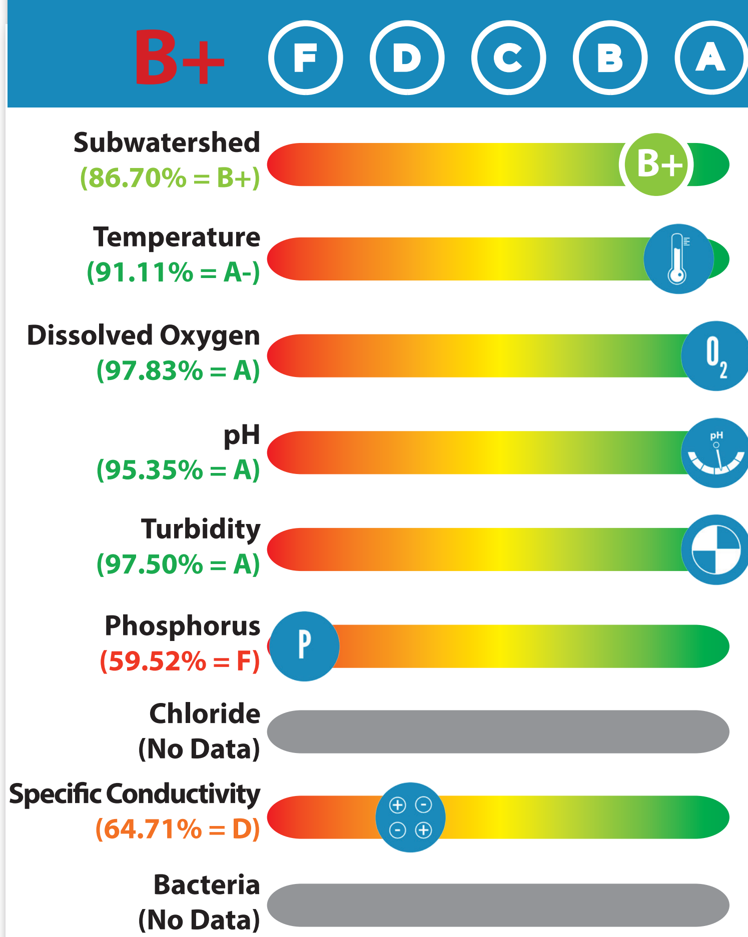
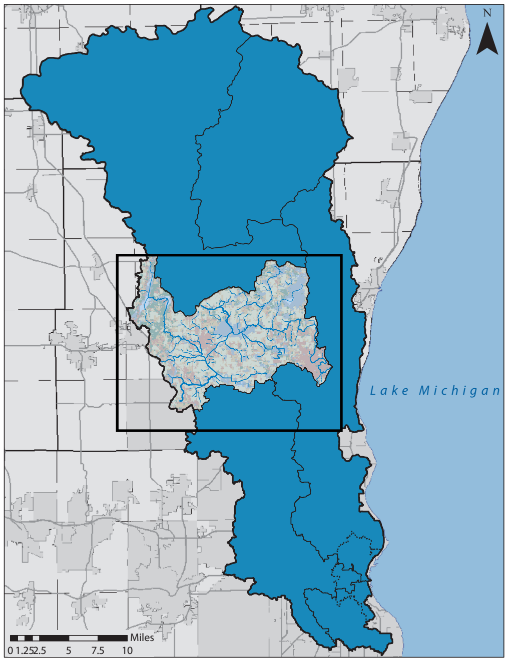


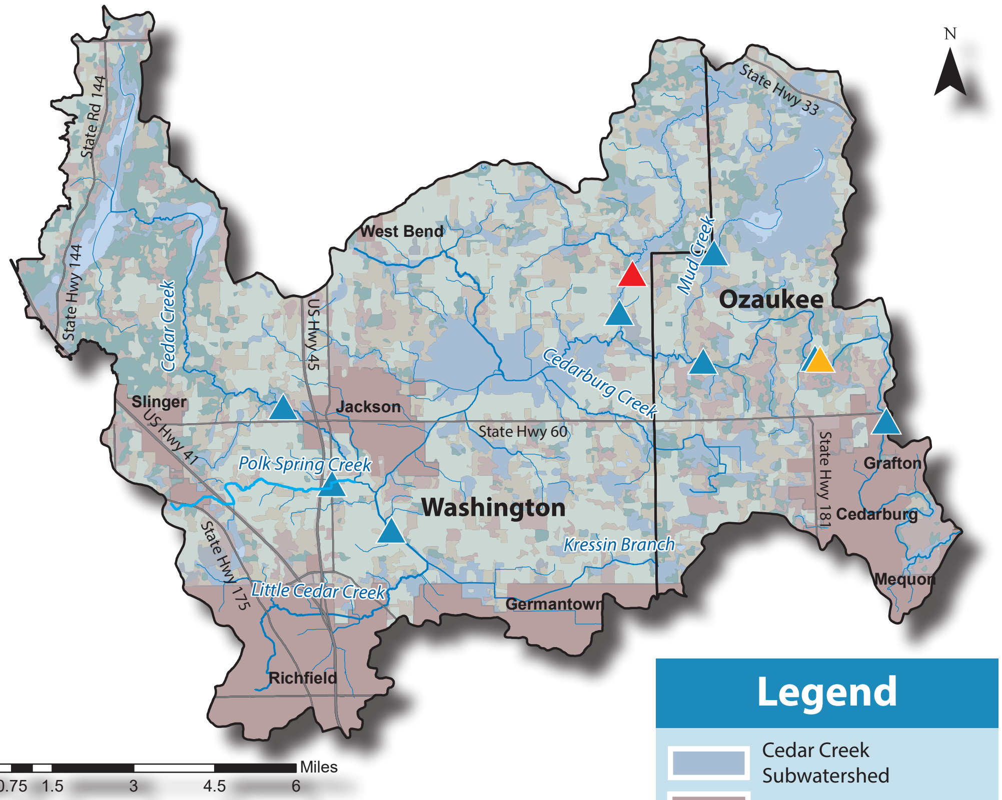
Figure 3. During the summer of 2016, temperature was recorded monthly at Auburn Lake Creek. Since Auburn Lake Creek is a cold water stream, we applied higher water quality standards for temperature compared to other monitoring locations. This resulted in Auburn Lake Creek exceeding the temperature standard much more often than if we would have applied the warm water stream standard.

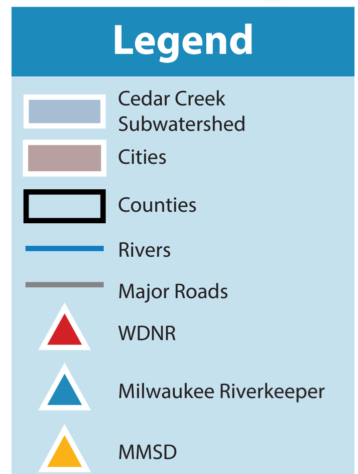
2016 Subwatershed Parameter Grades



Cedar Creek Subwatershed D+







The Milwaukee River's Cedar Creek Subwatershed covers an area of 128 square miles located in Ozaukee and Washington Counties. Cedar Creek flows approximately 28 miles through a predominantly rural landscape before meeting the Milwaukee River near the Town of Cedarburg. Land cover within the Subwatershed is 16% urban, 34% agricultural, 31% forest/grassland habitat, and 18% wetland habitat.

In 2016, Milwaukee Riverkeeper volunteers monitored a total of eight Cedar Creek sites on 42 occasions, and WDNR staff monitored a single location on Cedar Creek on one occasion. In addition to the parameters assessed in previous Report Cards, Milwaukee Riverkeeper volunteers began measuring specific conductivity values at each site, and a new MMSD monitoring location at Covered Bridge Park added measurements for bacteria and chloride. MMSD also started collecting continuous data at this location, but that data is not included in our grade calculation. Cedar Creek received a D+ in 2016. This year's grade is a dramatic drop from last year's grade of B+, but it is identical to the Milwaukee River Basin grade of D+ and water quality is similar to the overall Milwaukee River Watershed grade of C. Differences in the number of parameters being monitored between years, as well as by changes to the number and location of monitoring sites throughout the Cedar Creek Subwatershed heavily impacted the change in grade. Despite those differences, this year's monitoring did reveal substantial drops in the grades of specific parameters that were monitored in 2015, such as turbidity and phosphorus.

The most concerning water quality parameters monitored in 2016 were phosphorus, specific conductivity, and bacteria, which all received F letter grades. It is likely that these parameters are at least partially influenced by the land use surrounding Cedar Creek. High levels of phosphorus, specific conductivity, and bacteria are common water quality concerns in areas of predominantly agricultural and rural land use (WDNR 2001). Specific conductivity levels exceeded our standard on nearly every sampling date at each site throughout the Cedar Creek Subwatershed.

It is possible that the levels of bacteria found in Cedar Creek are related to the break down and decay of plant and algae growth promoted by phosphorus. However, other potential sources include agricultural runoff and failing septic systems. With only one monitoring site for bacteria, analysis or interpretation is limited.

Large portions of the Cedar Creek Subwatershed downstream from Cedarburg are contaminated by toxic levels of Polychlorinated Biphenyls (PCB's) found within the sediment downstream of facilities historically owned by Mercury Marine and Amcast. Though our monitoring does not include measurements of PCB's, it is likely that the negative impact of PCBs on the health of ecosystems within the Milwaukee River affects our monitoring results by influencing the ecological function of those systems. In 2016, a considerable amount of work was done to prepare sections of Cedar Creek for dredging in 2017 that will remove contaminated sediments from the Columbia and Wire & Nail Ponds (Figure 4). The US EPA and WDNR approved the plans for the first phase of cleanup on a 4.6 mile section of stream stretching from the formerly remediated Ruck Pond Dam to Cedar Creek's

Progress Towards Removing PCB's from Cedar Creek

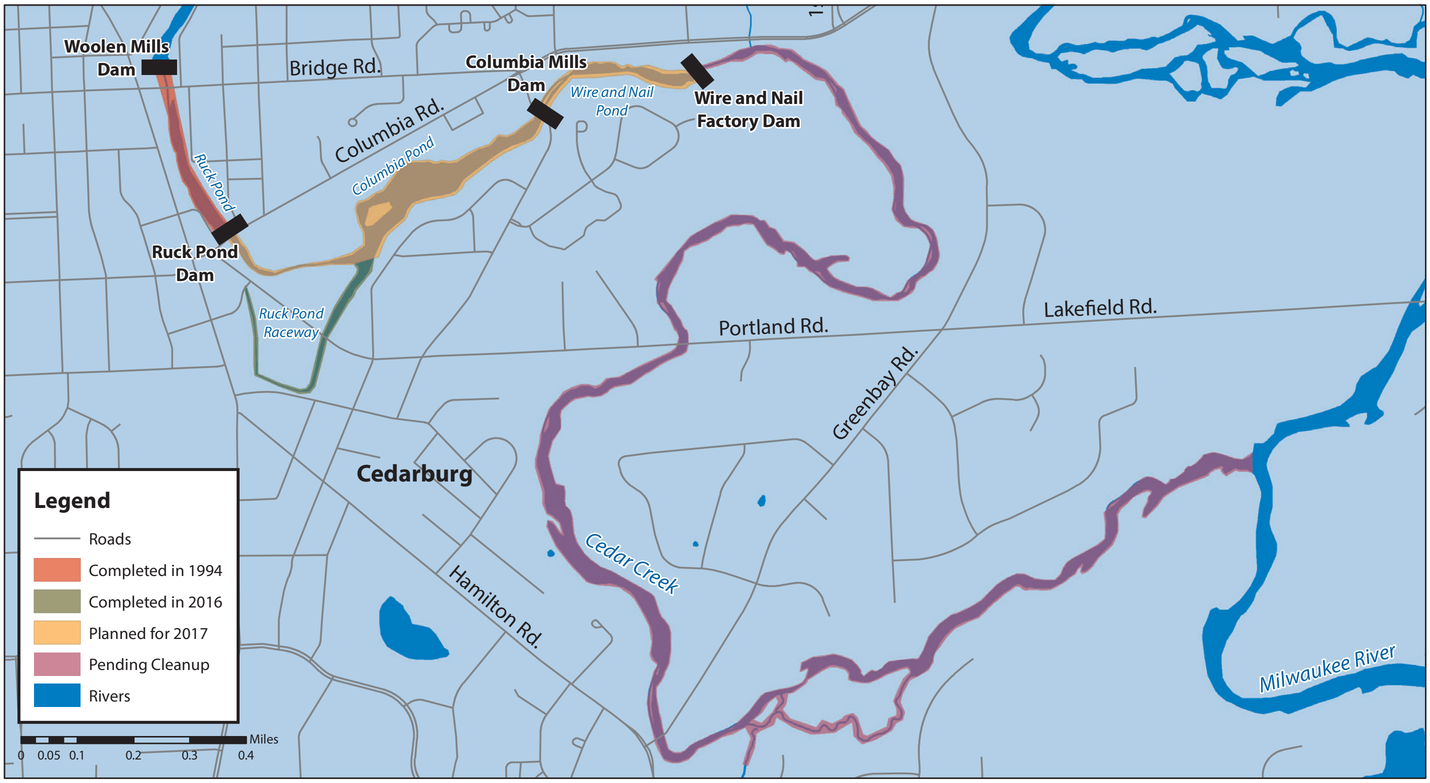
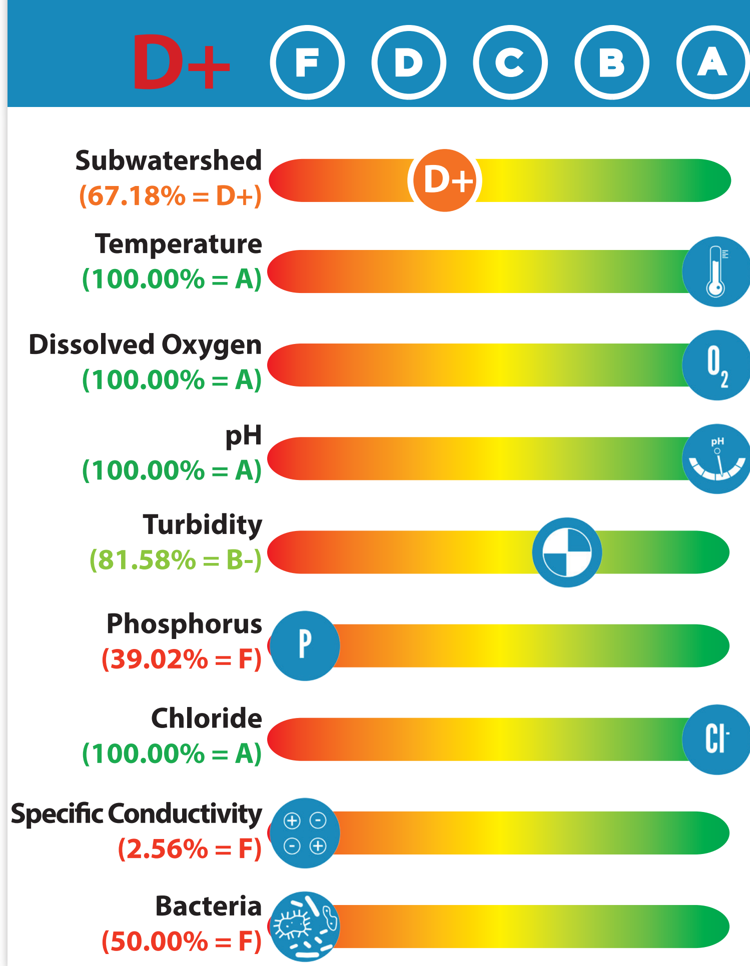


Figure 4. A map displaying the previous, current, and planned removal of PCB's from Cedar Creek stretching from the former Woolen Mills Dam to the confluence of Cedar Creek with the Milwaukee River.

