2014 Surface Water Quality Annual Summary Report

Fresh Water Resources
Monitoring Department

Background

The Federal Water Pollution Control Act of 1965, through amendments and revisions, became known as the Clean Water Act of 1977. This act mandates that all states have an Environmental Protection Agency (EPA) approved water quality protection process. In Wisconsin, the legislature has authorized the Department of Natural Resources (WDNR) to formulate and place into effect long-range water resources plans and set water quality standards, or criteria, for a given waterbody according to its highest potential use. In addition, the Southeastern Wisconsin Regional Planning Commission (SEWRPC) helps implement regional water quality plans as part of Section 208 of the Clean Water Act.

In 1979, the Milwaukee Metropolitan Sewerage District (the District) began its surface water quality monitoring program to comply with the Federal Water Pollution Control Act objectives and state water quality standards. The District also began its massive Water Pollution Abatement Program (WPAP) to eliminate bypassing and combined sewer overflows while improving and upgrading the District's two wastewater treatment facilities. As part of the WPAP, the Inline Storage System (ISS) was built and subsequently came online in 1994. At inception, the surface water quality monitoring program consisted of eight monitoring locations on the three major rivers (Milwaukee, Menomonee, and Kinnickinnic) and eleven monitoring locations on Lake Michigan.

Since that time, the District's surface water quality monitoring program has expanded to include greater spatial and temporal coverage. The program currently has 97 monitoring locations on 12 different rivers and creeks as well as Lake Michigan (Figure 1). Two boats, the *Pelagos* and the *ORP*, are used to monitor the lake and the Milwaukee Harbor Estuary (lower estuary sites), while vans are used to sample the rivers, creeks, and upper estuary sites. The Milwaukee Harbor Estuary extends up the Milwaukee River to the former North Avenue Dam, upstream on the Menomonee River to the former Falk Dam (approximately 38th Street), and upstream on the Kinnickinnic River to approximately Chase Avenue.

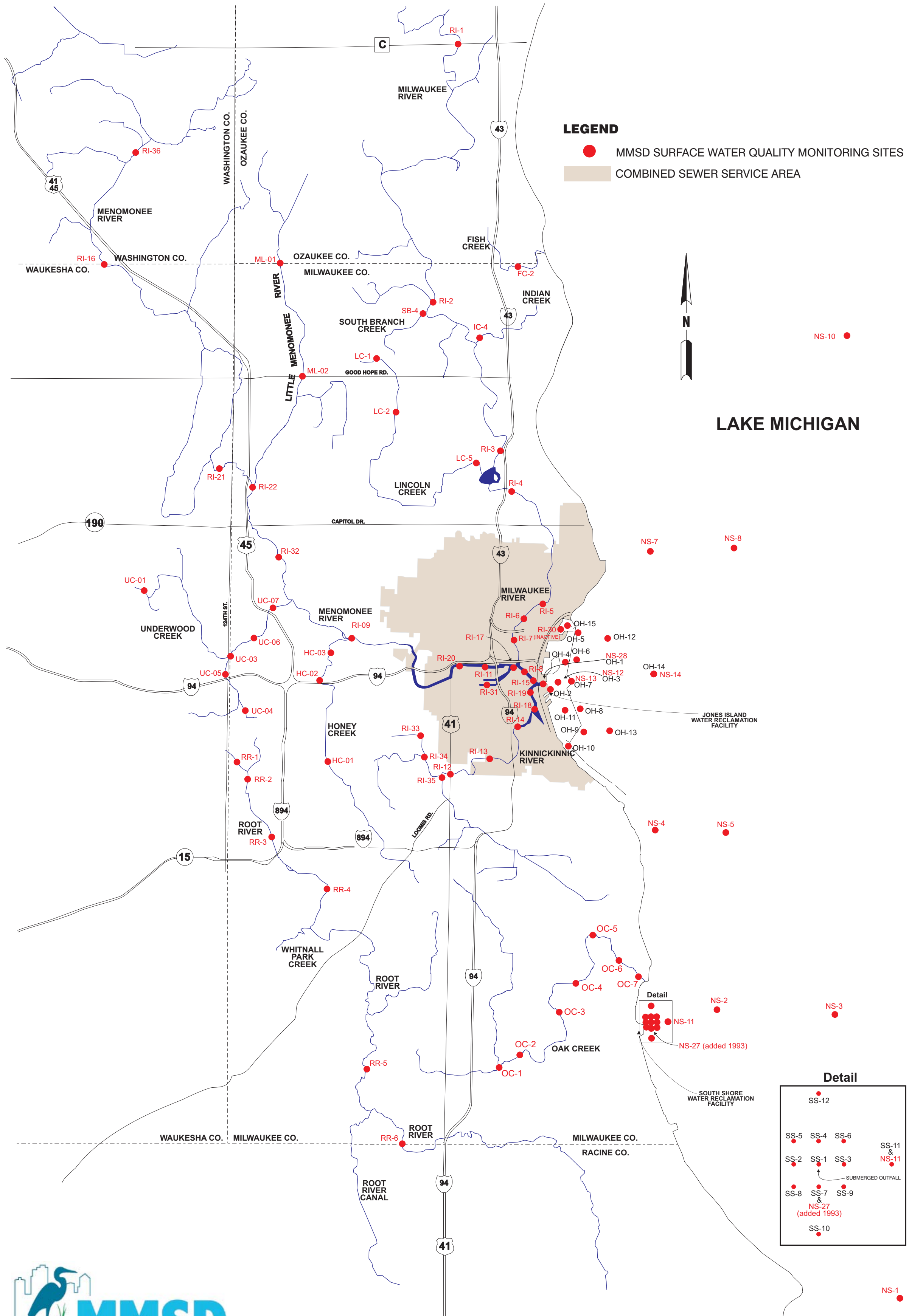
Introduction

MMSD's surface water quality monitoring program is required under the District's Wisconsin Pollutant Discharge Elimination System (WPDES) permit and the data are submitted annually to the WDNR. Monitoring requirements follow the Surface Water Quality Monitoring Plan (September 2011) and include the survey types listed in Table 1.

In addition to being a permit requirement, other objectives of the surface water quality monitoring program include:

- Monitor the biological, chemical and physical characteristics of Lake Michigan and local waterways, within the District's jurisdiction, to assess the impact of District watercourse improvement projects, stormwater management rules, and nonpoint pollution prevention programs on water quality.
- Provide physical, chemical and biological data on the quality of water, wastewater and sediments in order to maintain and improve District operations and facilities and to satisfy external customer requests for related project data.
- Supply water quality data interpretation and reports on environmental monitoring related to District operations and facilities planning.
- Maintain a historical water quality database and provide this information to the general public.
- Provide public education and outreach as it relates to the District's mission.

Fresh Water Resources Monitoring Sites



MMSD
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14-053

Table 1: Survey types and frequencies.

Survey Type	Number of Scheduled Surveys per Year	Number of Sampling Sites	Year Sampling Commenced
Nearshore	9	14	1979
Outer Harbor	14	15	1979
South Shore	14	12	1979
River	20	27	1980
Little Menomonee River	20	2	2007
Indian Creek	8	1	2002
Southbranch Creek	9	1	1999
Lincoln Creek	9	3	1997
Underwood Creek	9	6	2003
Honey Creek	9	3	2001
Fish Creek	8	1	2002
Oak Creek	9	7	1985
Root River	9	6	1999
CP (dry, wet, CSO)	2 - 4	25	1995

Description of Surveys

Nearshore Survey

The purpose of this effort is to provide a database for the District to assess the impact of MMSD discharges, as well as all other sources of pollution, including stormwater runoff, on overall nearshore water quality. Some Nearshore survey sampling sites are located a distance from shore to provide data for determining Lake Michigan background levels; these data have been useful in developing some of the District's effluent limitations and permit discharge fees. This survey covers the area of the nearshore environs of Lake Michigan from Fox Point on the north to Wind Point on the south and from the western shore of Lake Michigan to a point ten miles east of the western shore. The total area of lake covered by this survey is approximately 350 square miles.

Outer Harbor/South Shore Surveys

Water quality data from these two survey types are utilized to evaluate the impact that the Jones Island Water Reclamation Facility (WRF) and the South Shore WRF are having on Lake Michigan. The areas surrounding both of these WRF outfalls are intensively used for recreational boating and fishing. Sampling sites for these surveys were selected based upon their position relative to the effluent outfalls and the movement of water (or currents) found in the areas. The point identified as OH-02 is the existing outfall for the Jones Island WRF. The point identified as SS-01 is the point of discharge from the South Shore WRF. A major drinking water plant intake (Oak Creek) is located approximately one-mile southeast of SS-01. Water quality in both of these nearshore areas is also affected by the Milwaukee River as well as Oak Creek.

River Survey

Extensive monitoring of the three major river systems within the District's sewer service boundaries provides baseline data for measuring and documenting potential sources of pollution both inside and outside the District boundaries. The River survey helps document the benefits of the Deep Tunnel (ISS), watercourse improvement projects, nonpoint pollution prevention programs, and stormwater management plans. The Milwaukee River is the largest river within the District's service area and is currently recognized by community leaders as an important recreational water resource within the metropolitan area. The headwaters of the Milwaukee River originate in Fond du Lac County near Eden; the river enters the District at Pioneer Road (County Trunk C) after passing through 86% of its drainage area. The main stem of the Milwaukee River totals 43.5 miles, and the Milwaukee River watershed covers 698 square miles. The Menomonee River watershed covers 136 square miles and is nearly 28 miles in length. The Menomonee River originates in a wetland area in the northeast corner of the Village of Germantown. Approximately 90% of the watershed is within the MMSD sewer service area. The Kinnickinnic River is located entirely within Milwaukee County and has a 26 square-mile drainage area. The Kinnickinnic River originates from a storm sewer at S. 60th Street and is 8 miles long. The watershed is highly urbanized and, in contrast to the Milwaukee and Menomonee River basins, the Kinnickinnic watershed is completely serviced by sanitary sewers, i.e., there are no septic systems.

CP Survey

The CP survey, which is fundamentally similar to the River survey, is used to assess the impacts of a combined sewer overflow (CSO) and is sampled up to four times per year, under the following conditions: 1) in the event of a CSO (2 surveys per year required if multiple occurrences); 2) when rainfall equals a minimum of 0.25" basin-wide and there is no CSO (wet CP survey); and 3) when there has been no rain for at least seven days with no CSO (dry CP survey).

