SEWRPC Community Assistance Planning Report No. 266 (4th Edition)

RACINE COUNTY HAZARD MITIGATION PLAN UPDATE: 2023-2028

Chapter 3

ANALYSIS OF HAZARD CONDITIONS

To evaluate various potential hazard mitigation alternatives for Racine County and select the most effective and feasible hazard mitigation strategies, the existing potential hazard problems in the County must first be analyzed and the vulnerability to such hazards documented. Accordingly, this chapter provides the following:

- Identification of the hazards likely to affect Racine County
- Profiles of the extent and severity of recent hazard events which occurred in the County
- Assessment of the vulnerability and risk associated with each type of hazard
- Identification of the potential for changes in hazard severity and risk under future conditions

The vulnerability assessment focuses on the County and community assets described in Chapter 2.

3.1 HAZARD IDENTIFICATION

The process of identifying those hazards that should be specifically addressed in the Racine County hazard mitigation plan was based upon consideration of a number of factors. The process included input from the Racine County Hazard Mitigation Local Planning Team, including a priority ranking of hazards; review of the hazard identification set forth in the State hazard mitigation plan; review of documentation of past hazard events; and review of related available mapping, plans, and assessments. As part of the updating process, the identification of hazards likely to affect Racine County was reviewed and reevaluated. This reevaluation included additional input from the Racine County Hazard Mitigation Local Planning Team.

As part of the updating process for this third plan update (4th Edition), the Local Planning Team reevaluated the hazards to be considered using a hazard and vulnerability assessment tool similar to the one used for reviewing hazard identification for the previous plan update. However, for this plan update the assessment was in the form of an online survey using Survey123. In this survey, members of the Local Planning Team indicated the likelihood of each hazard occurring in Racine County and evaluated the severity of each hazard on the basis of possible impacts to people, property, and businesses. Finally, the Local Planning Team evaluated the relative state of preparedness for each hazard. The ratings given by the Local Planning Team for each hazard were used to derive a perceived level of risk posed by each hazard. Following this, the hazards were ranked by perceived level of risk (Table 3.1).

Summary of Hazard Vulnerability and Risk Assessment Survey Results

Methods

The assessment survey was completed at the April 13, 2022, meeting of the Racine County Hazard Mitigation Local Planning Team, with 33 surveys returned and analyzed. For each of the hazards, a risk was computed for each survey using the formula:

Total risk (in weighted average) = [(Probability) x (Human impact + Property impact + Business impact - Preparedness)].

Probability (likelihood that an event would occur), Human impact (possibility of death or injury), Property impact (physical losses and damages), Business impact (interruption of services), and Preparedness (mitigation or pre-planning) were each assigned a number from 0 to 3, with 0 indicating not applicable, 1 indicating low probability/impact/level of preparedness, 2 indicating moderate probability/impact/level of preparedness, and 3 indicating high probability/impact/level of preparedness.

The interpretation of the results returned by this formula is that the perceived risk increases with increasing weighted average risk. For each hazard, an average risk was calculated using the results of all the returned surveys. The hazards were then ranked by average risk, with a rank of 1 indicating the highest perceived risk.

Results

The results from the assessment survey are summarized in Table 3.1. Hazard events are listed in order of highest perceived risk to lowest perceived risk. The average level of risk for hazards ranged from 1.938 (5.9 percent) for the lowest ranked hazard (dust storm) to 11.294 (34.2 percent) percent for the highest ranked hazard (tornado).

Summary and Ranking of Hazards

There are several ways the Racine County hazards can be ranked and summarized to be considered in the County hazard mitigation plan. Current guidance for all hazard mitigation plans promotes comprehensive consideration of all natural hazards. These hazards have been ranked by consideration of their frequency, amount of damage, and death and injuries incurred, as well as by concerns of, and degree of importance assigned by, the collective judgment of the Racine County Hazard Mitigation Local Planning Team.

The hazards to be considered in this plan are summarized in Table 3.2[1], along with qualitative information on the hazard severity. As part of the updating process, the hazards considered in the previous plan update were reevaluated based on data related to the occurrence of hazards since the previous plan update and to the perceived risk associated with each hazard, as summarized in Table 3.1.

Hazard severity can be assessed and ranked in a variety of ways. The purpose of ranking hazards is to help set priorities and direct more resources to address those hazards of the greatest severity. However, the kinds of mitigation actions that will be needed and warranted depend on the type of vulnerability to be addressed. Some hazards, such as excessive heat and lightning, are unlikely to cause a disaster, but they can be fatal and, therefore, are serious hazards. Vulnerability to such hazards can best be addressed by preventative measures, such as public information to encourage hazard awareness and personal protection. Other hazards, such as flooding, are pervasive and devastating, and may require a variety of tools—mapping, building codes, zoning laws, insurance, elevation or acquisition of flood-prone structures, and public awareness—to effectively reduce the risk of disaster. However, flooding might not result in more fatalities than a heat wave. In general, ranking hazards solely or primarily by the number of deaths that they

[1] *The rankings in Table 3.2 were assigned by combining rankings of the natural hazards listed based upon the number of occurrences, amount of damages, numbers of fatalities and injuries reported since 1950, and the perceived risk associated with each hazard as identified by the Local Planning Team and summarized in Table 3.1. It is important to note that some of the natural hazards listed in Table 3.2 represent combinations of hazards listed in Table 3.1. For example, while specific risks associated with thunderstorms, such as hail and lightning are listed separately in Table 3.1, they are combined into one category in Table 3.2.*

cause shifts the focus away from major and largely avoidable disasters such as floods. In addition, weather related hazards that have caused past Racine County disasters are likely the hazards that will cause future disasters. However, the types of natural hazards that result in fatalities will also remain a public health and safety concern.

The summary listing of hazards in Tables 3.1 and 3.2 does include some hazards that have been found to have minimal chance of occurring or offer only limited applicable mitigation options. Due to this, the hazards listed below will only be briefly discussed here and will not be further addressed..

Fog

Fog is low-level moisture caused by many contributing factors, including ice or snowmelt, moist air from Lake Michigan, or rain evaporation with light winds, which may reduce visibility levels, especially in river valleys and other low spots. Dense fog is often seen with clearing skies the day following a heavy rainstorm. Fog is a widespread natural hazard event that usually covers several counties during an episode. There have been 66 fog events reported in and around Racine County from 2001 through 2021. Although no deaths or injuries were recorded during that period, fog can affect mobility. Dense fog may persist for several hours or days, reducing visibility and leading to vehicle accidents, flight delays, or cancellations at airports. This natural hazard event does not offer significant mitigation alternatives to warrant individual examination.

Wildfires

A forest fire is an uncontrolled fire occurring on forest or woodlands typically located outside the limits of incorporated villages or cities. A wildfire is any instance of uncontrolled burning in brush, marshes, grasslands or field lands. The most common of these in Racine County is marsh fires which do occasionally occur. However, these are normally responded to by local fire suppression departments in accordance with established response procedures and no specific mitigation actions are deemed warranted. The causes of these fires include lightning, sparks from trains, human carelessness, or arson. Land use, vegetation, amount of combustible materials present, and weather conditions, such as wind, low humidity, and lack of precipitation, are the chief factors determining the number of fires and acreage burned.

Only about 6.5 percent of the land area in Racine County is woodland. Historical agricultural land use and urbanization has reduced the threat of a large-scale forest or wildfire event. According to the Wisconsin Department of Natural Resources (WDNR), Bureau of Forestry, no forest fires or wildfires over 500 acres have occurred in Racine County from 2011 through 2021. Based on guidance from the National Association of State Foresters, the WDNR, in conjunction with its Federal and tribal partners, developed a Statewide assessment of communities at risk from wildfires. None of the communities in Racine County were determined to be at high or very high risk. Considering the low risk and lack of historic incidents, forest and wildfire hazards will not be addressed in later chapters.

Dust Storms

There have been no dust storm events reported in Racine County from 2011 through 2021. Natural hazard events that occurred in the past are likely to reoccur in the future, providing the opportunity to plan for them. A dust storm event in Racine County would be atypical, therefore, mitigation strategies will not be recommended for this hazard in the current plan.

