

Planning Report No. 57

A CHLORIDE IMPACT STUDY FOR SOUTHEASTERN WISCONSIN

Chapter 2

DESCRIPTION OF THE STUDY AREA

This Chapter utilizes information and data from a series of Technical Reports developed by the Southeastern Wisconsin Regional Planning Commission (Commission or SEWRPC) for the Chloride Impact Study (Study). These reports include SEWRPC Technical Report No. 62, *Impacts of Chloride on the Natural and Built Environment*, April 2024 (TR-62); SEWRPC Technical Report No. 63, *Chloride Conditions and Trends in Southeastern Wisconsin, Month* 2026 (TR-63); and SEWRPC Technical Report No. 65, *Mass Balance Analysis for Chloride in Southeastern Wisconsin*, December 2025 (TR-65). Refer to these reports for additional details.

2.1 INTRODUCTION

Chloride salts are highly soluble in water and are present in some concentration in all surface waters. Natural chloride concentrations in surface water reflect the composition of the underlying bedrock and soils, as well as deposition from precipitation. In southeastern Wisconsin, surface water and groundwater typically have very low natural chloride concentrations due to the prevalence of dolomite bedrock that contains little chloride. While chloride can enter the environment through various pathways, in the study area for the Chloride Impact Study, most of the chloride can be traced back to human sources.¹ This Chapter summarizes the setting and characteristics of the study area that could influence chloride levels in the environment.

¹ Sources and pathways of chloride to surface water and groundwater in the Region are discussed in detail in TR-62, TR-63, and TR-65.

2.2 STUDY AREA CHARACTERISTICS

The Chloride Impact Study examined how chloride affects nearly 3,000 square miles, across 11 counties and 177 municipalities in Southeastern Wisconsin (see [Map 2.1](#)). The area is home to over 2 million people, 3,900 miles of streams, and 5,500 waterbodies.

Water Resources

Because water does not stop at municipal boundaries or county lines, this Study examined water quality through the 12 major watersheds within the study area including the Des Plaines River, Fox River, Kinnickinnic River, Menomonee River, Milwaukee River, Oak Creek, Pike River, Rock River, Root River, Sauk Creek, and Sheboygan River watersheds, as well as land draining directly to Lake Michigan. By focusing on watersheds – the natural drainage basins for lakes and streams – we can better understand how human activity in one community impacts the water quality of its neighbors.

Surface water resources consisting of rivers, streams, lakes, ponds, and wetlands form a critical element of the natural resource base of the Southeastern Wisconsin Region (Region). In addition, groundwater resources are closely interrelated with the surface water resources because they sustain lake levels and provide baseflow for streams. Equally important, the residents and businesses in the Region rely on both Lake Michigan water and groundwater resources to provide a reliable source of domestic, municipal, and industrial water supply. Combined, these water resources are the backbone of the local economy, recreation, and public health. For these reasons, the impacts of chloride affect all local communities and residents within the study area to some extent.

The surface water drainage networks of streams, rivers, and lakes in the study area are shown on [Map 2.1](#). The study area streams are divided almost equally between perennial streams with year-round flows and intermittent channels that only flow during wet seasons or after heavy rainfall. These streams are primarily fed by surface runoff and groundwater discharge, with groundwater providing the essential baseflow that keeps perennial streams flowing during dry periods. Most of the study area waterways are small with first- and second-order headwater tributaries making up nearly 75 percent of the total stream length within the study area. Smaller headwater streams are often the most affected by chloride pollution because they have less water to dilute the chloride, meaning even a small amount of salt can quickly reach high, harmful concentrations. As these smaller streams merge, they form larger and deeper river systems, reaching up to fifth-order reaches in the Milwaukee River and Root River, and sixth-order reaches in the Fox River.

The study area also features many diverse lakes, including 379 waterbodies larger than two acres in surface area, with the highest density of lakes located in Waukesha, Washington, and Walworth Counties. While there are several large and deep lakes in the study area (up to 5,400 acres and 135 feet deep in Geneva Lake), the median lake size is relatively small and shallow, with a surface area of 16 acres and a maximum depth of 14 feet. Lakes are categorized by the Wisconsin Department of Natural Resources (WDNR) into four hydrological types within the study area – seepage, spring, drainage, and drained – and 10 “natural community” types based on how water flows through them and the aquatic life they support. A critical concept for understanding chloride impacts on lakes is residence time, which is the average time water spends in a lake. While lakes with short residence times are sensitive to sudden spikes in pollution, some lakes with longer residence times can allow chloride to accumulate over many years, requiring long-term management to protect their water quality.

Population and Land Use

Chloride pollution can usually be traced back to human activities that introduce it into the environment. Tracking population density and how we use the land can help to explain where chloride is impacting water resources and to what extent. Based on the 2010 U.S. Census, population density for the watersheds in the study area ranged from about 100 people per square mile to more than 6,200 people per square mile.

Historical Development

In the early 1950s, only 5 percent of the Region was developed for urban uses. Urban land use has increased from about 16 percent of the Region in 1963 to almost 32 percent by 2020. Each of the major watersheds in the study area experienced some degree of urban development during this time period (see [Figure 2.1](#) and [Map 2.2](#)).² The western portions of the Oak Creek watershed, portions of the northern Fox River watershed, northern Pike River watershed, southeastern Des Plaines River watershed, northeastern Rock River watershed, northern Menomonee River watershed, and central direct drainage area to Lake Michigan have seen the greatest increases in urban land use, as represented by red, orange, and dark yellow colors on [Map 2.2](#).

The results of the analysis presented in TR-65 indicated that the largest source of chloride to the environment is due to winter road and parking lot deicing. The increase in the urban land uses and density

² Comparison of land use trends from 1950 through 2020 is only possible for the portions of the study area that are within the seven-county Southeastern Wisconsin Region where historical land use inventories are available, including Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties.

of roads and parking lots in the Region has likely played a significant role in increasing concentrations of chloride in surface waters and groundwater. Similar to the trends in urban development, each watershed in the Region has experienced increasing trends in road and parking lot density from 1963 to 2020 (see [Figure 2.2](#) and [Map 2.3](#)). Areas that have seen the largest increases in road and parking lot density include much of the Menomonee River watershed, the Oak Creek watershed, the southern Kinnickinnic River watershed, the northern Fox River watershed, the northern and southcentral Root River watershed, and the northern Pike River watershed, as represented by dark orange, red, and brown colors on [Map 2.3](#).

Existing Land Use

While historical land use inventories were only available for the seven-county Southeastern Wisconsin Region, as part of this Study, a uniform land use inventory representing existing conditions was assembled for the entire study area, including out-of-Region areas (see [Map 2.4](#)). The percentage of each land use group within the 12 major watersheds in the study area is provided in [Table 2.1](#).

While over 70 percent of the study area has existing land uses considered to be non-urban, large areas of highly urbanized development with a high density of roads and parking lots are evident in the central and eastern portion of the study area. The areas with the highest percentage of existing urban land uses were observed in the Kinnickinnic River watershed, Menomonee River watershed, southern Milwaukee River watershed, Oak Creek watershed, northern Root River watershed, the northeastern portion of the Fox River watershed, and portions of the direct drainage area to Lake Michigan, as represented in red, orange, and yellow on [Map 2.5](#). Predictably, most portions of the study area that exhibit the highest percentage of urban land uses also contain the highest road and parking lot densities, as represented by the dark orange and brown areas on [Map 2.6](#). The Kinnickinnic River (30 percent), the Menomonee River (21 percent), and Oak Creek (20 percent) watersheds have the highest percentage of land dedicated specifically to roads and parking lots. Conversely, the areas shown in darker green on [Map 2.5](#), and in white, tan, and yellow on [Map 2.6](#), indicate areas with low levels of urban lands and roads and parking lots. These areas consist mostly of agricultural, wetland, or woodland uses.

Wastewater

Chlorides can enter wastewater through a variety of human activities including industrial waste, food processing, winter deicing (via infiltration and inflow to sanitary sewers), and residential water softening, as described in TR-62, TR-63, and TR-65. The majority of this wastewater arrives at one of the 48 active wastewater treatment plants (WWTPs) in the study area. [Map 2.7](#) shows the locations of active WWTPs, along with colored areas representing the planned public sanitary sewer service areas (SSSA) from which

each facility receives wastewater, as well as the locations of 28 WWTPs that have been abandoned.³ The study area WWTPs are not designed to remove chloride ions from wastewater, thus, any chloride that arrives in wastewater to these facilities will remain in the water even after treatment. Effluent from a WWTP is typically discharged into a nearby local waterway or more rarely to infiltration ponds that allow the effluent to infiltrate into soil and eventually reach groundwater.

In 2020, approximately 35 percent of the study area was located within a planned public SSSA, however there were clusters of urban development scattered across the study area that rely on private onsite systems like septic tanks or mound systems.⁴ Because these private systems also do not remove chlorides, they allow chloride salts to infiltrate into the soil and surrounding water resources.

Stormwater Management

Municipal Separate Storm Sewer System (MS4) permits are mandatory for municipalities within qualified urbanized areas and require communities to implement management strategies to reduce pollutants entering waterways. MS4 permits address stormwater related issues including construction site controls, illicit discharge screenings, and good housekeeping practices such as winter road management programs and regular facility inspections. Permitted entities must submit annual reports and maintain detailed inventories that track road salt usage, map storm sewer outfalls, and document structural stormwater facilities like detention basins.

Across the study area, 95 municipalities, eight counties, and several large-scale institutions are required to have MS4 permits.⁵ Because storm sewer systems collect and convey stormwater directly to receiving waters, they serve as a primary pathway for large quantities of chloride to enter local waterways. Analyzing how these systems collect and convey urban runoff is essential for identifying chloride trends and implementing effective management strategies to protect the long-term health of the Region's water resources.

³ Table 2.2 from TR-63 provides additional information about these public WWTPs, including the major watershed where the facility is located, the SSSAs from which each facility currently (or formerly) receives wastewater, the estimated population served, the annual average design flow for the facility, the facility status and year abandoned, and the water body that receives treated effluent from the facility.

