



City of Waukesha Root River

2024 Monitoring Summary

(Reporting period October 2023 – September 2024)

The Wisconsin DNR developed a 2024 technical summary of the City of Waukesha's (City) Root River monitoring conducted by the City in compliance with the City's Lake Michigan diversion approval. The City diversion approval requires river monitoring to assess treated wastewater discharge impacts to the Root River. Starting in October 2023, when the City's diversion of Lake Michigan water came online, the City began to return their diverted Lake Michigan water back to the lake while adhering to wastewater permit and diversion approval requirements. The Root River is in southeast Wisconsin with headwaters in Waukesha and Milwaukee counties and flows to Lake Michigan in Racine. The City began water quality and streamflow monitoring in the Root River in February 2017 to collect reference data on the Root River water quality *prior* to starting the diversion and their discharge to the Root River.

Reference conditions for the Root River monitoring



Photo credit: DNR/Craig Helker, 7/22/2024

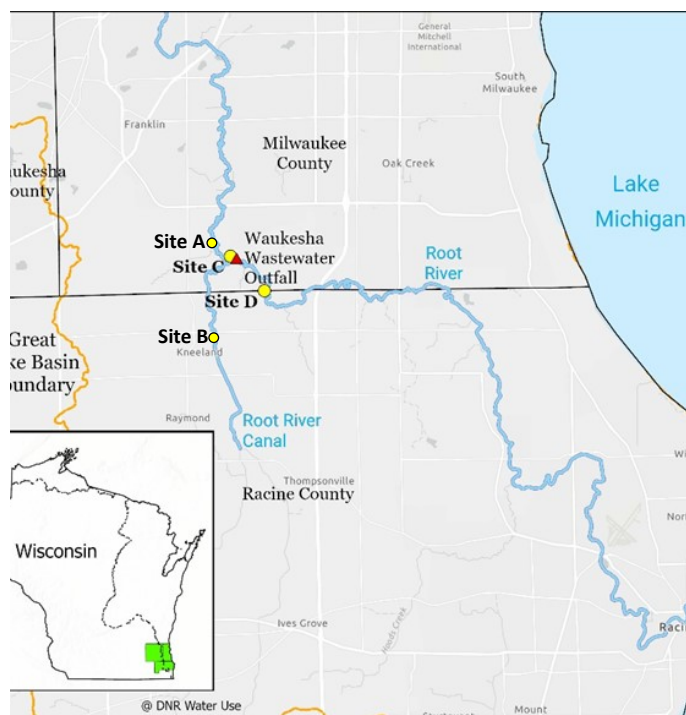


Figure 1 Root River Monitoring Sites A, B, C and D

are covered in the period February 2017 – September 2023. The City is required to report annually on their Root River monitoring program. The report submitted to the Wisconsin DNR in February 2025 covers the monitoring period from October 2023 – September 2024, which corresponds to the USGS water year.

Monitoring

The City's Root River monitoring program includes monitoring at four locations (A, B, C and D) for water quality parameters including total suspended solids, orthophosphate, total phosphorus, dissolved oxygen, chloride, E. coli, pH and temperature. See figures 1 and 2. The monitoring program also includes a USGS flow gage at Site C and habitat, fish and macroinvertebrate monitoring at site's A, B, C and D. Finally, the City also monitors temperature