Land Subsidence

Land subsidence occurs when large amounts of groundwater have been withdrawn from certain types of rocks, such as fine-grained sediments. The rock compacts because the water is partly responsible for holding the ground up. When the water is withdrawn, the rock falls in on itself.[2] Land subsidence is not immediately noticeable because it occurs over large areas over a certain amount of time, unlike sinkholes. Due to the karst terrain of Wisconsin and high groundwater levels, there have been no land subsidence events reports in Racine County from 2011 through 2021. A land subsidence event in Racine County would be atypical, and therefore, mitigation strategies will not be recommended for this hazard in the current plan.

Inland Landslide

The most frequent and widespread damaging landslides in the U.S. are started by prolonged or heavy rainfall. The majority of rainfall-induced landslides are shallow, small, and move rapidly. Many rainfall-induced landslides transform into debris flows (fast-moving slurries of water, soil, and rock) as they travel down steep slopes, especially those that enter stream channels where they may mix with additional water and sediment.[3] The major concern for the U.S. Geological Survey (USGS) in regard to landslides resides in the State of California. Due to the lack of bare (no plants or trees to hold the soil in place) hills or steep slopes in congruence with heavy rainfall, inland landslides in Racine County are considered a very low hazard level.[4] There have been no inland landslides reported in Racine County from 2011 through 2021. Thus, mitigation strategies for this hazard will not be recommended in the current plan.

---

[2] *U.S. Geological Survey, "Land Subsidence", Water Science School, June 2018.*

[3] *U.S. Geological Survey, "Overview of Rainfall-Induced Landslides", Landslide Hazards, July 2018.*

[4] *Global Facility for Disaster Reduction and Recovery (GFDRR), "Think Hazard: Wisconsin Landslide", Retrieved May 31, 2022, from www.thinkhazard.org/en/report/3263-united-states-of-america-wisconsin.*

Earthquake

An earthquake is a shaking or sometimes violent trembling of the earth that results from the sudden shifting of rock beneath the earth's crust. This sudden shifting releases energy in the form of seismic waves or wave-like movement of the earth's surface. Earthquakes can strike without warning and may range in intensity from slight tremors to great shocks lasting a few seconds or over five minutes. The actual movement of the ground during earthquakes is seldom the direct cause of injury or death. Casualties may result from falling objects and debris; and disruption of communications, electrical power supplies, and gas, sewer, and water lines should be expected from earthquakes. The severity of an earthquake can be measured by comparing the peak acceleration associated with the horizontal shaking it produces to the normal acceleration a falling object experiences due to the force of gravity. This is usually expressed as a percentage of g, the acceleration due to gravity. The level of risk due to an earthquake can be expressed as the percentage of g, for which there is a 2 percent probability of being exceeded in a 50-year period. Depending on location, sites in Racine County have a 2 percent probability of experiencing earthquakes in a 50-year period in which the peak acceleration associated with horizontal shaking exceeds between 4 percent and 8 percent of g.[5] These are low values. While these levels of shaking can be noticeable, they are rarely associated with damages to structures. The earthquake threat to the State and Racine County is considered low, therefore earthquakes will not be considered further in subsequent sections of this report.

Past Hazard Experience

Past experiences with disasters are an indication of the potential for future disasters for which Racine County would be vulnerable. Accordingly, a review was made of the hazards that Racine County has faced in the past. Tables 3.3-3.5 detail the history since 2001 of estimated disaster damages caused by federally declared emergencies, the total number of weather hazard events recorded, and the severe weather history in the County.

As shown in Table 3.3, Racine County has had 18 major disaster declarations and 3 emergency disaster declarations between 2001 and 2021. The total documented estimated damages of these 21 events exceeded $17 million.

[5] *U.S. Geological Survey, "2008 United States National Seismic Hazard Maps", USGS Fact Sheet 2008-3018, April 2008.*

Since 2001, Racine County has experienced 567 weather hazard events, as summarized in Table 3.4. To illustrate the broader hazard damage potential, Table 3.4 summarizes the damages associated with the 567 natural hazard events. Those hazard events were estimated to have caused over $52 million in damages.

The historical events summarized in Table 3.4 shows that snow and ice are the most frequent weather hazards, closely followed by high straight-line winds. However, flooding is the most damaging weather hazard, followed by tornadoes and high straight-line winds. Extreme temperatures, high straight-line winds, floods, and snow and ice each accounted for one documented death.

To illustrate the potential frequency of thunderstorms and tornadoes, a review was made of the warnings historically issued by the National Weather Service, as shown in Table 3.5. Over the period of 2001 through 2021, there have been 384 thunderstorm-related watches or warnings and 70 tornado-related watches or warnings. In comparison, over the period 1990 through 2000, there were only 158 thunderstorm-related watches or warnings and only 41 tornado-related watches or warnings. This indicates that the frequency of such events is increasing over time.

3.2 DESCRIPTION OF ANALYSIS, METHODS, AND PROCEDURES

In the previous section of this report, the hazards considered applicable to Racine County were identified and ranked (Table 3.1). This section of the report develops a vulnerability assessment procedure for the identified hazards. This vulnerability assessment provides the basis for developing mitigation strategies that address the identified vulnerabilities.

The procedures utilized in the vulnerability analyses are based upon guidance provided by the Federal Emergency Management Agency (FEMA) and the Wisconsin Department of Military Affairs, Division of Emergency Management (WEM).[6] The analysis includes three components: 1) profile of hazard events, 2) inventory of assets, and 3) estimation of losses. In addition, potential changes in vulnerability under future conditions and the variance of vulnerability among the 17 communities within Racine County are analyzed. The profiling of hazard events was developed by utilizing the HAZUS methodology, data available on the

---

[6] *Federal Emergency Management Agency, State and Local Mitigation Planning How-to Guide, "Understanding Your Risks, Identifying Hazards and Estimating Losses," Publication No. FEMA 386-2, August 2001; Federal Emergency Management Agency, State Mitigation Planning Policy Guide, April. 2022; Federal Emergency Management Agency, Local Mitigation Planning Policy Guide, April 19, 2022.*

FEMA and National Oceanic and Atmospheric Administration National Climatic web sites, USDA-RMA, data provided by the Wisconsin Department of Military Affairs, Division of Emergency Management, file data available from the Racine County Office of Emergency Management, and SEWRPC.

Data and estimated losses and vulnerability were developed utilizing standard risk assessment methodology as set forth in FEMA and WEM guidelines for hazard mitigation planning where hazards can be estimated spatially and by order of magnitude over a range of events. For hazards which cannot be quantified, alternative approaches have been used relying on qualitative measures. A vulnerability description has been included for each of the applicable hazards listed in Table 3.2. The hazard analyzed in the next section are mainly listed in the order of ranking from Table 3.1, with the exceptions of the combining of certain hazards.

3.3 HAZARD VULNERABILITY AND RISK ASSESSMENTS

Tornados

Wisconsin lies along the northern edge of an area of the United States commonly known as "tornado alley." This area extends northeasterly along an axis extending from Oklahoma and Iowa in the west, to Michigan and Ohio in the east. This corridor accounts for about one-fourth of the total number of tornadoes that occur within the U.S. in any given year, with 758 tornadoes reported in the U.S. during the year 2011.

A tornado is defined as a violently rotating column of air extending from the ground up to the thunderstorm base. It generally lasts for only a short period. The tornado appears as a funnel-shaped column with its lower, narrower end touching the ground and upper, broader end extending into the thunderstorm cloud system. In some cases, the visible condensation cloud may not appear to reach the ground, but meanwhile tornado-force winds may be causing severe destruction (rotating winds can be nearly invisible, except for dust and debris). Similar events, not reaching the land surface, are known as funnel clouds. Funnel clouds may be a precursor to a tornado event. In Wisconsin, tornadoes usually occur in company with thunderstorms formed by eastward-moving cold fronts striking warm moist air streaming up from the south. However, it is not possible to predict all tornado activity based upon the occurrence of thunderstorms, and, occasionally, multiple outbreaks of tornadoes can occur along the frontal boundaries of a thunderstorm, affecting large areas of the Region or the State at one time. Tornadoes generally occur near the trailing edge of a thunderstorm. It is not uncommon to see clear, sunlit skies behind a tornado.

Historically, tornadoes have been categorized based upon the most intense damage along their paths using the Fujita Scale. Since February 2007, the Fujita Scale has been replaced by the Enhanced Fujita Scale, which retains the same basic design of its predecessor with six strength categories. This scale is shown in Table 3.6. The newer scale reflects more refined assessments of tornado damage surveys, more standardization, and consideration of damage over a wider range of structures.