⁴ Areas of urban development outside of public SSSAs accounted for roughly 6 percent of the Region in 2010. Locations of these areas are shown on Map 2.11 in TR-63.

⁵ Locations of MS4 permitted communities and other entities are shown on Map 2.12 in TR-63.

Water Supply

The geological composition of many groundwater aquifers in southeastern Wisconsin yield naturally “hard” water containing high levels of calcium and magnesium. Hard water is often treated at homes and businesses using water softeners that are recharged by chloride salts. Once the softening process is complete, the chloride-heavy brine is flushed into WWTPs or private onsite septic systems. As described earlier, neither of these systems are designed to remove chloride ions, meaning the chloride remains dissolved in the water and is eventually discharged into local streams or filtered through the soil into shallow groundwater.

The impact of these softening practices on surface water and groundwater quality depends heavily on the hardness of the source of water supply for a community. Lake Michigan water is not nearly as hard as the groundwater in the Region and it generally does not require the use of salt-based softeners. Consequently, chloride contributions from water softening are most significant and common in areas that rely primarily on groundwater supplies.⁶ **Map 2.8** shows locations of areas served by municipal utilities providing groundwater (dark blue) and utilities providing Lake Michigan water (light blue) as of 2005. The map also indicates areas of urban development that are not served by municipal water supply systems and therefore likely rely on groundwater from private wells (see tan areas on **Map 2.8**).

Areas Vulnerable to Groundwater Contamination

Groundwater is highly susceptible to chloride contamination from surface sources such as road salt runoff, agricultural fertilizers, and private septic systems, among others. Shallow aquifers are at the greatest risk because their proximity to the surface provides less soil depth to naturally dilute chlorides before they reach the water table. This is a significant concern for the Region, as approximately 34 percent of the study area has groundwater located within just 25 feet of the surface, creating a moderate to high potential for contamination.⁷

Critical areas with high groundwater recharge potential, which are vital for replenishing the groundwater aquifers of the Region and sustaining the water levels of lakes and streams, can also act as direct conduits for pollutants, such as chloride in runoff, to enter the groundwater. The highest concentrations of these

⁶ Location of areas served by municipal utilities providing groundwater as of 2005 are shown on Map 2.13 of TR-63. The map also indicates areas of urban development that are not served by municipal water supply systems and therefore likely rely on groundwater from private wells.

⁷ Map 2.14 in TR-63 provides estimated depth to groundwater for the study area.

high recharge areas are found in the upper Milwaukee River, central Rock River, and western and central Fox River watersheds; however, there are smaller pockets found in all watersheds in the study area.⁸ Because many of these vulnerable areas are located directly adjacent to rivers and lakes, managing chloride usage and winter deicing applications near these recharge areas is essential to protecting both surface waters and groundwater in the study area.

Summary of Watershed Characteristics

The following subsections provide summaries and key characteristics of the major watersheds in the study area. Refer to **Table 2.1** for the total size and land use summaries for each watershed. More detailed summaries of these watersheds, including watershed specific maps, can be found in TR-63.

Des Plaines River Watershed

Predominantly rural (81 percent), this watershed consists mainly of agricultural land (55 percent). Urban influence is concentrated along the high-traffic Interstate Highway (IH) 94 corridor and near the City of Kenosha, which has seen significant recent growth. The watershed has a population of approximately 31,500, with 78 percent of residents served by a public sanitary sewer system.⁹ There are two active WWTPs that discharge treated wastewater to surface waters in the watershed.

Fox River Watershed

The Fox River watershed, the largest watershed in the study area, is mostly rural (74 percent). However, the northern portion of the watershed is fairly urban and contains pockets of highly urbanized areas, particularly within the Cities of Waukesha and Brookfield, as well as along the IH 43 and IH 94 corridors. The watershed is home to approximately 365,000 people, 73 percent of whom are served by a public sanitary sewer system. There are 15 active WWTPs that discharge treated wastewater within its boundaries.

Kinnickinnic River Watershed

Located in one of the most densely developed areas in the State, the Kinnickinnic River watershed is 97 percent urban and home to approximately 157,000 people, all served by a public sanitary sewer system. Nearly 30 percent of the watershed is covered by roads and parking lots and another 26 percent by high-density residential land use. The watershed is also home to Milwaukee Mitchell International Airport, the State's largest and busiest aviation hub.

⁸ See Map 2.15 in TR-63 for locations of areas with high potential for groundwater recharge.

⁹ In this Study, estimates of population and population served by public sanitary sewers represent 2010 conditions.

Menomonee River Watershed

Primarily urban (70 percent), the Menomonee River watershed features a dense grid of local streets and major highway corridors of IH 41 and IH 94. These transportation networks contribute to nearly 21 percent of the land being covered by roads and parking lots. Several subwatersheds in the southern portion of the watershed are nearly 100 percent urbanized. The watershed has an estimated population of 321,000 residents, with 98 percent of residents served by public sanitary sewers.

Milwaukee River Watershed

This large watershed is mostly rural (77 percent), consisting primarily of agricultural lands (43 percent), wetlands (16 percent), and woodlands (9 percent). Urban land use is highly concentrated in the southern portion of the watershed, particularly in the Lincoln Creek and Lower Milwaukee River subwatersheds, which are 98 percent and 64 percent urban, respectively. The watershed is home to an estimated 493,000 residents, 89 percent of whom are served by a public sanitary sewer system. There are 12 active WWTPs in the watershed.

Oak Creek Watershed

The Oak Creek watershed is the fastest-urbanizing watershed in the Region, with nearly 74 percent of the land devoted to urban use. This urban development consists primarily of roads and parking lots (20 percent) and various densities of residential neighborhoods (27 percent). Significant growth has occurred across all subwatersheds – one seeing a 60 percent increase in urban land use since 1963. The area is further shaped by the busy IH 94 corridor and drainage from the southern portion of Milwaukee Mitchell International Airport. The watershed is home to approximately 56,500 people, all served by public sanitary sewers.

Pike River Watershed

The Pike River watershed maintains a relatively even split between rural (55 percent) and urban (45 percent) land uses. Agriculture remains the most prevalent land use at 40 percent, followed by roads and parking lots (11 percent) and lower-density residential areas (9 percent). Most of the urban development is located within the northern and eastern portions of the watershed. Approximately 52,000 residents live in the Pike River watershed, with 98 percent served by public sanitary sewers.

Rock River Watershed

Although a portion of the Rock River watershed covers much of the western edge of the study area, the majority of its total drainage area lies outside of the study area. The portion of the watershed within the study area is largely rural (81 percent) and consists mostly of agricultural lands (48 percent) and wetlands

(13 percent). Despite containing long stretches of IH 41, IH 94, and IH 43, the overall density of roads and parking lots is low (6 percent). The watershed has an estimated population of 155,500, with 61 percent served by public sanitary sewers. There are 10 active WWTPs within the study area portion of the watershed.

Root River Watershed

The Root River watershed is 63 percent rural, with agricultural uses covering 44 percent of the land, which dominate a large portion of the central and southern portions of the watershed. However, the northern and far southern portions of the watershed are highly urbanized, with some subwatersheds reaching more than 90 percent developed. The watershed is bisected by 11 miles of the IH 94 corridor and is home to approximately 179,000 residents, 94 percent of whom are served by public sanitary sewers. There were two active WWTPs in the watershed during the period of record analyzed for this Study.¹⁰

Sauk Creek Watershed

The Sauk Creek watershed is one of the most rural (86 percent) watersheds in the study area, primarily consisting of agricultural lands (73 percent). Urban development is concentrated in the southern portion, which includes the City of Port Washington and two miles of the IH 43 corridor, accounting for most of the watershed's road and parking lot coverage (5 percent of watershed). Approximately 9,700 residents live within the Sauk Creek watershed, with 88 percent served by public sanitary sewers.

Sheboygan River Watershed

Only a small portion of the Sheboygan River watershed falls within the study area, and this area remains 91 percent rural. Primarily consisting of agricultural lands (68 percent), this portion of the watershed features very little urban development, with only 3 percent of the area covered by roads and parking lots. The population in this portion of the study area is estimated at 1,550, with 87 percent served by sanitary sewer systems. There is one active WWTP within the watershed.

Direct Drainage Area to Lake Michigan

Consisting of a narrow coastal strip, this area features many small streams that flow directly into Lake Michigan. The area is over 63 percent urban, consisting primarily of roads and parking lots (16 percent) and residential neighborhoods of various densities (30 percent). The estimated population for this drainage area

¹⁰ In October 2023, the City of Waukesha began supplying residents with Lake Michigan water, requiring the City's WWTP to return treated effluent to the Lake Michigan basin via the Root River near W. Oakwood Road and 60th Street in the City of Franklin. This occurred after the period of record for this Study and was not considered in the analysis.

is 217,500 residents, with 99 percent served by sanitary sewer systems. There are six WWTPs that serve portions of this drainage area and discharge treated wastewater directly to Lake Michigan. Areas served by these WWTPs include the major population centers of the Cities of Port Washington, South Milwaukee, Racine, Kenosha and the Milwaukee County metropolitan area.¹¹

2.3 STUDY AREA CLIMATE CONDITIONS AND TRENDS

Climate is a primary driver of the hydrologic cycle and can have a significant effect on chloride in the environment, as discussed in TR-62 and other reports prepared for this Study. The mid-continental location of the Southeastern Wisconsin Region is far removed from the moderating effect of the oceans, giving the study area a typical continental climate. The study area climate is characterized primarily by a continuous progression of markedly different seasons and a large range in annual temperature. Low temperatures during winter are intensified by prevailing frigid northwesterly winds, while summer high temperatures are reinforced by the warm southwesterly winds common during that season.¹² The Region exhibits spatial variations in weather due primarily to its proximity to Lake Michigan, particularly during the spring, summer, and autumn seasons, when the temperature differential between the lake water and the land air masses tends to be the greatest. During these periods, the presence of the Lake tends to moderate the climate of the eastern portion of the Study Area. In winter, moisture from Lake Michigan can create a more humid atmosphere that contributes to wetter, heavier snow with higher liquid water content.