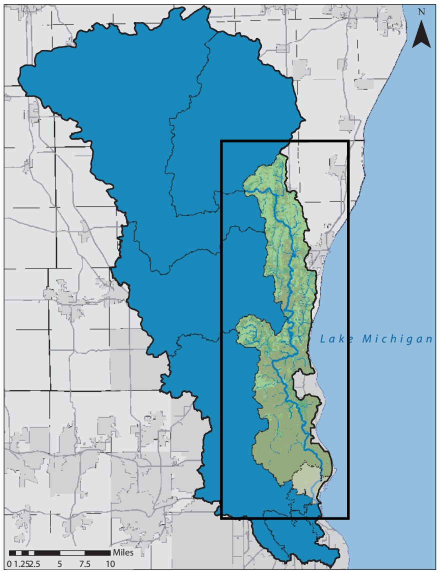
confluence with the Milwaukee River. Mercury Marine cleaned up contaminated sediments from the Ruck Pond Raceway, and also cleared portions of Cedar Creek Park and an adjoining church to serve as a temporary staging area for sediment removal of the downstream ponds. Plans for cleaning up the Creek below the Wire & Nail Pond, which is largely all in private hands, are still in development. Following the remediation, the Creek and affected adjoining properties will be restored to more natural conditions in cooperation with landowners.

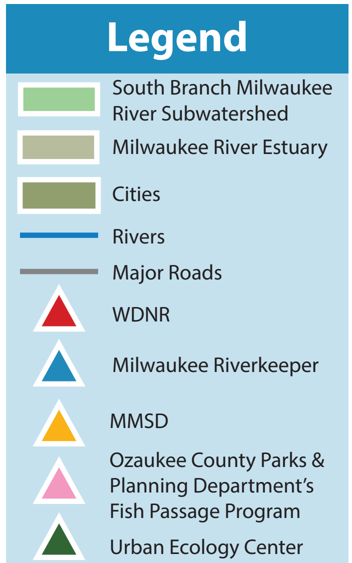
PCB removal in Cedar Creek from Columbia Pond.

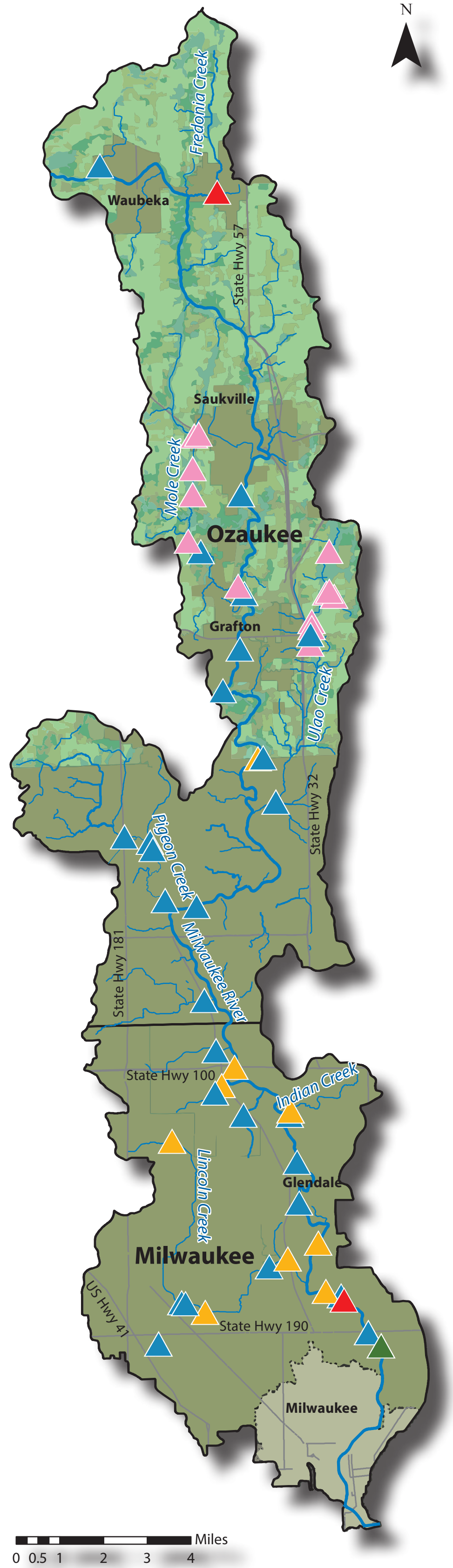
2016 Subwatershed Parameter Grades



South Branch Milwaukee River Subwatershed D+







The South Branch Milwaukee River Subwatershed covers an area of 167.9 square miles stretching between Milwaukee and Ozaukee County. Within the Subwatershed, the Milwaukee River runs for 48 miles between the Village of Fredonia and the Milwaukee Harbor. Land cover in the South Branch of the Milwaukee River is largely divided between urban and rural uses. The Watershed is about 51% urban, 19% agricultural, 12% grasslands, 9% forests, and 8% wetlands (WDNR 2016). However, within a 100 foot riparian buffer of streams within the Subwatershed, land cover is 24% urban, 14% agricultural, and 61% forest, grassland, or wetland, suggesting that streams in the Milwaukee River South Branch Subwatershed are generally well protected from soil particles, and other debris and pollutants entering the stream directly from overland flow.

Within the South Branch Subwatershed, 52 sites were sampled in 2016: nine by MMSD, two by the WDNR, 13 by the Ozaukee County Parks and Planning Department's Fish Passage Program, one by the Urban Ecology Center, and 27 by Milwaukee Riverkeeper volunteers. The South Branch Subwatershed received an overall grade of a D+, compared to the Milwaukee River Watershed's overall grade of C, and the Milwaukee River Basin's overall grade of D+. This year's grade dropped 5.6% from last year, where the South Branch received an overall grade of C. This drop may be, in part, explained by the removal of five MMSD monitoring sites from the South Branch Subwatarshed that fall within the Milwaukee River Estuary. We graded these five sites separately to remove any influence that Lake Michigan might have on our averaged assessment of each watershed. The drop might also reflect more targeted or increased monitoring occurring throughout the watershed in response to water quality concerns or special restoration projects. We saw a similar grade drop when Ulao Creek was restored in 2015 as a result of increased monitoring. Some parameters such as turbidity and bacteria showed slight improvements since 2015. However, others such as phosphorus, chloride, and dissolved oxygen showed measurable decreases.

Some of the trends revealed by 2016 sampling results indicate considerable water quality concerns in many tributaries to the South Branch Subwatershed. The water quality in the small tributaries directly impact downstream water quality in the Milwaukee River's main channel. The 2016 draft TMDL for the Milwaukee River Basin listed phosphorus as a major pollutant of concern throughout the Milwaukee River Basin with both rural and urban sources (CDM Smith 2016). Many tributaries to the Milwaukee River drain agricultural fields in the northern reaches, and drain urbanized and suburban neighborhoods further south. Considering the relative size and function of a stream can be useful when interpreting how different stream segments impact overall water quality. Comparing observed averages of total phosphorus measurements between streams of similar sizes highlights concerning trends in specific tributaries of the South Branch of the Milwaukee River (Figure 5), which potentially pose large water quality concerns for downstream segments of the River. This information also allows us to devise better management strategies and policies to improve water quality for "struggling" streams. Parameters such as specific conductivity, turbidity, and bacteria exhibit many of the same trends as phosphorus.

To combat some of the water quality concerns found in the tributaries of the South Branch of the Milwaukee River, many regional partners are studying and restoring sites throughout the Subwatershed. Following major efforts undertaken in the first phase of the Ulao Creek Restoration Project in 2015, the Ozaukee County Parks and Planning Department's Fish Passage Program coordinated extensive monitoring efforts on Ulao Creek to gain a better understanding of how the recent restoration work affected water quality in that system. This restoration work increased the number of natural meanders within the stream, removed a series of blockages to fish passage, and restored miles of habitat connectivity for Northern pike and other fisheries. Ozaukee County is also working on similar restoration projects in downstream portions of Ulao Creek as well as Mole Creek, which have both been impacted historically by stream straightening and channelization largely from agricultural activities. This important restoration work by Ozaukee County is expected to yield great rewards for both water quality and wildlife habitat in these historically channelized streams.

Volunteer water quality monitors receive Level I (top) and Level II (bottom) training at Hubbard Park along the South Branch of the Milwaukee River.