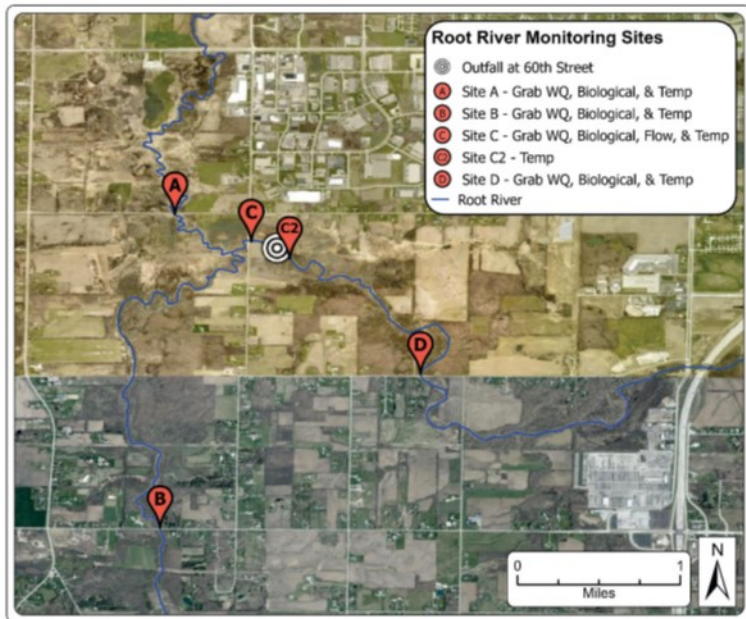


Figure 2 City of Waukesha monitoring locations.

Box-and-whisker plots (boxplots) are used to summarize key water quality parameter measurements from the 6-year reference period. Figure 3 shows an example of the boxplots used in this report (note reference data is not available from the City for *E.coli* and chloride). 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. Median values for October 2023 - September 2024 measurements are plotted as a red triangle on top of the pre-diversion reference period boxplots.

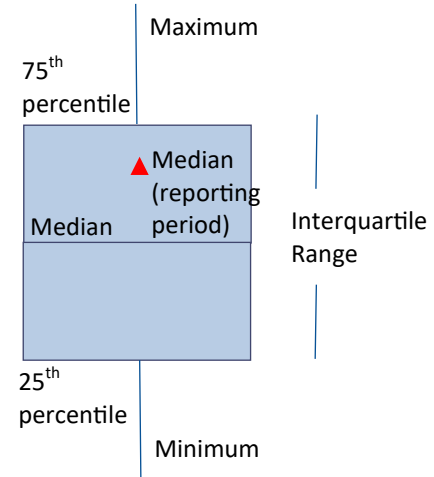


Figure 3 Description of boxplots.

Climate

Figure 4 shows the monthly temperature and precipitation data for the reporting period compared to the 30-year averages. The reporting period was generally warmer than the average and wetter until July through September 2024.

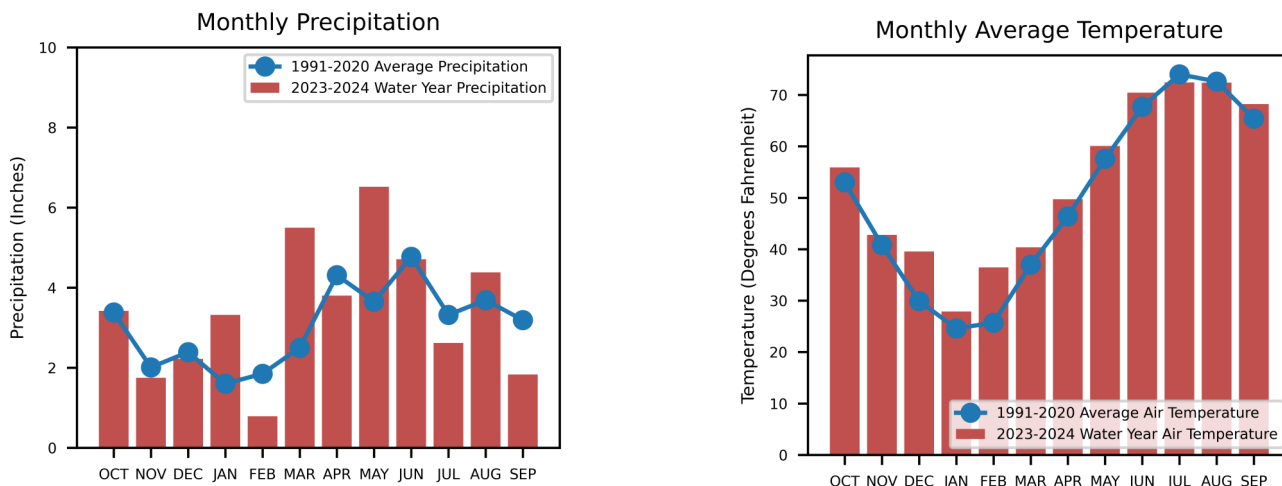


Figure 4 Weather data from station 4043413 (Cudahy, WI)