Little Menomonee River Survey

The Little Menomonee River originates in southern Ozaukee County near Freistadt Rd. and flows in a mostly southerly direction for a distance of approximately 10 miles to its confluence with the Menomonee River near Highway 100 and Hampton Avenue. The Little Menomonee River subwatershed encompasses approximately 21.8 square miles, or nearly 16 percent of the Menomonee River watershed.

Indian Creek Survey

Indian Creek is a tributary of the Milwaukee River located in northern Milwaukee County. The creek, 2.6 miles in length, originates in the Village of Bayside and has its confluence with the Milwaukee River just south of Bradley Road in River Hills. Large storms typically cause flooding in this watershed.

Southbranch Creek Survey

Southbranch Creek, approximately 1.5 miles long, drains a 2.95 square mile area before it enters the Milwaukee River. The entire watershed lies in an urban setting and drains by means of a storm sewer system. Southbranch Creek has a long history of flooding. In response to this flooding, the District, along with other concerned parties, implemented a flood management plan. The plan included removing houses from the floodplain as well as the installation of detention basins.

Lincoln Creek Survey

Lincoln Creek is approximately 9 miles in length and drains a 21-square mile watershed. There is a history of having poor water quality and flooding problems due to urbanization within its watershed. In response to these problems, the District, along with other concerned parties, implemented a flood management plan which involved environmental restoration, creation of wetland stormwater detention areas, changes in creek channel morphology, stream bank erosion controls, and improvements in creek bed substrate.

Underwood Creek Survey

Underwood Creek originates in the City of Brookfield and flows approximately 8 miles in a southeasterly direction to its confluence with the Menomonee River. The Underwood Creek subwatershed encompasses approximately 19.8 square miles and includes the Underwood Creek main stem, Dousman Ditch, and the South Branch of Underwood Creek. Much of Underwood Creek flows in a concrete-lined channel. Flooding problems have occurred in the subwatershed and sections of the creek have undergone flood management improvements.

Honey Creek Survey

Honey Creek originates at the S. 43rd Street storm sewer outfall in the City of Greenfield and flows in a northerly direction for approximately 8.8 miles until its confluence with the Menomonee River in the City of Wauwatosa. The Honey Creek subwatershed encompasses 11 square miles. Channel modifications such as deepening, straightening, and lining with concrete have been made to 7.1 miles of Honey Creek. The creek flows under State Fair Park in an enclosed channel that consists of three 10 by 15 foot pipes. The Honey Creek subwatershed has experienced minor flooding problems, but the biggest problem with this creek has been the ecological degradation and habitat loss due to channel modifications.

Fish Creek Survey

Fish Creek is located along the border between Milwaukee and Ozaukee Counties in the Village of Bayside and the City of Mequon. Fish Creek drains directly into Lake Michigan, approximately 3 miles downstream from the source. Major precipitation events result in rapid surface runoff to Fish Creek, thereby causing a flashy response in the creek, potentially causing flooding in the Village of Bayside.

Oak Creek Survey

Oak Creek flows into Lake Michigan about 2 miles north of the MMSD's South Shore WRF. Knowledge of its water quality is helpful in determining impacts to the lake's nearshore zone. When monitoring began on Oak Creek, the area was primarily rural; since then, it has undergone significant development. Continued urbanization will increase the flows that this stream will be required to handle.

Root River Survey

The Root River drains approximately 197 square miles within Milwaukee, Waukesha, Racine, and Kenosha Counties. The watershed includes all, or portions of, 18 communities, and includes five sanitary sewer service areas. The Root River empties into Lake Michigan in the City of Racine. This survey covers the upper 72 square miles of the watershed located within the District's service area.

Water Quality Standards

In accordance with the Federal Water Pollution Control Act and the Clean Water Act, each state is required to adopt water quality (WQ) standards and a plan of action for applying those standards. Waters are classified into different groups according to what they are or should be used for; these characteristics are then utilized in developing and establishing supportive standards for each classification. Water quality standards for a given body of water are set according to its highest potential use. Standards are used as a measuring stick or qualitative indicator of environmental characteristics of the water body that must be maintained if the water body is to be suitable for its specified use classification. Table 2 lists the WDNR surface water quality standards that are applicable to this report. Recommended EPA criteria for *E. Coli* and Nitrate/Nitrite are included as well.

Table 2: Applicable surface water quality standards.

Variable	Standard	Sampling Site	Reference	Notes/Variances
Chloride	395 mg/L	All sites	WDNR. Chapter NR 105. Surface Water Quality Criteria and Secondary Values for Toxic Substances. NR 105.06. July, 2010.	Chronic Criterion
E. coli	235 CFU/100 mL	None	2012 EPA Recreational Water Quality Criteria	EPA recommended beach action value for swimming beaches. Used as a guideline as it does not directly affect any MMSD WQ sampling sites.
Fecal Coliform	200 CFU/100 mL	All OH sites except OH 1. All NS sites except NS 28. All SS sites. All FC, SB, RR and OC sites. The Milwaukee River above the North Ave. Dam (RI sites 1, 2, 3, 4, 5). The Menomonee River above HC confluence (RI 36, 16, 21, 22, 32).	WDNR. Chapter NR 102. Water Quality Standards for Wisconsin Surface Waters. NR 102.04. November, 2010.	The membrane filter fecal coliform count may not exceed 200 colonies/100 mL as a geometric mean and may not exceed 400 colonies/100 mL in more than 10% of all samples during any month.
	1000 CFU/100 mL	UC, IC, HC, LC, the KK River, the Menomonee River below the confluence with HC (RI Sites 9, 20, 11, 17), the Milwaukee River below the North Ave. Dam (RI sites 6, 7, 8, 15)(OH 1/NS 28), the South Menomonee Canal, and the Burnham Canal (RI site 31).	WDNR. Chapter NR 104. Uses and Designated Standards. NR 104.06. February, 2004.	The membrane filter fecal coliform count shall not exceed 1,000 CFU/100 mL as a monthly geometric mean based on not less than 5 samples per month nor exceed 2,000 CFU/100 mL in more than 10% of all samples during any month. The latter part of this variance (2,000 CFU/100 mL in more than 10% of all samples during any month) only applies to RI sites 6, 7, 8, 15, 31, and OH 1/NS 28.

Table 2 (cont'd): Applicable surface water quality standards.

Variable	Standard	Sampling Site	Reference	Notes/Variances
Nitrate/Nitrite	0.3 mg/L	All river and all creek sites	EPA. Ambient Water Quality Criteria Recommendations. Information Supporting the Development of State and Tribal Nutrient Criteria. Rivers and Streams in Nutrient Ecoregion VII. December, 2000.	Recommended EPA guideline for rivers and streams.
Total Phosphorus	0.007 mg/L	OH sites 6, 8, 12, 13, 14. NS sites 1, 2, 3, 4, 5, 7, 8, 10, 11, 14, 27. All SS sites.	WDNR. Chapter NR 102. Water Quality Standards for Wisconsin Surface Waters. NR 102.06. November, 2010.	
	0.075 mg/L	All creek sites. River sites 36, 16, 21, 33, 34, 35. ML 1 and ML 2.	WDNR Chapter NR 102. Water Quality Standards for Wisconsin Surface Waters. NR 102.06. November, 2010.	
	0.1 mg/L	River sites, 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 17, 18, 19, 20, 22, 31, 32. OH sites 1, 2, 3, 4, 5, 7, 9, 10, 11, 15. NS sites 12, 13, 28	WDNR. Chapter NR 102. Water Quality Standards for Wisconsin Surface Waters. NR 102.06. November, 2010.	

Methodology

Sample Collection

In order to get an overall assessment of a waterway's health, physical, chemical, and biological variables are analyzed as part of MMSD's surface water quality monitoring program (Table 3). Some variables are captured by sonde *in situ* (temperature, pH, specific conductance, dissolved oxygen, turbidity, and depth); remaining variables are run in-house by the MMSD Central Laboratory.

The monitoring program addresses, by random design, both dry and wet weather sampling periods. The sampling program is designed to not only capture both wet and dry events but to be representative of the annual fluctuations in the number of wet and dry events each year. For example, during rainy years, a higher proportion of samples will be collected during rain events.

Exact sampling depths at any location may vary from year to year depending on lake levels, dam operations, seiches, and precipitation. Generally, three samples are collected at sites greater than four meters deep, i.e., one meter below the surface, one meter above the bottom, and mid-depth. Locations less than four meters deep are generally sampled at either two depths, i.e., one meter below the surface and one meter above the

Table 3: MMSD's surface water quality monitoring variable list.

Variable	Unit of Measure
1% Light Level (photometer)	meters
Ammonia Nitrogen	mg/L
Biochemical Oxygen Demand (5 & 20 day)	mg/L
Chloride	mg/L
Chlorophyll *a*	mg/m^3
Depth	meters
Dissolved Oxygen	mg/L
***Escherichia coli* Bacteria**	MPN/100 mL
Fecal Coliform Bacteria	CFU/100 mL
Hardness	mg/L
Nitrate Nitrogen	mg/L
Nitrite Nitrogen	mg/L
Nitrate + Nitrite Nitrogen	mg/L
pH	Std. Units
Soluble Silica	mg/L
Specific Conductance	µmhos/cm
Temperature	°C
Total Alkalinity	mg/L
Total Arsenic	µg/L
Total Cadmium	µg/L
Total Calcium	mg/L
Total Carbon	mg/L
Total Chromium	µg/L
Total Copper	µg/L
Total Dissolved Organic Carbon	mg/L
Total Inorganic Carbon	mg/L
Total Kjeldahl Nitrogen	mg/L
Total Lead	µg/L
Total Magnesium	mg/L
Total Nickel	µg/L
Total Organic Carbon	mg/L
Total Phosphorus	mg/L
Total Selenium	µg/L
Total Silver	µg/L
Total Solids	mg/L
Total Soluble Phosphorus	mg/L
Total Suspended Solids	mg/L
Total Zinc	µg/L
Turbidity	FNU
Volatile Suspended Solids	mg/L
Water Transparency (Secchi Disk)	meters

bottom, or one depth, depending on site conditions. Samples are collected from mid-channel, where feasible. Samples for metals testing are collected at mid-depth for sites greater than four meters deep and at the surface for shallower sites.

Analysis

Wet and dry events were determined using daily mean flow data collected by the USGS and were confirmed using daily precipitation collected by the MMSD. Using the Web-based Hydrograph Analysis Tool (WHAT), the flow data were retrieved and separated into runoff and base flow using the Local Minimum Method[1]. This produced a total flow, direct runoff, and base flow value for each day. The ratio of runoff to total flow was used to determine wet/dry conditions. All days where the total flow was comprised of more than 20% runoff were considered "wet" (Table 4).

Table 4: Breakdown of wet/dry surveys as determined by WHAT.