2016 Spatial Trends in Total Phosphorus

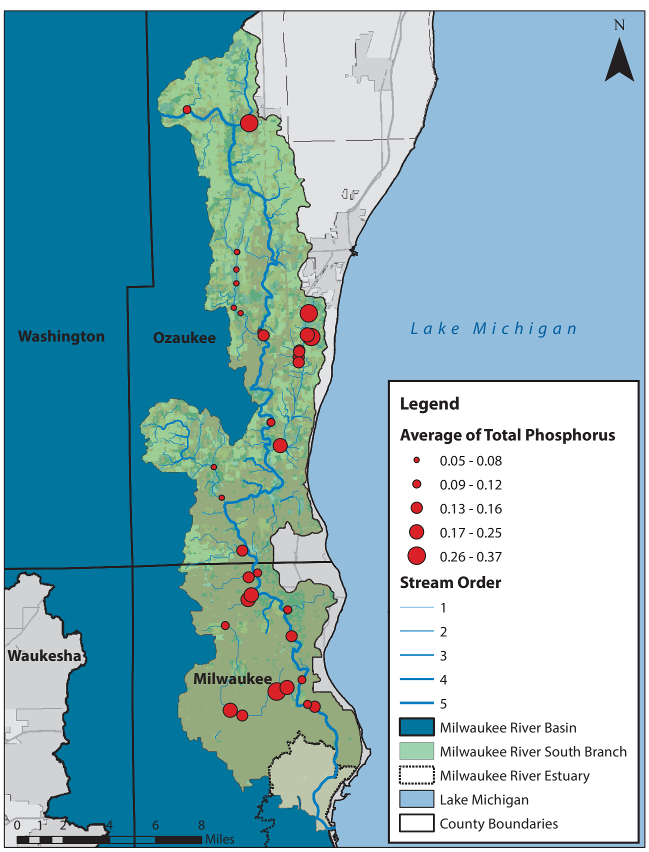
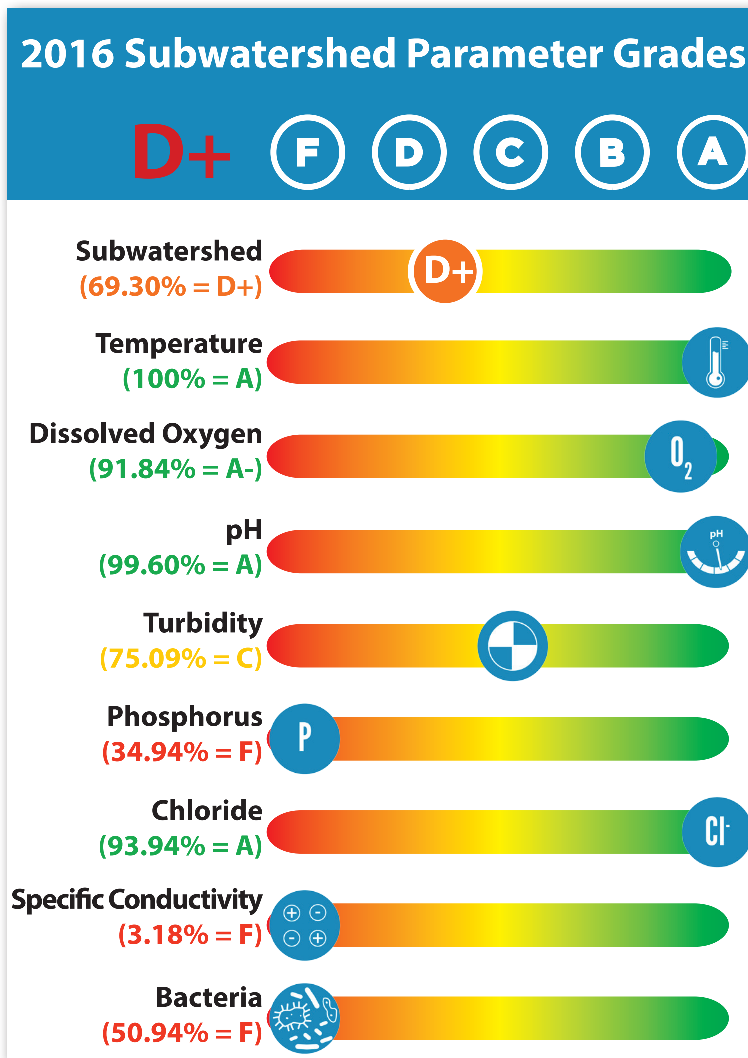
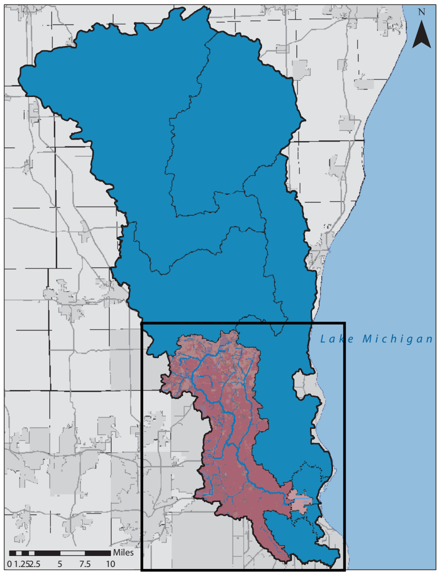
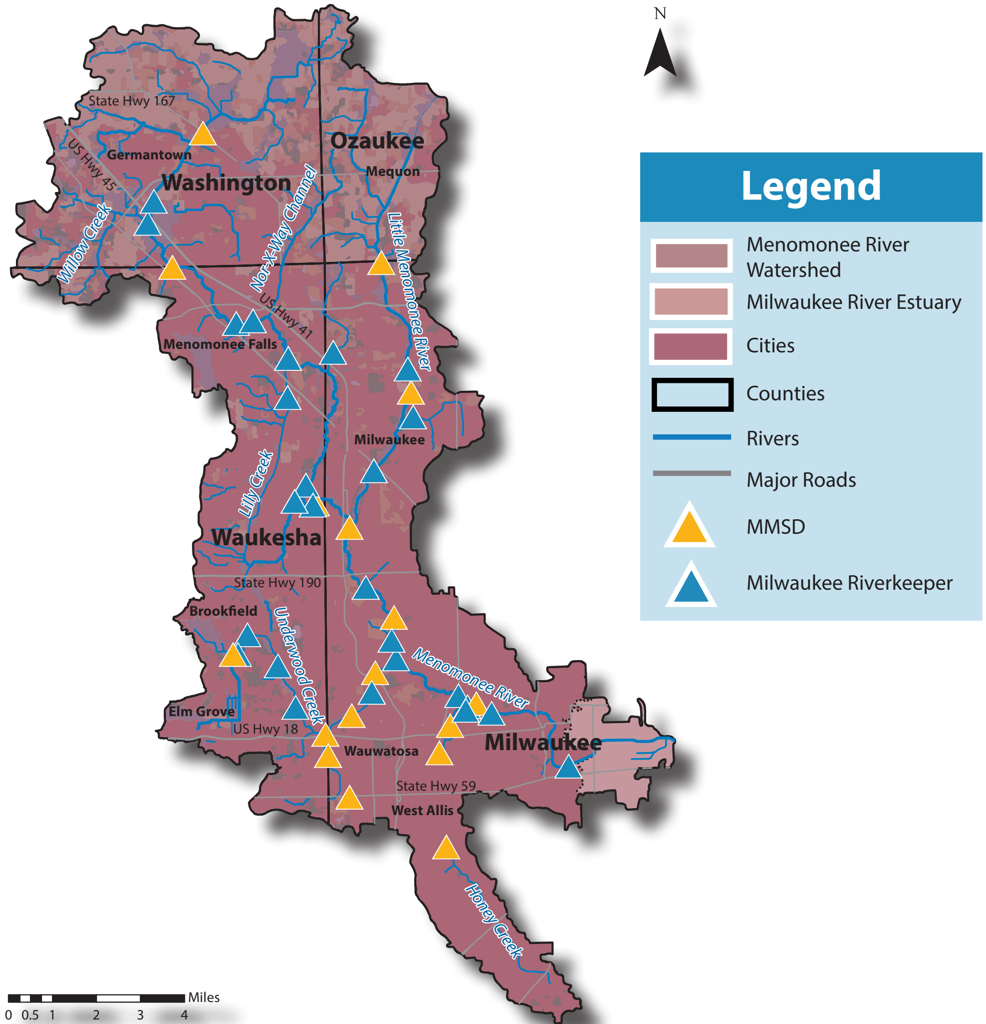


Figure 5. A map showing the average total phosphorus (mg/L) measured at sites around the Milwaukee River South Branch in 2016.



Menomonee River Watershed D





The Menomonee River Watershed covers an area of approximately 136 square miles located in Ozaukee, Waukesha, Washington, and Milwaukee Counties. The River begins in Mequon and Germantown, and flows southeast for 32 miles until its confluence with the Milwaukee and Kinnickinnic Rivers. The Menomonee River Watershed is densely populated; its land cover is approximately 67% urban/developed, 11% agriculture, and 12% grassland/forest (WDNR 2016). Only around 9% of the land use within the Menomonee River Watershed is defined as wetland; those wetlands make up around 39% of the 100 foot riparian corridor surrounding the Menomonee River (WDNR 2016).

Historically, to control how water moved through populated stream segments to limit flooding and maximize the space available for the growth of urban and suburban communities, large portions of the Menomonee River were channelized, straightened, lined with concrete, and/or dammed. Around 8% of the 96 stream miles in the Menomonee River Watershed were at one point lined with concrete, and around 36 dams or drop structures and 269 culverts were put in place to manage stream conditions (WDNR 2010). The extensive history of urban and suburban development in the Menomonee River Watershed significantly impacted the function of its streams, destroyed habitat, and disconnected the river from its surrounding lands and wildlife.

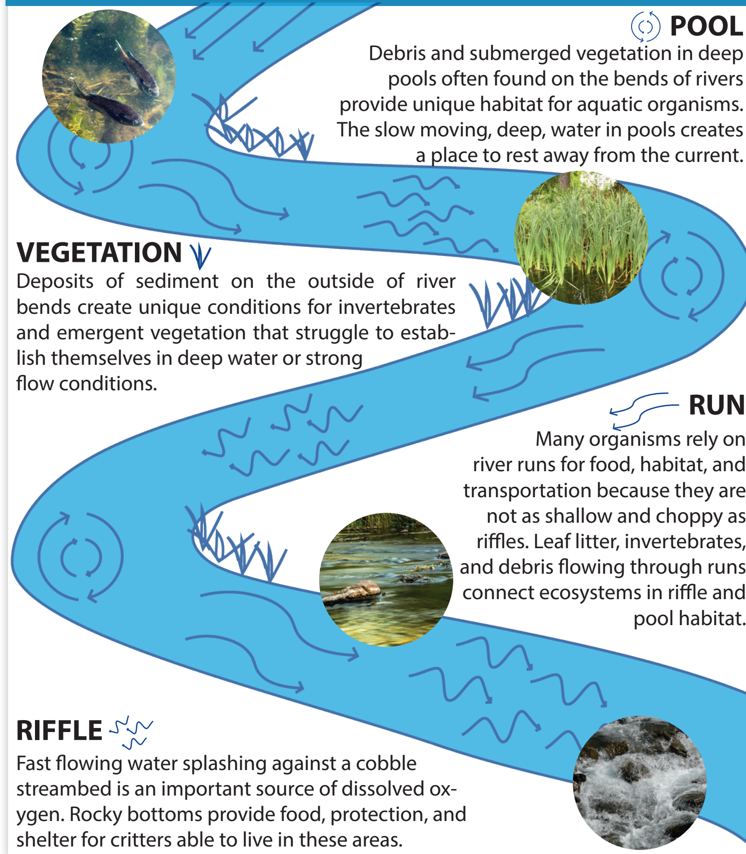
Some of the most substantial threats to the Menomonee River include extensive channel modifications that minimize the diversity of aquatic habitats, and increase the amount of runoff that enters the river from impervious surfaces. Straightened and concrete lined channels are designed to quickly move water through a stream to reduce the risk of flooding. However, these alterations also limit the interactions between aquatic communities and habitat that naturally exists along the banks, floodplains, and bends of stream channels. As a result of human modifications and development in the Menomonee River Watershed, many streams are incredibly flashy, and rise drastically during precipitation events, and quickly shift into small or medium sized streams when runoff ceases (WDNR 2010). Changes to flow can limit the diversity of habitat available to organisms that might be better suited for warm slow flowing water, or colder water moving rapidly through a channel, but not both. Dams and culverts also restrict mobility of aquatic organisms as well as particulates traveling the length of the stream, which are essential in constructing different types of stream habitats. The presence of obstructions in the stream limit the ability of native fish and aquatic life to reach available habitat further upstream (WDNR 2010).

In 2016, Milwaukee Riverkeeper volunteers monitored water quality parameters at 26 sites for a total of 137 times, and MMSD staff monitored 17 sites for a total of 237 times. Based on those measurements, the Menomonee River received a D in 2016 continuing to decrease since receiving a C- in 2013. Turbidity, specific conductivity, phosphorus, and bacteria most influenced this year's grade. While nutrients such as phosphorus and bacteria naturally exist in stream systems, it is likely that the levels observed in the Menomonee River are significantly influenced by particulates and pollutants entering the river from erosion and stormwater runoff. In the Menomonee River Watershed, land use within a 100 foot riparian corridor is around 37% urban/developed, 9% agricultural, 12% grassland/forest, and 39% wetland. It is likely that many of the water quality concerns in the Menomonee River Watershed are related to lack of riparian buffers and natural habitat that filter and infiltrate runoff before it can reach the stream. Sediment, debris, and nutrients that enter the river during precipitation events influence other ecological changes such as plant and algae growth and impact water temperature and oxygen levels.

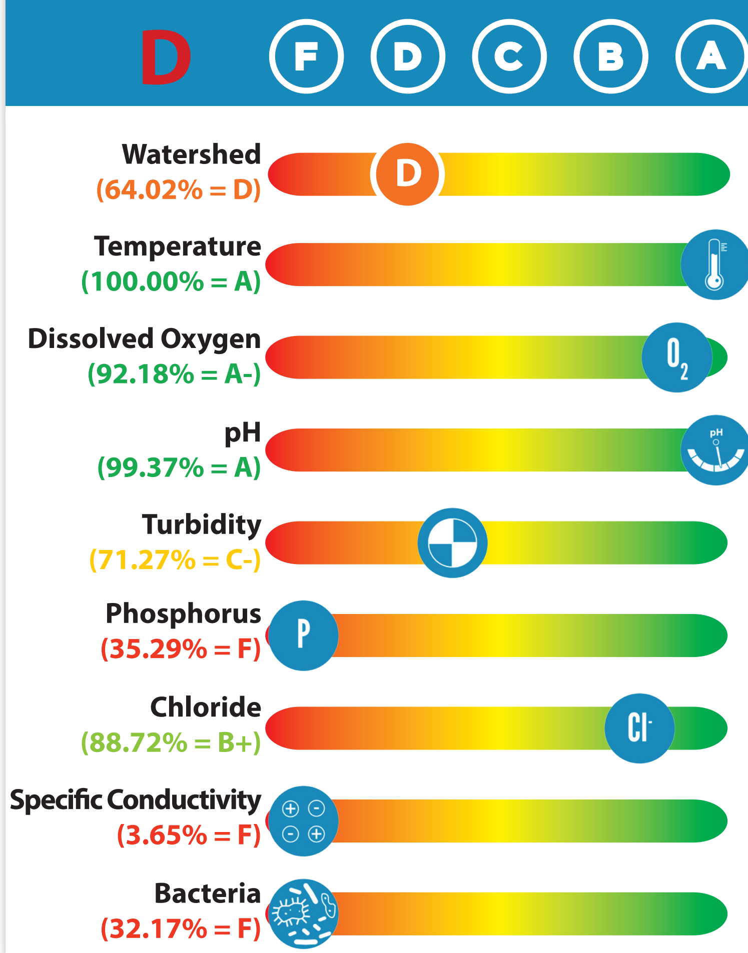
A considerable amount of work has been done in the Menomonee River Watershed to remediate some of the historical impacts to stream function. In recent years, approximately 2,700 feet of concrete has been removed along the river between Wisconsin Avenue and I-94, allowing for the river to flow more naturally. In 2016, MMSD finished removing four drop structures in Hoyt Park to allow for better natural passage of aquatic organisms to habitats upstream. Milwaukee Riverkeeper volunteers and staff removed 30 woody debris barriers that blocked stream flow, passage of fish and aquatic life, and created local water quality problems upstream. The continued effort to restore in-stream habitat within the Menomonee River Watershed is essential to improving the health of the Menomonee River. However, it is also essential that individuals reduce pollution reaching our rivers. Creating and maintaining rain gardens that soak up precipitation and runoff from homes and impervious surfaces such as driveways and sidewalks can help reduce the amount of runoff. Decreasing the use of fertilizers, and other household or gardening products that eventually make their way to the river, can have a great impact as well.

Volunteer monitors looking for macroinvertebrates at Honey Creek (top) and evaluating the aesthetics along the main branch of the Menomonee River (bottom).