Flow

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

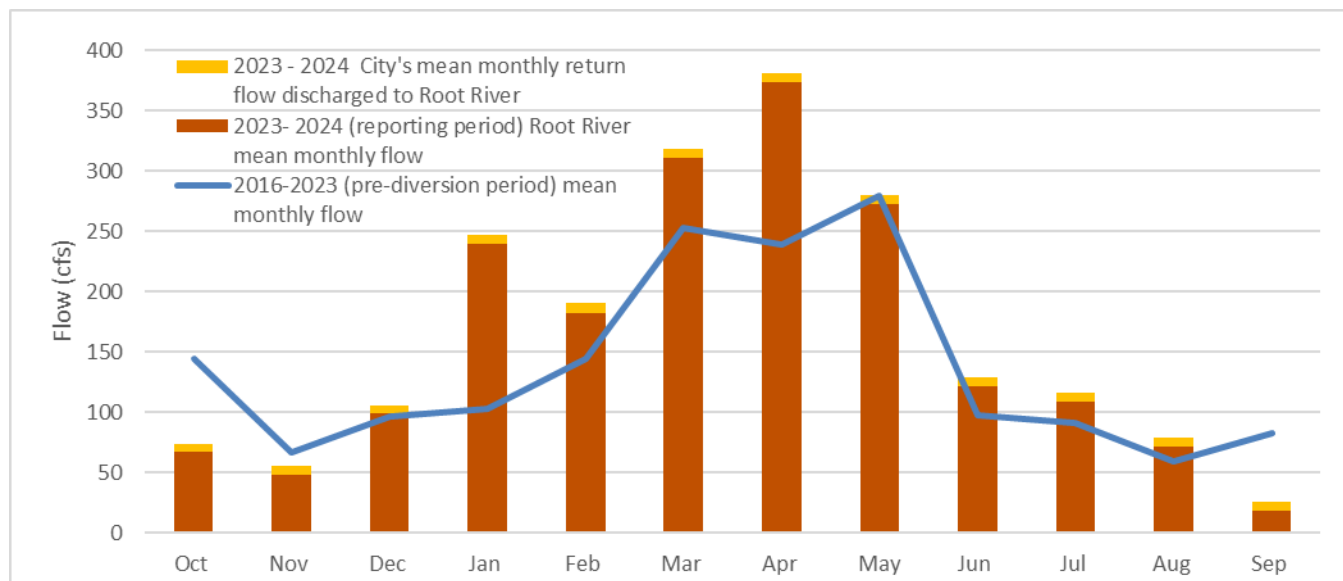


Figure 5 Streamflow is calculated by summing the flow from the Root River gage (red) upstream of the Waukesha wastewater outfall and the flow from the wastewater treatment plant (green).

Flow in the Root River is highly variable from year to year and month to month depending on precipitation patterns. Figure 5 shows that the City's return flow to the Root River (yellow/orange) is consistent throughout the year and a higher proportion of the flow in low flow periods. The September 2024 average monthly return flow was 31% of the total average monthly flow. The maximum average day return flow was 55% of the total average day flow.

Water Temperature

Water temperature is an important factor for the health of fish and aquatic communities. Water temperature can affect 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.