The destructive power of the tornado results primarily from its high-wind velocities, wind-driven debris, and uplifting force. These tornado characteristics probably account for 90 percent of tornado-caused damage. Since tornadoes are generally associated with severe storm systems, hail, torrential rain, and intense lightning usually accompany tornado events. In addition, tornadoes may be accompanied by downbursts, events which are characterized by strong downdrafts initiated by a thunderstorm that manifest as straight-line winds on or near the ground. These winds can be powerful, with speeds up to 70 to 100 mph. These winds interact with tornadoes and can affect the path of the tornado event in such a manner as to make tornadoes somewhat unpredictable. Depending on their intensity, tornadoes can uproot trees and crops, down power lines, and damage or destroy buildings and infrastructure. Flying debris can cause serious injury and death to humans, livestock, and wildlife in their path. An approaching cloud of debris can mark the location of a tornado, even if the classic funnel cloud is not visible. Before a tornado hits, the wind may die down and the air may become very still.

The National Weather Service monitors severe weather nationwide from its Norman, Oklahoma office. This office is the only entity that can issue a tornado watch. The National Weather Service office in Milwaukee/ Sullivan, and the Racine County Emergency Services, may issue tornado warnings. A tornado watch means that tornadoes are possible, and that persons within the area for which the watches are issued should remain alert for approaching storms. A tornado warning means that a tornado has been sighted in an area or indicated as likely to have occurred by weather radar. When tornado warnings are issued for an area, persons near and within that designated area are advised to move to a pre-designated place of safety. As discussed previously, Table 3.5 shows the total number of tornado watches and warnings in Racine County from 2001 through 2021. Tornado shelters are identified by appropriate signage in public buildings. The National Weather Service operates two 24-hour weather radio transmitters that serve all of Racine County.

Recent Events

In the State of Wisconsin, tornado paths historically have averaged 3.5 miles in length and 50 yards in width, although tornadoes of a mile or more in width and 300 miles in length have been known to occur elsewhere in the United States. On average, tornadoes in Southeastern Wisconsin move across the land surface at speeds of between 25 and 45 miles per hour, although overland speeds of up to 70 mph have been reported. Tornadoes rarely last more than a few minutes over a single spot or more than 15 to 20 minutes in a 10-mile area, but, in those few minutes, significant devastation may occur.

The severity of any particular tornado event is measured in terms of resulting deaths, injuries, and economic losses. The magnitudes of the tornadoes recorded in Southeastern Wisconsin have been low, primarily EF0 or EF1 events on the Enhanced Fujita Scale (see Table 3.6). The strongest tornado ever recorded in Racine County was an EF2. An EF2 tornado occurred in 1957, 1959, 1966, and 1972, but has not occurred in recent years. Nevertheless, tornadoes are second only to stormwater damage associated with floods, as the costliest natural hazard to impact Southeastern Wisconsin.

2015 – Recently, there has only been one reported tornado in Racine County between 2011 and 2021. This tornado occurred on August 18, 2015, and was categorized as an EF0, causing sporadic tree damage along its path. Property and crops damage totaled $1,000.

Vulnerability and Community Impact Assessment

In order to assess the vulnerability of the Racine County area to tornado hazards, a review of the community assets described in Chapter 2 was made which indicates the potential for significant tornado impacts to: 1) a variety of residential, commercial, and other developed land uses; 2) agricultural lands; 3) critical community facilities; and 4) historic sites. Significant impacts may also be possible to other infrastructure or utility systems, solid waste disposal sites, or hazardous material storage sites.

Based on the National Climatic Data Center's (NCDC) 71-year record history, 21 tornadoes have been reported between 1950 and 2021, with about one tornado occurring every 3.4 years in Southeastern Wisconsin. In total, the tornadoes that have occurred in the last 71 years have resulted in 10 injuries and nearly $9.3 million in property and crop damages. From the distribution of historic tornado events, shown on Map 3.1, the locations of tornado impact points are widely scattered throughout the County, although the northwestern portion of the County appears to be more susceptible to tornado events than other portions of the County.

During a tornado, homes, businesses, public buildings, and infrastructure may be damaged or destroyed by the high winds, rain, and/or hail often associated with a tornado. In addition, airborne debris, carried by the tornado and associated high winds, can break windows and doors, allowing winds and rain access to interior spaces. Fixed infrastructure, such as roads and bridges, can also be damaged by exposure to high winds, although more damage appears to result from washout associated with flash flooding and debris jams, as opposed to direct damage due to contact with funnel clouds. In an extreme tornado event, such as a F4 event, the force of the wind alone can cause tremendous devastation, uprooting trees, toppling power lines, and inducing the failure of weak structural elements in homes and buildings. Due to the unpredictability of tornado events, all buildings, infrastructure, and critical facilities within the County are considered at risk.

Future Changes and Conditions

Changes in land use can have an impact on the potential for damage due to tornadoes and related hazards to occur. Such changes relate to the potential future increase in development within the County. Changing land use patterns within Racine County, as documented in the adopted VISION 2050 land use and transportation plan that is summarized in Chapter 2, and the assumption that current trends in the number and severity of tornadoes will continue into the future, indicate a continuing level of moderate risk of tornado damage and related losses in the County. However, because of the actions that have been taken by the County and local units of government and individuals, the current vulnerability to tornadoes and related hazards has generally decreased in recent years. These ongoing mitigation measures are described further in Chapter 5.

The likely effects of climate change on tornado frequency and severity are not clear. The projections based upon downscaled climate model results do not address potential trends in tornado conditions. A recent study that examined the evolving contributors of risk and vulnerability to produce disaster potential for tornadoes into the future found that growth in the human-built environment is projected to outweigh the effects of impacts from tornado disasters., however, an increase in risk and exposure of tornadoes may lead to a significant increase in the magnitude and disaster impact of tornadoes on that built environment from 2010 to 2100.[7] Additionally, high-risk tornado regions may experience increased disaster probability, and historically vulnerable regions may be at greater risk of tornado disaster due to a combination of factors: Increased tornado risk, increased exposure, and pre-existing social and physical vulnerabilities.

Multi-Jurisdictional Risk Management

Based upon a review of the historic patterns of tornado events in Racine County, and consideration of potential future changes and conditions, it appears there are no specific municipalities that have unusual tornado related risks. Rather, the events are considered to be relatively uniform and of a countywide concern.

---

[7] *Strader, S. M., Ashley, W. S., Pingel, T. J., & Krmenec, A. J. (2017). Projected 21st century changes in tornado exposure, risk, and disaster potential. Climatic Change, 141(2), 301–313. doi.org/10.1007/s10584-017-1905-4.*

Inland Flooding (Stormwater, Riverine, Inland Lake, Dam Failure)

Flooding is a significant hazard in Racine County. As mentioned in Chapter 2, Racine County has a significant amount of surface water and floodplains that can cause flooding issues. Watershed boundaries, wetlands, and major streams and lakes within the County are shown on Map 3.2. The land area within the 1-percent-annual-probability floodplain in each community is given in Table 3.7.

In addition to flooding, stormwater drainage problems exist on a scattered basis throughout Racine County. The distinction between stormwater drainage, stormwater management, and flood control is not always clear. For the purpose of this report, flood control is defined as the prevention of damage from the overflow of natural streams and watercourses. Drainage is defined as the control of excess stormwater on the land surface before such water has entered stream channels. The term "stormwater management" encompasses both stormwater drainage and nonpoint source pollution control measures. While the focus of this section is on the flooding hazard, the related stormwater drainage hazards are also considered because of the interrelationship between those two hazard conditions.

Dam Failure

A consideration in flood hazard mitigation is the potential for increased flooding due to dam failures, as such, future evaluation of floodplain areas related to dam failure should be considered. As indicated in Table 3.8 and Map 3.3, there are 19 dams identified by the WDNR in Racine County. Dams built according to accepted engineering principles at the time of construction and dams built without application of engineering principles can both equally fail. When a dam fails, or is subject to overtopping, large quantities of water can rush downstream with great destructive force. In the State of Wisconsin, WDNR inspects and assigns hazard ratings to dams.

The WDNR assigns hazard ratings to large dams within the State. Two factors are considered when assigning hazard ratings: existing land use and land use controls (zoning) downstream of the dam. Dams are classified, by law, in three categories that identify the potential hazard to life and property.[8]

- A **low hazard** rating is assigned to those dams that have no development unrelated to allowable open space use in the hydraulic shadow where the failure or mis-operation of the dam would result in no probable loss of human life, low economic losses (losses are principally limited to the owners

[8] *Wisconsin Administrative Code, NR 333.06*

property), low environmental damage, no significant disruption of lifeline facilities, and have land use controls in place to restrict future development in the hydraulic shadow.