Despite the weather variability across the Region, from a climate perspective the Southeastern Wisconsin Region is considered similar enough to be entirely encompassed by one of the nine climate divisions in Wisconsin. The U.S. Climate Divisional Dataset was developed by the National Oceanic and Atmospheric Administration (NOAA) to divide the contiguous United States into regional areas that have relatively uniform climate characteristics. The boundaries of Wisconsin Climate Division 9 match the seven-county Region in Southeastern Wisconsin, and the climate data for Climate Division 9 were used to characterize the climatological conditions in the Region as presented in the following paragraphs.

¹¹ *In addition to communities in Milwaukee County, the Milwaukee Metropolitan Sewerage District's (MMSD) Jones Island and South Shore facilities serve portions of Germantown, Mequon, Theinville, Menomonee Falls, Butler, Brookfield, Elm Grove, New Berlin, Muskego, and Caledonia.*

¹² *In meteorology and climatology, the seasons are defined based on the calendar with three-month durations as follows: Winter spans from December through February, Spring runs from March through May, Summer extends from June through August, and Autumn covers the period from September through November.*

Climate Data

NOAA's National Centers for Environmental Information (NCEI, formerly the National Climatic Data Center or NCDC) maintains one of the most comprehensive climate data archives in the world. The NCEI climate datasets provide the underlying data source for most of the information presented in this section. The national climate datasets for temperature and precipitation within Wisconsin Climate Division 9 extend back to 1895 and have been compiled from meteorological data collected at stations within the Region.¹³ The NCEI does not provide similar long-term datasets for snowfall. Monthly snowfall data for the Region was obtained from the Wisconsin State Climatology Office, which maintains snowfall datasets for each climate division from 1950 to present.¹⁴

Historical climate trends and associated data were also obtained from the 2011 and 2021 WICCI reports and the latest climate trend data published on the WICCI website, which covers the period of record from 1950 to 2024.¹⁵ Longer-term trends for temperature and precipitation data in the Region were obtained from the NCEI.¹⁶ While some long-term data from as early as 1895 is presented herein, the climate trends discussed in this section largely focus on a more recent period extending back to 1950, matching the WICCI approach to reporting climate trends. The 2011 WICCI report explains that using 1950 as the starting point for analyzing climate trends is preferable because the data collected at weather stations since 1950 are more reliable and consistent than earlier data.¹⁷

Climate Normals for Southeastern Wisconsin

U.S. Climate Normals are developed by NOAA's NCEI every 10 years and represent typical or average climatological conditions over a 30-year period. Climate normals are often used as a baseline for climate data comparisons, and departures from normal represent the difference between a specific meteorological

¹³ NOAA National Centers for Environmental Information, Climate Division Datasets (nClimDiv), www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.ncdc:C00005, accessed February 2026.

¹⁴ Wisconsin State Climatology Office, Wisconsin Climate Divisions: Divisional 12-Month Snowfall, climatology.nelson.wisc.edu/wisconsin-climate-divisions/divisional-12-month-snowfall, accessed February 2026.

¹⁵ Wisconsin Initiative on Climate Change Impacts (WICCI), Trends and Projections, wicci.wisc.edu/wisconsin-climate-trends-and-projection, accessed February 2026.

¹⁶ NOAA National Centers for Environmental Information, Climate at a Glance: Divisional Time Series, www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/divisional/time-series/4709, accessed February 2026.

¹⁷ WICCI, Wisconsin's Changing Climate: Impacts and Adaptation, *Nelson Institute for Environmental Studies, University of Wisconsin-Madison and Wisconsin Department of Natural Resources, 2011.*

observation and the 30-year average. The 30-year period is considered long enough to dampen the influence of short-term fluctuations and anomalies. The 1991-2020 climate normals for the Region are presented in [Table 2.2](#), and show the 30-year averages for temperature, precipitation, and snowfall on a monthly basis, along with average annual temperatures and annual precipitation and snowfall totals.

Temperature Conditions and Historical Trends

The average annual mean temperature in the Region is 47.1 degrees Fahrenheit (°F) based on the most recent climate normals (1991-2020). Throughout the year the average daily temperatures range from 20.7°F in January to 71.3°F in July as shown in [Table 2.2](#). During the winter months, typically defined by meteorologists and climatologists as December, January, and February, the normal daily high temperatures range from 28.3°F to 33.5°F and the normal daily low temperatures range from 13.0°F to 19.2°F.

When evaluated over a variety of timescales, mean temperatures show increasing trends across the Region. The latest historical climate trends published on the WICCI website cover the period from 1950 to 2024. [Figure 2.3](#) presents the change in annual average daily temperatures and average daily winter temperatures from 1950 to 2024. The annual average daily temperature in the Region has increased by approximately 3°F since 1950. The warming trends in the Region are more significant during the winter months, with average daily winter temperatures increasing by about 5°F over the same time period.

Long-term temperature variability for the Region can also be evaluated going back to 1895. [Figure 2.4](#) presents the average annual daily mean temperature along with a trendline extending from 1950 to 2024. The long-term average winter temperatures for the Region are shown in [Figure 2.5](#) and demonstrate a significant winter warming trend. The average rate of increase for winter season mean temperatures from 1950 to 2024 is approximately 0.6 degrees per decade, which is about 1.5 times the average rate of increase for annual mean temperatures over the same period. The 2021 WICCI report indicates that Wisconsin winters are warming more rapidly than summers and nighttime low temperatures are warming faster than daytime high temperatures.¹⁸ Overall, Wisconsin's warming climate is having the greatest effect on colder weather periods with fewer extended stretches of extreme cold temperatures.

¹⁸ WICCI, Wisconsin's Changing Climate: Impacts and Solutions for a Warmer Climate, *Nelson Institute for Environmental Studies, University of Wisconsin-Madison and Wisconsin Department of Natural Resources, 2021.*

Precipitation Conditions and Historical Trends

Precipitation within the Southeastern Wisconsin Region takes the form of rain, sleet, hail, and snow. Climatological records for precipitation data represent the liquid water equivalent and depth totals include all forms of liquid and frozen precipitation. The Southeastern Wisconsin Region receives on average 35.3 inches of precipitation per year, and nearly three-quarters of this precipitation falls within the months of April through October. June is typically the wettest month of the year and the driest periods occur during the winter months.

Recent precipitation trends indicate that Wisconsin is getting wetter, and the decade from 2010-2019 was the wettest decade on record.¹⁹ Based on climate division rankings for the period from 1895 to 2024, 2019 holds the record as the wettest year (45.0 inches) in Southeastern Wisconsin and 2018 (44.9 inches) ranks as the second wettest year.²⁰ Furthermore, six of the top ten wettest years on record have occurred between 2000 and 2024. **Figure 2.6** shows the statewide historical changes in annual precipitation and winter season precipitation from 1950 to 2024. While there was substantial variability in the change in precipitation statewide, all seven counties in the Region exhibited significant increasing precipitation trends from 15 to 20 percent. During the winter months, the seasonal precipitation total for the entire Region shows a significant increasing trend of approximately 20 percent from 1950 to 2024.

The long-term variability of total annual precipitation in the Southeastern Wisconsin Region from 1895 to 2024 is shown in **Figure 2.7**.²¹ Based on the NCEI climate divisional time series for Southeastern Wisconsin, annual precipitation totals in the Region have increased at an average rate of +0.48 inches per decade from 1895 to 2024. More significant precipitation trends have been observed in recent decades with an average rate of increase of +0.77 inches per decade from 1950 to 2024. Overall, the WICCI study concluded that Wisconsin is experiencing more extreme rainfall events, with increased frequency and magnitude.²²

¹⁹ Ibid.

²⁰ NOAA National Centers for Environmental Information, *Climate at a Glance: Divisional Rankings*, www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/divisional/rankings, accessed February 2026.

²¹ *When working with annual precipitation data, it's important to note that the total precipitation in a year may be relatively close to the average but the monthly precipitation totals can vary widely from extreme drought conditions to severe flood conditions.*

²² WICCI, 2021, op. cit.

Snowfall Conditions and Historical Trends

Based on the 1991-2020 climate normals, the Region receives on average 42.3 inches of snow annually, with nearly 80 percent falling within the months spanning from December through February. The snowfall data is reported as the average of the actual snowfall depth measured at all available stations across the Region. While the WICCI assessment does not include historical snowfall trends, some conclusions may be drawn from the snowfall dataset for the Southeastern Wisconsin Region maintained by the State Climatology Office. **Figure 2.8** presents the total snowfall for every winter season from 1950-1951 to 2023-2024. The average seasonal snowfall for the Region over the entire period of record is 42.5 inches. The maximum snowfall for one winter season was 93.8 inches recorded during the 2007-2008 winter. The highest seasonal snowfall is over 18 inches greater than the second highest snowfall total recorded during winter 1951-1952. The lowest snowfall total of 12.3 inches was recorded during the 1967-1968 winter season, nearly 10 inches less than the second lowest seasonal snowfall on record. This data shows the variability of snowfall from one winter to another, but no discernible trend was observed.

The Wisconsin State Climatology Office also tracks weather extremes and records. The statewide record one-day snowfall for February occurred in Walworth County on February 2, 2011 during the Groundhog Day blizzard. Much of the Region was blanketed in snow and 26 inches of snow was recorded at the former Pell Lake wastewater treatment facility in the Village of Bloomfield, tying the all-time statewide one-day snowfall record for Wisconsin set in Clark County on December 26, 1904.²³

²³ Wisconsin State Climatology Office, Historic Climate Data: Statewide Extremes, climatology.nelson.wisc.edu/wisconsin-historic-climate-data/statewide-extremes, accessed September 2024.

