2025 Root River Monitoring Summary For City of Waukesha Diversion Approval

(Reporting Period October 2024 – September 2025)

The Wisconsin DNR developed a 2025 technical summary of the City of Waukesha's (City) Root River monitoring program conducted by the City in compliance with its Lake Michigan diversion approval. The City's diversion approval requires river monitoring to assess the impacts of treated wastewater discharge (return flow) on the Root River. The Root River is located in southeast Wisconsin, with headwaters in Waukesha and Milwaukee Counties, flowing to Lake Michigan in Racine.

In October 2023, the City's diversion of Lake Michigan water came online. At that point the City began returning diverted Lake Michigan water back to the lake via the Root River, while adhering to wastewater permit and diversion approval requirements. Beginning February 2017, the City began water quality and streamflow monitoring in the Root River to collect reference data ***prior*** to starting the diversion and return flow to the Root River.

Reference conditions for the Root River monitoring cover the period February 2017 through September

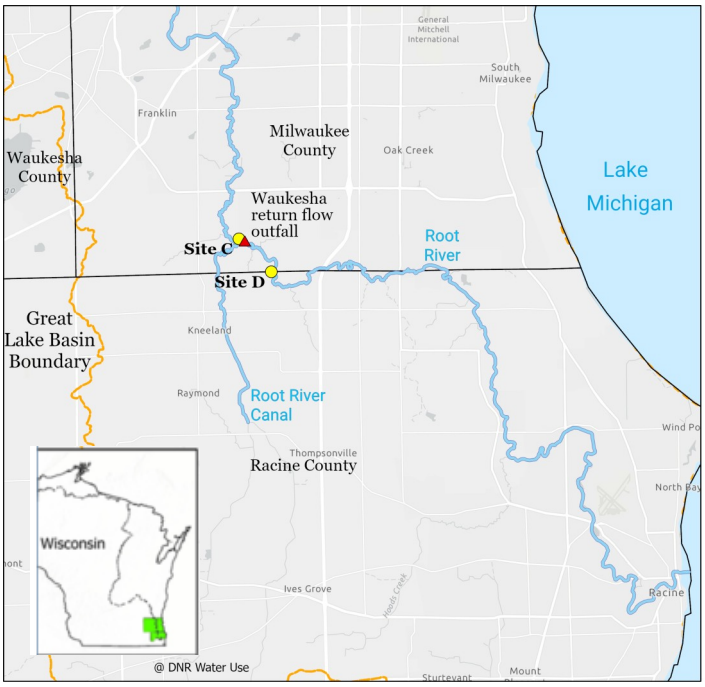


Figure 1 Root River Monitoring Sites C and D

Photo credit: DNR/Craig Helker.

2023. The City is required to report annually on its Root River monitoring program. The report submitted to the Wisconsin DNR in February 2026 covers the monitoring period from October 2024 through September 2025, corresponding to the USGS water year.

Monitoring

The City's Root River monitoring program includes monitoring at four locations: A, B, C and D. Water quality parameters monitored include total suspended solids, orthophosphate, total phosphorus, dissolved oxygen, chloride, E. coli, pH and temperature (Figures 1 and 2). The monitoring program also includes a USGS flow gage at Site D and habitat, fish and macroinvertebrate monitoring at Sites A, B, C and D. Finally, the City also monitors temperature at Site C2.

Figure 2 City of Waukesha monitoring locations.

This summary includes monitoring data from Site C (located upstream of the City's return flow outfall), the City's return flow outfall and Site D (located downstream of the return flow outfall), to provide an overview of river water quality and flow directly adjacent to the return flow outfall. The City also collects data at additional sites to provide further context on the river's water quality. The City's comprehensive Root River monitoring report is available in Appendix F of the City's *Diversion Approval Report for 2025 (Report).* This report generally compares reference conditions from the pre-diversion period to the October 2024 - September 2025 reporting period and the October 2023 - September 2025 post-diversion period.

Box-and-whisker plots (boxplots) are used to summarize key water quality parameter from the 6-year reference period. Figure 3 shows an example of the boxplots used in this report. Fifty percent of the data points fall within the box, with the centerline delineating the median. The outer extents of the whiskers identify the maximum and minimum values that are within 1.5 times the interquartile range. Points outside of this range are included as outliers. Median values for the reporting period are plotted as a red triangle on top of the post-diversion period boxplots.