USGS Station for Flow Data	USGS Station ID	Total Number of Surveys	Number of Wet Surveys	Number of Dry Surveys
Milwaukee River @ Estabrook	04087000	22	7	15
Menomonee River @ 16th St.	04087142	22	14	8
Menomonee River @ 70th St.	04087120	22	11	11
Kinnickinnic River @ 11th St.	04087159	22	13	9
Oak Creek @ 15th Ave.	04087204	9	4	5
Root River @ Grange	04087214	9	2	7
Lincoln Creek @ Sherman Blvd.	040869416	9	3	6
Honey Creek @ Wauwatosa	04087119	9	6	3
Underwood Creek @ Wauwatosa	04087088	9	4	5

All data points that were reported as less than the method detection limit (MDL) by the laboratory were replaced with one-half of the MDL for subsequent analyses. River and creek sites are predominately sampled at the surface only, while lake sites are generally sampled at three depths. For consistency throughout similar sites, all river/creek analysis was performed using the surface sample only when more than one depth was sampled. Lake analysis was done by pooling all depths together. Seasonal analysis was performed by comparing summer data (May-October) to winter data (November-April).

Data Verification (Quality Assurance)

After all laboratory analyses have been completed for a survey, Freshwater Resources Monitoring (FRM) staff check the survey results. Any questionable results are sent to the FRM Supervisor for further review. The supervisor may request that certain samples be rerun by the laboratory. In the event that a value for an analysis is deemed questionable, the FRM Supervisor may flag the result with a Q flag. Data are Q flagged for a partial measure that is greater than 140% of the total, e.g., total soluble phosphorus is greater than 140% of total phosphorus, or data may be flagged as a potential outlier based on the FRM data quality assurance (QA) procedure. Data that were Q flagged were not included in this report.

Results and Discussion

Rivers and Creeks

Annual median values for select parameters have been calculated and mapped for all river and creek sites (Figures 2-6). Categories were selected based on the criteria listed previously in Table 2. Generally speaking, the creeks and the Kinnickinnic River have degraded water quality compared to the Milwaukee and Menomonee Rivers. High concentrations of fecal coliform bacteria, *E. coli* bacteria, total phosphorous, and total soluble phosphorous are found in many of the creeks, tributaries to the Kinnickinnic River, as well as the Kinnickinnic River main stem. Results from the above four parameters are found in lower concentrations on the Milwaukee or Menomonee Rivers. High nitrate/nitrite values, however, are seen in the Milwaukee River, including the downtown estuary sites. The most upstream site on the Menomonee River also has high nitrate/nitrite values.

Fecal coliform bacteria are a group of bacteria that are found in the intestinal tract of warm-blooded animals. Although fecal coliform bacteria are not harmful, their presence indicates that other pathogenic bacterial, viral, protozoan, or fungal species may be present in the water. Sources of fecal contamination to surface waters include wastewater treatment plant effluent, on-site septic systems, failing infrastructure, domestic and wild animal feces, and stormwater runoff. High concentrations of fecal coliform bacteria (exceeding the water quality standard) were found in nearly all of the creeks and the upper, more urbanized portions of the Root River. Moderate levels of fecal coliform bacteria were found in the Kinnickinnic River and portions of Oak Creek. The remaining sites, predominately the Milwaukee and Menomonee Rivers, are either meeting or nearly meeting the water quality standard for fecal coliform.

Escherichia coli, or *E. coli*, are also found in the intestinal tract of warm-blooded animals. Most strains of *E. coli* are harmless; however, some strains of *E. coli* bacteria can cause serious illness. *E. coli* are found in high concentrations for the majority of Underwood Creek, most of Honey Creek, as well as several locations on the Kinnickinnic River. Lincoln Creek, just prior to its junction with the Milwaukee River, has moderately high *E. coli* values. Most sites along the Milwaukee, upper Menomonee, and Little Menomonee Rivers are meeting the *E. coli* criterion of 235 cfu/100 ml, EPA beach action value.

Phosphorus as phosphate is one of the major nutrients required for plant growth. Excess phosphorus can lead to eutrophication of a water body, resulting in algal blooms, hypoxia, and fish kills. Phosphorus attaches to soil particles, thus entering the water body during storm runoff events. Sources of phosphorus include fertilizers, manure, organic wastes in sewage, and industrial effluent. The 43rd Street Ditch, a tributary to the Kinnickinnic River, has the highest median total phosphorus value of any site sampled. Underwood Creek, Honey Creek, and the downstream portions of the Root River have high values as well. To the north, high elevated total phosphorus values are found on the Little Menomonee River, Southbranch Creek, Indian Creek, and all of Lincoln Creek. Many sites along the Menomonee River, Underwood Creek, Root River, the Kinnickinnic River, and Oak Creek are meeting the more stringent criterion of 0.075 mg/L.

Soluble phosphorus is the form of phosphorus which is most readily available for metabolism by aquatic plant communities and is not attached or sorbed to particulate material. Total soluble phosphorus concentration appears to be elevated in a few select sites on Southbranch Creek, Lincoln Creek, and the 43rd Street Ditch. Most other sites, particularly the sites north of the City of Milwaukee, are slightly elevated for soluble phosphorus. Root River, Underwood Creek, and Oak Creek are generally doing well in terms of soluble phosphorus.
Nitrates and nitrites, along with ammonia, are forms of nitrogen that are found in aquatic environments. Nitrites are an intermediate product of nitrification and are usually found in low concentrations in the environment. Nitrates are needed for plant growth but excess nitrates can lead to eutrophication of a

waterbody. Unlike phosphorus, nitrates are readily dissolved in water. Sources of nitrates include wastewater treatment plant effluent, runoff from fertilized lawns and cropland, failing septic systems, runoff from animal manure storage areas, and industrial discharges that contain corrosion inhibitors. Numerous locations are displaying high nitrate/nitrite values. All sampling sites on the Milwaukee River reflect high nitrate/nitrite values, as well as the upper reaches of the Menomonee River and the Little Menomonee River. All Milwaukee Harbor Estuary sites are reflective of increased nitrites/nitrates. Generally speaking, the higher nitrite/nitrate values seem to be associated with rural land uses.

Parameters of interest were analyzed for wet and dry events for all river and creek sites. Of the parameters analyzed, fecal coliform and total suspended solids showed the largest differences (Figures 7 and 8). Both of these parameters are highly impacted by wet weather. Underwood Creek, Honey Creek, and Root River show the adverse effects of wet weather on fecal coliform values, with median values as high as 27,500 CFU/100 mL. There was one occurrence of a dry weather sanitary sewer overflow at HC site 1. Since there were only two dry weather samples, this overflow skewed the dry weather median fecal coliform value for this site. The concrete lining along the channel for Underwood Creek and Honey Creek likely contributes to the high fecal coliform values. Water quality during wet events can also be impacted by service area; stormwater runoff within the CSO area is combined with sanitary waste and is treated at the WRFs, whereas stormwater outside of the CSO area is sent directly to the nearest stream via storm sewers. Therefore, sites outside of the CSO area receive stormwater runoff from all the land within that watershed.

Total suspended solids show an increase at nearly every river and creek site during wet weather events. Downstream sites on both the Root River and Oak Creek appear to show significant increases in total suspended solids during wet weather. Nutrients (e.g., phosphorus), pesticides, and other potentially toxic materials (e.g., heavy metals) are both adsorbed onto and absorbed by suspended solids. Excessive amounts of suspended solids can reduce spawning habitat, smother fish eggs during spawning, clog the gills of fish, and affect the ability of invertebrates to filter feed. Eliminating stream bank erosion and installing riparian borders will help curb suspended solids entering our rivers and streams.

The effects of seasonality were also examined for multiple parameters with biochemical oxygen demand and chloride showing the largest differences between seasons (Figures 9 and 10). Biochemical oxygen demand, or BOD, is used to estimate the concentration of oxygen-demanding material in water. Bacteria break down organic matter in the aquatic environment; during this process, oxygen is consumed by the bacterial population. A high BOD value exerts an indirect effect on water quality, potentially depressing dissolved oxygen concentrations to levels harmful to aquatic organisms. Decaying algae will exert a significant BOD and is possibly the cause of the high summer BOD values seen along Underwood Creek, Honey Creek, and the Root River (Figure 9). Very high BOD values are routinely observed during the winter along the Kinnickinnic River. Orange microbial communities can be observed along the concrete lining. This is primarily due to deicing fluids which are entering the river through Wilson Park Creek. The BOD values within the CSO area have been greatly reduced since the ISS came online, resulting in increased dissolved oxygen at many sites.

All river and creek sites display higher median chloride values during the winter months (Figure 10). High chloride values are a direct result of road salting practices, although minor contributions also stem from industrial effluent discharges, water softeners, fertilizer applications, and sewage treatment plant effluent discharges. Of noteworthy importance are the levels of chlorides during the summer months. USGS studies