- A **significant hazard** rating is assigned to those dams that have no existing development in the hydraulic shadow that would be inundated to a depth greater than 2 feet and have land use controls in place to restrict future development in the hydraulic shadow. Potential for loss of human life during failure is unlikely. Failure or mis-operation of the dam would result in no probable loss of human life but can cause economic loss, environmental damage, or disruption of lifeline facilities.

- A **high hazard** rating is assigned to those dams that have existing development in the hydraulic shadow that will be inundated to a depth greater than 2 feet or do not have land use controls in place to restrict future development in the hydraulic shadow. This rating is assigned if loss of human life during failure or mis-operation of the dam is probable.

In Racine County, three dams are currently assigned significant hazard ratings and the remaining 17 have been assigned low hazard ratings. The risk of dam failure is monitored closely by the WDNR.

Recent Events

A total of 16 flood events have been recorded in Racine County between 2011 and 2021. These events are shown in Table 3.9, based upon data published by the National Climatic Data Center. As shown in Table 3.9 these flood events can range from one event per year or up to 5 events per year, which demonstrates the likelihood and unpredictability of these events. In total, these flood events have resulted in 0 injuries, 1 death, and over $23 million in property and crop damages within Racine County. See Table 3.9 for a full list of recent flood events. A few examples of recent events from Table 3.9 are noted below.

2011 – On September 25 and 26, 2011, showers and thunderstorms produced up to three inches of rain across parts of southern Wisconsin over a 48-hour period ending the morning of September 26. The heavy rains flooded low-lying areas and ditches across the Region, with standing water three to four feet deep in some locations. Heavy rains resulted in flash flooding of a construction zone on the west frontage road of IH 94 between STH 20 and CTH C. This flood caused an estimated $6,300 of property damage and $1,050 in crop damage.

2017 – On July 12, 2017, four to eight inches of rain fell over the southwest half of the County for several hours. Racine County and the city and town of Burlington declared emergencies. The city of Burlington was divided in half from east to west due to flooding on the Fox River (see Figure 3.1). Various road closures over the southwest half of Racine County continued due to flooding through July 17th. The power was out for much of Burlington for a few days. Property damages resulting from this flood were estimated to be $23,800,000. Crop damages were estimated at $16,000.

2019 – On March 14, 2019, mild temperatures and some rainfall led to snow melt and excessive runoff on a frozen ground. Numerous rivers flooded including flooding in atypical areas due to ice jams. Evacuations were needed in some communities. The Fox River at Burlington reached minor flood stage, cresting at 11.9 feet. There was lowland flooding in the Burlington and Big Bend areas. Property damages resulting from this flood were estimated to be $1,000.

2020 – In the middle of May 2020, a slow-moving low-pressure area brought a moderate to heavy rainfall over an 18 to 24 hour period. 3 to 6 inches of rain fell, which resulted in river, creek, and lowland flooding. Numerous roads were flooded and closed. A small number of water rescues were executed. Property damages resulting from this flood were estimated to be $10,000.

Vulnerability and Community Impact Assessment

To assess the vulnerability of the Racine County area to flooding hazards and related stormwater drainage problems, consideration was specifically given to potential structure flooding, including critical facilities, and cropland flood damages.

A review of the community assets described in Chapter 2 indicate the potential for flooding impacts to: 1) a variety of flood-prone residential, commercial, and other developed land uses; 2) agricultural lands; and 3) critical community facilities. No significant impacts are expected to other infrastructure or utility systems, solid waste disposal sites, or hazardous material storage sites.

There are currently 648 structures estimated to be located within the 1-percent-annual-probability (100-year recurrence interval) floodplain hazard areas of Racine County. The approximate locations of these structures are shown on Map 3.4. There are 576 residential structures (including 54 residential manufactured homes), 22 industrial, business, and commercial structures, 29 agricultural buildings, four government buildings, six community utility buildings, and 12 other buildings (including one private school, one adult day care center, one group home, five recreational buildings, two churches, and two miscellaneous buildings). The specific location of each structure and its relationship to the floodplain is shown on the FEMA digital flood insurance rate maps for Racine County, which were finalized in 2020.

As of August 2022, there were six structures which are considered by FEMA to be repetitive- or substantial-loss properties in Racine County. All six structures are residential. There are two multi-family residential structures considered repetitive loss in the City of Racine, two single-family structures in the Town of Dover, and one single-family structure in both the Towns of Norway and Waterford. Repetitive-loss structures are those that have two or more flood insurance claims of at least $1,000 each. Most of these structures sustained damages during the June 7-9, 2008, flood event. The May 17, 2020, flood event was the most recent event to damage one of these repetitive loss structures.

Detailed floodplain hazard data are available for all floodplain hazard areas identified. Estimated damages are included in Table 3.10 for a 1-percent-annual-probability (100-year recurrence interval) flood event. The total value of the 648 structures (not including land value), which are identified as being subject to flooding or stormwater drainage problems, is about $93 million. The total market value plus contents within these structures are estimated at over $136 million. Damages expected during a 1-percent-annual-probability flood event are estimated to be approximately $19.3 million.

It should be noted that, with a few exceptions, all of these structures were identified as being in the floodplain based upon the best available topographic mapping. Field surveys would be required to determine the precise relationship to the floodplain. Some structures may be found to be outside the flood hazard areas based upon detailed field survey data.

Maps 3.5 and 3.6 show the location relative to the 1-percent-annual-probability floodplain of emergency service structures and critical community facilities. There are 585 buildings identified as critical community facilities, emergency service structures, and historical sites that are distributed geographically throughout the County. A listing of those facilities can be found in Appendices B and C. Seven of these facilities—a private high school, an adult care facility, two historical sites, the Village of Waterford Public library, the Racine County Sheriff's Department Water Patrol Office, and the City of Burlington Police Department—are located within the floodplain hazard area. In addition, other facilities are located in the immediate vicinity of the floodplain hazard area. Because of the need for access to and from these facilities, Maps 3.5 and 3.6 include their location and show the relationship to the flood hazard areas.

In addition, east to west travel in the County could potentially be restricted during flood events due to overtopping of a number of arterial streets and highways by the Root River and Root River Canal in the northeastern portion of the County and the Fox River and its tributaries in the western portion of the County. This review of the extent and severity of flooding conditions within Racine County indicates that there is a significant potential community impact due to the damages caused by flooding of buildings and disruption of the transportation system during extreme flooding events.

The flooding impacts on the community infrastructure and the need to prepare for major evacuations and other emergency actions are not a significant concern given the isolated nature and limited severity of the overland flooding problems. However, the ongoing coordinated Racine County and local emergency operations planning programs do have provisions for carrying out such actions if necessary. Significant flood-related impacts on the community economy and businesses are of an infrequent and short-term nature. The only impacts on County and local government operations which are relatively frequent involve posting and closure of roadways at locations where floodwaters frequently overtop structures and cause short-term roadway flooding.

Another potential impact for emergency and police vehicles to consider is the need to utilize alternative transportation routes when providing services during periods of flooding. In most of the County, this is expected to be a rare occurrence. However, in the Town of Norway, where a major portion of the flood-prone structures exist, there is a need for further mitigative action because of the extent of the flooding and emergency vehicle access concerns.

Agricultural Flood Damages

Historically, flood damages to agricultural land have been significant, with crop damages totaling $8.8 million over the period of 2001 to 2021. Thus, the average annual reported damages in the County can be approximated at $443,800 per year. There are about 10,497 acres of agricultural land located within the identified flood hazard area. Thus, the average annual flood damage is about $42 per acre.

Two particularly flood-prone agricultural areas of the County can be considered on a more site-specific basis. The first area is the agricultural lands lying adjacent to the Fox River in the Town of Waterford upstream of the Village of Waterford. Specific data on flood damages was developed for these lands under a 1995 water level control plan developed for the area.[9] In that planning program, 370 acres of land in the Town of Waterford were identified as being frequently flooded. Based upon estimates of the frequency of agricultural damages in a typical year, the total annual agricultural flood damages were estimated at $44,000

[9] *SEWRPC Memorandum Report No. 102,* Water Level Control Plan for the Waterford-Vernon Area of the Middle Fox River Watershed, Racine and Waukesha Counties, Wisconsin*, March 1995.*

in 1995 dollars, or about $76,873 in 2021 dollars, and about $207 per acre per year, for the flood-prone lands located in the Town of Waterford.