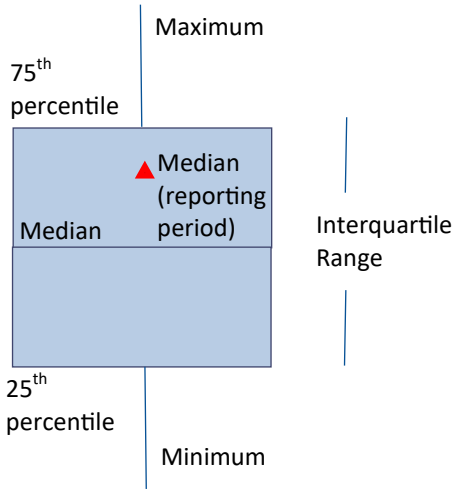


Figure 3 Description of boxplots.

Climate

Figure 4 shows the monthly temperature and precipitation data for the reporting period compared to the 30-year averages. October 2024 through December 2024 were warmer, January and February 2025 cooler, and March 2025 through September 2025 average to slightly warmer. Precipitation varied from the norm with below average precipitation in December 2024 through February 2025 and historic high precipitation in August 2025.

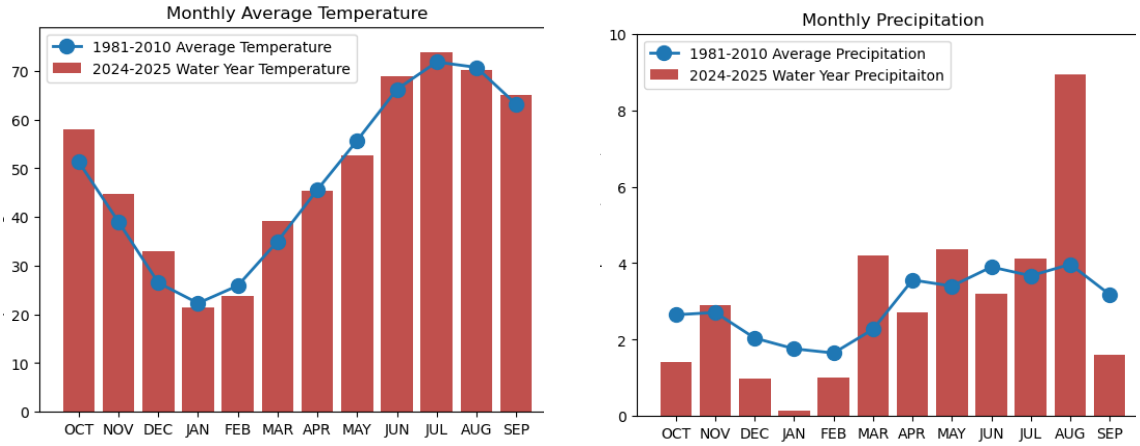


Figure 4 Temperature and precipitation data from station 4043413 (Cudahy, WI)

Flow

Water flow affects aquatic organisms, fish, channel shape and pollutant loading.