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A CHLORIDE IMPACT STUDY FOR SOUTHEASTERN WISCONSIN

Chapter 2

DESCRIPTION OF THE STUDY AREA

TABLES

Table 2.1
Existing Land Use for Major Watersheds Within the Study Area by Percentage of Watershed Area

Land Use Groups ^a	Des Plaines River	Fox River	Kinnickinnic River	Menomonee River	Milwaukee River	Oak Creek	Pike River	Rock River	Root River	Sauk Creek	Sheboygan River	Direct Drainage
Urban												
Lower-Density Residential	5.0	10.1	0.8	13.2	6.6	9.8	8.6	8.5	11.8	2.4	1.7	11.3
Medium-Density Residential	2.0	2.8	7.1	8.2	1.9	11.5	6.9	1.5	5.1	2.3	1.4	9.6
High-Density Residential	0.2	0.7	25.9	8.8	2.5	5.3	2.2	0.3	2.2	0.6	0.2	9.1
Commercial	0.4	0.5	3.5	2.2	0.5	2.2	1.2	0.3	0.8	0.2	0.1	1.3
Industrial	1.1	0.6	5.4	3.1	0.7	3.5	2.3	0.4	0.9	0.7	0.5	1.6
Government and Institutional	0.4	0.6	6.8	3.1	0.9	2.9	2.0	0.6	1.1	0.7	0.2	2.6
Roads and Parking Lots	6.2	6.7	29.7	20.8	7.2	20.1	11.2	5.5	10.0	5.4	3.0	16.0
TCU ^b	0.7	0.4	7.7	1.6	0.4	3.0	2.6	0.4	0.5	0.5	0.7	2.3
Recreational	1.5	1.9	3.8	3.6	1.5	3.8	2.3	1.1	2.7	0.5	0.6	3.6
Urban Unused Lands	1.4	1.4	6.7	5.3	1.2	11.4	5.9	0.8	2.3	1.1	0.8	6.0
Urban Subtotal	18.9	25.7	97.4	69.9	23.4	73.5	45.2	19.4	37.4	14.4	9.2	63.4
Nonurban												
Agricultural	55.2	39.0	0.2	13.2	43.3	9.2	39.5	47.9	44.4	72.5	68.3	18.7
Wetlands	10.2	13.2	0.8	8.7	16.0	7.7	3.3	13.0	7.4	6.3	11.9	4.9
Woodlands	6.1	9.7	0.6	3.1	9.4	4.7	3.6	9.2	4.7	2.4	1.4	4.9
Rural Unused Lands	7.1	6.9	0.0	3.6	5.6	4.0	6.6	6.0	4.5	3.9	8.8	7.0
Extractive and Landfills	0.5	0.9	0.0	0.7	0.4	0.3	0.6	0.7	0.5	0.1	0.1	0.5
Surface Water	2.0	4.6	1.0	0.8	1.9	0.6	1.2	3.8	1.1	0.4	0.3	0.6
Nonurban Subtotal	81.1	74.3	2.6	30.1	76.6	26.5	54.8	80.6	62.6	85.6	90.8	36.6
Tota Acreage	85,114	600,044	15,796	86,897	448,433	18,044	32,643	404,649	126,528	22,139	7,322	60,228

Note: Existing conditions land use for the study area is based on the following inventory years: 2015 (seven-county SEWRPC Region); 2018 (Jefferson County); 2014 (Dodge County); 2002 (Sheboygan County portion of the Sauk Creek watershed); and 2000 (Fond du Lac County and Sheboygan County portion of the Milwaukee River watershed). See TR-61 for a detailed description of the assembly and integration of existing land use inventories for the study area.

^a See Table 2.3 in TR-61 for detailed land use categories that comprise each land use group.

^b TCU = Transportation, Communication, and Utilities.

Source: SEWRPC

Table 2.2
30-Year Climate Normals for Southeastern Wisconsin: 1991-2020

Month	Mean Daily Temperature (°F)	Maximum Daily Temperature (°F)	Minimum Daily Temperature (°F)	Precipitation (inches)^a	Snowfall (inches)
January	20.7	28.3	13.0	1.64	12.6
February	24.2	32.2	16.1	1.56	10.7
March	34.3	43.3	25.3	2.05	5.3
April	45.4	55.8	35.1	3.67	1.7
May	56.7	67.6	45.8	3.96	0.1
June	66.7	77.5	55.8	4.60	0.0
July	71.3	81.8	60.8	3.67	0.0
August	69.6	79.8	59.4	3.80	0.0
September	62.3	72.9	51.8	3.33	0.0
October	50.2	60.1	40.3	2.91	0.2
November	37.5	45.5	29.4	2.22	2.1
December	26.3	33.5	19.2	1.87	9.8
Annual Average/Total	47.1	56.5	37.7	35.28	42.3

^a Precipitation totals include the liquid water equivalent of all forms of liquid and frozen precipitation.

Source: Wisconsin State Climatology Office and NOAA NCEI

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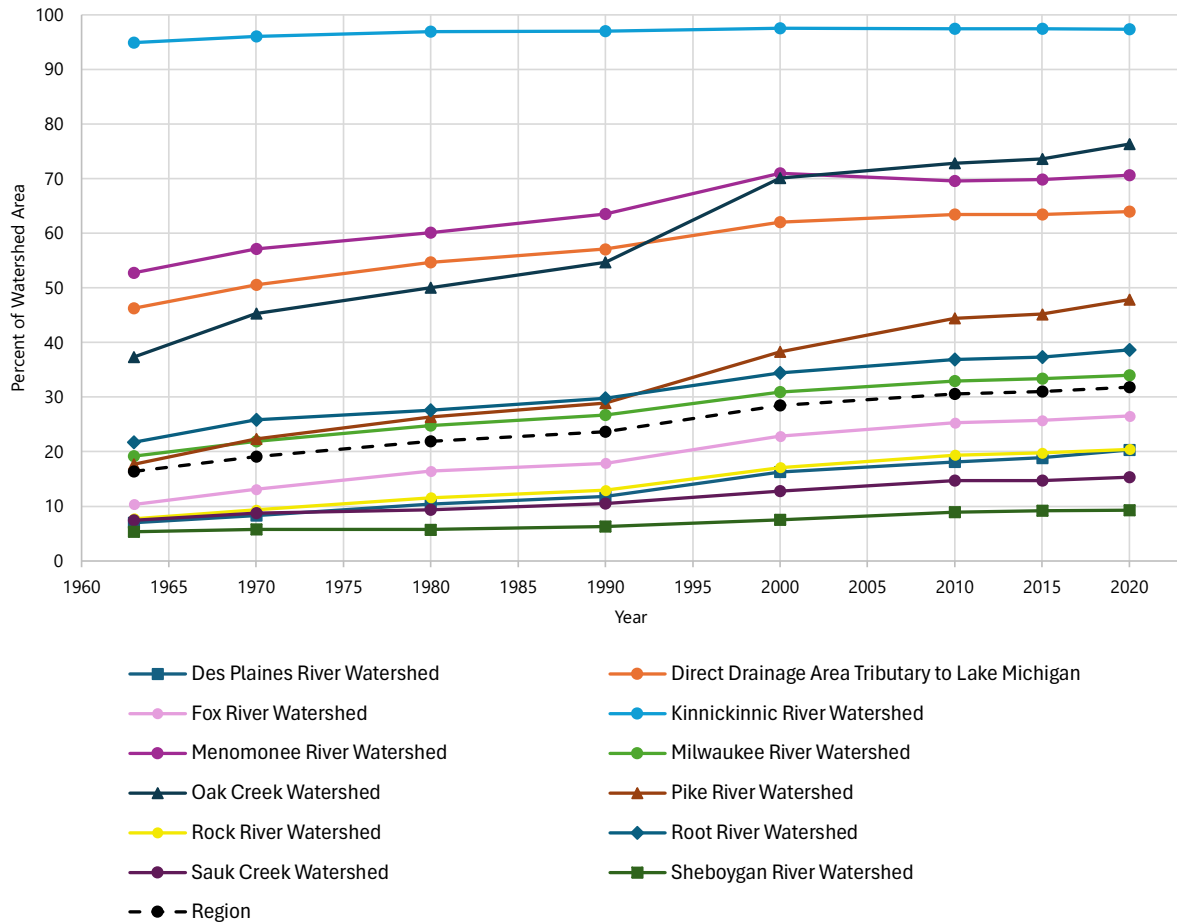
A CHLORIDE IMPACT STUDY FOR SOUTHEASTERN WISCONSIN

Chapter 2

DESCRIPTION OF THE STUDY AREA

FIGURES

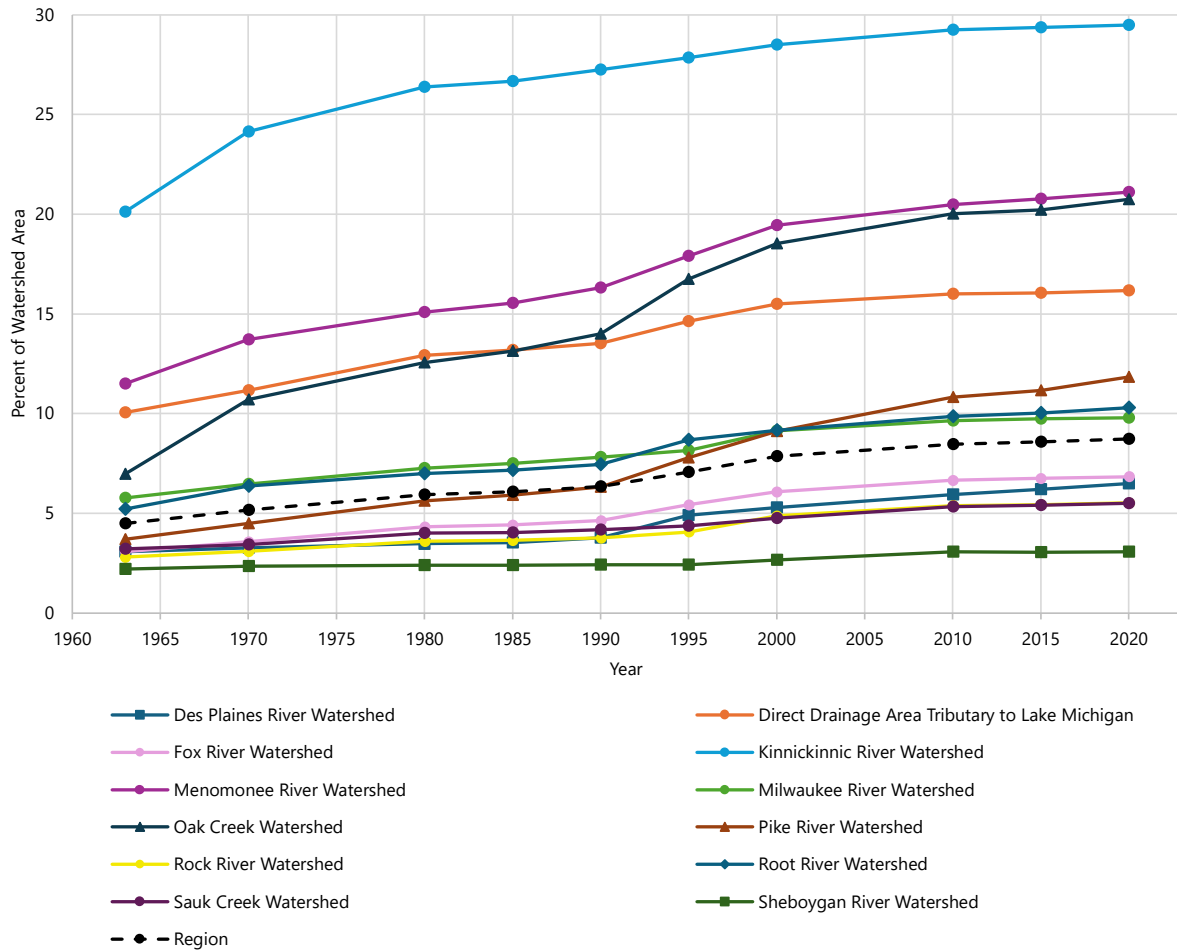
Figure 2.1
Trends in Urban Land Uses Within the Watersheds of the Region: 1963–2020