The second area of particular concern is lands in the Town of Norway drained by the Wind Lake Canal. These lands total about 4,000 acres, of which about 2,000 acres actually sustain damage during flood events. The frequency and severity of flooding in this area was analyzed in a 1975 drainage and water level control plan.[10] That study estimated the average annual damages on those lands at $186,000 in 1975, or $92 per acre. Using the Consumer Price Index (CPI) to convert the losses from this 1975 study to 2021 dollars, indicates that about $978,090 in damages occur in this area, or about $489 per acre per year, assuming 2,000 acres are still impaired. Given the abovementioned, the two agricultural areas specifically considered above account for a total of $1,054,963 in agricultural damages per year in all of Racine County.

Stormwater Drainage Problems

Because of the interrelationship between stormwater management and floodland management, stormwater management actions are an important consideration of the flood vulnerability assessment. Small area stormwater drainage problems are known to exist throughout the urbanized portions of the County. Most of the communities have undertaken stormwater management planning programs or stormwater management system inventories as the initial step in developing comprehensive stormwater management plans. Stormwater management planning in Racine County is described further in the following chapters, and that planning serves as the basis of the assessment of stormwater drainage problem vulnerability. Such problems largely impact community facilities by causing nuisance conditions and are not generally of concern for community health and welfare.

Future Changes and Conditions

Changes in land use can have a direct impact on flood flows and stages and, accordingly, can impact flooding problems. For the Root River watershed, more detailed data under current and future conditions by land use category is documented in the restoration plan for the Root River watershed.[11] The changes in urban land use over the 35-year period from 2015 through 2050 are expected to result in an increase in the amounts of impervious surface in these watersheds. In the absence of mitigative measures, this could lead to increases in future flood flows and stages, especially in downstream areas. As is discussed previously in this report, there are a number of programs in place that are intended to mitigate the potential for such

[10] *SEWRPC Community Assistance Planning Report No. 5, op. cit.*

[11] *SEWRPC Community Assistance Planning Report No. 316,* A Restoration Plan for the Root River Watershed*, July 2014.*

increases in flood flows. Nevertheless, it is important that future condition flood flows and stages be considered as mitigative actions are being considered.

Based upon the above, it can be concluded that the extent and severity of the flooding problem within the County has the potential to become more severe to a limited extent in the near future. This conclusion highlights the importance of carrying out and implementing current floodplain and related ordinances and existing and ongoing stormwater management plans and regulations.

In addition, changes in climate are likely to affect the potential for flooding in Racine County during the 21st century. As previously described in Chapter 2, model projections show Wisconsin receiving more precipitation and more frequent intense precipitation events. By the mid-21st century, Racine County may receive three more precipitation events of two or more inches in 24 hours per decade, roughly a 25 percent increase in the frequency of heavy precipitation events.[12] This is likely to increase the frequency of high flows and high water levels and potentially increase the frequency and severity of flooding. In particular, the expected increases in the magnitude and frequency of large rainfall events will likely increase flood magnitudes in streams and rivers in Wisconsin, although the amount of increase will vary from place to place. The amount of precipitation that falls as rain during winter and early spring months is expected to significantly increase. Winter rain can create stormwater management problems due to icing and runoff over frozen ground which may also lead to increased risk of flooding.

These changes may lead to several flood and stormwater related impacts. Increased rainfall and shifting precipitation patterns that favor more rain during periods of low infiltration and evapotranspiration may lead to more frequent and severe stream and river flooding. Increased precipitation during winter and spring may result in increased occurrence of inland lake flooding. Increased cold-weather precipitation and increased variability in frost conditions may cause a rise in water tables in some areas leading to an increase in groundwater flooding.

The projected increase in the magnitude and frequency of heavy storms could also affect the performance of existing and planned stormwater management and flood mitigation systems. This increase could also expand flood hazard areas, such as the 1-percent-annual-probability flood hazard area, beyond their

[12] *Wisconsin Initiative on Climate Change Impacts, Wisconsin's Changing Climate: Impacts and Adaptation, Nelson Institute for Environmental Studies, University of Wisconsin-Madison and Wisconsin Department of Natural Resources, 2021.*

existing boundaries, potentially encompassing more existing development. This could lead to an increase in the risk of flood damages and a need for larger stormwater management facilities and programs.

The magnitudes of potential increases in flooding are unknown, and there is a complex interrelationship between the climatological factors that will be affected by climate change and the features of watersheds that produce runoff. In some cases, climate change-induced changes in certain climatological factors may offset the changes in other factors relative to their effects on flood flows. In other cases, the effects will reinforce one another. Thus, it is very important to continue to improve methods for downscaling climatological data, to expand the climatological parameters for which downscaled data can be developed, and to apply hydrologic and hydraulic simulation models to quantify the potential effects on flooding resulting from climate change.

Multi-Jurisdictional Risk Management

Flooding and associated stormwater drainage problems have been identified as a significant risk in Racine County. As noted earlier and shown on Map 3.4, structures within flood hazard areas have been identified within all of the 17 general-purpose local units of government in the County, except for the Villages of Elmwood Park, North Bay, Union Grove, and Wind Point. In addition, there are related stormwater drainage problems in selected areas of many communities. Based upon the number of structures potentially impacted (see Map 3.4), the extent of the agricultural flood damage potential, and the extent of roadway flooding, 10 of the 17 communities will require special consideration with regard to the selection of mitigation measures for flooding and related stormwater problems. Based on census tract data, vulnerable populations (such as low-income areas and minority groups) that are found mainly in the City of Racine are not affected by flooding or the floodplains.[13]

Severe Thunderstorms Combined (Thunderstorms, High Straight-Line Winds, Hail, Lightning)

Compared to other natural hazards within the State of Wisconsin, and Racine County thunderstorms are the most common type of severe weather event. A thunderstorm is defined as a severe and violent form of convection produced when warm, moist air is overrun by dry, cool air. As the warm air rises, thunderheads (cumulonimbus clouds) form. These thunderheads produce the strong winds, lightning, thunder, hail, and heavy rain that are associated with these storm events. The thunderheads formed may be a towering mass averaging 15 miles in diameter and reach up to 40,000 to 50,000 feet in height. These storm systems may contain as much as 1.5 million tons of water and enormous amounts of energy that often are released in

---

[13] *SEWRPC,* Comprehensive Economic Development Strategy for Southeastern Wisconsin: 2021-2025*, September 2021.*

one of several destructive forms, such as high winds, lightning, hail, excessive rains, and tornadoes. Thunderstorms and their related high winds, lightning, hail hazards, and non-thunderstorm high winds are covered within this section. However, excessive rains that cause flash flooding, such as occurred in the summer storm events in 1998, 2000, 2007, and 2008 when the request for Presidential disaster declaration was approved (see Vulnerability Assessment for Flooding and Associated Stormwater Drainage Problems) and tornadoes are covered separately from this hazard analysis (see Vulnerability Assessment for Tornadoes).

A thunderstorm often lasts approximately 30 minutes in a given location, because an individual thunderstorm cell frequently moves at an average velocity that ranges between 30 to 50 miles per hour. However, strong frontal systems may produce more than one squall line composed of many individual thunderstorm cells. In Wisconsin, these fronts can often be tracked across the entire State from west to east.[14] Thunderstorms may occur individually, form clusters, or as a portion of a large line of storms. Therefore, it is possible that several thunderstorms may affect one particular area in the course of a few hours, as well as larger areas of the State or County, within a relatively short period of time.

All thunderstorms are potentially dangerous. However, only about 10 percent of the thunderstorms that occur each year nationwide are classified as severe. According to the National Weather Service, a thunderstorm is considered severe if it produces hail sizes at least one-inch in diameter, wind speeds equal to or greater than 58 miles per hour (measured or implied by tree and/or structural damage), or a tornado. A thunderstorm with wind speeds equal to or greater than 40 miles per hour or hail at least 0.5 inch in diameter is defined as approaching severe. Severe thunderstorms can cause injury or death and can also result in substantial property and crop damage. They may cause power outages, disrupt telephone service, and severely affect radio communications, as well as surface and air transportation, which may seriously impair the emergency management capabilities of the impacted areas.