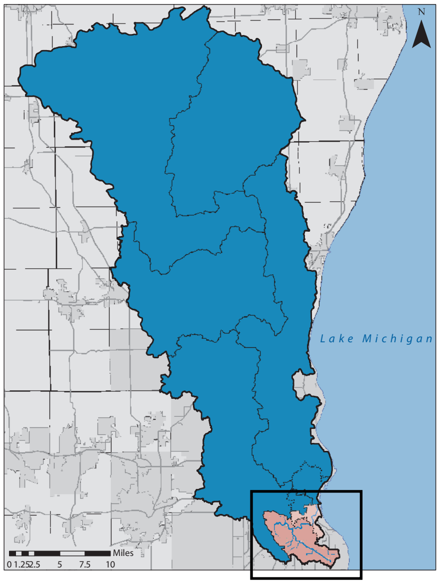
Importance of Natural Stream Habitat

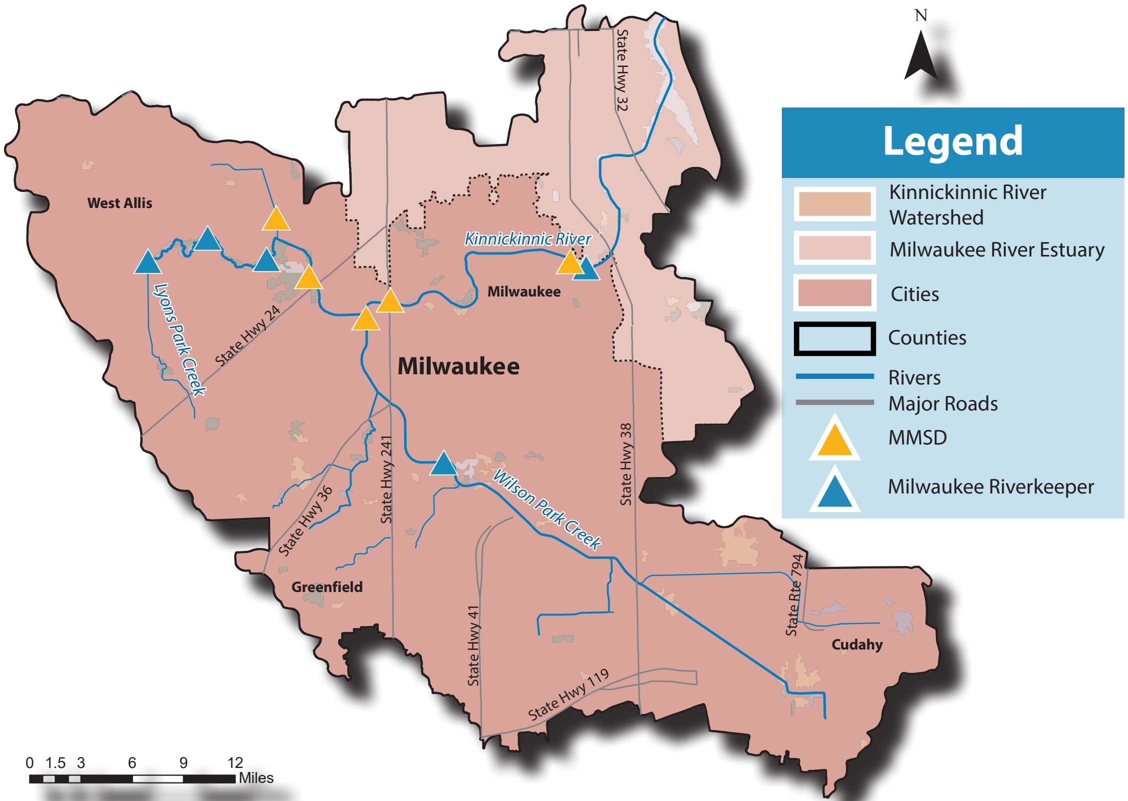


2016 Watershed Parameter Grades



Kinnickinnic River Watershed F





The Kinnickinnic River Watershed covers an area of 33.4 square miles located entirely within Milwaukee County. The Watershed contains 25 miles of perennial streams including Wilson Park Creek and its tributaries. The Kinnickinnic River is the smallest of the watersheds within the Milwaukee River Basin, but it is also the most developed, with approximately 40% of its area covered in impervious surfaces (SEWRPC 2009). Land cover in the Kinnickinnic River Watershed is about 97% urban, 2% grassland/forested, 0.39% wetlands, and approximately 0.77% allocated between seven park ponds (WDNR 2016).

Historically, to facilitate extensive development and reduce flooding within the Kinnickinnic River Watershed, the river was channelized with concrete and leveed to quickly move water downstream. As a result, water levels rise rapidly during precipitation events in these streams, and then quickly return to low flow as water flushes through their channels on its way to Lake Michigan (Figure 8). Sections of stream that are channelized with concrete and straightened provide minimal habitat for aquatic organisms, and sections that are not channelized experience high levels of erosion because of the huge volumes of water coming from concrete channels upstream. Around 60% of the streams within the Kinnickinnic River Watershed are lined with concrete or held within a modified enclosed channel (WDNR 2011).

Furthermore, around 85% of the land use within 100 feet of streams in the Kinnickinnic River Watershed is categorized as urban/developed (WDNR 2016). The WDNR recommends at least a 75-100 foot natural buffer adjacent to Wisconsin streams to protect water quality. Riparian buffers help create habitat for aquatic species, minimize the levels of contaminants that enter our streams during precipitation events, and generally improve the resilience of stream ecosystems (WDNR 2013). Many Kinnickinnic River ecosystems are also impeded by a series of culverts, conduits, and drop structures that fragment the stream and limit habitat connectivity. Physical barriers within and along the stream (e.g., seawalls and stone) can reduce the diversity and connectivity of existing habitat, by making it difficult for aquatic organisms to move up and downstream, or between instream and riparian habitat, while also causing significant impacts to water quality.

In 2016, Milwaukee Riverkeeper volunteers monitored five sites throughout the Kinnickinnic River Watershed a total of 22 times, and MMSD staff monitored an additional five monitoring locations 99 times. The Kinnickinnic River Watershed received a grade of F for 2016, a drastic drop from its 2015 grade of C-. The change to this year's grade was influenced by the removal of three previously analyzed monitoring locations in the river that are now being graded separately as part of the Milwaukee River Estuary. Separating sites that fell within the Milwaukee River Estuary from our watershed analysis was meant to remove any influence that Lake Michigan may have on our grades for water quality in each watershed. In the case of the Kinnickinnic River, estuary sites brought up the grade in past years.

Many of the water quality parameter grades in the Kinnickinnic River in 2016, such as dissolved oxygen, pH, and turbidity, improved or remained relatively consistent since 2015. However, specific parameters such as phosphorus, bacteria, and chloride dropped substantially. The Kinnickinnic River's most serious water quality concerns can be largely explained by the ecological limitations posed by extreme channel modifications, like the conversion of natural streams to concrete lined streams. The resulting loss of riparian and instream habitat has reduced the system's resiliency to additions of polluted stormwater runoff.

Case Study: Kinnickinnic River at 7th Street

Most impairments in the Kinnickinnic River relate to high levels of bacteria (WDNR 2016). High levels of aerobic bacteria generally limit the amount of oxygen dissolved in aquatic systems. However, often measurements at sites throughout the Kinnickinnic River Watershed have noticeably high dissolved oxygen concentrations (Figure 7) despite high levels of bacteria and minimal opportunities for oxygen exchange due to concrete modified channels that limit in-stream riffles and groundwater inputs. No standards for over-oxygenated water exist, but high oxygen concentrations signal that something is off. Levels of dissolved oxygen are likely connected to large amounts of photosynthesizing algae and aquatic plants (Figure 6) that release oxygen into the stream during the day. However, when the sun sets, these same photosynthesizers stop producing oxygen and only consume it, augmenting the consumption of oxygen from bacterial productivity. Therefore, the abnormally high oxygen concentrations during the day, may indicate an abnormally low oxygen level during the night. This high level of daytime oxygen likely skews our oxygen grade "higher" than it should be for this watershed.

Monthly measurements of dissolved oxygen and bacterial communities of fecal coliform and *E. coli* (Figure 7) suggest that oxygen variability is related to the seasonal growth of algae and other aquatic plants and the bacteria that feed on them. Algal blooms and plant communities generally respond to changes in the amount of nutrients, like phosphorus, that enter aquatic systems. Unnatural additions of nutrients impact the productivity of river systems and affect the types of plants and algae that grow (Figure 6). During the late summer, as photosynthesizers that take up nutrients begin to die, the nutrients available to bacteria increase. This can result in explosive rises in the measured levels of bacteria well above Wisconsin's water quality standard of 200 CFU/100ml for fecal coliform (Figure 7). Many bacteria need oxygen to live, and so higher bacteria levels result in decreased oxygen levels.

Figure 6. A photo of the Kinnickinnic River at 7th Street taken on 6/20/2017.

Fecal Coliform versus Dissolved Oxygen in 2016

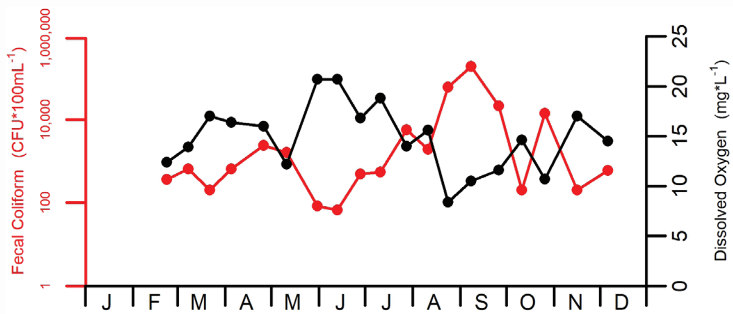


Figure 7. A line plot showing trends observed during sampling of fecal coliform and dissolved oxygen conducted at MMSD's "RI13" monitoring site on the Kinnickinnic River at S. 7th Street.

Each year, extensive work is done to plan for the removal of concrete and restoration of the Kinnickinnic River Watershed as part of flood management efforts. In 2016, MMSD continued to purchase houses within the floodplain of the Kinnickinnic River to enable stream restoration upstream from 6th St. to 43rd St. and along a major section of Wilson Park Creek. Many organizations throughout the Watershed, such as Sixteenth Street Community Health Center, Milwaukee Riverkeeper, and Sweet Water continue to educate residents about the future of the Kinnickinnic River and ways that they can make an impact on improving water quality. Reducing the amount of litter, nutrients, and chemicals that make their way into the river is something we can all work to improve.

Comparison of Stream Flows Following a Storm Event

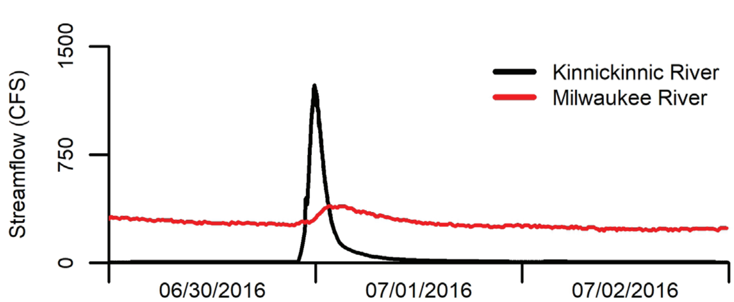
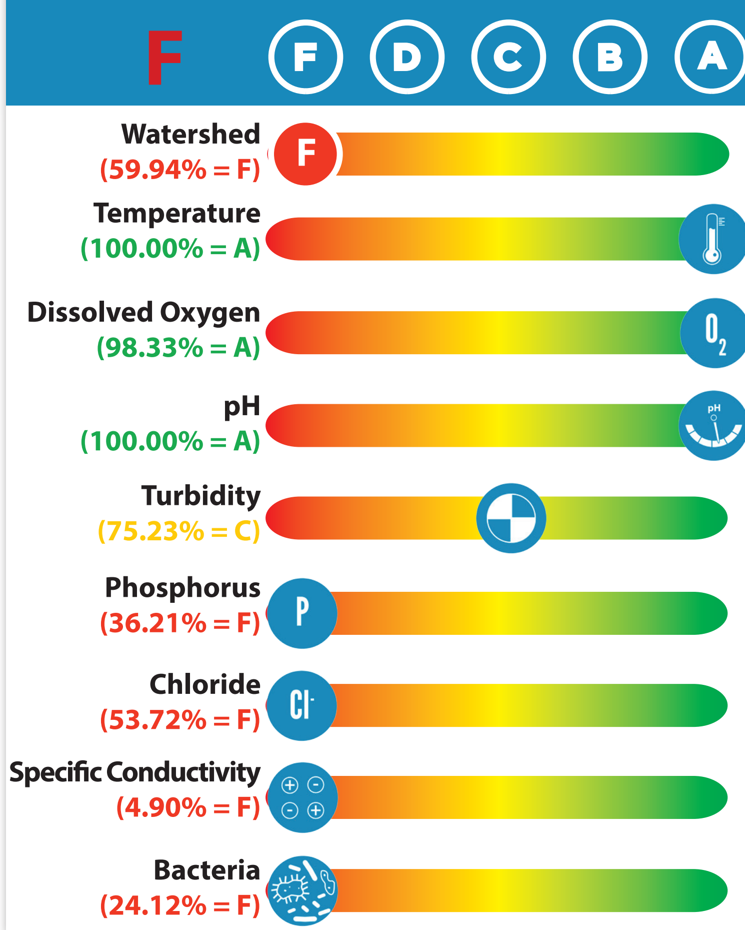
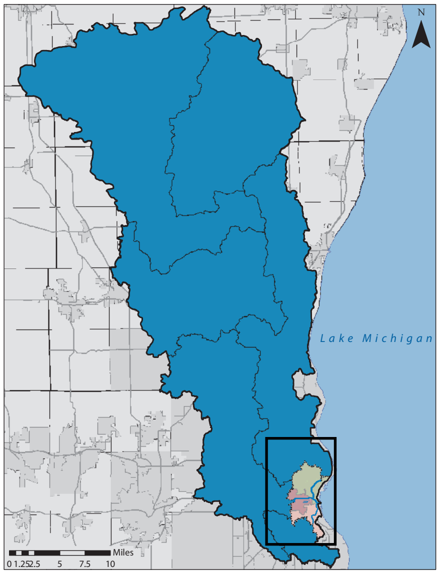