Note: SEWRPC land use inventories are only available for the seven-county Southeastern Wisconsin Region including Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties. Portions of the study area outside of these counties are not included in this figure.

Source: SEWRPC

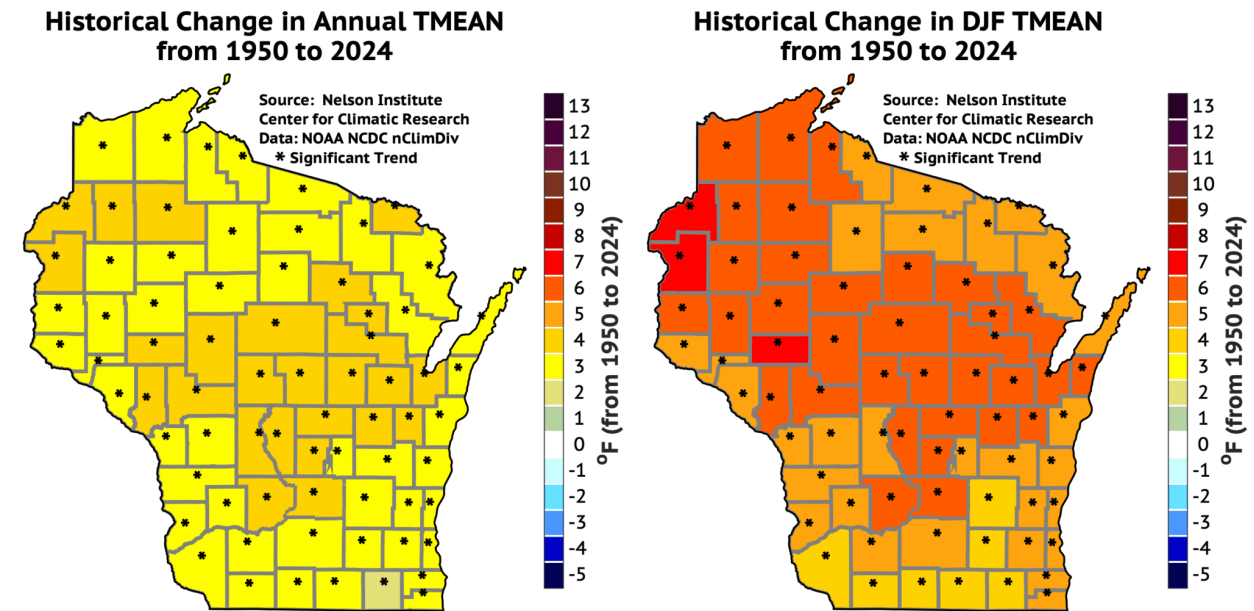
Figure 2.2
Trends in the Density of Roads and Parking Lots Within the Watersheds of the Region: 1963–2020



Note: SEWRPC land use inventories are only available for the seven-county Southeastern Wisconsin Region including Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties. Portions of the study area outside of these counties are not included in this figure.

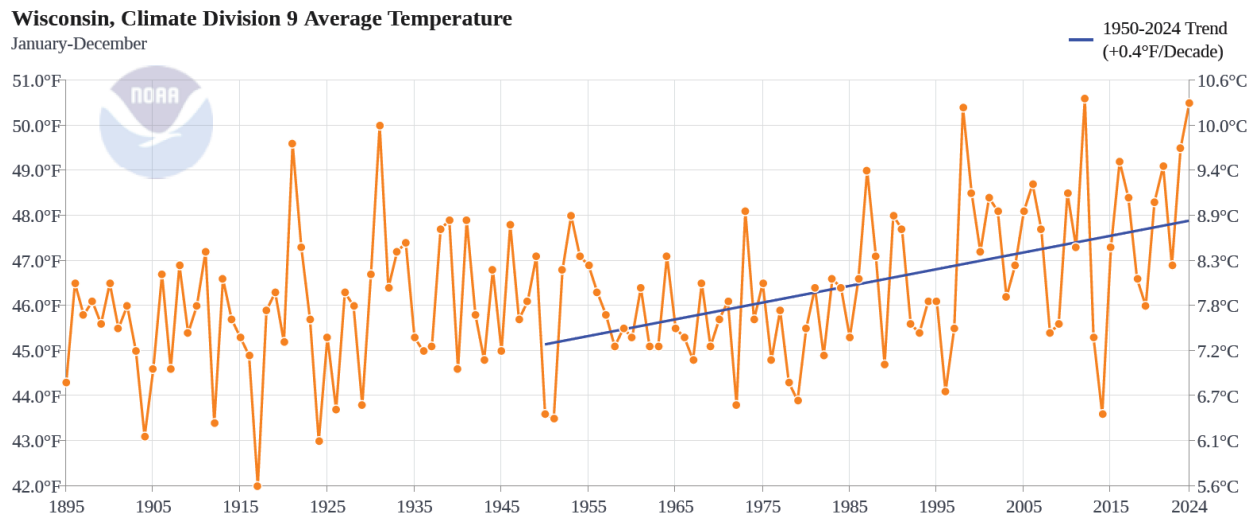
Source: SEWRPC

Figure 2.3
Historical Change in Annual Average Temperature and Average Winter Temperature: 1950-2024