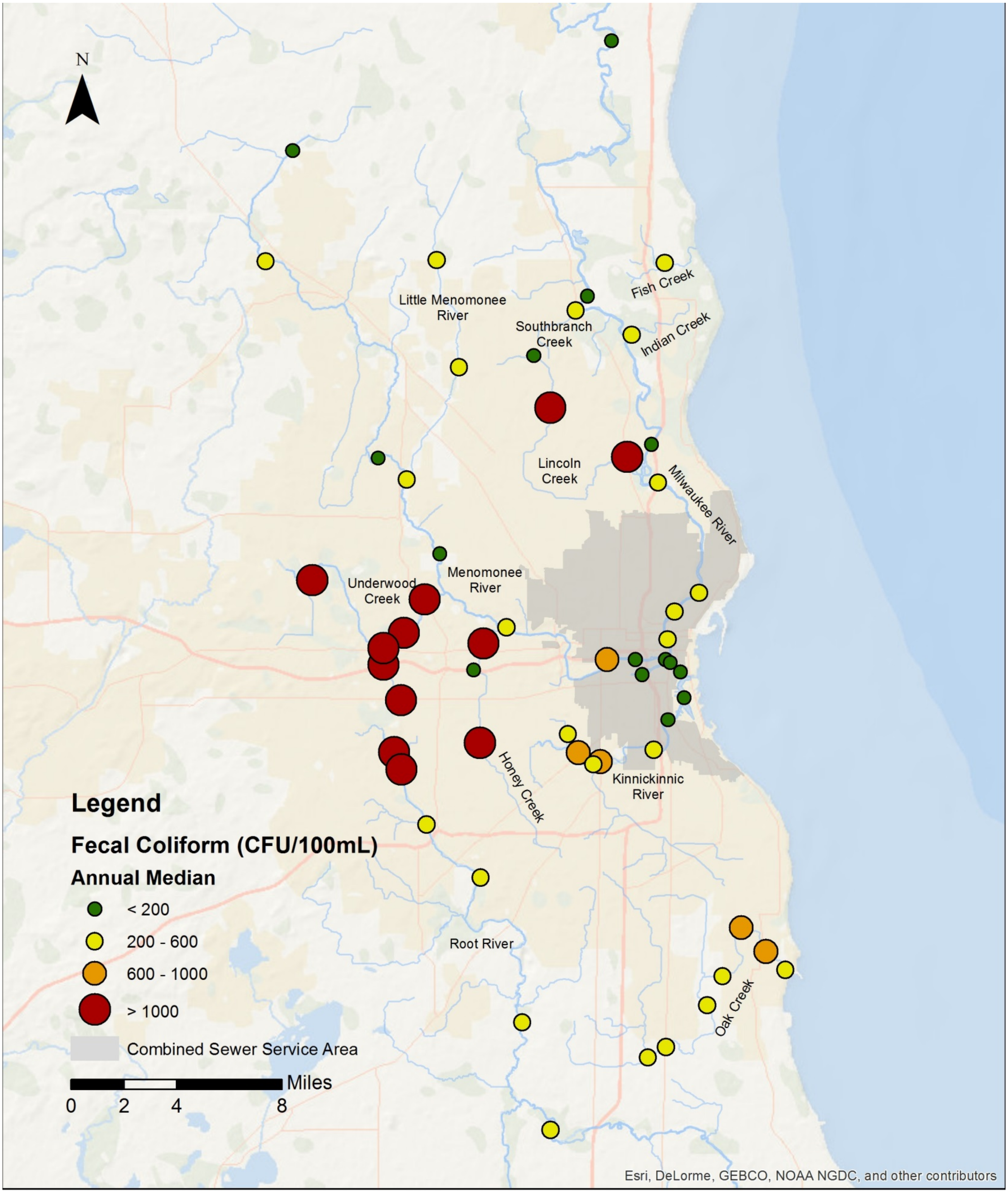


Figure 2: Annual median fecal coliform values (2014).

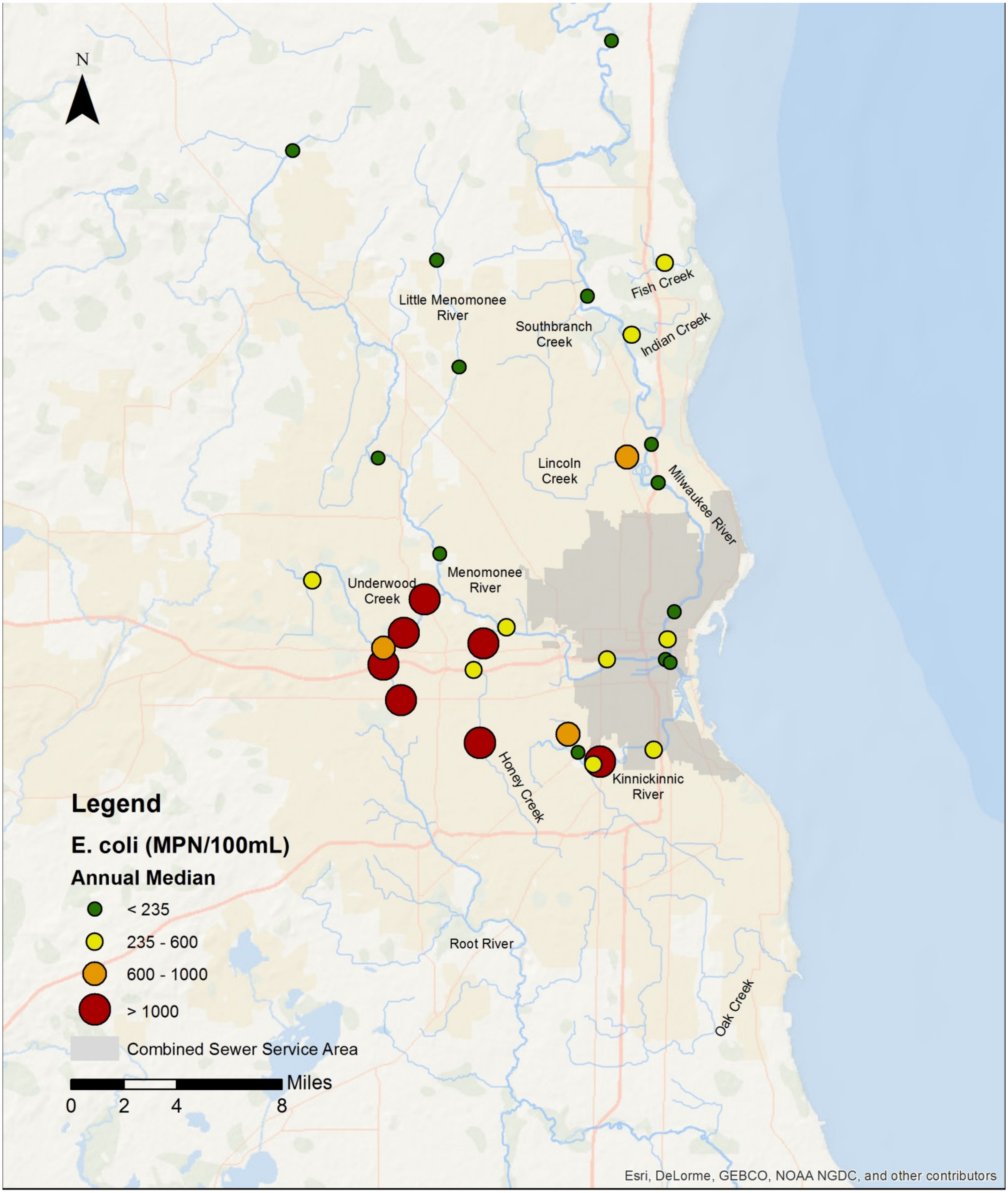


Figure 3: Annual median *E. coli* values (2014).

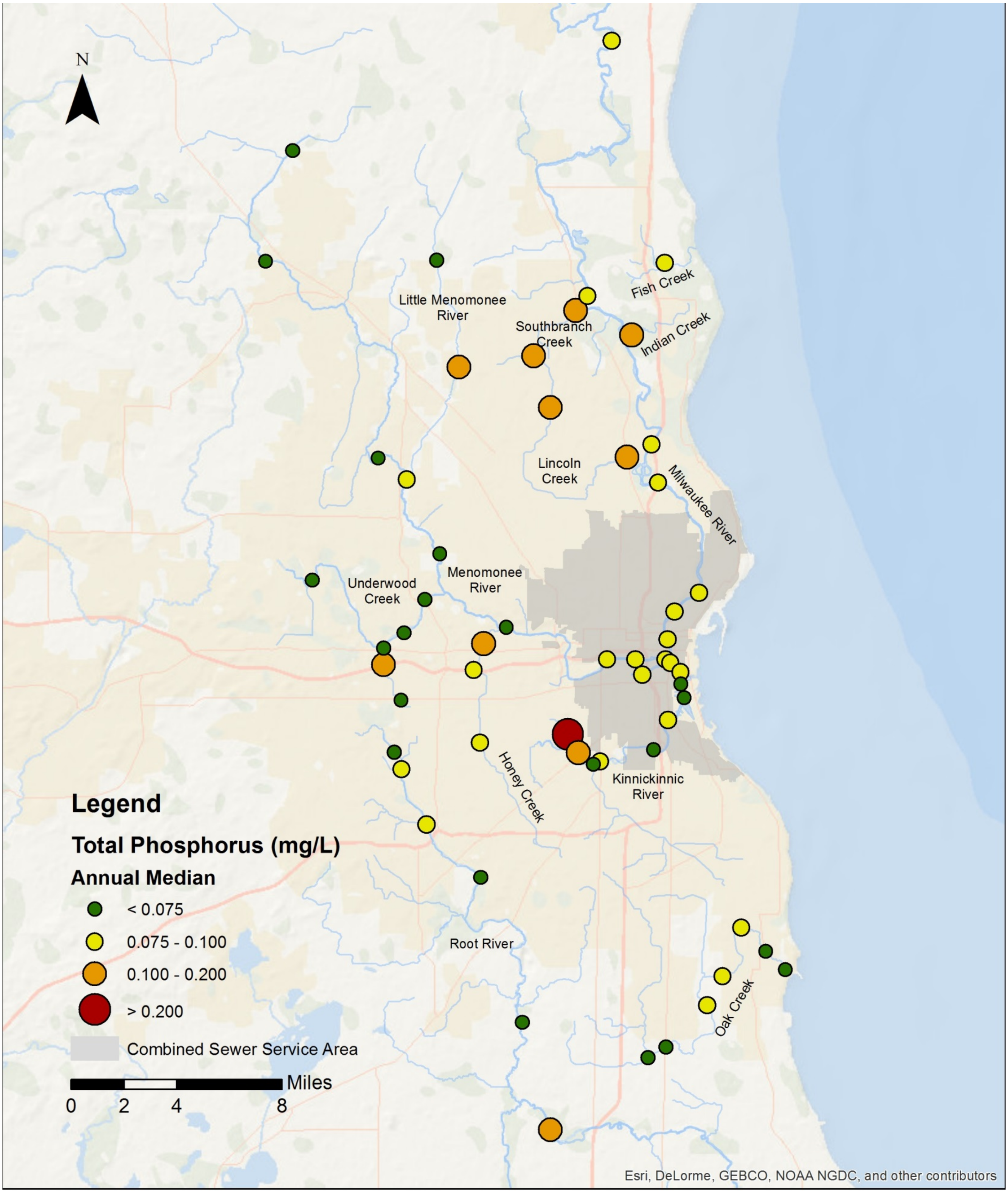


Figure 4: Annual median total phosphorus values (2014).