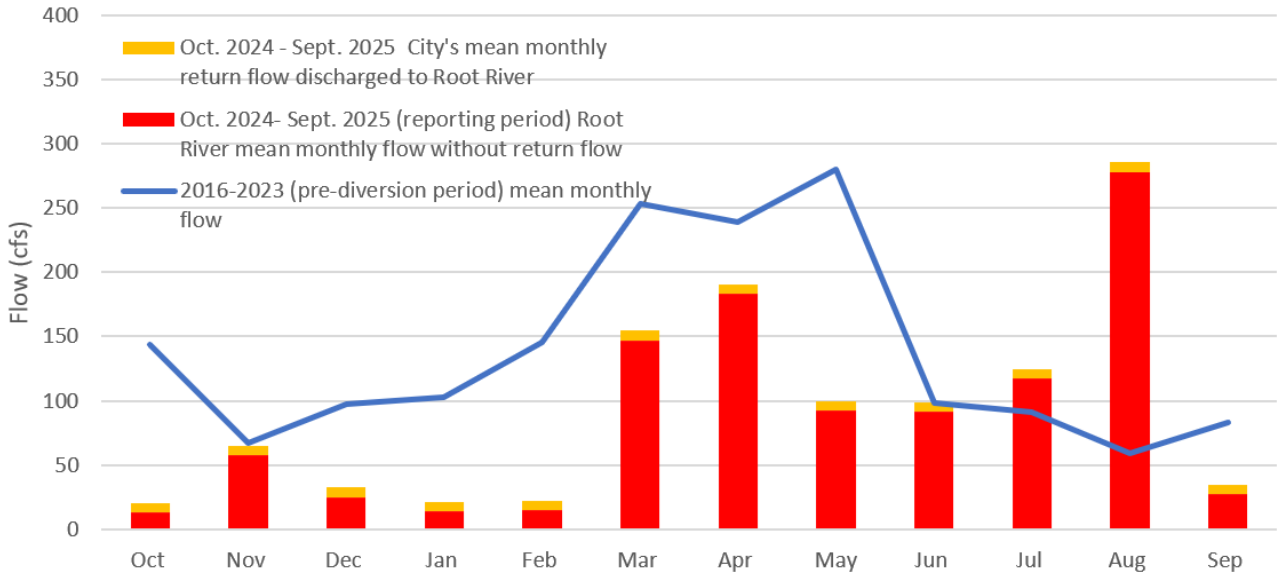


Figure 5 October 2024 through September 2025 streamflow is flow from the Root River gage (site 040872343) downstream of the Waukesha return flow outfall. The portion of the monthly streamflow that is the City of Waukesha return flow is in orange.

Flow in the Root River varies considerably from year to year and month to month depending on precipitation patterns. In contrast, the City's return flow to the Root River is consistent throughout the year and represents a higher proportion of the river flow in low flow periods (Figure 5). The Root River's average monthly flow was lowest in February 2025, when the City's return flow was 43% of the total that month. The average daily flow was lowest on February 23, 2025; at which point the City's return flow was 77% of the Root River's total flow.

Water Temperature

Water temperature can be an important factor in the health of fish and aquatic communities affecting embryonic development, growth cycles, migration patterns, competition with aquatic invasive species, and disease risk and severity. Water temperature also affects the concentration of dissolved oxygen, influencing aquatic organism respiration, bacteria activity and toxic chemical availability in water and sediment.

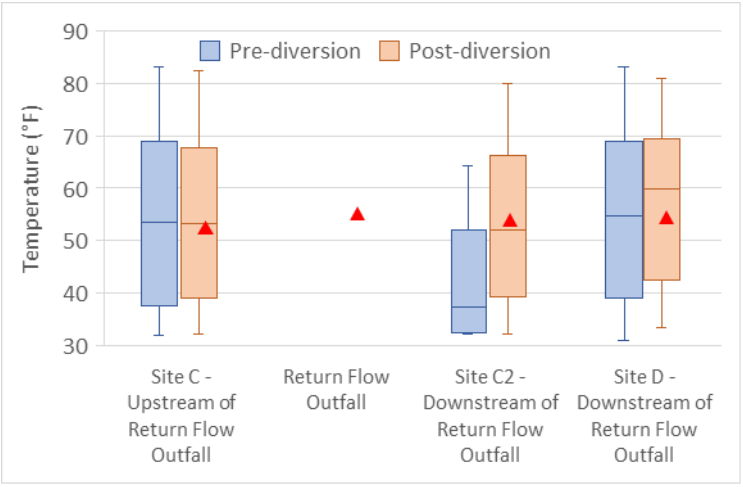


Figure 6 Plots show maximum, minimum and median water temperature for the pre-diversion period and post-diversion period. Red triangles are the current period median water temperature.

Annual median water temperatures show a slight increase between the monitoring site upstream of the return flow outfall and the two monitoring sites downstream of the outfall (Figure 6). Further monthly data provided in the Report suggest the return flow outfall water may have a slight warming effect in winter and a slight cooling effect in summer. Monthly data is available in Appendix F of the City's *Diversion Approval Report for 2025.*