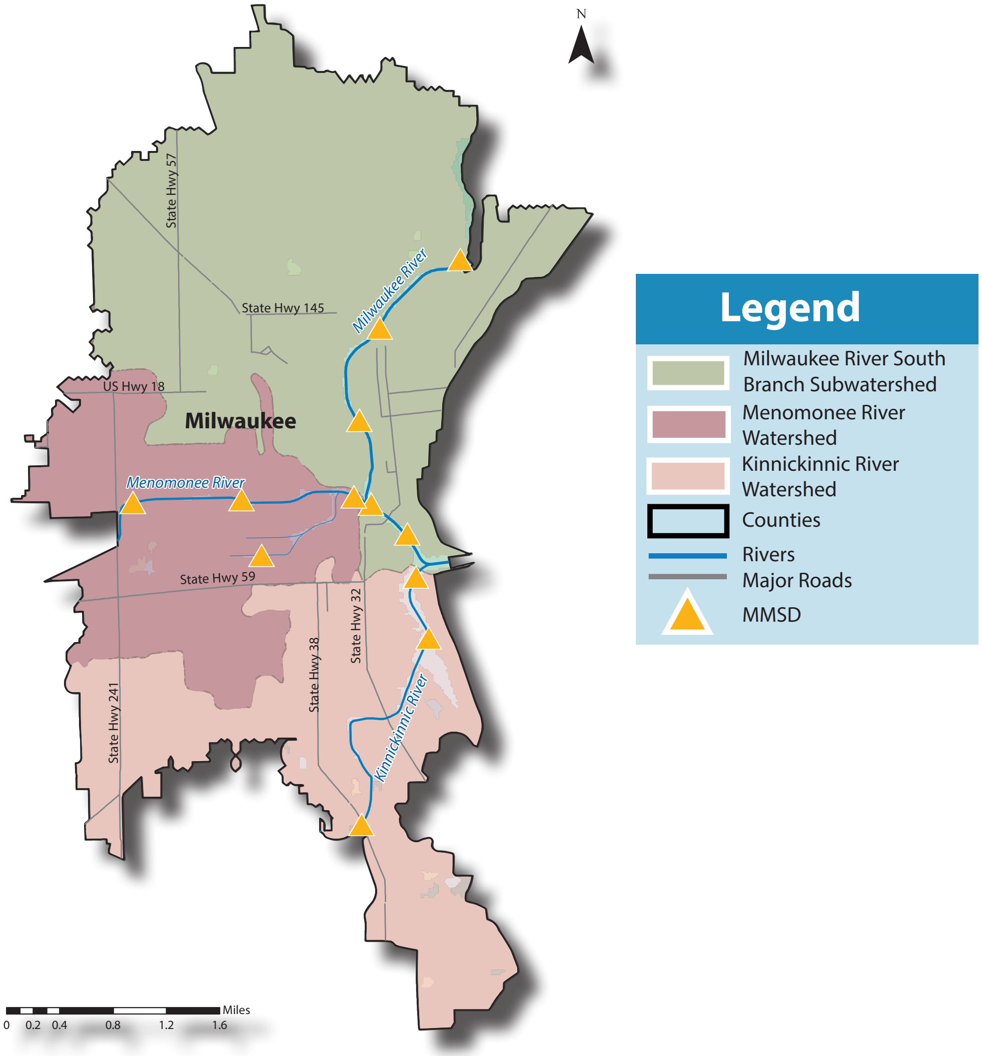
Figure 8. A hydrograph comparing the measured discharge of the Kinnickinnic and Milwaukee Rivers following a storm event. Data was recorded by the United States Geologic Survey (USGS) between 6/30/2016 and 7/2/2016.

2016 Watershed Parameter Grades



Milwaukee River Estuary C+





New this year, our team graded sites that fell within the geographical extent of the Milwaukee River Estuary separately from their watersheds. The intention was to eliminate any influence that interactions with Lake Michigan might have on our assessment of the Milwaukee, Menomonee, and Kinnickinnic River Watersheds. The Milwaukee River Estuary is the natural drainage area of the three watersheds and corresponds to the stream miles designated by the US EPA as the Milwaukee River Estuary Area of Concern (SEWRPC). The Milwaukee River Estuary's history includes significant modifications to the rivers and estuary stemming from extensive land use modifications from industry, channel dredging for shipping, and flood control features. By changing how the rivers connect with Lake Michigan, these modifications influenced water quality within the Estuary, as well the Estuary's ability to function naturally. Today, many features of the Milwaukee River Estuary are more similar to the shallow waters of Lake Michigan than traditional river mouths or monitoring locations upstream on the Milwaukee, Menomonee, and Kinnickinnic Rivers. While the area defined as the Milwaukee River Estuary is not actually its own watershed, for the purpose of this analysis, we interpreted the Estuary's natural drainage area as part of a distinctly unique system. We graded the Estuary separately to remove any bias that its relationship with Lake Michigan would have on our interpretation of each watershed and subwatershed in the Milwaukee River Basin.

The drainage of the Milwaukee River Estuary makes up an area of 16.24 square miles. The streams within that drainage cover the lower 3.1 miles of the Milwaukee River, the lower 3 miles of the Menomonee River, and the lower 2.5 miles of the Kinnickinnic River (US EPA 2017). Land coverage surrounding the Milwaukee River Estuary is approximately 97% urban. The development surrounding the Milwaukee River Estuary is protected from flooding by a nearly continuous series of steel sheet pile levees, which confine the dredged channels of the Milwaukee, Menomonee, and Kinnickinnic Rivers. This design is maintained to make the channels of the Milwaukee River Estuary more accessible for shipping, supporting one of Milwaukee's oldest industries, as well as to provide flood protection for adjacent development. Though the mouths of large river basins are generally defined by large deposits of sediment, and consistent flooding during precipitation events (Vannote et al. 1980), the Milwaukee River Estuary has been historically dredged to maintain a specific depth and is cut off from adjacent floodplains by steel walls, making it largely immune to flood events (with historic lake levels). As a result, many features of the Milwaukee River Estuary are more similar to near shore areas of Lake Michigan. On any given day, water can be readily exchanged in either direction between our rivers and Lake Michigan.

Milwaukee Harbor where the Milwaukee, Menomonee, and Kinnickinnic Rivers meet and flow out to Lake Michigan. Photo Credit: Thomas Ochnikowski

To understand this unique system, MMSD monitors 12 sites within the Milwaukee River Estuary. In 2016, those sites were monitored on 223 separate occasions. Samples were collected at each site from the bottom, middle, and surface of the water column to interpret specific trends at or between each depth. Our analysis averaged the values collected from each depth to avoid any influence that repeated values would have on the accuracy of our grades. The results of our analysis highlighted considerable water quality concerns surrounding specific conductivity and bacteria, which each received a failing grade. Specific issues were also observed with dissolved oxygen and bacteria at sites in the lower Menomonee and Kinnickinnic Rivers during late summer. Likewise, dissolved oxygen measurements taken in the Menomonee River Canals consistently reached much lower levels than other stream segments, likely due to the reduced flow in each canal, as well as high water temperatures from the Valley Power Plant discharge.

Additionally, as mentioned above, water from Lake Michigan greatly impacts the water quality of the Milwaukee River Estuary. This occurs when relatively clean Lake Michigan water moves into the Estuary, diluting the river water. Our 2016 dataset illustrates this dilution. For example, specific conductivity levels tended to increase as the distance from Lake Michigan increased (Figure 9). Similar trends were also observed for phosphorus, bacteria, and turbidity.

The separation of the Milwaukee River Estuary from our traditional analysis substantially influenced the grades of each watershed, especially in those watersheds with numerous sampling locations in the Estuary and fewer total sampling locations. Though the Milwaukee River Estuary holds significant portions of the Milwaukee, Menomonee, and Kinnickinnic Rivers, the influence of Lake Michigan on water chemistry parameters within the Estuary dilutes the averaged grades, making it more difficult to highlight water quality concerns and data trends in each individual watershed. Additionally, focusing on the Estuary as a unique system allowed our analysis to examine water quality concerns specific to that area. A unique set of variables impacting habitat and water chemistry exist within the Estuary, which points to different restoration and rehabilitation needs at sites within the Milwaukee River Estuary as opposed to the upper reaches of each watershed.

Spatial Trends in Specific Conductivity in the Milwaukee River Estuary

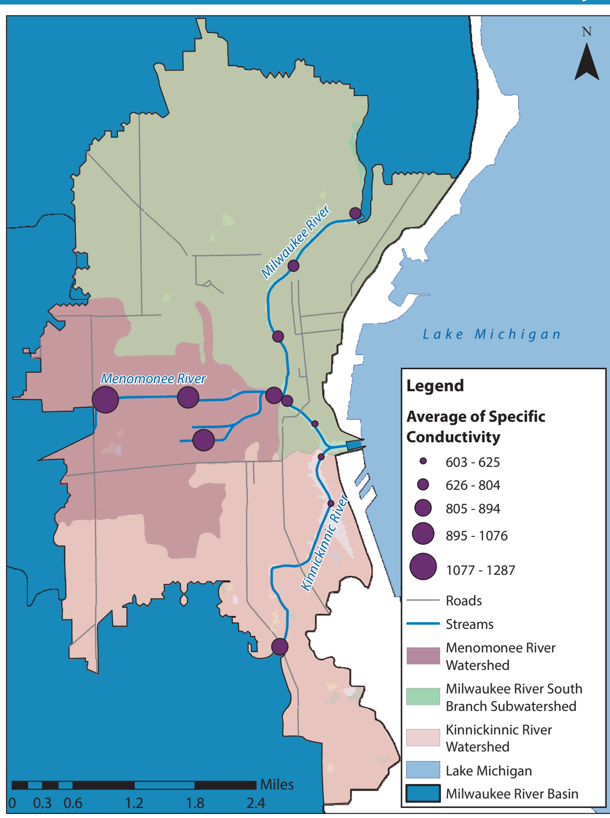
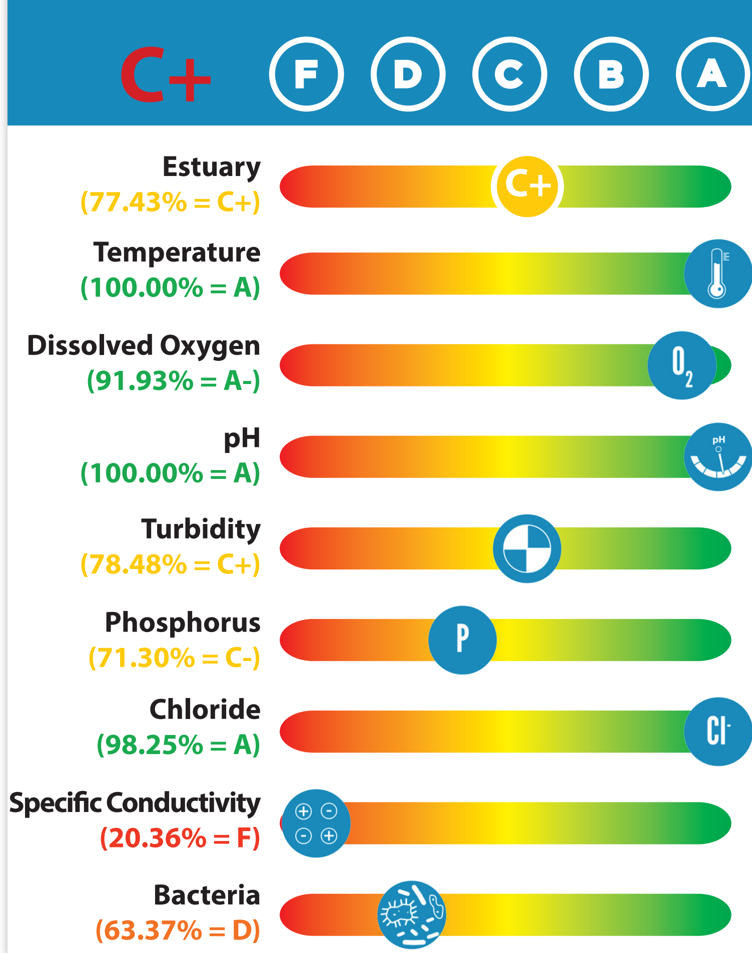


Figure 9. A map displaying the average specific conductivity values measured in µS/cm the Milwaukee River Estuary in 2016. Values tend to increase as distance from Lake Michigan increases.

2016 Estuary Parameter Grades



Stormwater Monitoring

Finding and Fixing Sewage Contamination of Stormwater in Greater Milwaukee

In Milwaukee, like many cities around the country, centuries old sewer infrastructure is failing and leaking, and sewage can make its way into our waterways. Sewage contamination, which leads to high bacteria loads, prevents us from achieving the goals set out in the Great Lakes Water Quality Agreement and the Clean Water Act and contributes to Lake Michigan beach closings in the Milwaukee area. Data shows that bacteria loads in local streams greatly exceed expected amounts from stormwater runoff alone, and these loads have increased over the past two decades. Almost every portion of the Menomonee and Kinnickinnic River within the Milwaukee Estuary is listed as impaired, or proposed to be listed for bacteria in recent impaired waters lists approved by US EPA.

To help identify unknown sources of bacteria in "hot spots" of contamination, Milwaukee Riverkeeper began working with the University of Wisconsin-Milwaukee School of Freshwater Sciences' Professor Sandra McLellan and her lab in 2008. Dr. McLellan had done past stormwater monitoring work identifying bacteria inputs to the rivers at a small selection of sites. In 2008, we identified and mapped stormwater pipes, and began to monitor for sources of sanitary-sewage contamination in targeted areas of the Menomonee and Kinnickinnic River Watersheds. We focused on two areas: 1) a 10 mile section of the lower Menomonee River (Figure 11) where bacteria levels were 10 to 100 fold higher than expected amounts from stormwater runoff alone (per several water quality models developed for MMSD and SEWRPC) and, 2) the entire Kinnickinnic River Watershed, which is uniformly high in bacteria loading, starting with the highest loading areas identified by models. We aimed to collect one dry-weather (if pipes were running) and three wet-weather samples from all stormwater outfalls along bacteria "hot spots" in both watersheds. This work is mostly completed in both hot spot areas, with most of the stormwater outfalls tested multiple times (some pipes were discontinued from further testing for multiple reasons). All stormwater samples have been tested for *E. coli*, enterococcus and, using DNA analysis, for several human-specific strains of bacteria including Bacteroides and Lachnospiraceae. This type of monitoring was essential to help identify sources of likely sewage contamination, allowing municipalities to better prioritize additional "find and fix" efforts.