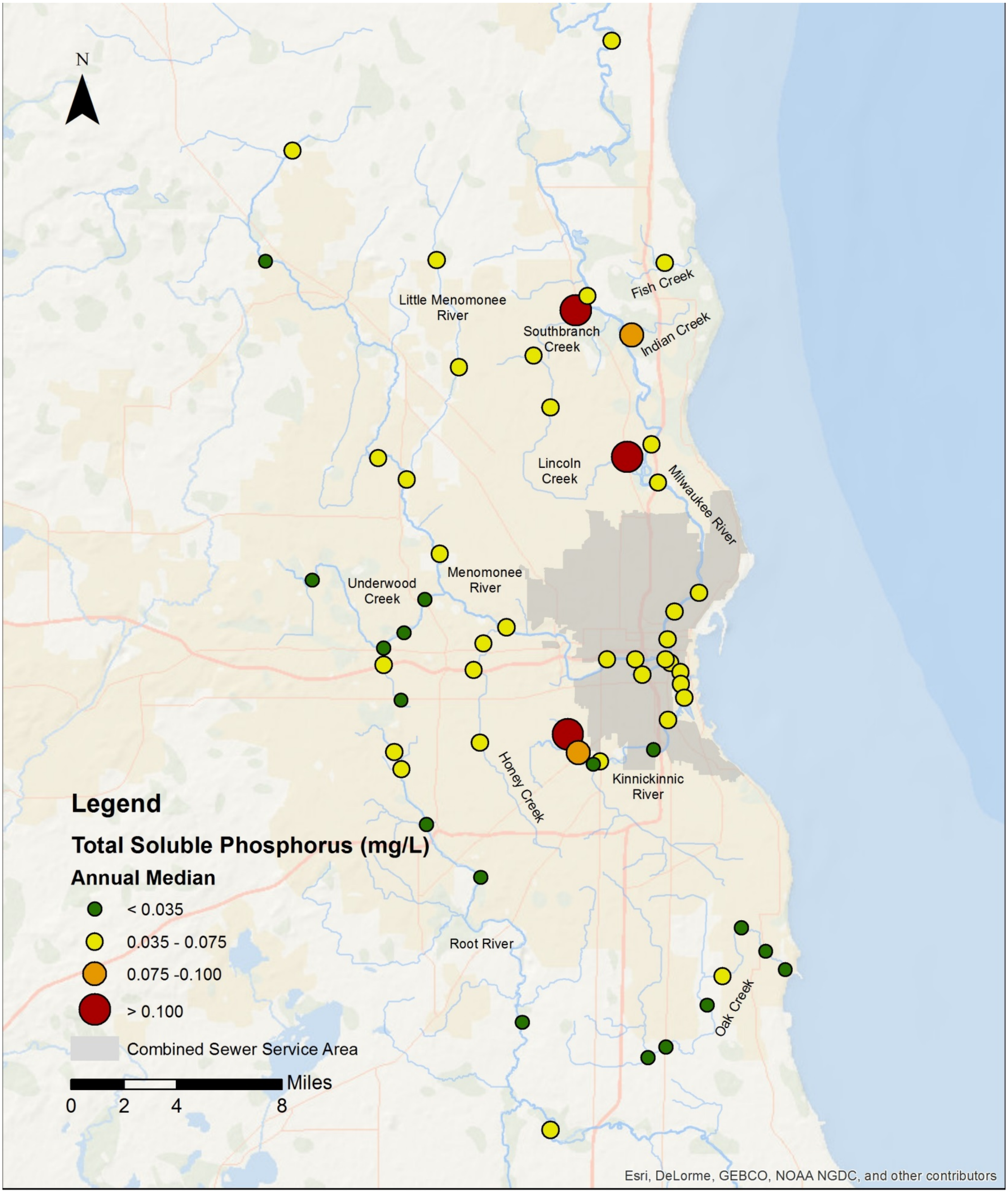


Figure 5: Annual median total soluble phosphorus values (2014).

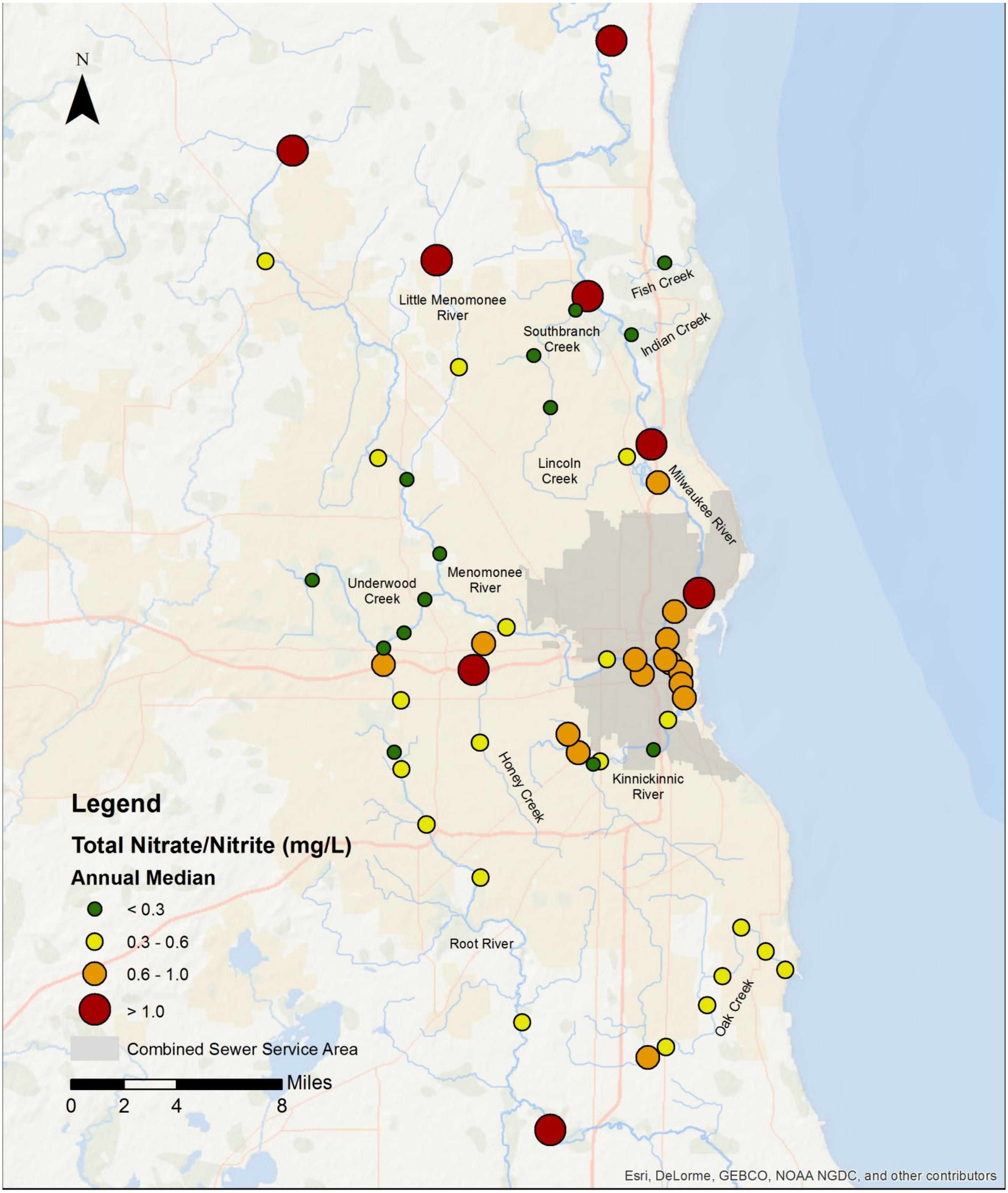


Figure 6: Annual median total nitrate/nitrite values (2014).

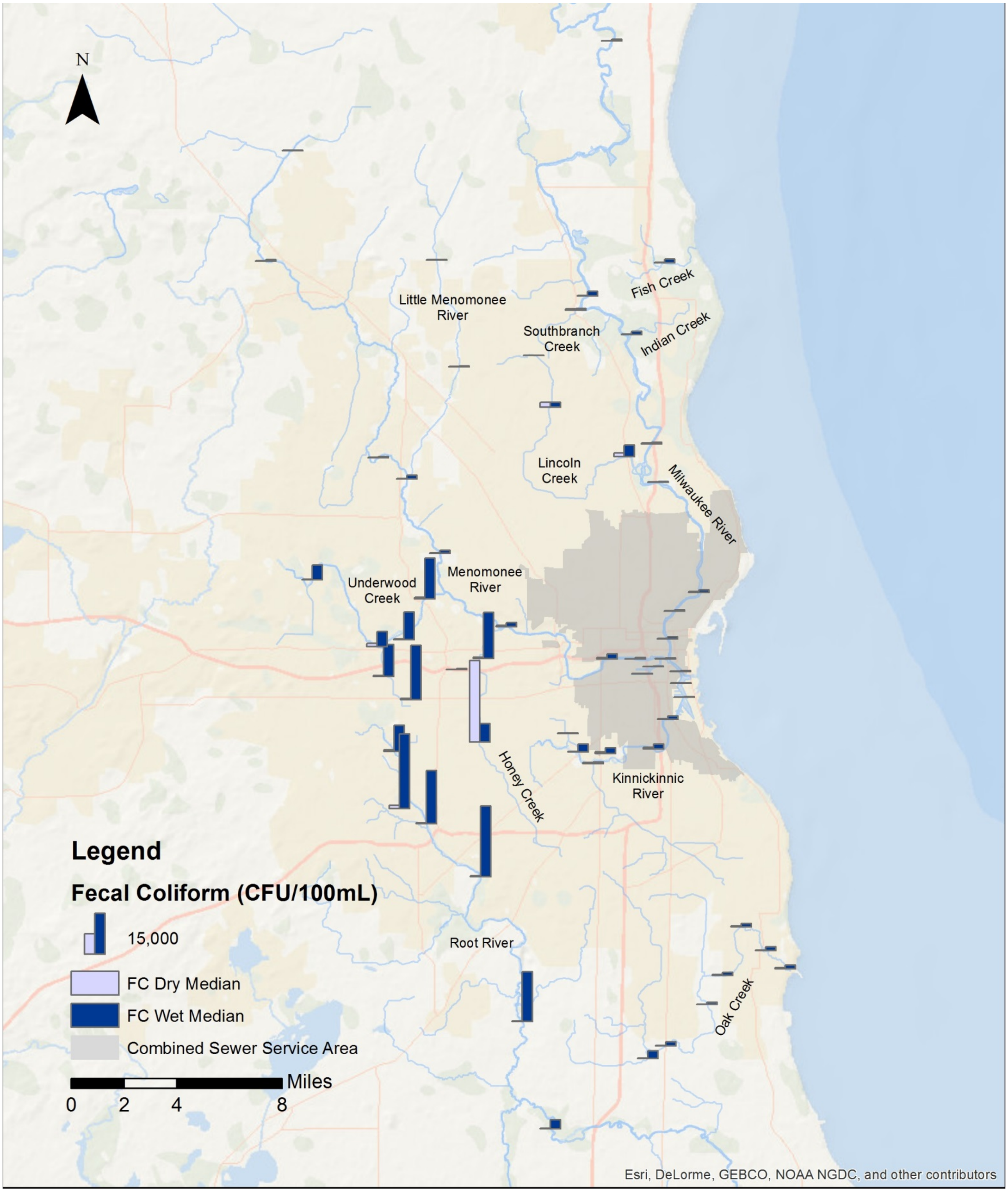


Figure 7: Median fecal coliform values for wet vs. dry surveys (2014).