Phosphorus

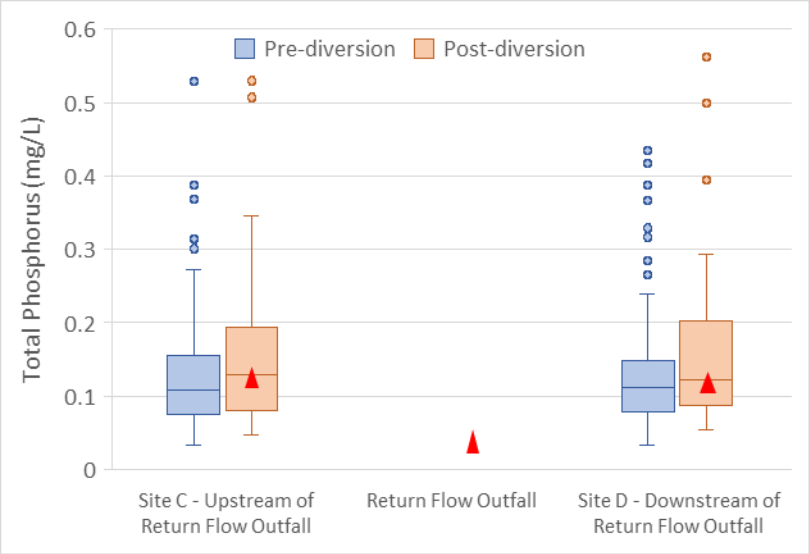


Figure 7 Plot compares the phosphorus concentrations from the pre-diversion period (blue) to the post-diversion period (red). Median reporting year values are shown as red triangles.

Phosphorus is a vital nutrient in aquatic ecosystems. However, excessive phosphorus in the Root River from urban stormwater runoff, wastewater treatment plants, agricultural runoff, and septic systems can lead to degraded stream habitat, eutrophic conditions and unbalanced fish populations. High levels of algal growth in the stream driven by increased phosphorus can decrease water clarity, raise water temperature, increase the magnitude of oxygen swings and reduce light availability for beneficial macrophytes and periphyton communities. The entire Root River is listed on Wisconsin's 303(d) list as impaired for phosphorus, a listing that predates the City's return flow to the Root River.

Phosphorus concentrations in the river are elevated, but consistent above and below the return flow outfall (Figure 7). Median phosphorus concentrations in the river from the reporting period are elevated relative to the pre-diversion median, which may be due to high stream flows or other environmental factors in the river during the reporting period. The return flow median phosphorus concentration is lower than the river's and the monitoring location downstream of return flow outfall shows a slight decrease in the median phosphorus concentration in the river.

pH

Aquatic organisms thrive in a pH range of 6 to 9; concentrations above or below these limits harm aquatic organism survival.

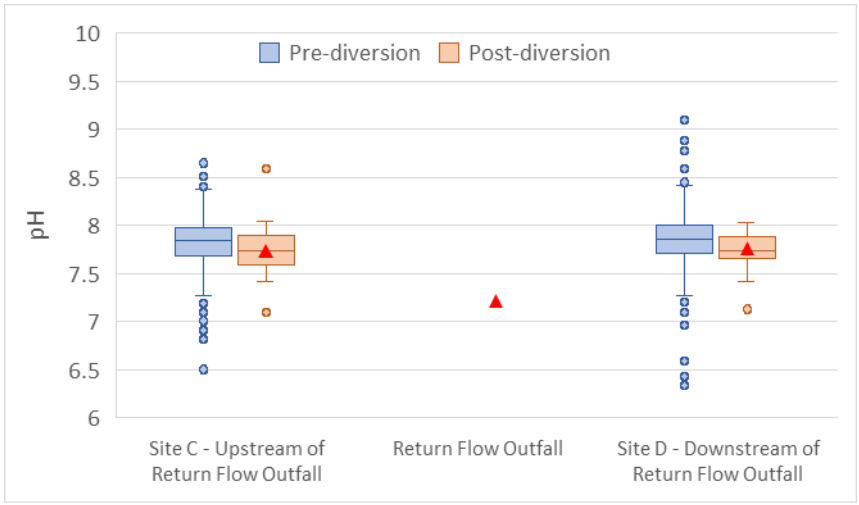


Figure 8 Plot compares the pH concentrations from the pre-diversion period (blue) to the post-diversion period (red). Median reporting year values are shown as red triangles.

Median pH concentrations in the Root River for the reporting period upstream and downstream of the return flow outfall were within the desired pH range and were lower than the median pre-diversion values (Figure 8).