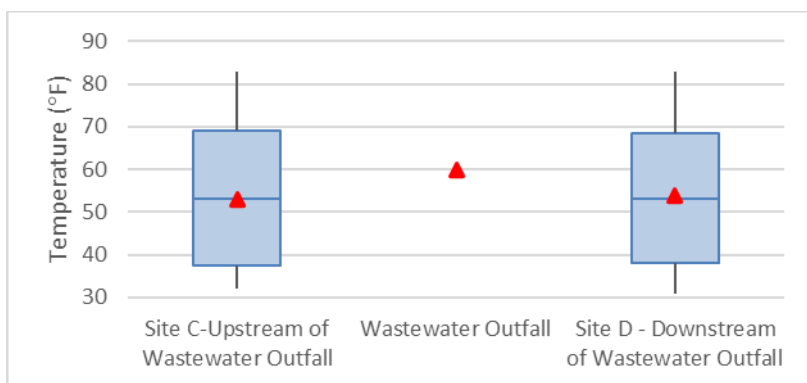


Figure 6 Plots show maximum, minimum and median water temperature for the pre-diversion period. Red triangles are the current period median water temperature.

Median water temperatures show a slight temperature increase between the monitoring site upstream of the wastewater outfall and downstream of the outfall in October – February and a slight decrease between the two sites from June through August (Figure 6). These temperature changes suggest that the outfall may have a slight warming effect in the winter and a slight cooling effect in the summer. Monthly data is available in Appendix G of the City's [Diversion Approval Report for 2024](#).

Phosphorus

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 failing septic systems may lead

to degraded stream habitat, eutrophic conditions, and unbalanced fish populations. High levels of excessive algal growth in the stream due to increased phosphorus can decrease water clarity, increase 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, this listing predates the City's wastewater discharge to the Root River.

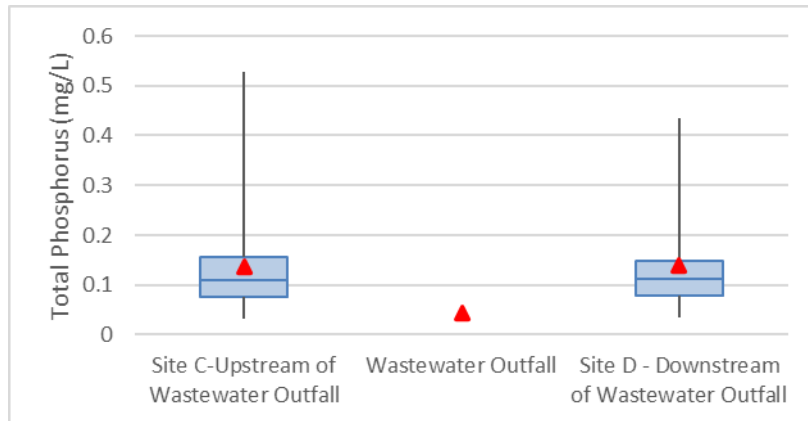
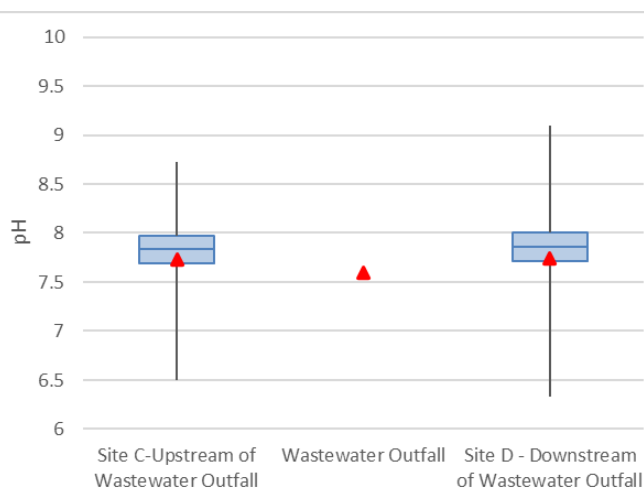


Figure 7 Plot compares the phosphorus concentrations from the pre-diversion period (blue) to the current period (red).