Analysis of data from 2008 to 2016 shows that approximately 122 of the 263 stormwater outfalls that were sampled were positive for human-sewage contamination (for both markers or for only Bacteroides, in older samples), which is about 46% of all outfalls tested. Notably, considerable variability existed, depending on the

		Number of Outfalls Tested	Contaminated Outfalls	Number of Samples Tested
Total Stormwater Samples 2008-2016	Menomonee River	62	42 (68%)	228
	Honey Creek	37	20 (54%)	137
	Underwood Creek	26	14 (54%)	100
	Kinnickinnic River	54	30 (56%)	153
	Holmes Ave. Creek	32	1 (3%)	64
	Villa Mann Creek	8	3 (38%)	10
	Wilson Park Creek	44	12 (27%)	80

Figure 10. Overall results for our stormwater monitoring program taken between 2008-2016. Contaminated outfalls are ones that tested positive for human sewage.

stream, with a high of 68% of outfalls tested on the mainstem of the Menomonee found to be contaminated and 3% of the outfalls on Holmes Avenue Creek (tributary of the Kinnickinnic) testing positive for human sewage (Figure 10). Over 772 total samples were collected and analyzed. In 36 outfalls, human bacteria were found in every sample tested or 100% of the time (depending on sampling techniques used at the time). Given the huge extent of this problem, project partners are focusing efforts on outfalls with consistently high results for human bacteria, and on pipes that flow in dry weather, a sure indicator that these stormwater outfalls are likely discharging sewage to area waterways on a continual basis.

The data collected is helping Milwaukee, Wauwatosa, and surrounding municipalities to conduct diagnostic testing of failing stormwater sewer systems, using such methods as dye testing and smoke testing, and to prioritize repair of damaged infrastructure. Over the years of this project, the team worked closely with MMSD to locate broken pipes and illicit connections "up the pipe" that contribute to contamination of our rivers at the stormwater outfall. We retained Environmental Canine Services on several occasions to help find sources of contamination throughout the drainage area for each stormwater pipe. USGS is collaborating with the McLellan lab and other experts to develop a sensor, or water quality meter that more precisely predicts when water contains sewage contamination. During the 8 years of this project, 12 projects have been undertaken to repair some of the worst stormwater pipes.

"Total Maximum Daily Load" pollution reduction plans, targeting bacteria in all three rivers, are in draft form, and will likely be approved by end of 2017. An Implementation Plan will be drafted for these Plans to help solidify best practices and procedures for addressing bacteria pollution in our rivers. Besides failing sewers and illicit connections, other sources of bacteria include failing septic, wildlife, and manure spreading from agriculture. In addition, the Menomonee River Watershed-Based Stormwater Permit, the first such permit in the US, will continue to require municipalities to work together to target sources of bacterial contamination to stormwater sewer systems and the rivers.

The goal of bacteria monitoring is to better understand the flow of bacteria from stormwater systems to local rivers, with an ultimate goal of finding and eliminating the sources of sewage contamination in local rivers. Bacteria, along with associated viruses and pathogens, is threatening public health and keeping local waterways from meeting the "swimmable, fishable" goals of the Clean Water Act. Much work remains, both monitoring and infrastructure repair, but considerable strides have been made toward identifying specific sources of bacterial contamination in our stormwater system, which is the first step to reducing bacteria loading to our rivers and beaches.

Menomonee River Watershed Stormwater Outfall Human Bacteriodes Results 2008 - 2016

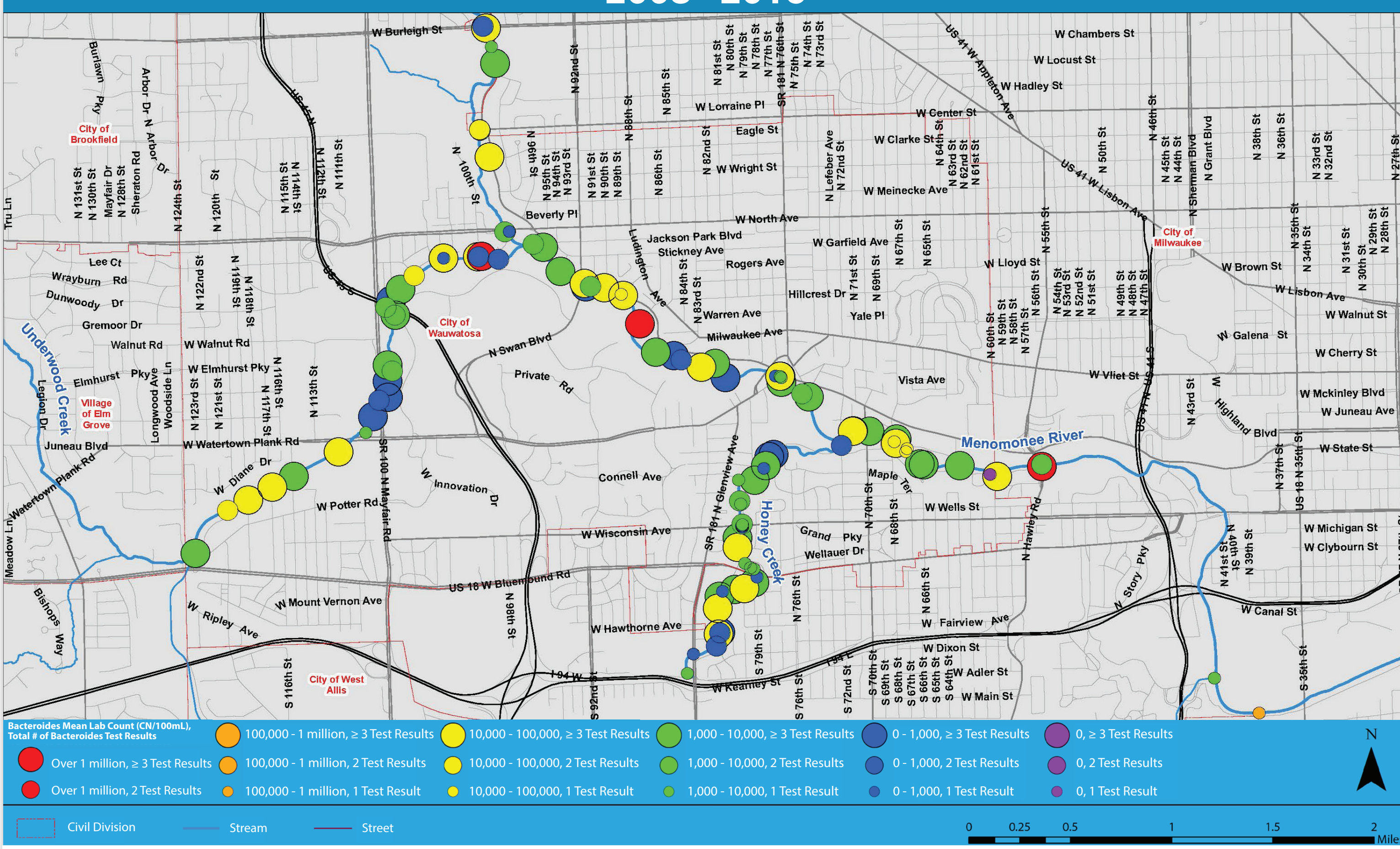


Figure 11. A map showing the results of our stormwater monitoring program from the Menomonee River Watershed. Points on the map represent the results from individual stormwater outfalls. The color of each point indicates mean Human Bacteroides count number while the size of the point indicates the number of samples taken. A higher Human Bacteroides count number greater than 1,000 suggests that a stormwater outfall is contaminated with human sewage.

Road Salt or Winter Chloride Monitoring

Identifying Hots Spots of Chloride Pollution in the Milwaukee River Basin

Extensive monitoring conducted throughout Southeastern Wisconsin since 1964 highlight rising chloride levels as a significant barrier to the success of aquatic ecosystems in the Milwaukee River Basin (SEWRPC 2016). Though certain residential water softeners and Wisconsin industries like cheese and beets can discharge considerable amounts of chloride, research shows that the application of road salts more severely impacts the concentrations of chloride found in our environment (SEWRPC 2016). Southern Wisconsin residents began using chloride-based deicers to eliminate ice build up on roads following WWII. As communities grew and developed, so did the amount of salt applied to the pavement, which inevitably runs into our waterways during precipitation (SEWRPC 2016). Though the price of salt has increased from \$38.29 to \$50.00 per ton from 2011-2015, salt imports and production increased by 12.4 million tons (USGS 2016). Meanwhile, chloride concentrations measured in Lake Michigan increased from ~6.53 mg/L in 1970 to 12.05 mg/L in 2009 (Chapra et al. 2012).

Chloride entering the environment can have a slew of impacts on the function and quality of natural and man-made systems, impacting both biotic and abiotic processes. Organisms that thrive in freshwater systems are not capable of processing large levels of chloride, and must maintain a higher salt concentration than the water around them in order to survive. To compensate, when chloride is present, freshwater organisms release water from their bodies proportional to the amount of chloride in their environment. This process can have both instant and extended consequences on an organism's health. Therefore, the effects of chloride are considered by comparing levels in the water with standards for both acute and chronic toxicity.

In the State of Wisconsin, the chronic toxicity standard is 395 mg/L for a period of four days. At this level, native organisms become less active and less competitive, and if chloride levels are high for an extended period of time, they could die. The acute toxicity standard in Wisconsin is 757 mg/L, which represents the chloride level where aquatic organisms are instantly impacted, resulting in permanently stunted reproduction or die-offs of specific species. Aside from impacting the health of aquatic organisms, excess chloride in our environment poses a series of

2016 Seasonal Trends in Chloride in the Milwaukee River Basin

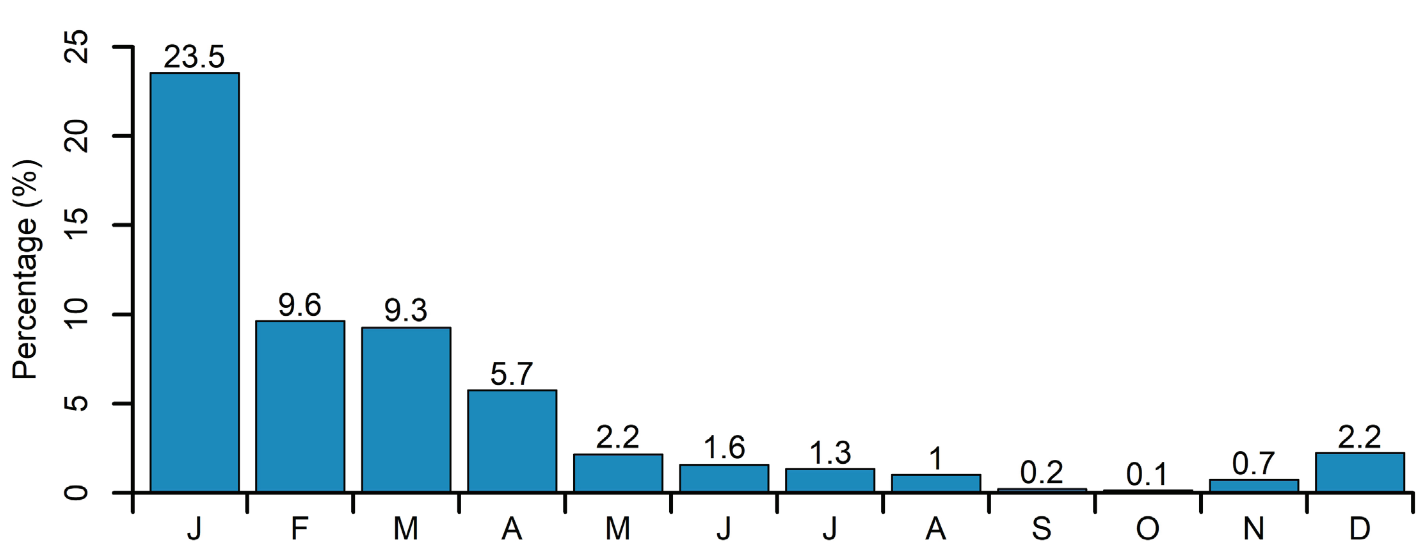


Figure 12. A graph displaying the percentage of samples that exceeded the chloride standard for chronic toxicity (395mg/L) in 2016. Values tended to be the highest during the winter months.