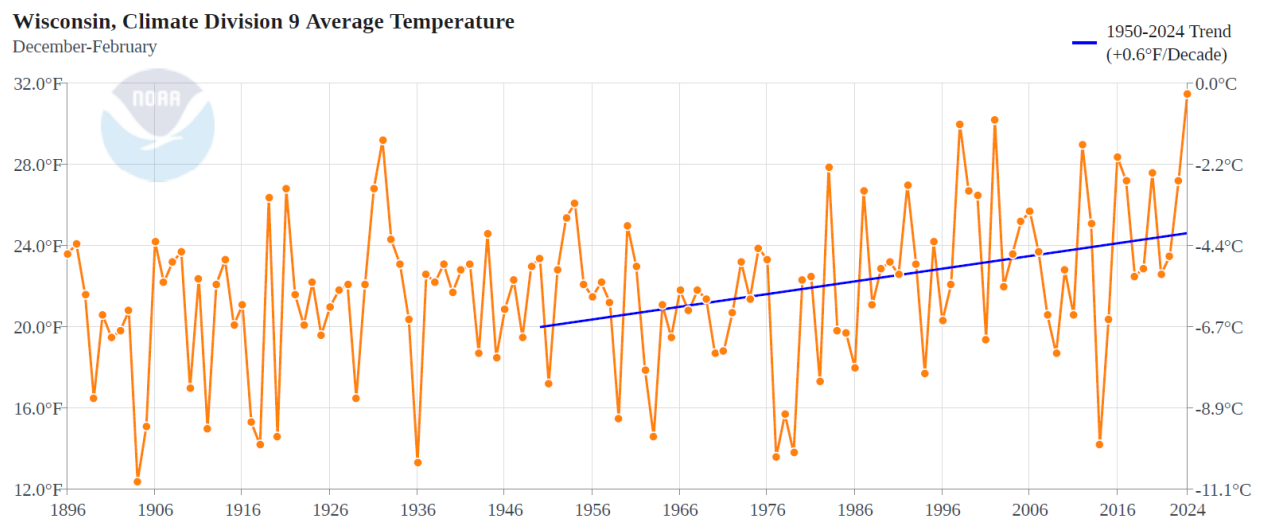
Source: WICCI

Figure 2.4
Annual Average Temperature for Southeastern Wisconsin: 1895-2024



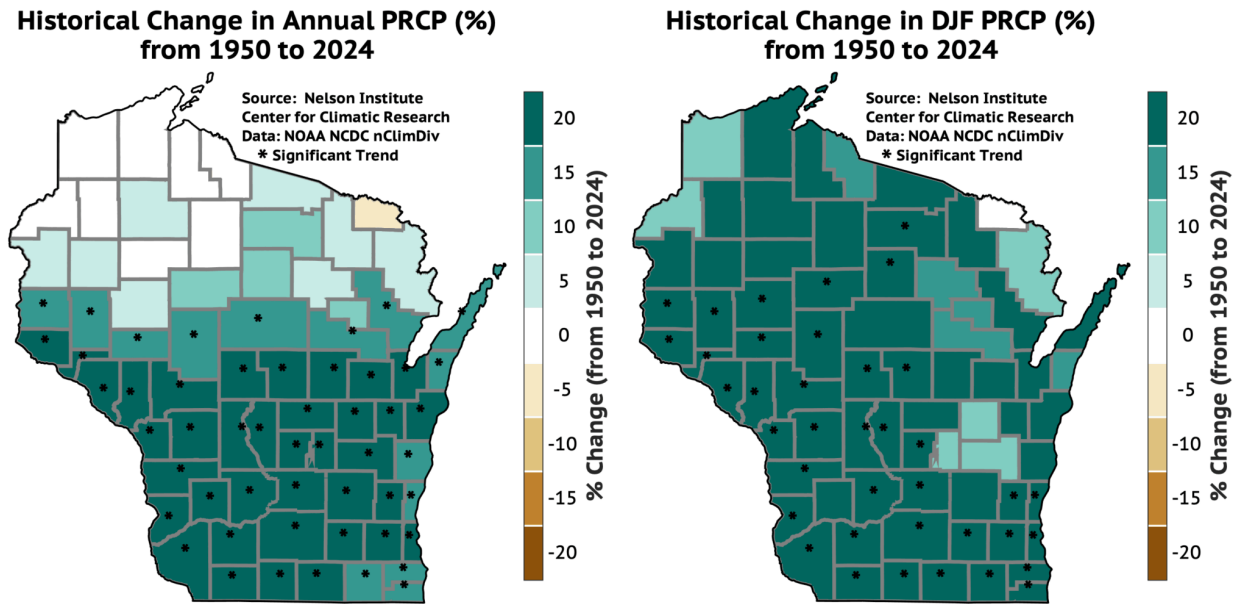
Source: NOAA NCEI

Figure 2.5
Average Winter Temperature for Southeastern Wisconsin: 1895-2024



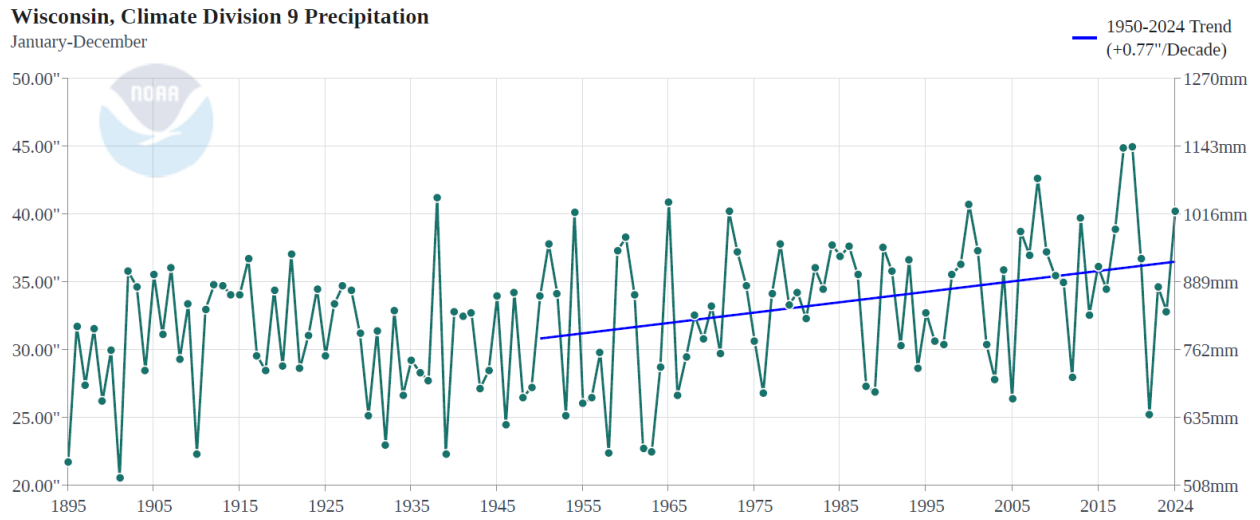
Source: NOAA NCEI

Figure 2.6
Historical Change in Annual Precipitation and Winter Season Precipitation: 1950-2024



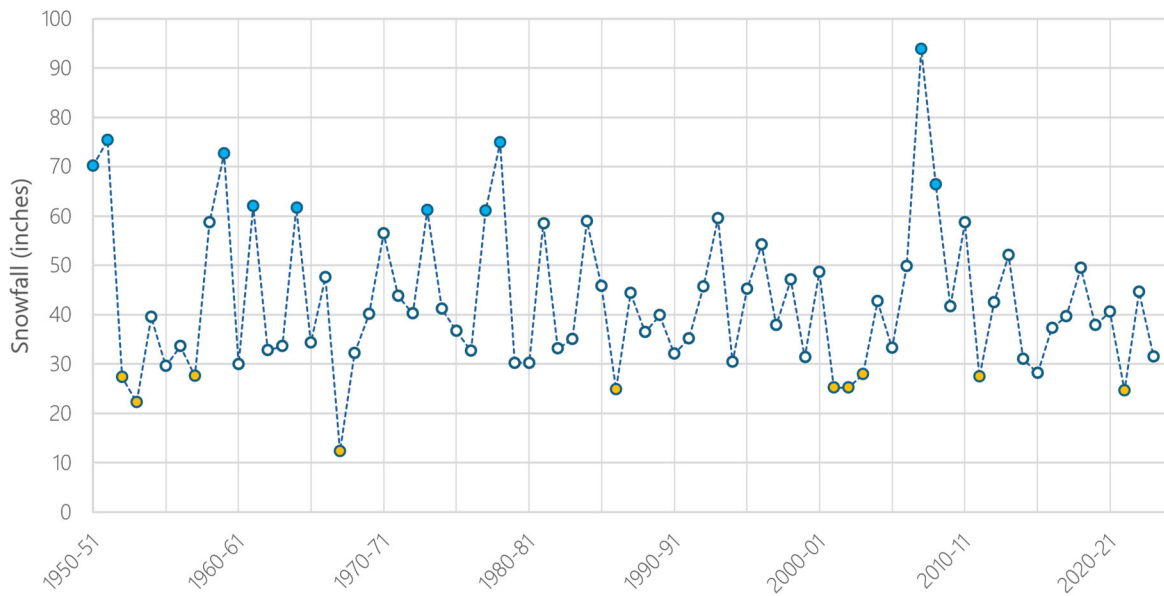
Source: WICCI

Figure 2.7
Annual Precipitation for Southeastern Wisconsin: 1895-2024



Source: NOAA NCEI

Figure 2.8
Total Winter Season Snowfall for Southeastern Wisconsin: 1950-1951 to 2023-2024



Note: The 10 winters with the most snow are highlighted blue and the 10 winters with the least snow are highlighted orange.

Source: Wisconsin State Climatology Office

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Chapter 2

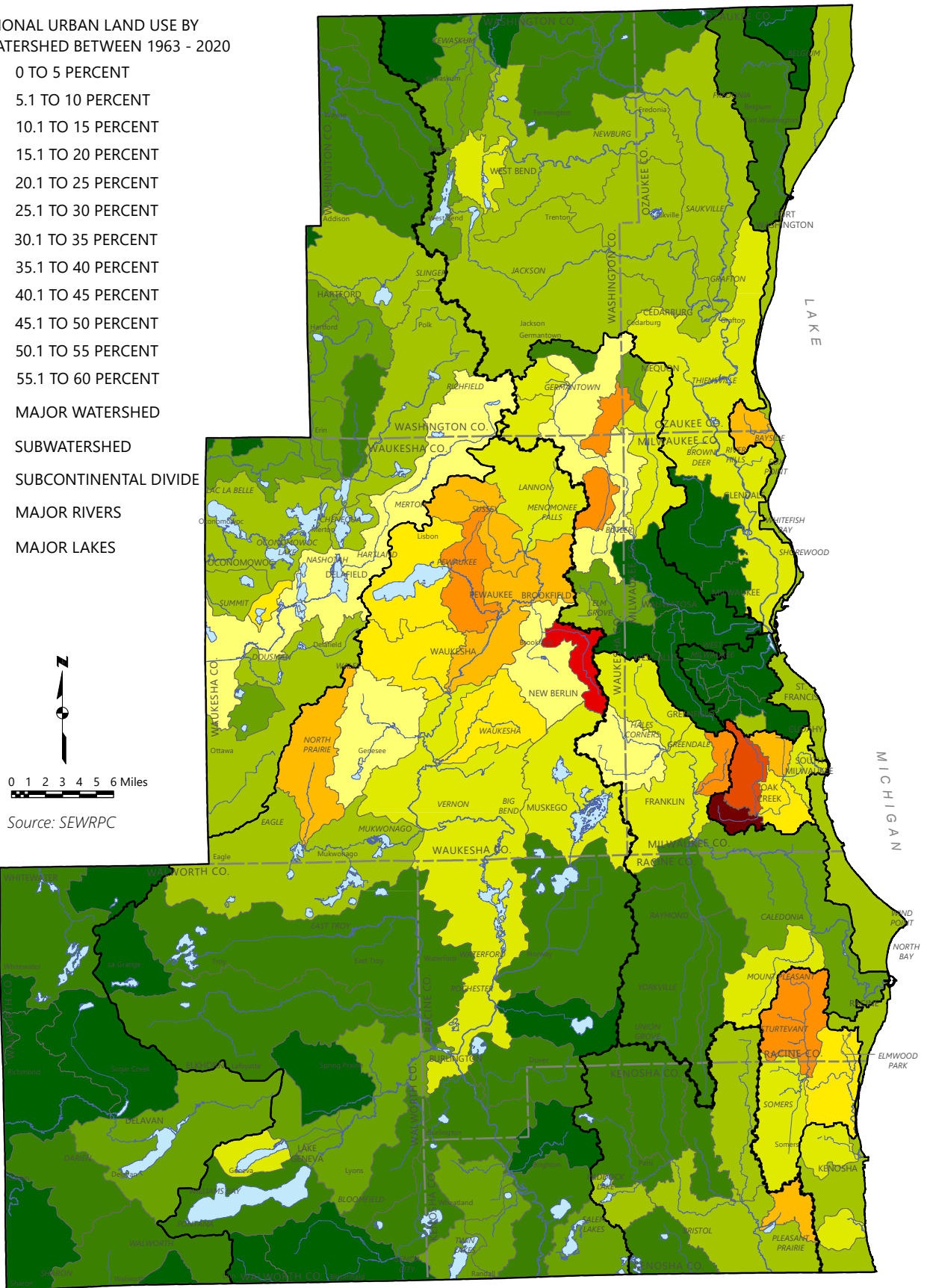
DESCRIPTION OF THE STUDY AREA

MAPS

Map 2.2
Increases in Urban Land Use Within Subwatersheds of the Region: 1963–2020