Dissolved Oxygen

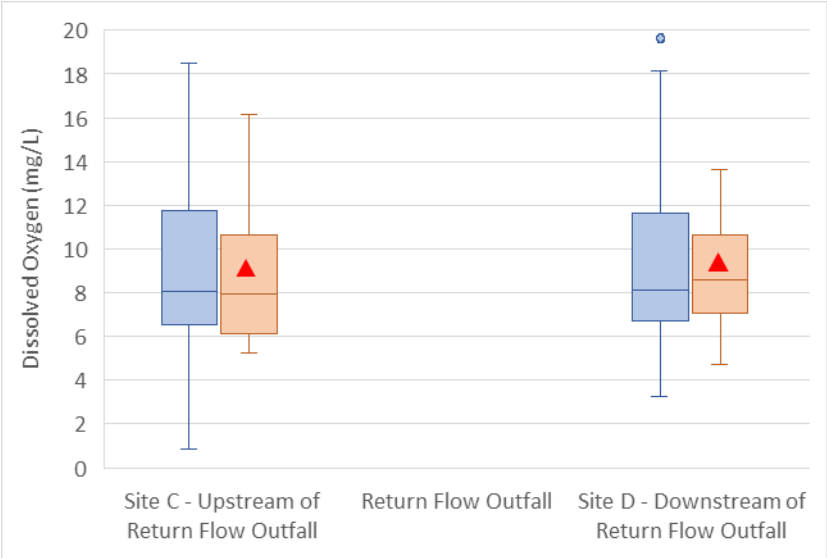


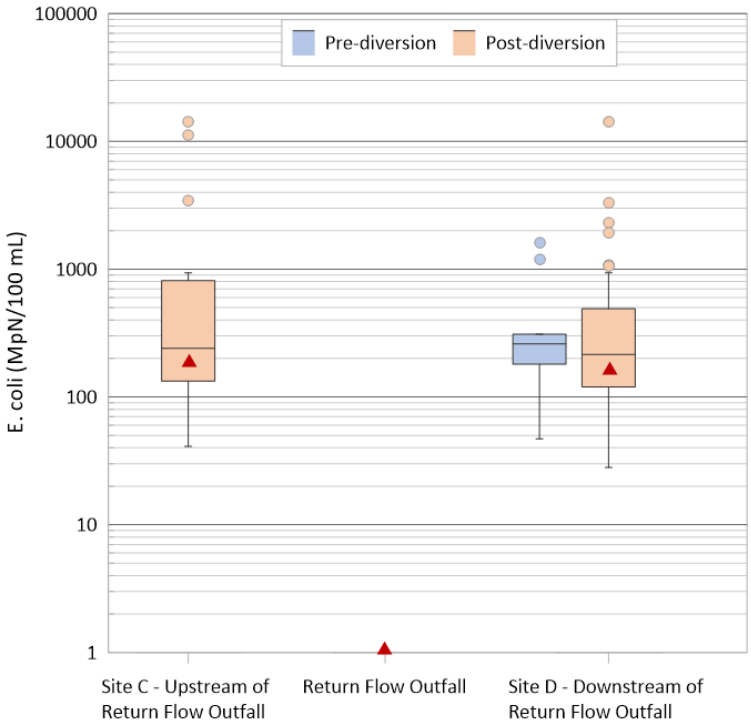
Figure 9 Plot compares the dissolved oxygen concentrations from the pre-diversion period (blue) to the post-diversion period (red). Median reporting year values are shown as red triangles.

Dissolved oxygen is important for aquatic life and can change depending on water temperature or excessive algal growth.

Median dissolved oxygen concentrations for the reporting period upstream and downstream of the return flow outfall, were higher than the pre-diversion median. This difference is likely due to interannual variability (Figure 9). Dissolved oxygen concentrations at these monitoring sites are within the stressful to supportive range for fish as defined by USEPA. The median dissolved oxygen concentration during the reporting period are in the *supportive* range.

E. coli

E. coli is an indicator organism used to indicate if disease-causing bacteria may be present in freshwater. *E. coli* concentrations are regulated to protect human health during recreational use of water bodies. Potential sources of *E. coli* in surface water include wastewater treatment plant effluent, septic systems, livestock, stormwater runoff and wildlife.



The City of Waukesha began monitoring the Root River for *E. coli* in October 2023. For reference, recreational waters in Wisconsin tested for *E. coli* are considered safe for recreational use at concentrations between 0 to 235 MPN/100 mL. Median concentrations of E. coli at Sites C and D are above these concentrations (Figure 10). The City disinfects its wastewater with UV radiation from May through September during the recreation season. See *Diversion Approval Report for 2025* for more details.

Figure 10 Plot compares the E. coli concentrations from the pre-diversion period (blue to the post-diversion period (red). Median reporting year values are shown as red triangles. Outliers above 4000 MpN /100mL are not shown. The highest E. coli concentrations were measured at 14,000 MPN/100mL. Note: Plot includes limited pre-diversion data for Site D collected and analyzed by MMSD. Post diversion data includes both the City of Waukesha and MMSD data. This graph is different from the earlier graphs in this summary that include pre-diversion data for both upstream and downstream time periods.