The National Weather Service monitors severe weather for 20 southern Wisconsin counties, including Racine County, from its Milwaukee/Sullivan office.[15] A thunderstorm watch indicates that conditions are favorable for severe weather, and that persons within the area for which the watches are issued should remain alert for approaching storms. A severe thunderstorm warning indicates that severe weather has been sighted in an area or indicated by weather radar and persons should seek shelter immediately. These severe

---

[14] *National Weather Service Forecast Office.*

[15] *National Weather Service, Milwaukee/Sullivan Weather Forecast Office.*

thunderstorms watch and warning bulletins and advisories are disseminated over a number of telecommunication channels, including the NOAA Weather Radio, the NOAA Weather Wire, and the State Law Enforcement TIME System. NOAA Weather Radio is available to any individual with a weather alert radio. This system and the other sources are routinely monitored by local media which rebroadcast the weather bulletins over public and private television stations, radio stations, and mobile alert applications on cell phones. In addition, the National Weather Service operates two 24-hour weather radio transmitters that serve all of Racine County. KZZ76, operating at a frequency of 162.450 megahertz (MHz), transmits from a location at CTH KR and Wood Road in Racine County. KEC60, operating at a frequency of 162.400 MHz, transmits from a location near Delafield in Waukesha County.

Thunderstorm Winds

High-velocity, straight-line winds that are produced by thunderstorms and widespread non-thunderstorm high winds are a very destructive natural hazard in Wisconsin and are responsible for most wind-related damages to property.[16] Although distinctly different from tornadoes, straight-line winds produced by thunderstorms can be very powerful, are fairly common, and can cause damage similar to that of a tornado event.

Depending upon their intensity, thunderstorm winds can uproot trees and crops, down power lines, and damage or destroy buildings and infrastructure. Flying debris can cause serious injury and death to humans, livestock, and wildlife in their path. Boats, manufactured homes, and airplanes are also extremely vulnerable to damage from thunderstorm winds.

High Straight-Line Wind

High winds are also produced in the absence of thunderstorms. Non-thunderstorm high winds tend to be less forceful than thunderstorm winds but are typically more sustained and widespread. These high winds can affect a region for hours, or even several days. Longer lasting windstorms have two main causes: large differences in atmospheric pressure across a region, and strong jet-stream winds overhead. Horizontal pressure differences can accelerate the surface winds substantially as air travels from a region of higher atmospheric pressure to one of lower pressure. Intense winter storms can also cause long-lasting and damaging high winds. Cold fronts associated with intense low-pressure systems can produce high winds both as they pass and for a period afterward as colder air flows overhead. High winds in the winter can

[16] *Wisconsin Emergency Management Department of Military Affairs, State of Wisconsin Hazard Mitigation Plan, December 2021.*

produce dangerous wind chills when air temperatures are cold. Severe wind chills are discussed further in the extreme temperature section later in this chapter.

Like thunderstorm winds, non-thunderstorm high winds can uproot trees and crops, cause widespread power outages, damage buildings, and make travel treacherous. Non-thunderstorm high winds tend to be more sustained and widespread, leading to more damage over a whole region, as compared to thunderstorm winds.

Hail

Hailstorms are also associated with thunderstorms and are the fourth most destructive type of weather hazard in the State of Wisconsin and Racine County. A hailstorm is a product of strong thunderstorms and unique weather condition where atmospheric water particles form into rounded or irregular masses of ice that fall to earth. Hail normally falls near the center of the moving storm along with the heaviest rain. In some instances, strong winds at high altitudes can blow the hailstones away from the storm center, causing unexpected hazards at places that otherwise might not appear threatened. Hailstones normally range from the size of a pea to the size of a golf ball, but hailstones 1.5 inches or larger in diameter are not uncommon in the State of Wisconsin. Hailstones form when subfreezing temperatures cause water in thunderstorm clouds to accumulate in layers around an icy core. When strong underlying, updraft winds no longer can support their weight, the hailstones fall earthward. Hail tends to fall in swaths that may be 20 to 115 miles long and five to 30 miles wide and can fall continuously or sporadically in a series of hail strikes. Hail strikes are typically one-half mile wide and five miles long. They may partially overlap, but often leave completely undamaged gaps between them.

Hailstorms are considered formidable among the weather and climatic hazards to property and farm crops, because they dent vehicles and structures, break windows, damage roofs, and batter crops to the point that significant agricultural losses result. Falling hailstones can also cause serious injury and loss of human life and livestock, however these occurrences are rarely associated with hailstorms. In addition to impact damage, thick hail combined with heavy rain can clog storm sewers and contribute to stormwater flooding. Hail sufficiently thick to cover a road will pose a traffic hazard. The peak season for hailstorms is April through August, although hail has been reported with thunderstorms in every month of the year.

Lightning

Every thunderstorm produces lightning, and lightning has been shown to kill more people within the United States each year than tornadoes.[17] Lightning is defined as a sudden and violent discharge of electricity from within a thunderstorm due to a difference in electrical charges and represents a flow of electrical current from cloud to cloud or cloud to ground. Water and ice particles also affect the distribution of electrical charge. Lightning bolts can travel 20 miles before striking the ground. The air near a lightning bolt can be heated to 50,000 degrees Fahrenheit (°F), which is hotter than the surface of the sun. The rapid heating and cooling of the air near the lightning channel causes a shock wave that results in thunder.

Lightning is a significant hazard associated with any thunderstorm and can cause extensive damage to buildings and structures, kill or injure people and livestock, start forest fires and wildfires, and damage electrical and electronic equipment. Lightning is a major cause of damage to farm buildings and equipment, responsible for more than 80 percent of all livestock losses, and is the number one cause of farm fires. Counties in southern Wisconsin have been observed to experience a higher number of lightning events than other parts of the State due to higher thunderstorm frequency and more thorough documentation by the local media. Statistics have also shown that 92 percent of lightning-related fatalities occur during May through September and 73 percent of these events occur during the afternoon and early evening. Approximately 30 percent of persons struck by lightning die and 74 percent of lightning strike survivors have permanent disabilities.

Recent Events

A total of 103 thunderstorm-related events have been recorded in Racine County between 2011 and 2021. This total includes thunderstorm winds, strong winds, hail, and lightning. These events are documented in Table 3.11, based upon data published by the National Climatic Data Center. As shown in Table 3.11 these storms can range from one to two events per year or up to 10 events per year, which demonstrates the high unpredictability of these events. In total, these severe thunderstorms combined events have resulted in 2 injuries, 1 death, and over $800,000 in property and crop damages within Racine County. A few examples of recent events from Table 3.11 are noted below.

2011 – On June 8th, strong winds knocked large branches out of trees and uprooted a couple dozen large trees, causing a few power-lines to snap and two roads to be blocked. Semi-tractor trailers were blown over on Interstate-94 at STH 11 and CTH K, resulting in in the injury of two drivers. The moist, unstable air mass

---

[17] *National Oceanic and Atmospheric Administration.*

over the region produced severe thunderstorms with damaging winds and large hail. A cluster of supercell thunderstorms from Lafayette into Dane County moved east and created damaging wind gusts of 60 to 80 mph across much of the area along and south of Interstate-94. At the height of the event, over 27,000 customers had no electric power in Southeast Wisconsin.

2014 – On October 31st, high winds blew over a 51-foot grain auger early in the afternoon, killing a farmer. Also, large tree branches fell in two separate areas of the City of Racine landing in the streets. One large tree branch landed on a vehicle. Strong low pressure and associated cold front moved southeastward from Canada into the Great Lakes region.

2016 – On June 5th, clusters of strong to severe thunderstorms produced areas of straight line wind damage in southern Wisconsin as a cold front was passing through the region. Sporadic trees, branches, and power lines were down. A car was flipped near 7 mile Road during high winds and heavy rain. WE Energies approximated 20,000 customers were without power for at least a brief period across southeast Wisconsin.

2021 – On August 11th, supercell thunderstorms developed in the afternoon and continued to east into southern Wisconsin, bringing a few tornadoes and damaging winds. Multiple trees and power lines were down.

Vulnerability and Community Impact Assessment

The National Weather Service can forecast and track a line of thunderstorms that may be likely to produce severe high winds, hail, lightning, and tornadoes, but where these related hazards form or touch down and how powerful they might be, remains unpredictable and the locations of storm impact points are widely scattered throughout the County.