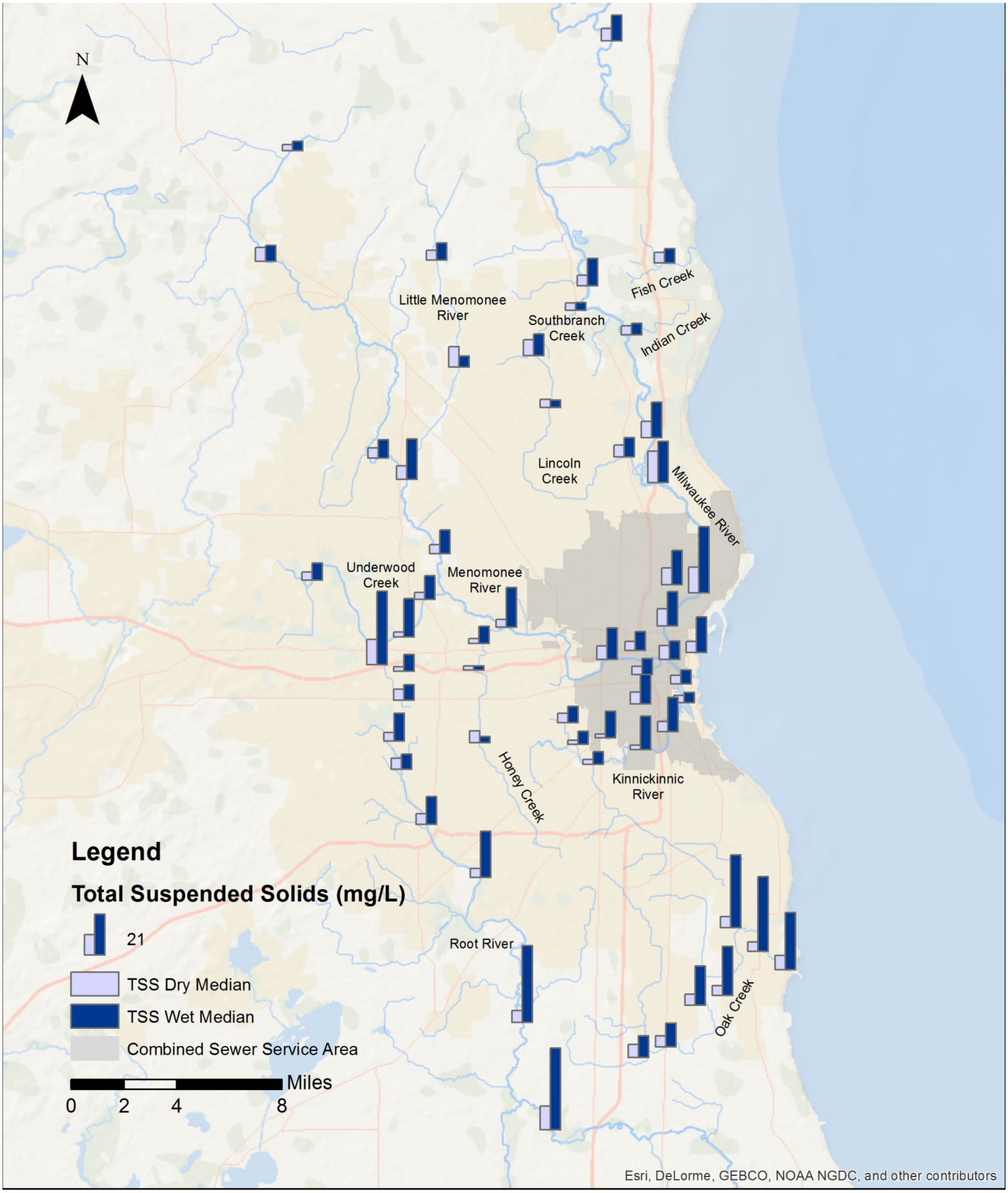


Figure 8: Median total suspended solids concentrations for wet vs. dry surveys (2014).

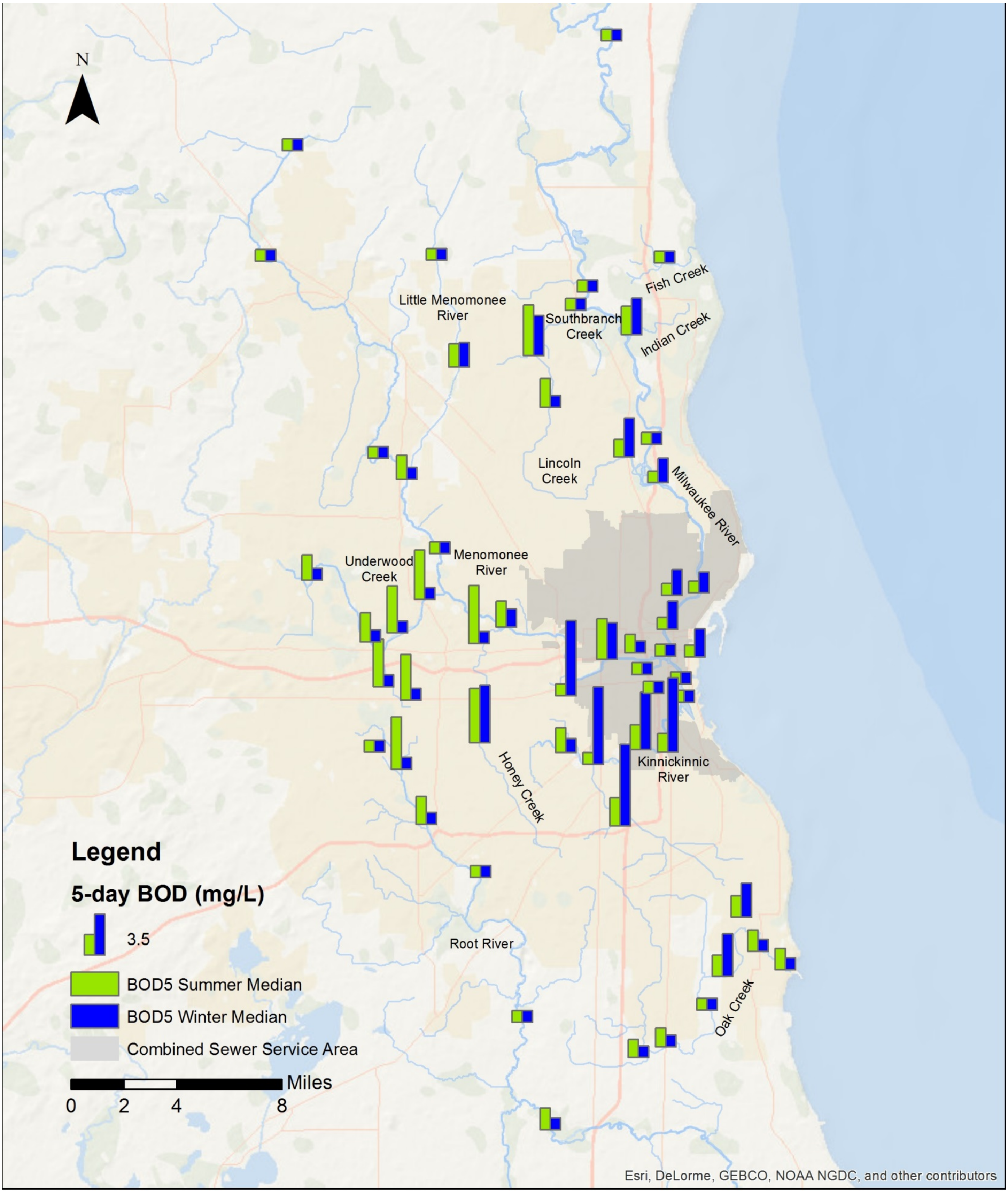


Figure 9: Median 5-day biochemical oxygen demand concentrations for summer vs. winter (2014).