A Comparison of Land Use Surrounding Monitoring Stations with High and Low Chloride Levels

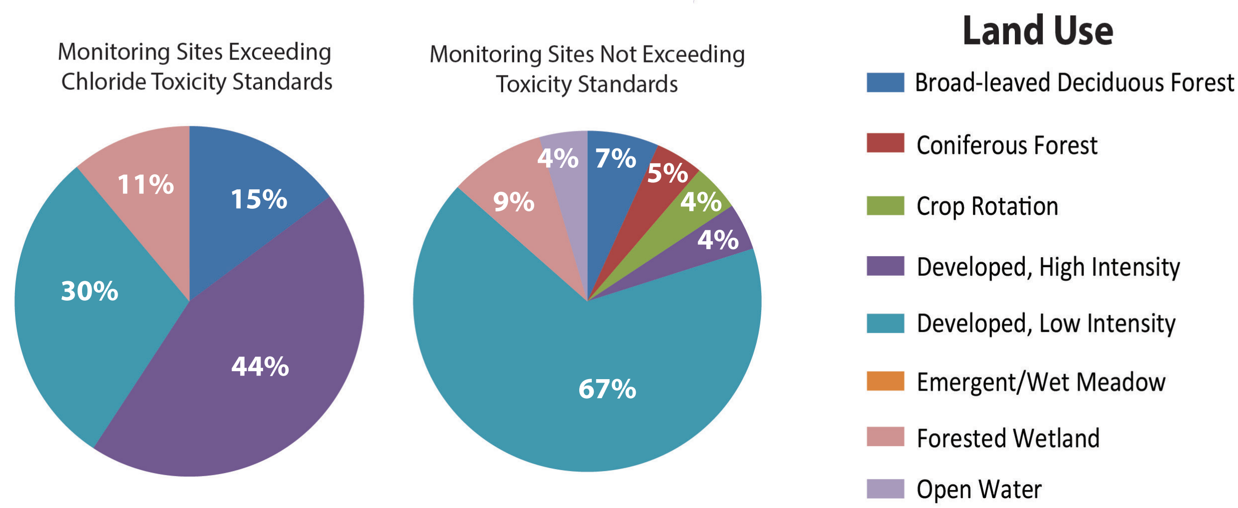


Figure 13. Pie charts showing the land use within a 100 foot zone surrounding Milwaukee Riverkeeper's 2016-2017 chloride monitoring stations. Land use data for each site was separated based on observed values that exceeded water quality standards or not. Sites not meeting water quality standards for chloride had a higher percentage of "Developed, High Intensity" urban land use.

consequences to terrestrial ecosystems, infrastructure, and water quality in both surface water and groundwater. More extensive descriptions of these consequences can be found online at milwaukeeriverkeeper.org/become-road-salt-monitor/.

In 2016, thanks to funding provided by the Fund for Lake Michigan, Milwaukee Riverkeeper continued our seventh year of winter road salt monitoring, and kicked off an educational initiative, too. Milwaukee Riverkeeper's Chloride Education Program aims to inform the public of the impacts of road salts and ways to use them more sustainably. It includes two parts: 1) a community outreach program that connected with groups around the Basin to promote further discussions about the impacts of road salts and what people can do to minimize their impact, and 2) a road salt application workshop aimed at educating private salt applicators about best practices for salt application and salt alternatives (private applicators are typically ignored in other educational initiatives to reduce road salt application). In addition to outreach, Milwaukee Riverkeeper actively engaged community members in this mission through chloride monitoring on the river.

In 2016-2017, 27 volunteers were sent to 28 targeted locations in the Milwaukee River Basin to assess the chloride concentration near potential hot spots for runoff (e.g., downstream of roads) following staff designated runoff events. A runoff event could be a period of heavy precipitation, or a date with considerably warmer temperatures that followed a large snowfall. With the help of our volunteer team, the "Winter Watchdogs," we were able to reach a much larger sampling area and collect a sizeable dataset for our analysis. For each sampling event, our volunteer monitors measured the levels of specific conductivity at their assigned site. Given the strength of the relationship between chloride levels and specific conductivity determined by the US Geological Survey, our team identified the specific conductivity threshold where a likely chloride exceedance would occur. When our volunteer water monitors recorded levels of specific conductivity above that threshold, they also collected a water sample that day and for the next three days, which were sent to the State Lab of Hygiene to be analyzed for chloride concentration. The concentrations of chloride within those samples determined whether that site had experienced a chronic or acute exceedance. A graph of chronic exceedances by month is shown in Figure 12.

Thanks to the work of our volunteers, we identified 9 sites with multiple chloride exceedances. Those results were sent to the WDNR to add the identified stream segments to the proposed list of impaired waters in Wisconsin. The data gathered during our chloride monitoring program also allowed us to do some further analysis on the relationship between land use at specific sites and chloride concentrations. The WDNR recommends at least a 100 foot natural riparian buffer surrounding streams and rivers in Wisconsin. To better understand how land use surrounding monitoring sites might relate to chloride concentrations, our team compared land use within a 100 foot buffer surrounding monitoring sites that exceeded Wisconsin's chloride standards and those that did not (Figure 13). Our examination of riparian habitat showed that the majority of our sites are located within urbanized areas. However, sites exceeding toxicity thresholds are overwhelmingly located within high intensity development. Without any form of natural buffer from development, it is likely that road salts run directly off of the road and into the stream rather than being filtered by some form of wetland or forested land use.

Many variables contribute to high chloride levels in a river. Education about the impact of over-application of road salt on the environment, including sustainable usage, is critical to improving Basin health. Beyond monitoring, three messages that Milwaukee Riverkeeper asserted in our chloride education programs were the importance of: 1) shoveling early and often during snowstorms to reduce the formation of ice, 2) reducing salt usage to only spots on the pavement where ice is likely to form, and 3) sweeping up excess salt after each storm to save money and reduce the amount running off the pavement.

Emerging Contaminants Monitoring *(Guest Article)*

Citizens of the Rivers and Lake Emerging Contaminant Monitoring Program by Joseph J. Piatt, Ph.D., M.S.C.E.

Some folks enjoy cooking, but everyone enjoys a good meal! Preparing meals seems like a pretty benign common activity and, for the most part, it is. Have you ever considered a link between what happens in your kitchen and water quality? There seems to be a lot of public awareness about major contamination of waterways from industrial, commercial, or agricultural activities. But somehow "those" activities are not connected with our individual human activities. "Citizens of the Rivers and Lake Monitoring Program" is a one-year pilot to demonstrate that what you do in your home is DIRECTLY linked to what happens with our water. With the help of some amazing volunteers, the project team members (Carroll University, Milwaukee Riverkeeper, Urban Ecology Center, UW-Milwaukee) are sampling the waters of the three rivers (Kinnickinnic, Menomonee, Milwaukee) that feed the Milwaukee Harbor and Lake Michigan and analyzing those samples for commonly used cooking products and pharmaceuticals (Figure 15). The cooking products, like vanilla, cinnamon, and caffeine, may not be harmful to humans, but they do demonstrate the link between our kitchens and our surface waters.

Emerging Contaminants Found in Milwaukee River Basin in 2016

- Acetaminophen – Pain Reliever
- Atrazine – Pesticide
- BE – Metabolite of Cocaine
- Caffeine – Stimulant
- Carbamazepine – Seizure Medication
- Ciproflaxin - Antibiotic
- Cotinine – Metabolite of Nicotine
- Enrofloxacin – Antibiotic
- Ibuprofen – Anti-inflammatory Drug
- Miconazole – Anti-fungal Medication
- Paraxanthine – Metabolite of Caffeine
- Ranitidine – Stomach Ulcer Medication
- Sulfamethoxazole – Antibiotic
- THC-OH – Metabolite of Cannabis
- Triclocarban – Antibacterial Agent found in Personal Care Products
- Triclosan – Antibacterial and Antifungal Agent

Figure 14. A list of emerging contaminants found in the Milwaukee River Basin in the 2016 Citizens of the Rivers and Lake Emerging Contaminants project.

Of more concern is the occurrence of pharmaceutical and personal care products (PPCP) in our waters as they pose hazards to aquatic organisms and human health. Typical classes of PPCP are beta-blockers, anti-inflammatory drugs, birth control drugs, antibiotics, antidepressants, anti-epileptic drugs, etc. The PPCP are suspected to impact aquatic systems by acting as endocrine disruptors/estrogen-mimickers, increasing microbial resistance, and impacting other developmental processes in aquatic organisms. The human health impacts of PPCP are less certain, as epidemiological studies are difficult to conduct and confirm causality[1,2]. Even though PPCP exist at "trace" levels, parts-per-billion to parts-per-trillion, because these compounds were designed to have specific biological impacts, their individual or synergistic effects on receptor organisms are not known.

The "trace" amounts of PPCP and other emerging contaminants (EC) in water are reported in parts-per-billion (ppb, micrograms per liter) or parts-per-trillion (pptr, nanograms per liter). It can be difficult to conceptualize breaking a "unit" of something into that many small pieces. So let's think big first! The U.S. National Debt is approximately $20 trillion dollars. Let's say you make $50,000 per year and you have to contribute it all to paying off the national debt. It would take you 400 million years to pay off that debt! But, when it comes to thinking about "trace-level" concentrations of compounds in the water, you need to invert your brain to think small. Instead of big dollar amounts, think of breaking a single unit of water in billions or trillions of pieces. The chemical instrumentation now exists for scientists to measure compounds at these "trace" levels.

Over the past couple decades, the interest in researching the occurrence and impacts of PPCP continues to grow. For example, the discharge from wastewater treatment plants (WWTP) are of concern because they are a point source to natural surface waters – typically rivers. However, WWTP are not designed to remove PPCP or other trace level compounds. They are designed to remove grit, organic solids, and dissolved natural organic material[3]. Although WWTP are considered a major integrator of PPCP, the non-point source runoff of animal medicines (antibiotics, growth hormones, nutrients) from feedlots and farms is also a concern.

As WWTP serve as collectors/integrators of human waste, sewage effluent is thought to be the main route of PPCP into the aquatic environment in urban areas[2,4,6]. Pharmaceuticals are designed to be relatively stable in the body in order to maintain the desired effect, therefore, it can be expected that many pharmaceuticals have a relatively high persistence under environmental conditions[6]. Thus, many pharmaceuticals are resistant to degradation in wastewater treatment plants and enter the natural environment[4,5]. Anywhere from 20-90% of pharmaceuticals that enter a WWTP are discharged in the treated effluent[7,8] and enter surface water with the potential to leach into groundwater[6]. The balance is believed to either stick to bio-solids or degrade during the treatment process.

The preliminary results of this study are not surprising. Guess what? Milwaukee is not different from other parts of the country. At all 14 sampling locations, multiple PPCP and other compounds (Figure 14) have been positively identified from a target list of sixty-two (62) compounds. So far, the most commonly occurring compounds are caffeine (stimulant), ciproflaxin (antibiotic), cotinine (metabolite of nicotine), ibuprofen (NSAID), miconazole (antifungal), and triclosan (antibacterial).

So what do you do? Don't stop enjoying the outdoors! But do change your behavior to minimize purchase and use of consumer and medicinal goods. Choose to take only the medications you need and at the prescribed dosages. Be sure to communicate with your health providers about what medicines you are taking and why. And when you have leftover medicines, be sure to take advantage of permanent drug drop off locations and the "Drug Take Back Days" organized a few times each year in almost every county of the State. www.doj.state.wi.us/dles/prescription-drug-take-back-day.

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Joseph J. Piatt, Ph.D., M.S.C.E.

Joseph J. Piatt is a professor of Chemistry and Environmental Science at Carroll University in Waukesha, Wisconsin. Dr. Piatt teaches courses in analytical chemistry, instrumentation, environmental science, and soil and water resources. In addition, he is active in developing and teaching courses in Carroll's cross-cultural experience program. His main research interests are related water quality in natural and engineered systems. Recently, he has been investigating the occurrence of human pharmaceuticals in ground water and surface water systems and in studying calcite precipitation dynamics in a calcareous fen system.

Emerging Contaminants Monitoring Locations

Figure 15. A map showing monitoring locations for the 2016 emerging contaminants monitoring.

Take Back Your Meds Milwaukee

Milwaukee Riverkeeper is a proud member of the Take Back Your Meds Milwaukee Coalition! The goal of the Coalition is to reduce the risks unused pharmaceuticals pose to our drinking water and our children's safety. About 30% of medicines are not used. Pharmaceuticals can pollute our waterways when drugs are flushed down the toilet or thrown in the trash. When prescriptions are improperly disposed of by flushing them down the toilet, they make their way through the sewer system which empties into Lake Michigan – the source of Milwaukee County's drinking water. Recent studies by the UW-Milwaukee School of Freshwater Sciences showed the presence of intact pharmaceutical compounds up to three miles from sewer outfalls – meaning they are not breaking down. Drugs thrown in the trash end up in landfill leachate, which is often processed at wastewater treatment plants that cannot filter out prescription drugs. The Coalition's goal is to have a drop box for unused medicine in every pharmacy in Milwaukee County in the next 10 years. Visit takebackyourmedsmilwaukee.org to learn more and to find your nearest drop off location!

Take Back Your Meds MILWAUKEE

Aesthetics Monitoring

Evaluating the Aesthetic Quality of the Milwaukee River Estuary Area of Concern (AOC)

In the early 1970's, following massive algae blooms and fish kills, newspaper headlines declared that Lake Erie was "dead". Articles about extreme pollution in the Cuyahoga River in Northeastern Ohio were often accompanied by photos of the famous Cuyahoga River fire, a three day period where the river itself caught fire due to high levels of contamination. By the late 1960's and early 1970's, the Great Lakes and their surrounding watersheds had been subject to such extensive environmental degradation that it became apparent a binational and multi-state solution would be necessary.

In 1978, government officials from the United States and Canada drafted the Great Lakes Water Quality Agreement. The agreement emphasized the need for collaborative efforts to restore the ecological health of the Great Lakes by focusing on key pollutants of concern. A major component of the Agreement was also the designation of 43 Areas of Concern (AOC's) throughout the Great Lakes Region. Areas of Concern, such as the Milwaukee River Estuary (Figure 16), were designated based on the observed and anticipated ecological impacts associated with historic industrial activity and legacy pollution in each of the 43 locations. In other words, sites listed as AOC's were considered to be critically degraded as compared to other similar, often urban, areas of the Great Lakes, and were determined to be in dire need of restoration to overcome existing legacy contamination.

To track those ecological impacts, and the progress of restoration and cleanup efforts in each AOC, the Agreement included a list of Beneficial Use Impairments (BUI's) associated with each AOC. A BUI can be thought of as "symptom of pollution" that can be monitored and assessed to help gauge the health of an AOC over time. Of the 14 potential BUI's, the Milwaukee River Estuary AOC has 11, ranging from contaminated sediments and fish health issues to degradation of aesthetic value.