Phosphorus concentrations in the river are elevated, but consistent above and below the wastewater outfall (Figure 7). Median phosphorus concentrations in the river from the reporting period are elevated from the pre-diversion median, which may be due to high streamflows or other environmental factors in the river during the reporting period.

pH



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

Median pH concentrations in the Root River for the reporting period upstream and downstream of the wastewater outfall were lower than the median pH concentrations during the pre-diversion period (Figure 8).

Figure 8 Plot compares the pH concentrations from the pre-diversion period (blue) to the current period (red).

Dissolved Oxygen

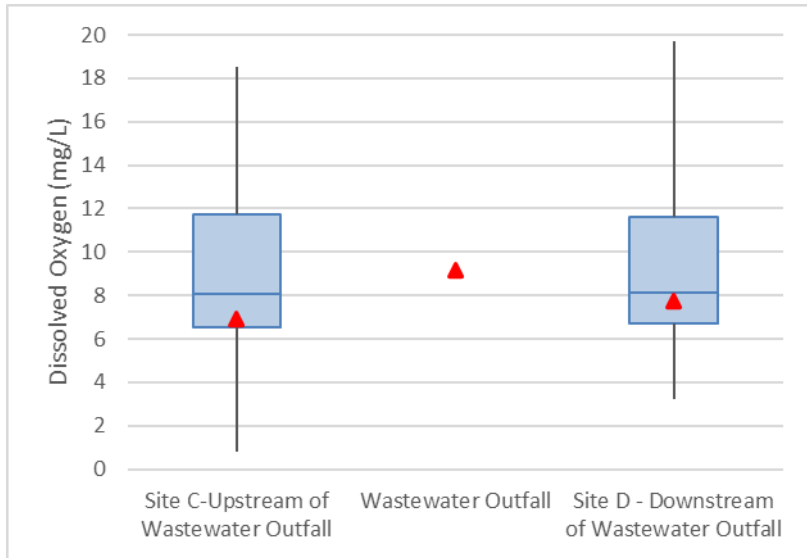


Figure 9 Plot compares the dissolved oxygen concentrations from the pre-diversion period (blue) to the current period (red).

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

Median dissolved oxygen concentration for the reporting period upstream and downstream of the wastewater outfall were lower than the median pre-diversion period, likely due to interannual variability (Figure 9). Median concentrations for dissolved oxygen at these monitoring sites are in the stressful to supportive range for fish as defined by [USEPA](#).

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, failing septic systems, livestock, stormwater runoff and wildlife.

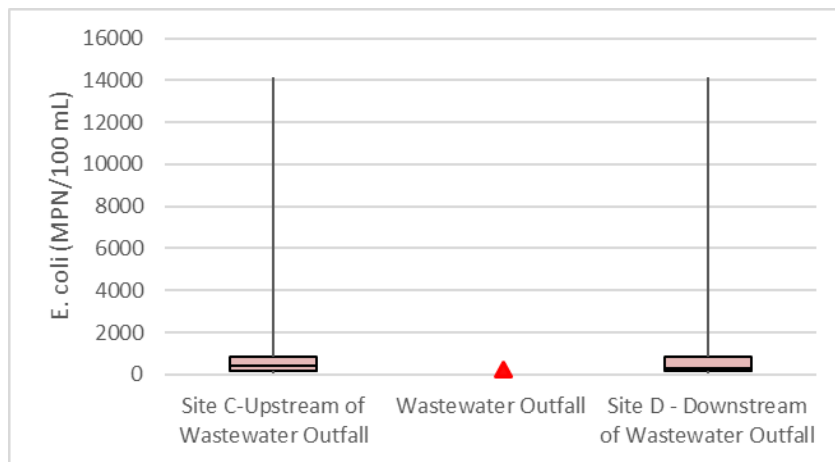


Figure 10 Plots show range and median concentrations of *E. coli* during the reporting period (October 2023 – September 2024)

Note: the companion graph only includes data for the one-year reporting period. This graph is different from the earlier graphs that include data from the pre-diversion time period. 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 from 0 - 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, therefore the City's wastewater is not contributing to bacteria present in the Root River. See [City of Waukesha Diversion Approval Report 2024 Appendix G](#) for more details.