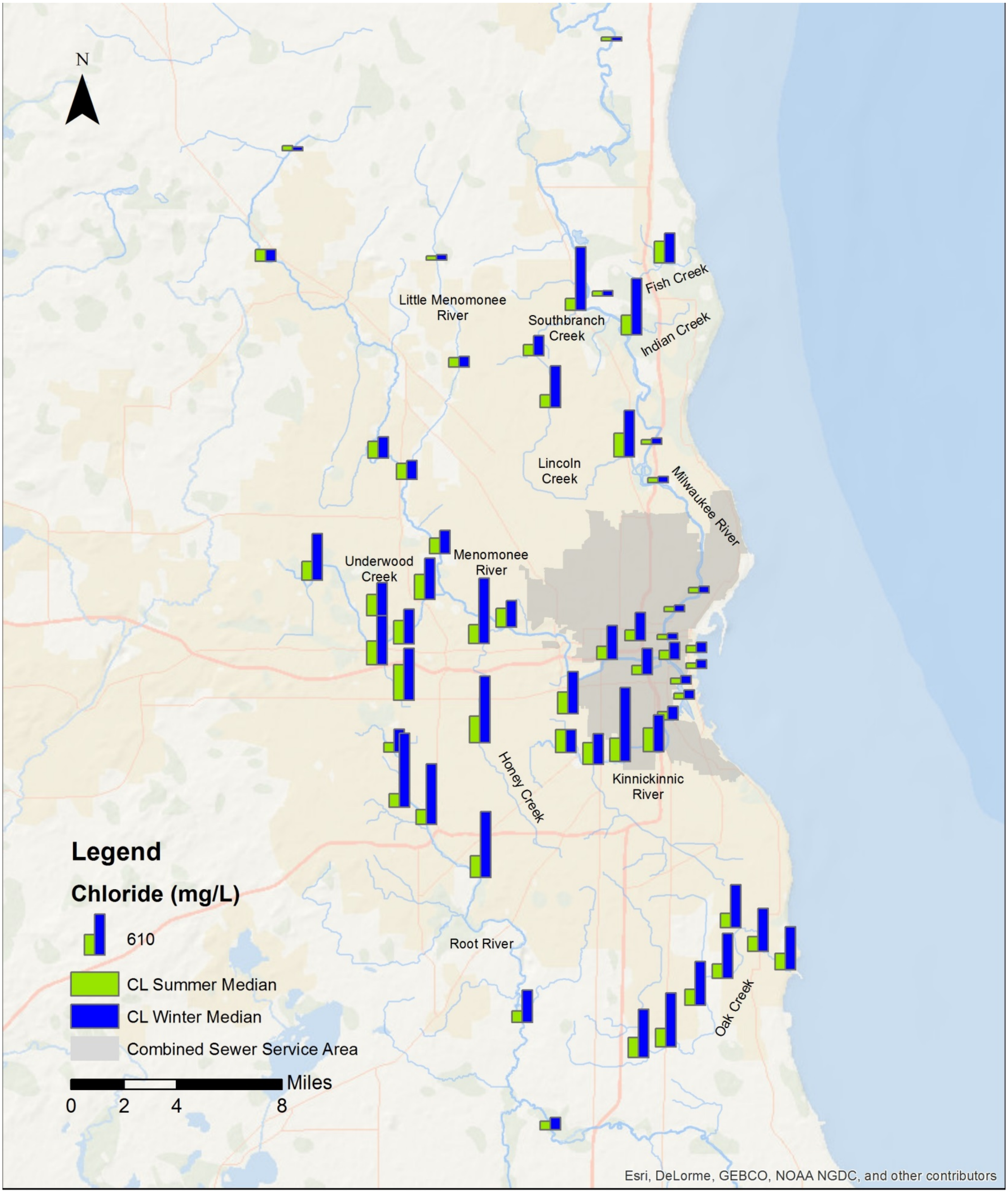
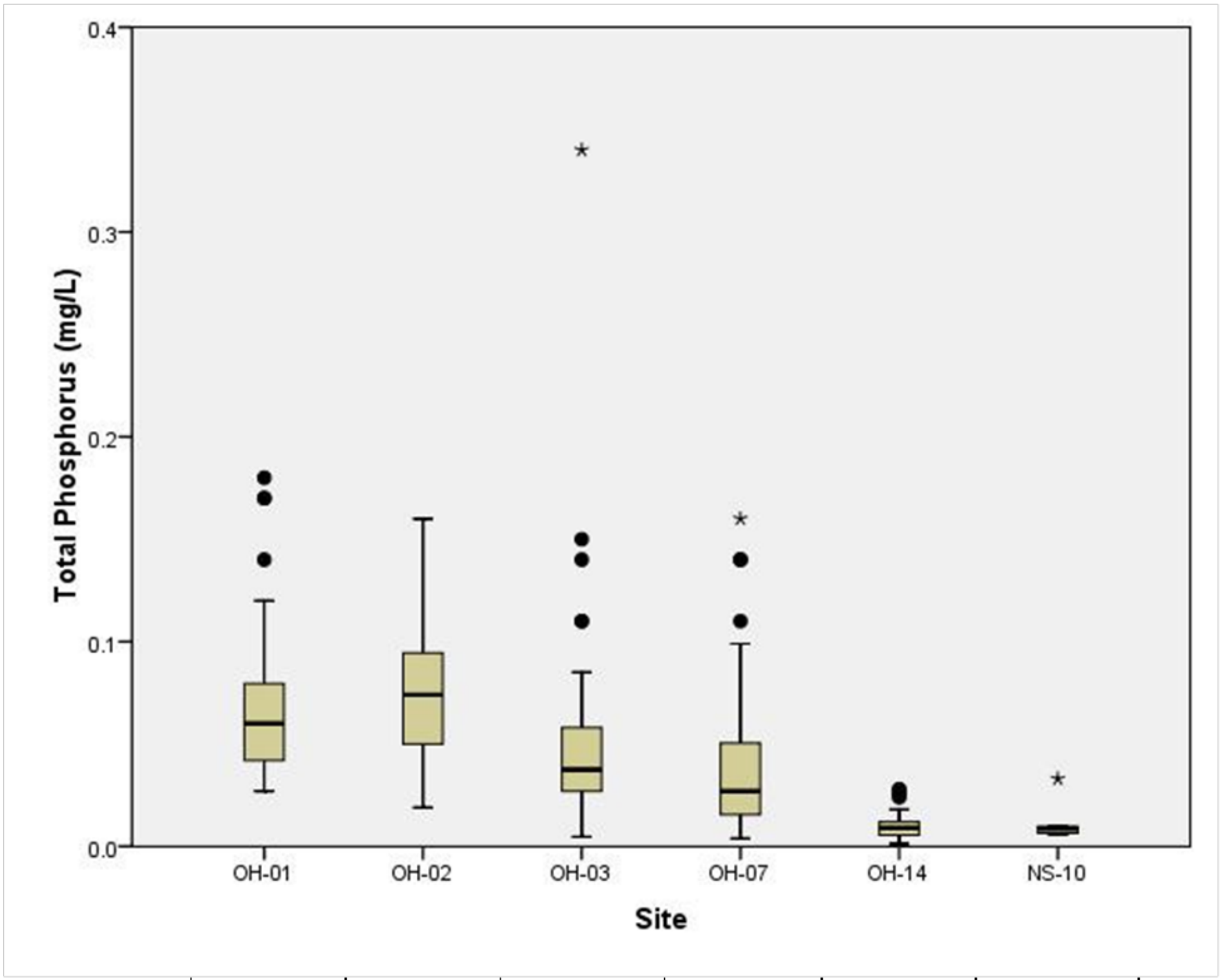


Figure 10: Median chloride concentrations for summer vs. winter (2014).

have shown that chlorides become trapped in the shallow groundwater system and are discharged to the stream year round[2]; the District's summer chloride median values substantiate this conclusion. Elevated chloride levels are seen year round, with 25 of 57 sites having at least one exceedance of the chloride criterion during the summer months.

Lake Michigan

Two parameters, total phosphorus and fecal coliform, were analyzed for select Lake Michigan sampling sites (Figures 11 – 14). Annual medians were calculated for select Outer Harbor, Nearshore and South Shore sites and plotted from west to east (shoreline to open-lake) with the addition of the Jones Island WRF (OH-02) and South Shore WRF (SS-01) outfalls.

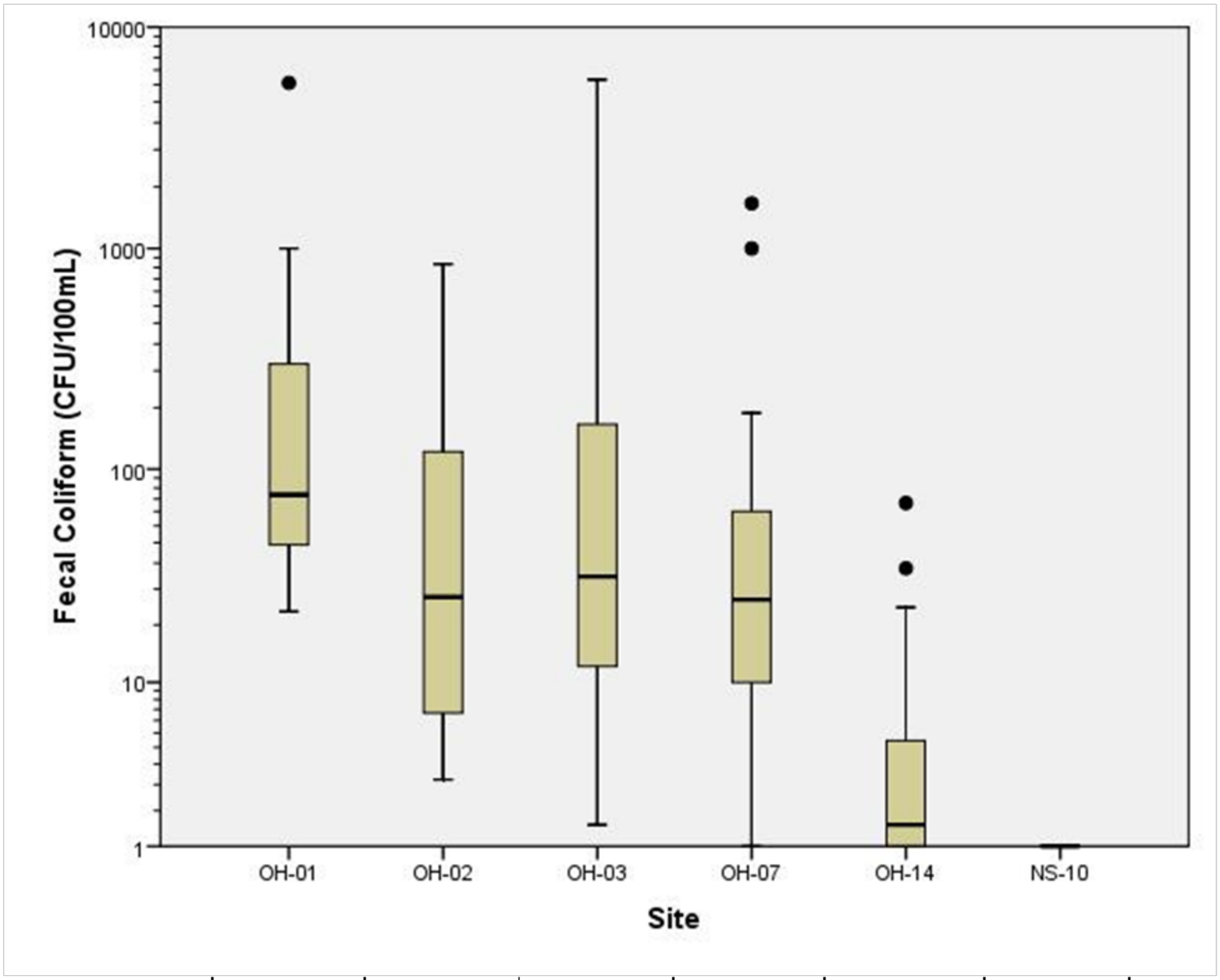


Medians	OH-01	OH-02	OH-03	OH-07	OH-14	NS-10
2014	0.06	0.074	0.0375	0.027	0.009	0.00855
2009-2013	0.054	0.062	0.034	0.019	0.0082	0.0085
2004-2013	0.055	0.066	0.039	0.021	0.0085	0.009

Figure 11: 2014 boxplots for total phosphorus concentrations for select harbor and open-lake sites. One, five and 10-year medians are shown below each site.

Figure 11 shows total phosphorus concentrations decreasing as the sites move farther away from shore. Results from within the harbor breakwater (OH- 01, -02, -03, and -07) are well below the water quality standard of 0.1 mg/L and are generally reflective of the influence of the Milwaukee River, while two sites outside of the breakwater, OH-14 and NS-10, are just slightly higher than the standard of 0.007 mg/L. No significant difference is observed between the Milwaukee River mouth (OH-01) and the Jones Island WRF outfall (OH-02). The annual median values are close in range to the longer-term medians.