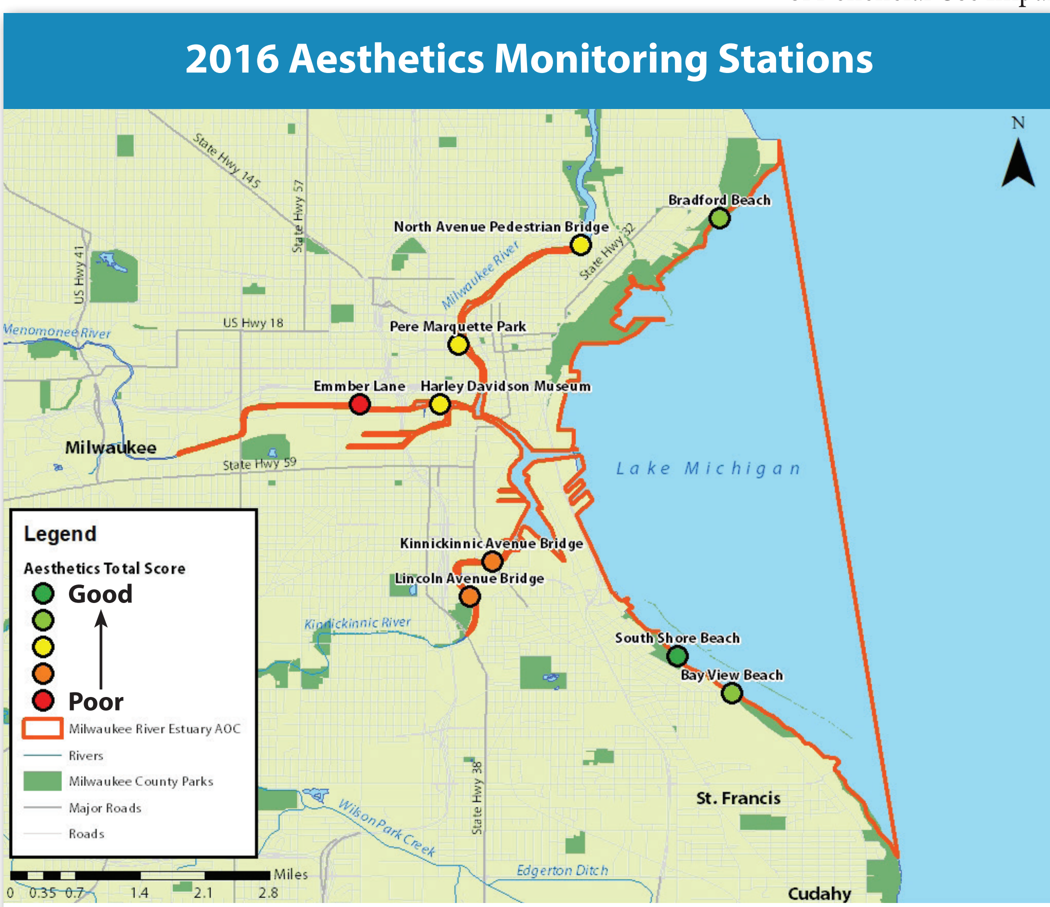

Figure 16. A map displaying the extents of the Milwaukee River Estuary Area of Concern, and the total aesthetics score associated with each site monitored by Milwaukee Riverkeeper volunteers in 2016.

In partnership with the WDNR and the US EPA, during 2015 and 2016, Milwaukee Riverkeeper organized a team of volunteers to rate the aesthetic value of various sites throughout the Milwaukee River Estuary. For this project, participants travelled to 9 sites total: two each on the Milwaukee, Menomonee, and Kinnickinnic Rivers; and three Lake Michigan beach sites - Bayview Beach, Bradford Beach, and South Shore Park Beach (Figure 16). The results of these assessments will be used to determine what progress has been made in the AOC to address the degradation of aesthetics BUI, and to evaluate whether a BUI can be removed.

Unlike other monitoring programs

organized by Milwaukee Riverkeeper, aesthetics monitoring involves little training, and is left almost entirely in the hands of community volunteers. An aesthetics monitor visits a specific site, and answers a WDNR prepared survey that contains a series of questions evaluating the aesthetics of each site. Volunteers answer questions like: "Are deposits of trash along the shoreline impacting your appreciation of this site?", or "Does nuisance vegetation prevent you from accessing, enjoying or using the water?" Survey results are compiled and analyzed to assess the "aesthetic impression score" of each site. To make sure that these scores represent a variety of perspectives of people living in or near the Milwaukee AOC, a minimum of 35 different people fill out a survey for each site during three seasons each year. Between 2015 and 2016, 143 total volunteers completed 962 surveys.

Comparing temporal trends of overall aesthetics scores for each site illuminates community opinions on the success of restoration and cleanup efforts to improve the aesthetic value of sites around the Milwaukee River Estuary. However, to understand how aesthetics are perceived, and where future efforts might be the most productive, we've also broke down each site's overall score into a series of parameters reflecting the questions asked in our surveys (Figure 17). For example, while Emmber Lane on the Menomonee River (a former turning basin for ships) is perceived as being much less aesthetically appealing than Bayview Beach, proportionally, that perception is much less impacted by the presence of nuisance vegetation, and more impacted by other factors such as nuisance birds and presence of trash (Figure 17).

Since each survey asks for answers to specific questions about each volunteer's experience at different sites, as well as for qualitative explanations of those answers, our results identify specific trends regarding perspectives of the aesthetics at each site, as well as common diction used to describe those perspectives (Figure 17). Sticking with the previous comparison, Emmber Lane, a site rated with significant nuisance gulls, associates strongly with words like feces and bird, while monitors at Bayview Beach mentioned debris and litter along the shoreline of that site more often. Additionally, since Bayview Beach received a higher aesthetic score, words that appear more consistently, like clean and quiet, demonstrate positive public perceptions of aesthetics.

To remove a BUI from an AOC, local agencies such as WDNR must make a case to the US EPA that significant progress has been made to alleviate a specific impairment, and that as a result, the AOC is currently meeting the publically approved goals for that impairment (as set out in a Remedial Action Plan for each AOC). Trends recorded during the 2015-2016 Milwaukee Riverkeeper Aesthetics Monitoring Program, looking at total aesthetics impression scores each year throughout the Milwaukee River Estuary, highlight public perspectives on the progress of restoration efforts over time and help identify specific restoration needs in the Milwaukee River Estuary. Thanks to the involvement of volunteers, we can begin to understand if we are closer to meeting our goals to remove this BUI, and/or to better understand what it will take to improve the aesthetic perception of sites around our AOC. Milwaukee Riverkeeper is proud to continue to work in partnership with WDNR and other organizations and communities around the Milwaukee River Basin to improve the quality and aesthetic value of our rivers. Initiatives like our Volunteer Aesthetics Monitoring, our Annual Spring River Cleanup, and our Adopt-a-River Program are all excellent ways to get involved and help promote clean, swimmable, fishable rivers.

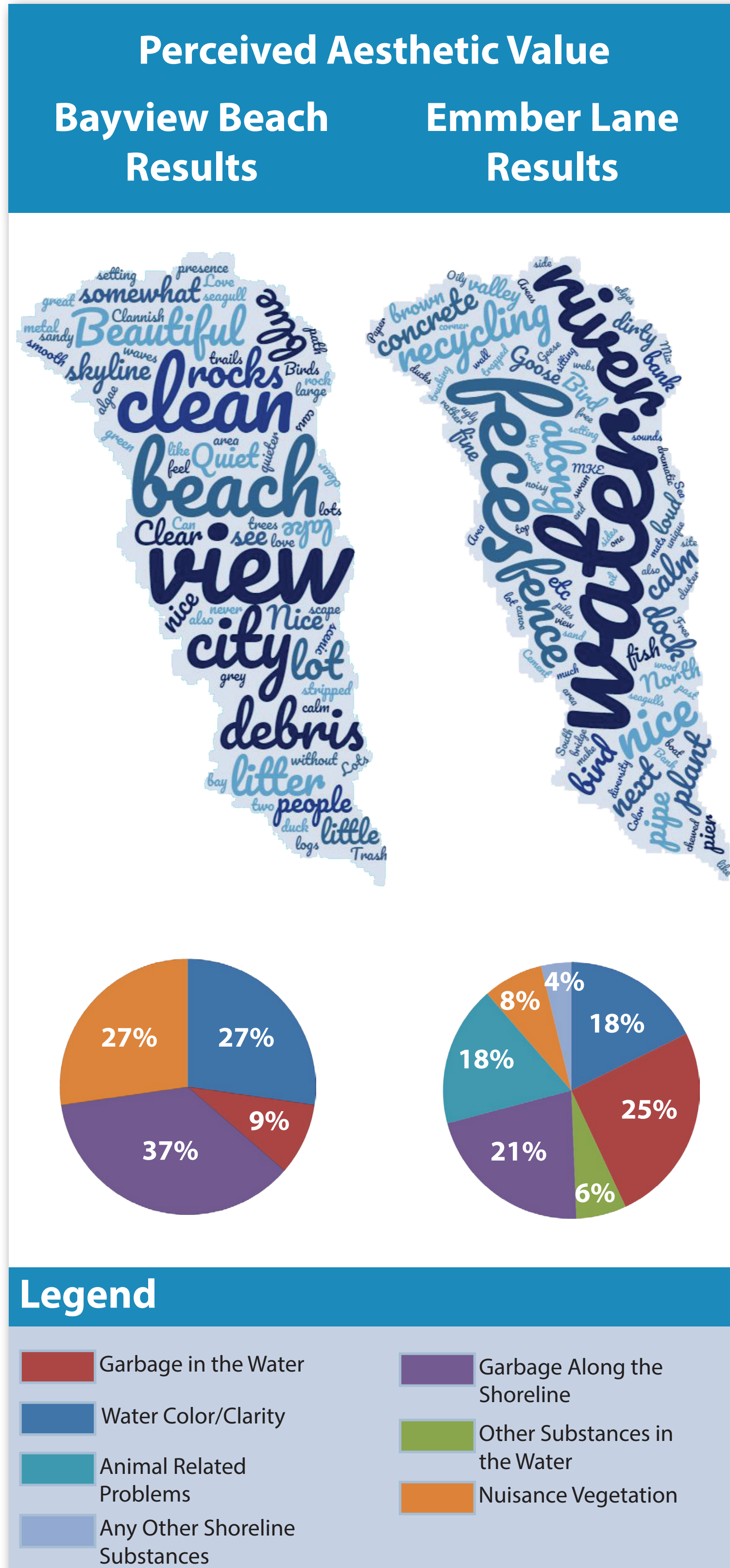

Figure 17. A series of charts that summarize the factors influencing the perceived aesthetic value of Emmber Lane and Bayview Beach. Each pie chart displays how answers to each survey question negatively impacted the overall aesthetic value for a site. Each word cloud is designed to visually present the occurrence of specific words that volunteers associated with each site as part of their qualitative responses, with words that appeared more frequently displayed in larger font.

	Overall Grade	Water Temp	DO	pH
Milwaukee River Basin				
Percentage*	68.10%	99.63%	92.60%	99.50%
Letter Grade	D+	A	A-	A
Milwaukee River Watershed				
Percentage	73.99%	99.15%	93.21%	99.32%
Letter Grade	C	A	A-	A
North Branch Milwaukee River Subwatershed				
Percentage	65.85%	100.00%	60.87%	100.00%
Letter Grade	D	A	D-	A
East and West Branch Milwaukee River Subwatershed				
Percentage	86.70%	91.11%	97.83%	95.35%
Letter Grade	B+	A-	A	A
Cedar Creek Subwatershed				
Percentage	67.18%	100.00%	100.00%	100.00%
Letter Grade	D+	A	A	A
South Branch Milwaukee River Subwatershed				
Percentage	69.30%	100.00%	91.84%	99.60%
Letter Grade	D+	A	A-	A
Menomonee River Watershed				
Percentage	64.02%	100.00%	92.18%	99.37%
Letter Grade	D	A	A-	A
Kinnickinnic River Watershed				
Percentage	59.94%	100.00%	98.33%	100.00%
Letter Grade	F	A	A	A
Milwaukee River Estuary				
Percentage	77.43%	100.00%	91.93%	100.00%
Letter Grade	C+	A	A-	A

*Percentage of data points that meet the water quality standard or goal for each individual parameter

Turbidity	Phosphorus	Chloride	Specific Conductivity	Bacteria
75.62%	37.01%	87.37%	8.57%	43.81%
C	F	B+	F	F
77.14%	39.35%	96.10%	29.57%	55.27%
C+	F	A	F	F
75.00%	38.10%		0.00%	
C	F	**	F	**
97.50%	59.52%		64.71%	
A	F	**	D	**
81.58%	39.02%	100.00%	2.56%	50.00%
B-	F	A	F	F
75.09%	34.94%	93.94%	3.18%	50.94%
C	F	A	F	F
71.27%	35.29%	88.72%	3.65%	32.17%
C-	F	B+	F	F
75.23%	36.21%	53.72%	4.90%	24.12%
C	F	F	F	F
78.48%	71.30%	98.25%	20.36%	63.37%
C+	C-	A	F	D

**Data not collected for this individual parameter and watershed

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Our Mission

Our mission is to protect, improve and advocate for water quality, riparian wildlife habitat, and sound land management in the Milwaukee, Menomonee, and Kinnickinnic River Watersheds. We envision a future in which people from all walks of life can enjoy the healthy waterways of the Milwaukee River Basin.

Milwaukee Riverkeeper serves as a voice for the Milwaukee, Menomonee, and Kinnickinnic Rivers and works tirelessly for swimmable, fishable waters. Our core programming involves water quality monitoring and advocating on behalf of the rivers. We also coordinate hands-on river restoration projects and organize thousands of volunteers each year in river cleanups. We connect people to water through river-focused events and educate our community about water quality and river health.

Milwaukee Riverkeeper is a licensed member of the Waterkeeper Alliance, an international coalition dedicated to clean water and healthy communities.

Help us achieve swimmable, fishable rivers.
Donate at www.milwaukeeriverkeeper.org.

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