ADDITIONAL URBAN LAND USE BY
 SUBWATERSHED BETWEEN 1963 - 2020

- 0 TO 5 PERCENT
- 5.1 TO 10 PERCENT
- 10.1 TO 15 PERCENT
- 15.1 TO 20 PERCENT
- 20.1 TO 25 PERCENT
- 25.1 TO 30 PERCENT
- 30.1 TO 35 PERCENT
- 35.1 TO 40 PERCENT
- 40.1 TO 45 PERCENT
- 45.1 TO 50 PERCENT
- 50.1 TO 55 PERCENT
- 55.1 TO 60 PERCENT
- MAJOR WATERSHED
- SUBWATERSHED
- SUBCONTINENTAL DIVIDE
- MAJOR RIVERS
- MAJOR LAKES



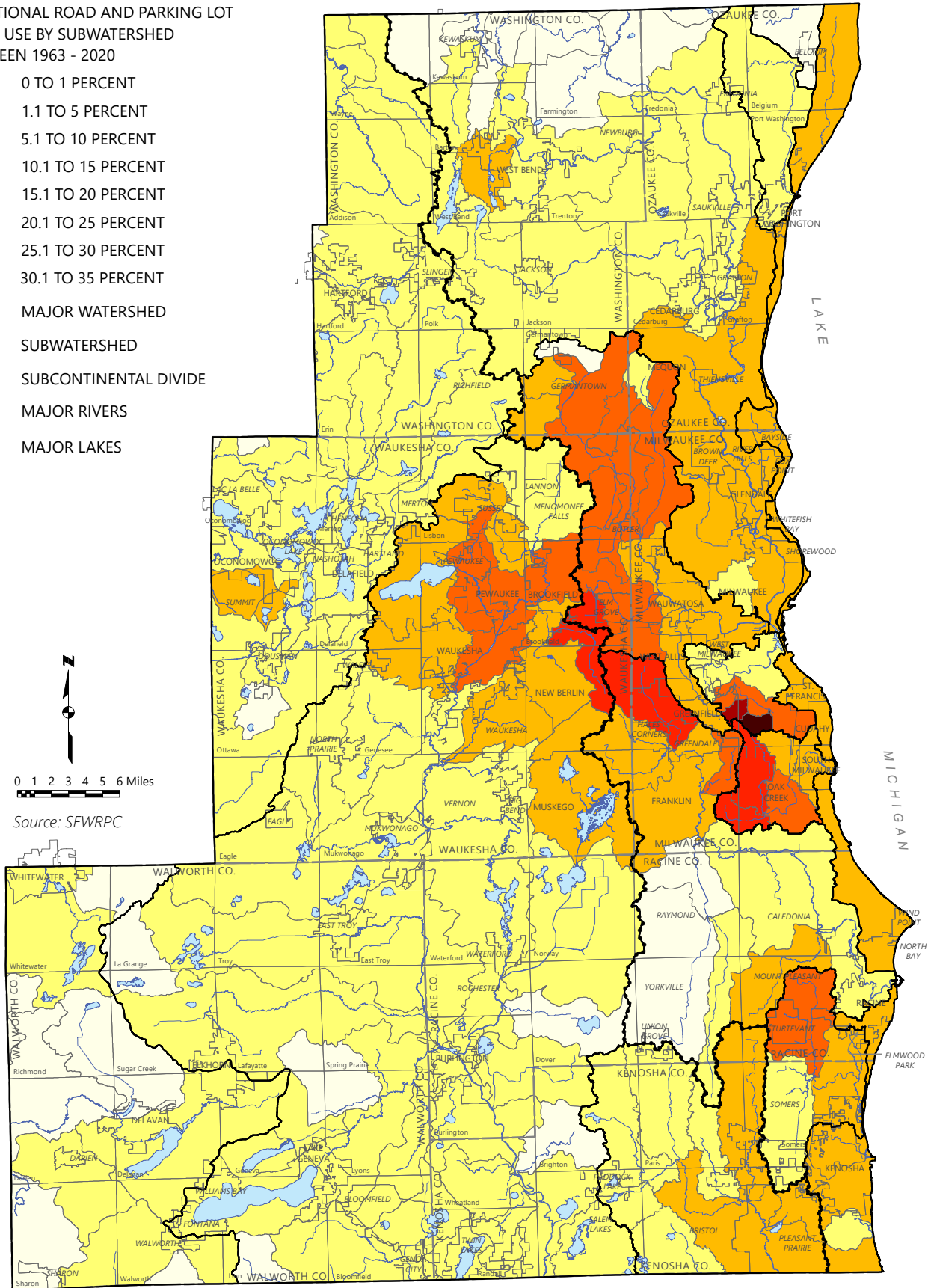
Source: SEWRPC

Map 2.3

Increases in Roads and Parking Lot Density Within Subwatersheds of the Region: 1963–2020

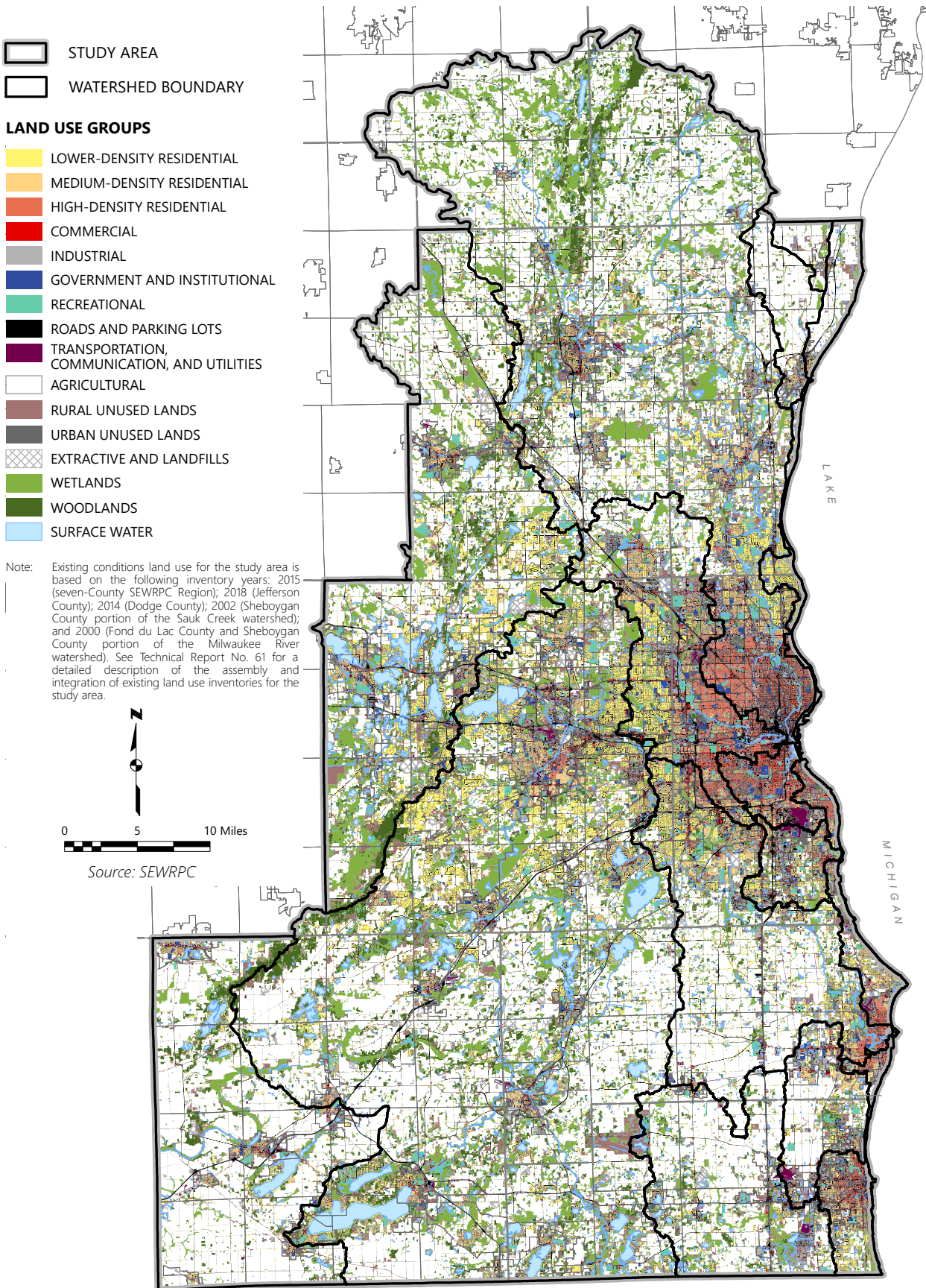
ADDITIONAL ROAD AND PARKING LOT
LAND USE BY SUBWATERSHED
BETWEEN 1963 - 2020

- 0 TO 1 PERCENT
- 1.1 TO 5 PERCENT
- 5.1 TO 10 PERCENT
- 10.1 TO 15 PERCENT
- 15.1 TO 20 PERCENT
- 20.1 TO 25 PERCENT
- 25.1 TO 30 PERCENT
- 30.1 TO 35 PERCENT
- MAJOR WATERSHED
- SUBWATERSHED
- SUBCONTINENTAL DIVIDE
- MAJOR RIVERS
- MAJOR LAKES