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Chloride

Chlorides are found in both saltwater and fresh water and are essential life elements. Chlorides in the Root River primarily result from anthropogenic sources (deicing road salt and discharge from water softeners), since geologic formations in the area contain relatively little chloride. High chloride concentrations in freshwater can be harmful to aquatic organisms, hindering reproduction, growth and survival.

Note: the companion graph only includes data for the one-year reporting period. This graph is different from the earlier graphs that include data from the pre-diversion time period. The City began sampling for chlorides in October 2023. Comparison chloride data from the City are not available from the pre-diversion period.

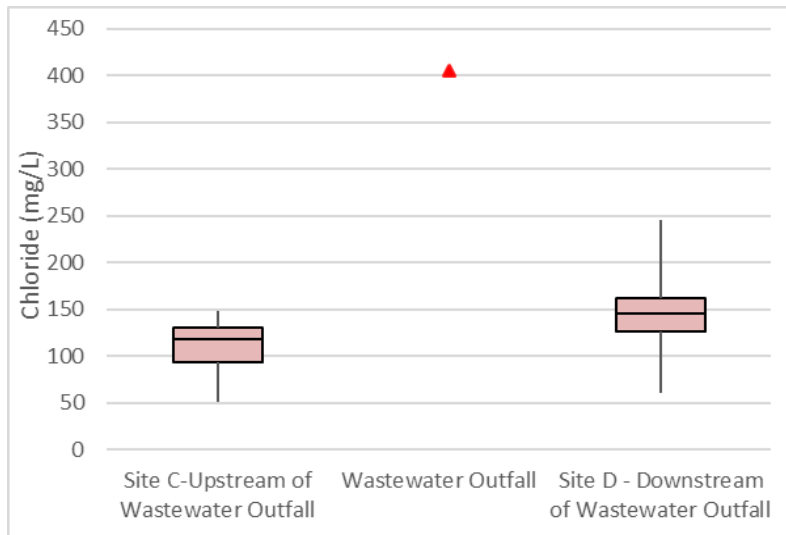


Figure 11 Plots show range and median concentrations of chlorides during the reporting period (October 2023 – September 2024).

Median chloride concentrations are below the water quality standard (395 mg/L) upstream and downstream of the wastewater outfall, however, chloride concentrations at the downstream monitoring location are elevated above the upstream location (Figure 11). The City has implemented a water softener chloride reduction program that requires all softeners to be fully optimized to minimize salt usage and chloride discharges. 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 previous groundwater source.

Habitat, Fish and Macroinvertebrates

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

Fish populations are monitored in the summer and fall. Shannon Diversity index calculations for the summer and fall monitoring are within the ranges of the pre-diversion index calculations at the sites above and below the return flow discharge site. The Shannon Diversity index indicates that the Root River has moderate to low fish species diversity.

Macroinvertebrate monitoring from the pre-diversion period using the Hilsenhoff Biotic Index indicates that water quality above and below the wastewater outfall location ranges from fair to fairly poor. Macroinvertebrate data from the reporting period were not available to compare to the pre-diversion period 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, 7/22/2024

Conclusion

The Root River water quality, water dependent natural resources and flow can be highly variable and influenced by weather patterns, seasonality and other activities in the watershed. When comparing the reference period upstream and downstream of the City's discharge location, the City of Waukesha's monitoring does not indicate changes in the Root River from the addition of treated wastewater effluent, except for additional flow during low flow periods, increased chloride concentrations and slight cooling during summer months and slight warming during cool weather months.