Similarly, fecal coliform bacterial levels decrease moving away from the mouth of the river. Once outside of the breakwater, fecal coliform drops down below the MDL of 2 CFU/100 mL. Values from OH-02 are within the same range as other sites within the breakwater. The one-year medians are slightly higher at some sites compared to historic values, although the differences are not large (Figure 12).

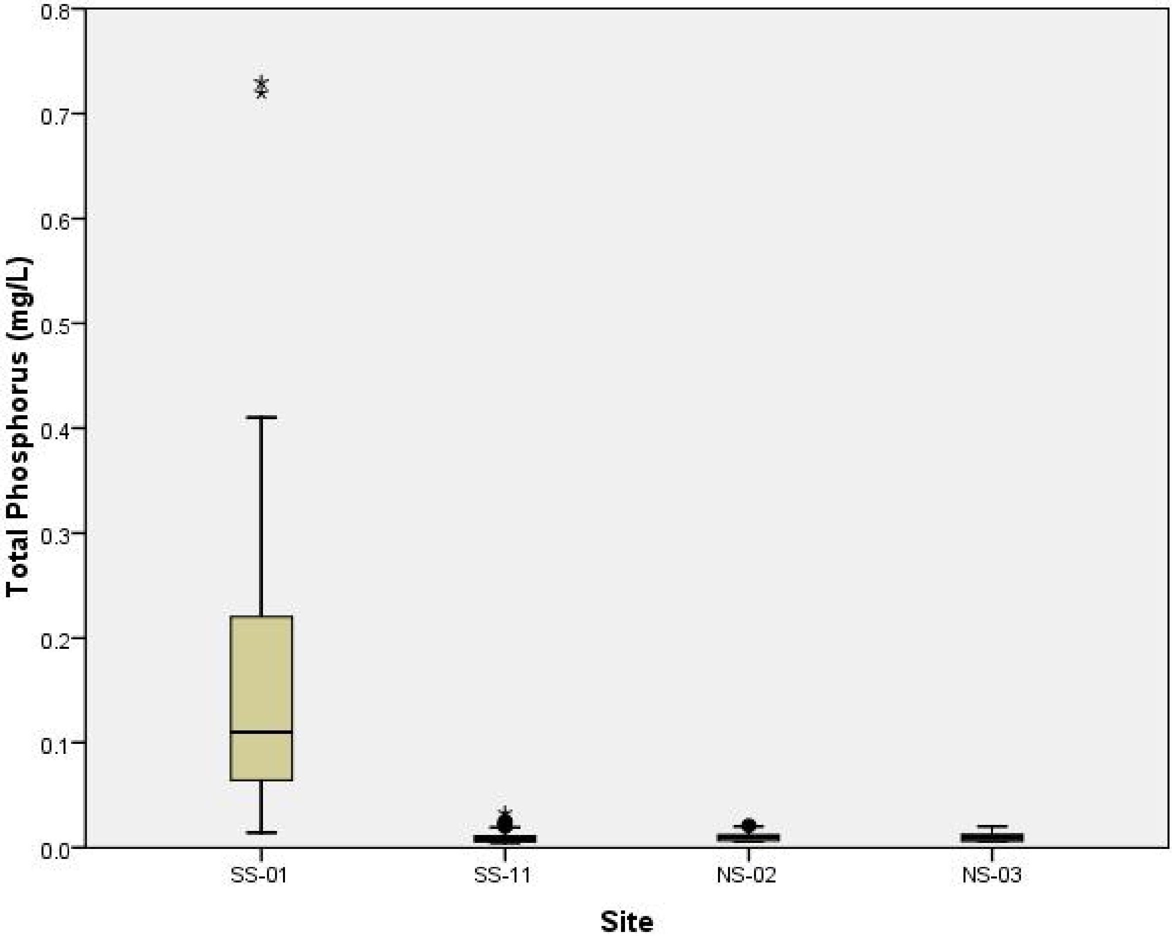


Medians	2014	76.5	26	32	25	1.5	1
	2009-2013	70	31	19	18	1.5	1
	2004-2013	59	28	24	18	1.5	1

Figure 12: 2014 boxplots for fecal coliform for select harbor and open-lake sites. One, five and 10-year medians are shown below each site.

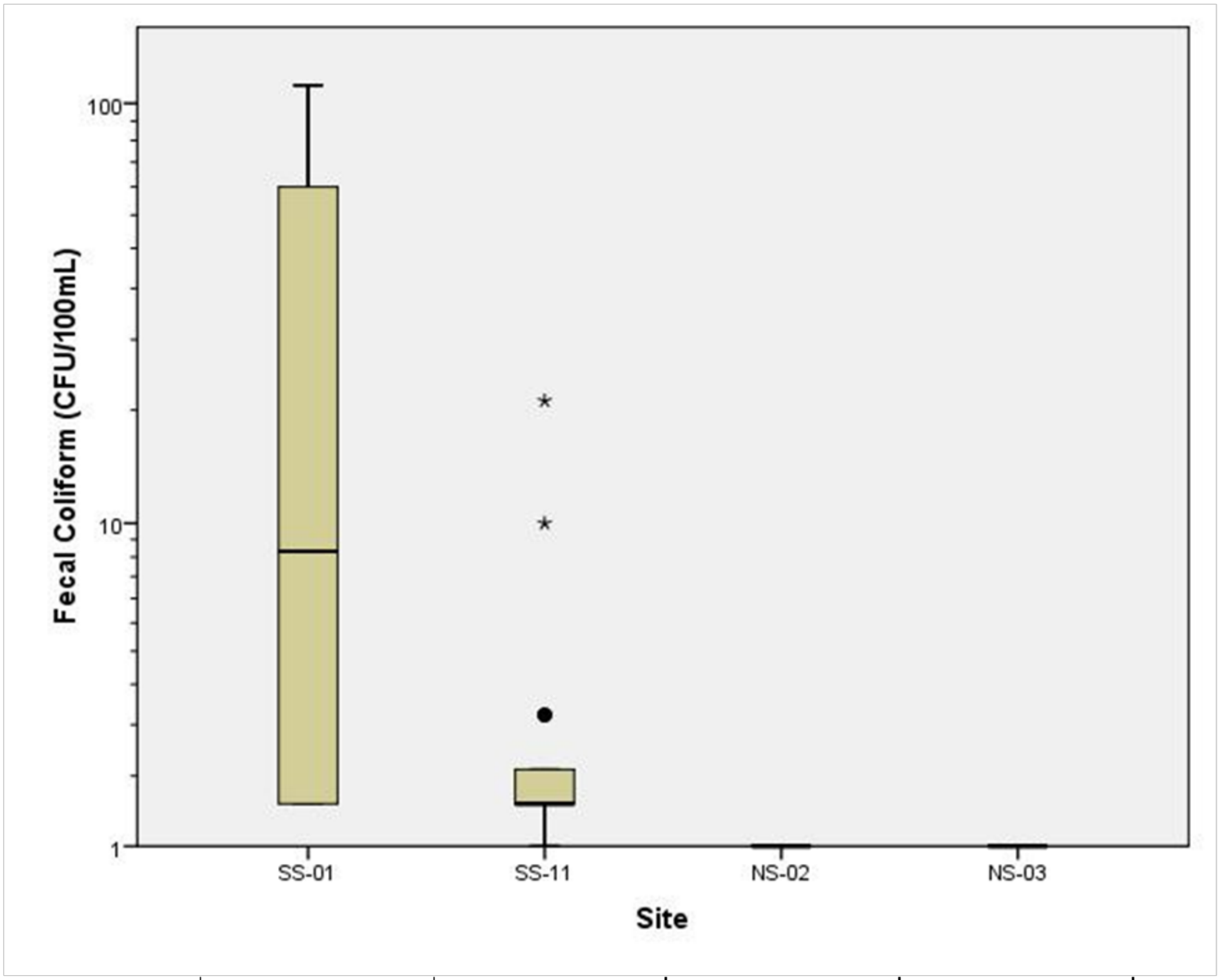
Without the constraints of a breakwater, the total phosphorus standard of .007 mg/L applies to all the South shore sampling sites. The sites are also plotted in a west to east direction (shoreline towards open-lake). With the exception of the outfall (SS-01), total phosphorus values are very low and are nearly meeting the standard (Figure 13). No obvious historic trends can be observed.

Fecal coliforms are nearly non-detectable in the water surrounding the South Shore WRF (Figure 14). Median values at the outfall are very low and the sites further away from shore are all below the MDL. Fecal coliform values have remained relatively unchanged over time.



Medians	SS-01	SS-11	NS-02	NS-03
2014	0.11	0.00765	0.0097	0.0094
2009-2013	0.0775	0.0068	0.0085	0.0061
2004-2013	0.1	0.0085	0.0085	0.0085

Figure 13: 2014 boxplots for total phosphorus concentrations for select open-lake sites. One, five and 10-year medians are shown below each site.



Medians	SS-01	SS-11	NS-02	NS-03
2014	8.5	1.5	1	1
2009-2013	7	1.5	1	1
2004-2013	7	1.5	1	1

Figure 14: 2014 boxplots for fecal coliform for select open-lake sites. One, five and 10-year medians are shown below each site.

Conclusion

This report is designed to summarize over 67,000 data points that were collected by the Freshwater Resources Monitoring Department in 2014. Some variables of interest were highlighted in this report, but additional data or analysis can be provided upon request.

The data generated by the District's surface water quality monitoring program have been utilized extensively in-house as well as by other agencies, organizations, and individual citizens. The District's extensive database has allowed other public agencies to make informed, defensible decisions regarding Milwaukee's valuable surface water resources. Examples of uses of this data include the MMSD 2020 Facilities Plan (developed by multi-agency and citizen stakeholder committees) and the Regional Water Quality Management Plan (required under the Clean Water Act). This type of long-term, comprehensive information has provided a valuable service to the community by eliminating the need for smaller, more expensive piecemeal projects that would be required each time a specific need for information arises.

Through water quality monitoring, the District has been able to document beneficial changes to the local aquatic environment. Continued tracking of water quality, along with stream restoration activities, will help ensure a healthy aquatic environment and will help retain the beneficial uses of Lake Michigan and Milwaukee-area waterways for the public.

The District's comprehensive surface water quality monitoring program reflects the District's commitment to the improvement and preservation of the community's surface water resources and it should be continued for use in future water resource decisions for the Milwaukee metropolitan area.

References

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