Source: SEWRPC

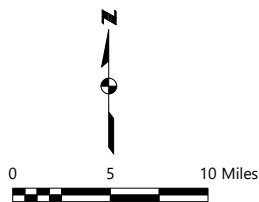
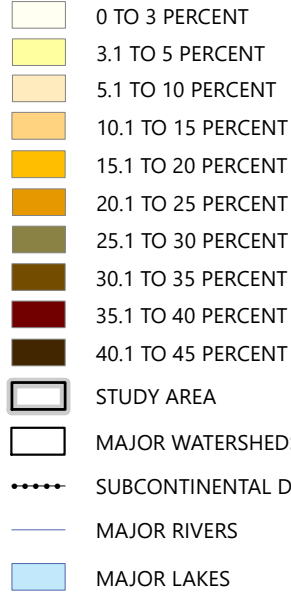
Map 2.4
Existing Land Use Within the Study Area



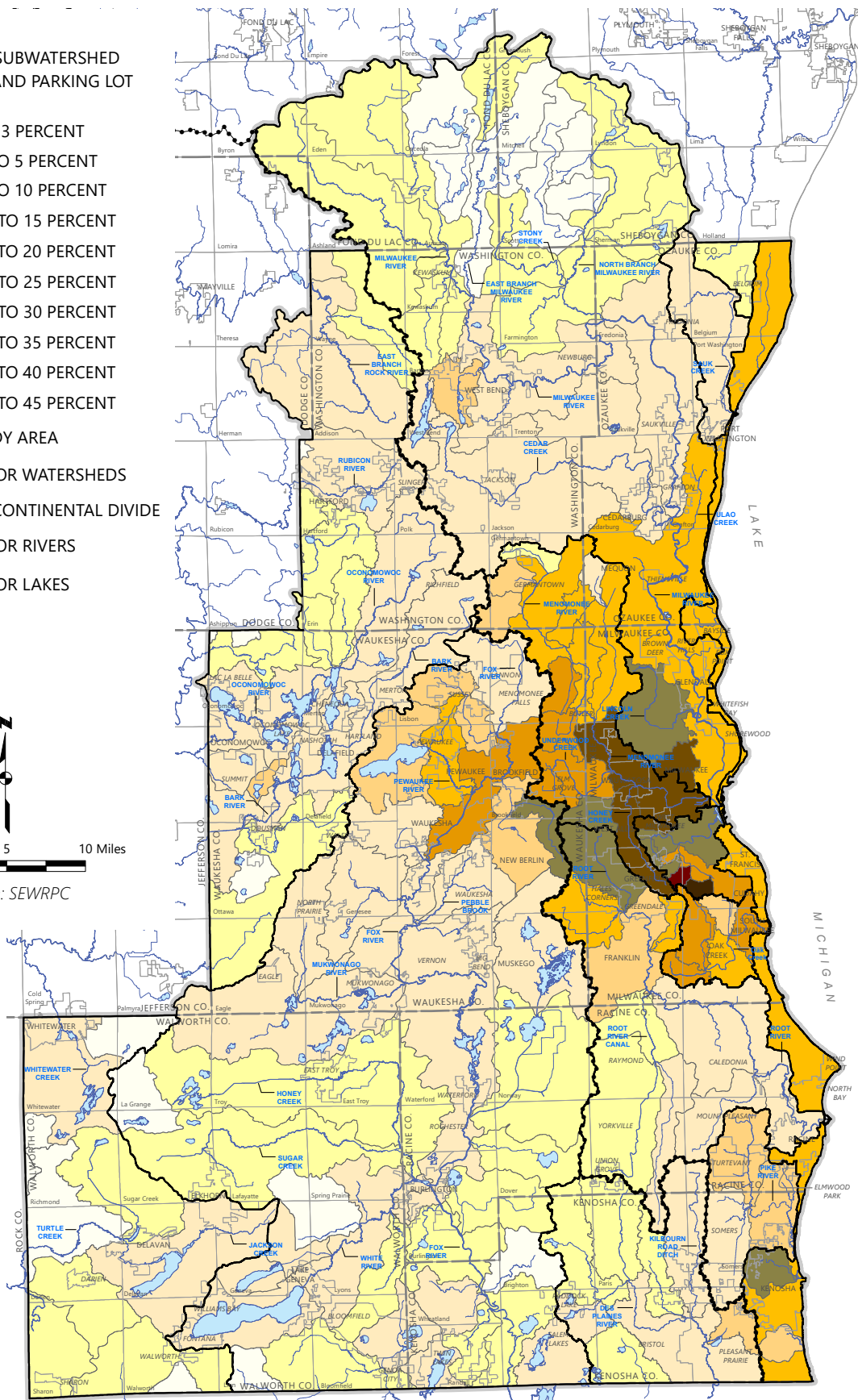
Map 2.6

Density of Roads and Parking Lots by Subwatersheds Within the Study Area: Existing Conditions

PERCENT OF SUBWATERSHED WITH ROAD AND PARKING LOT LAND USES



Source: SEWRPC



Map 2.7 Existing and Abandoned Wastewater Treatment Facilities and Planned Sanitary Sewer Service Areas

- ◆ EXISTING WASTEWATER TREATMENT FACILITY (DISCHARGES TO SURFACE WATER)
- ◆ EXISTING WASTEWATER TREATMENT FACILITY (DISCHARGES TO SOIL)
- ◆ ABANDONED WASTEWATER TREATMENT FACILITY (DISCHARGED TO SURFACE WATER)
- ▭ STUDY AREA
- ▭ MAJOR WATERSHEDS
- SUBCONTINENTAL DIVIDE
- MAJOR RIVERS
- MAJOR LAKES

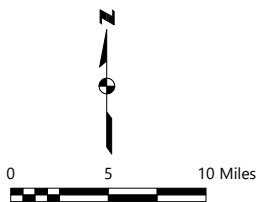
Notes: See Table 2.2 in SEWRPC Technical Report No. 63 for details on public wastewater treatment facilities.

The Delafield-Hartland WWTP discharges effluent to the Bark River at a point approximately four miles southwest of the facility.

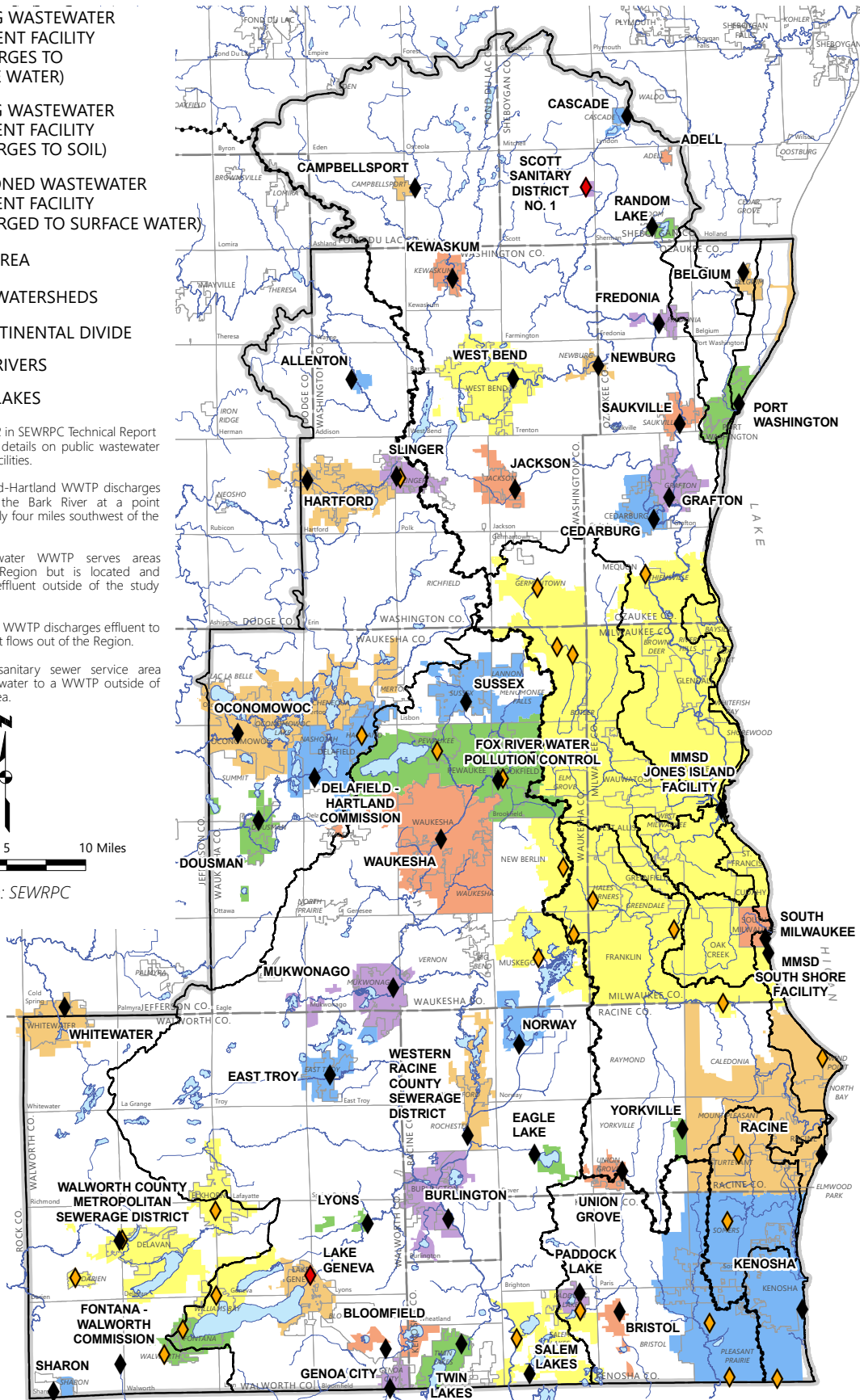
The Whitewater WWTP serves areas within the Region but is located and discharges effluent outside of the study area.

The Belgium WWTP discharges effluent to a stream that flows out of the Region.

The Adell sanitary sewer service area sends wastewater to a WWTP outside of the study area.



Source: SEWRPC



Map 2.8

Municipal Water Supply Service Areas and Sources of Supply in the Southeastern Wisconsin Region: 2005