In order to assess the vulnerability of the Racine County area to thunderstorm related hazards, a review of the community assets described in Chapter 2 indicate the potential for significant thunderstorm and related hazard impacts to: 1) a variety of residential, commercial, and other developed land uses; 2) agricultural lands; 3) roadway transportation system; 4) utilities; 5) critical community facilities; and 6) historic sites. Significant impacts may also be possible to other infrastructure or utility systems, or hazardous material storage sites.

On average, the thunderstorm related events occurring over the period of 2001-2021 have resulted in about $4,578,000 of total reported damages in the County, consisting of about $4,543,000 of damages to property and $35,000 in damages to crops. However, many events had no damages reported to the NCDC, and very few events have been responsible for a large percentage of the total damages. On average there are about one lightning related thunderstorm event per year, about three hail related thunderstorm events per year, and about four high straight-line wind related thunderstorm events per year in Racine County.

In 2021, total equalized assessed property value in Racine County was estimated at $19.5 billion. Based on the current average estimate of $227,150 in reported property damages per year it can be expected that approximately 0.001 percent of the value of all property, including buildings and infrastructure, in Racine County will be damaged from these events each year. Due to the unpredictability of severe thunderstorms combined that include high straight-line wind, hail, and lightning events, all buildings, infrastructure, and critical facilities within the County are considered at risk.

Future Changes and Conditions

Based upon recent historical data from the period 2011-2021, Racine County can expect to experience averages of 4.0 thunderstorm wind events per year, 3.3 hail events per year, 2.9 non-thunderstorm high-wind events per year, and 1 lightning event per year somewhere in the County. It should be noted that the historical record shows considerable variation among years in the numbers of these events that occurred. While it would be expected that in some years the County will experience either fewer events or more events than the average number, the average annual number of events is not expected to change.

The likely effect of climate change on severe thunderstorms combined events is not clear. While projections based upon downscaled climate model results indicate that the magnitude and frequency of heavy precipitation events are likely to increase by the middle of the 21st century, they do not address potential trends in wind, hail, or lightning conditions. Modeling studies utilizing the output of multiple climate models suggest that number of days per year in which atmospheric environments that are known to support the formation of severe thunderstorms under current climatic conditions will increase between now and the end of the 21st century.[18] It should also be noted that wind strengths over the Great Lakes have increased

[18] *Noah S. Diffenbaugh, Martin Scherer, and Robert J. Trapp, "Robust Increases in Severe Thunderstorm Environments in Response to Greenhouse Forcing," Proceedings of the National Academy of Sciences, Volume 110, pages 16,361-16366, 2013.*

and are expected to continue increasing in the future.[19] Surface wind speeds above the Lakes are increasing by about 5 percent per decade, exceeding trends in wind speed over land.

Changes in land use can have an impact on the potential for damage to occur from thunderstorm related events. Such changes relate to the potential future increase in development within the County. Changing land use patterns within Racine County, as documented in the adopted regional land use plan and County land and water resource management plan, and summarized in Chapter 2, indicate a potential increased risk of thunderstorm-related damage and related losses due to the expanding urbanized areas within the County. Because of the actions that have been taken by the County and local units of government and individuals, the current vulnerability to thunderstorms and related hazards has decreased in recent years. These ongoing mitigation measures are described further in Chapter 5.

Multi-Jurisdictional Risk Management

Based upon a review of the historic patterns of severe thunderstorms combined that include high straight-line wind, hail, and lightning events in Racine County, there are no specific municipalities that have unusual risks. Rather, the events are considered to be relatively uniform and of countywide concern.

Temperature Extremes (Extreme Heat, Extreme Cold)

The sections below describes extreme heat and extreme cold hazards that affect the County.

Extreme Heat

The Centers for Disease Control and Prevention (CDC) reports that nationwide between 2018 and 2020, a total of 3,066 heat-related deaths occurred.[20] Excessive heat has become the deadliest hazard in Wisconsin. According to the National Weather Service, 22 people have died in Wisconsin directly as a result of heat waves from 2011 to 2021. Temperature data for two selected observation stations in the Cities of Burlington and Racine in Racine County are shown in Table 3.12. The table shows extreme high and low temperatures and the departure from average temperatures recorded in the period from 2011 through 2021. The average annual high and low extreme temperatures for these two stations are 93.2°F and -11.1°F for the City of

---

[19] *Ankur R. Desai, Jay A. Austin, Val Bennington, and Galen A. McKinley, "Stronger Winds Over a Large Lake in Response to Weakening Air-to-Lake Temperature Gradient," Nature Geoscience, Volume 2, pages 855-858, 2009.*

[20] *Merianne R. Spencer and Matthew F. Garnett., "QuickStats: Percentage Distribution of Heat-Related Deaths, by Age Group – National Vital Statistics System, United States, 2018-2020". MMWR Morbidity and Mortal Weekly Rep 2022; 71:808. June 17, 2022.*

Burlington and 94.4°F and -6.3°F for the City of Racine during this period. Prolonged exposure to either of these temperatures could present a significant danger. It should be noted that Lake Michigan may be exerting some effect on the average annual temperature but is not appreciably reducing the average extreme high temperature.

Heat and humidity together can create the most severe problems to human health. High humidity makes heat more dangerous because it slows the evaporation of perspiration, which is the body's natural cooling process. The Heat Index (HI) is a measure of discomfort and the level of risk posed to people in high-risk groups by heat and humidity. The HI is expressed in degrees Fahrenheit (°F) and incorporates an adjustment to the air temperature for relative humidity (RH). For example, if the air temperature is 94°F and the RH is 55 percent, the HI would equal about 106°F (see Figure 3.2). Since HI values were devised for shady, light wind conditions, exposure to full sunshine can increase HI values by up to 15°F. The level of risk to people in high-risk groups associated with different levels of the HI is shown in Table 3.13. The NWS will initiate alert procedures (advisories or warnings) when the Heat Index is expected to have a significant impact on public safety. The expected severity of the heat wave determines whether advisories or warnings are issued. High temperature periods are often also accompanied by the related air quality problems related to ground-level ozone which can be harmful, especially to sensitive groups, such as active children and adults with respiratory problems.

Most heat-related deaths occur in cities. Large urban areas become "heat islands." Brick buildings, asphalt streets, and tar roofs store and radiate heat like a slow burning furnace. Heat builds up in a city during the day and cities are slower than rural areas to cool down at night. The amount of sunshine is an important contributing factor in urban heat waves. In addition, the stagnant atmospheric conditions associated with a heat wave trap ozone and other pollutants in urban areas. The worst heat disasters, in terms of loss of life, happen in large cities when a combination of high daytime temperatures, high humidity, warm nighttime temperatures, and an abundance of sunshine occurs for a period of several days. There are also socioeconomic problems that make some urban populations at greater risk. The elderly, disabled, and debilitated are especially susceptible to heat-related illness and death.

Recent Events

Extreme heat that affects Racine County are not localized events, as they usually encompass the entire south-central to southeastern portion of the State and may continue for several days or weeks. Table 3.14 lists the extreme heat events in southeastern Wisconsin from 2011-2021. A few examples of recent events from Table 3.14 are noted below.

2012 – On July 6th, a hot air mass settled over southern Wisconsin, bringing 100-degree heat to many locations for multiple days between July 2nd and July 6th. Maximum heat indices climbed between 100 and 115 during the hot spell. Based on news reports, hundreds of people received medical treatment at hospitals or clinics due to heat-related illnesses. Numerous new daily record highs were set as well as record high minimums. The long duration of this excessive heat period likely makes this one of the four most dangerous heat waves to strike southern Wisconsin in recorded history.

2018 – On June 29th, hot and humid conditions produced heat index values ranging from 100 to 110 degrees. Numerous cooling centers were opened by local communities throughout southern Wisconsin. Some public swimming pools hours were extended due to the heat. The heatwave continued into July 1st.

Vulnerability and Community Impact Assessment

Heat extremes are primarily a public health concern. The poor and elderly are much more susceptible to temperature-related deaths and injury. Education, improved social awareness, and community outreach programs have likely helped to reduce the number of individuals killed or injured by extreme temperature events. Those at greatest risk are the very young, the very old, and the sick. Most deaths during a heat wave are the result of heat stroke. Large and highly urbanized cities can create an island of heat that can raise the area temperature by 3ºF to 5ºF. Therefore, urban communities with substantial populations of elderly, disabled, and debilitated people could face a significant medical emergency during an extended period of excessive heat. Some residents in high crime areas, especially the elderly, are afraid to open windows or go out to cooling shelters. As neighborhoods change, some older residents become isolated because of cultural, ethnic, and language differences.