Chloride

Chlorides are found in both saltwater and fresh water and are essential to life. In the Root River, chlorides come primarily from anthropogenic sources (deicing salt and water softener discharges), since the area's geologic formations contain relatively little natural chloride. High chloride concentrations in freshwater can be harmful to aquatic organisms, hindering reproduction, growth and survival.

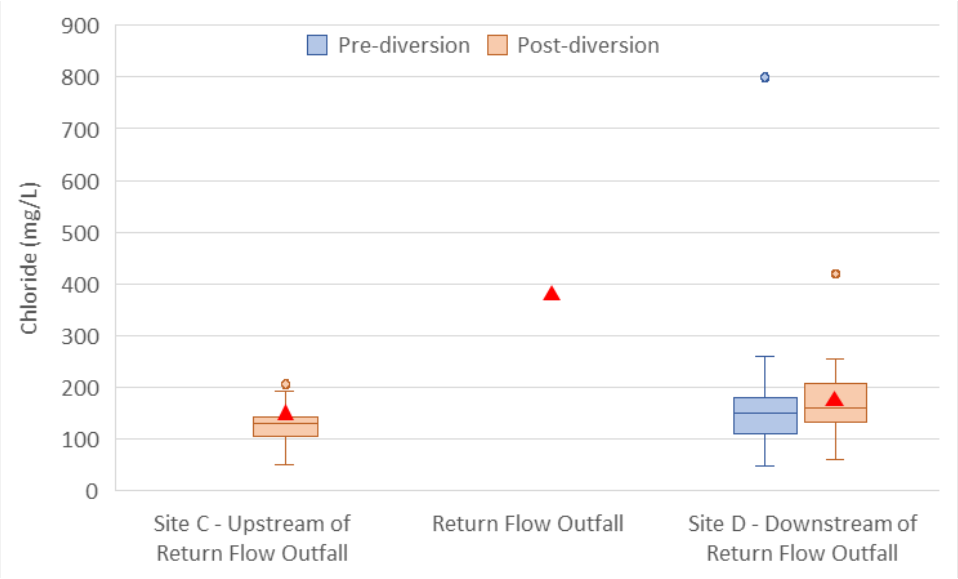


Figure 11 Plot compares the E. coli concentrations from the pre-diversion period (blue) to the post-diversion period (red). Median reporting year values are shown as red triangles. Note: Plot includes limited pre-diversion data for Site D collected and analyzed by MMSD. Post diversion data includes both the City of Waukesha and MMSD data. This graph is different from the earlier graphs in this summary that include pre-diversion data for both the upstream and downstream time periods.

The City began chloride sampling in October 2023 when the return flow discharge began. Comparison chloride data are not available from the pre-diversion period at Site C. Median chloride concentrations are below the water quality standard of 395 mg/L both upstream and downstream of the return flow outfall; however, chloride concentrations at Site D are elevated above the upstream location (Figure 11). The City has implemented a water softener chloride reduction program requiring all softeners to be fully optimized to minimize salt usage and chloride discharge. This program also includes a water softener rebate program that provides financial incentive to residents to remove water softeners, as the Lake Michigan water source is significantly softer than the City's previous groundwater source. Median return flow outfall concentrations decreased from 406 mg/L to 358 mg/L between the first year and second year of the diversion, respectively.

Habitat, Fish and Macroinvertebrates

The City's monitoring program also monitors the Root River's habitat, fish and macroinvertebrates .

Fish populations are monitored in the summer and fall at sites above and below the return flow discharge site. Shannon Diversity Index calculations show that the Root River has moderate to low fish species diversity, consistent with pre-diversion conditions.

Macroinvertebrate monitoring from the pre-diversion period through 2024 using the Hilsenhoff Biotic Index indicates water quality above and below the return flow outfall ranges from fair to fairly poor. Comparative pre-diversion data from the reporting period were not available at the time the report was submitted.

The City's full report includes additional information on the habitat in the Root River, including information on substrate, cover and algal abundance.

Photo credit: DNR/Craig Helker

Conclusion

Water quality, water-dependent natural resources and flow can be highly variable, influenced by weather patterns, seasonality and other watershed activities. Comparing upstream and downstream conditions of the City's discharge location, the City of Waukesha's monitoring data do not indicate the addition of return flow alters the Root River with the exception of a few effects; additional flow during low flow periods, increased chloride concentrations, slight cooling in summer months and slight warming during cooler weather. Some of these effects, such as additional flow during low river flow conditions and cooling the river in summer months are an improvement to the river function.