The Building Resilience Against Climate Effects (BRACE) program in the Wisconsin Department of Health Services has compiled heat vulnerability index maps for the State and each county. The results of the Racine County heat vulnerability index are shown in Figure 3.3. The heat vulnerability index is based on multiple indicators associated with risk for heat-related illnesses and mortality including health factors, demographic and household characteristics, natural and built environment factors, and population density. As indicated in Figure 3.3, areas within Racine County that have the highest vulnerability to an extreme heat event include portions of the City of Racine, Village of North Bay, and Village of Elmwood Park.

High demands for electricity can result in black outs and brown outs. Loss of water pressure can result from opening of fire hydrants in urban areas. Stagnant atmospheric conditions that occur with heat waves are also favorable for trapping ozone and other pollutants in urban areas. Pets and livestock can suffer from prolonged exposure to excessive heat. Although there has been no reported deaths, injuries, or damages between 2011 and 2021, on average, there are about 1.5 extreme heat events per year in Racine County that can still have an impact on people, pets, and other forms of life.

A review of the community assets described in Chapter 2 indicate the potential for extreme heat hazard events to impact: 1) residents at a countywide level, especially the poor, elderly, and sick, 2) agricultural croplands; 3) pets and livestock; 4) municipal water and electric utilities; and 5) natural surface and groundwater reserves. No specific cost data are estimated for extreme heat events, because the nature of such events does not readily permit direct cost analysis.

Future Changes and Conditions

Based upon recent historical data, Racine County can expect to experience an average of 1.5 extreme heat events per year. It should be noted that the historical record shows considerable variation among years in the numbers of these events that occurred. While it would be expected that in some years the County will experience either fewer events or more events than the average number, the average annual number of events is not expected to change over the five-year term of this plan update.

The projections based on downscaled results from climate models indicate that there will likely be substantial changes in the frequencies of extreme heat events over the 21st century. Extreme heat events are likely to occur more frequently and to be more severe by the middle of the century. As previously described in Chapter 2, average summertime temperatures in Racine County are projected to increase by 6.0 to 7.0ºF by year 2055.[21] The number of days per year in which temperatures in southern Wisconsin exceed 90ºF is expected to triple by 2055. Given that much of the documented increases in average temperature since 1950 have occurred through increases in night-time low temperatures, it is likely that there will be fewer night-time breaks in the heat during extreme heat events in the future. This could result in some extreme heat events persisting longer. Heat waves have direct impacts on human health, especially among sensitive populations such as the young children and the elderly. In the absence of mitigative measures, the projected increase in the frequency, duration, and severity of heat waves will be likely to cause increases in fatalities and/or illnesses related to extreme heat.

[21] *Wisconsin Initiative on Climate Change Impacts, 2021, op. cit.*

Multi-Jurisdictional Risk Management

Based upon a review of the historic patterns of extreme heat events in Racine County, there are no specific municipalities that have unusual risks. Rather, the events are of a uniform countywide concern. However, larger Cities, such as the City of Racine, may pose a bigger risk to heat related problems for the vulnerable populations located within the City, such as low-income areas and minority groups that may have less access to air conditioned shelters or cold water to keep them safe from extreme heat.

Extreme Cold

Like extreme heat, extreme cold is also a deadly hazard. The CDC reports nationwide that the death rate of excessive cold as the underlying cause ranges from 1 to 2.5 deaths per million people and over 19,000 people have died from exposure to cold since 1979.[22] Exposure to extreme cold temperatures can also cause a number of health conditions and can lead to loss of fingers and toes; or cause permanent kidney, pancreas, and liver injury, and even death. These health impacts often result from a combination of cold temperatures, winds, and precipitation. As a result, winter storms can pose substantial risks because they can last for several days and be accompanied by high winds, freezing rain or sleet, heavy snowfall, and cold temperatures. In addition, when deaths and injuries due to cold-related vehicle accidents and fatalities, fires due to dangerous use of heaters, carbon monoxide poisoning due to use of nontraditional sources of heat such as cooking ovens, and other winter weather fatalities are considered, the impact of severe cold periods becomes even greater.

Frostbite and hypothermia are two major health risks associated with severe cold. Frostbite is an injury caused by freezing of the skin and underlying tissues. Frostbite causes a loss of feeling and a white or pale appearance in extremities. Severe frostbite can damage skin and underlying tissues and requires medical attention. Potential complications of severe frostbite include infection and nerve damage. Frostbite is most common on fingers, toes, nose, ears, face, and chin. While exposed skin in cold, windy weather is most vulnerable to frostbite, this injury can also occur on skin covered by gloves or other clothing.

Hypothermia is a condition brought on when the core body temperature drops to less than 95°F. It occurs when the body loses heat more quickly than it is able to produce it. As with frostbite, wind or wetness can contribute to producing hypothermia. Symptoms of moderate to severe hypothermia include lack of coordination, slurred speech, confusion, drowsiness, progressive loss of consciousness, weak pulse, and shallow breathing. Hypothermia may cause lasting kidney, liver, and pancreas problems or death. Members

[22] *CDC, 2018.*

of certain populations are particularly vulnerable to hypothermia. These include older adults, infants and very young children, the homeless, persons consuming alcohol or other drugs, and persons taking certain medications.

Wind chill is an index used to evaluate the risk posed by the combination of cold temperatures and wind. It is based on temperature and wind speed. Table 3.15 shows the wind chill table used by the National Weather Service. Wind chill is not the actual temperature, but rather a measure of how the combination of wind and cold feel on exposed skin. As the wind increases, heat is carried away from the body at an accelerated rate, driving down the body temperature. This combination can strongly affect the risks associated with exposure to extreme cold. For example, a wind chill of -20°F will cause frostbite on exposed skin in just 30 minutes.

The National Weather Service issues wind chill advisories when wind chill temperatures are potentially hazardous and wind chill warnings when wind chill temperatures are life threatening. The exact criteria of a wind chill advisory and warning varies from state to state. A wind chill advisory in Wisconsin is issued when wind chill values reach -20°F to -34°F, with wind speeds of 4 mph or more. A wind chill warning in Wisconsin is issued when wind chill values will reach -35°F or colder, with wind speeds of at least four mph for three hours or more. In addition, a wind chill watch is issued 12 to 48 hours before these conditions are expected to occur.

What constitutes extreme cold varies in different parts of the country. In the south, near freezing temperatures are considered extreme cold. Freezing temperatures can cause severe damage to citrus fruit crops and other vegetation. Pipes may freeze and burst in homes that are poorly insulated or without heat. In the north, extreme cold means temperatures well below zero. Winter residents in Racine County may see heavy snow, strong winds/blizzards, extreme wind chill, lake-effect snow, and ice storms. The public can stay informed by listening to NOAA Weather Radio, commercial radio or television for the latest winter storm warnings and watches.

Recent Events

Extreme cold that affects Racine County are not localized events, as they usually encompass the entire south-central to southeastern portion of the State and may continue for several days or weeks. Between 2011 and 2021, about $91,335 in crop damages have been reported as a result of extreme cold temperatures. Table 3.16 lists the extreme cold events in southeastern Wisconsin from 2011-2021. A few examples of recent events from Table 3.16 are noted below.

2013 – On January 21st, arctic air spread into southern Wisconsin behind deep low pressure that tracked to the north of the state. High winds combined with surface temperatures in the single digits below zero to produce wind chills between -20 to -30. The frigid wind chills began the morning of January 21 and continued into the morning hours of January 22. This was one of the relatively few times Milwaukee recorded a low temperature below zero without having a snow cover.

2014 – On January 27th, an arctic cold wave affected southern Wisconsin. West to northwest winds of 10 to 20 mph with the passage of an arctic cold front brought wind chill temperatures of -20 to 38 beginning in the early morning of January 27. These wind chills did not end until the morning of January 29. The coldest period was the morning of January 28 when wind chills ranged from 30 to 38. Widespread school and business closings occurred during this time. The Governor declared a state of emergency due to a propane shortage across the state. Numerous water main breaks and frozen laterals continued to occur throughout the entire month of January. Two cold weather deaths occurred in the southeastern Wisconsin area.

2019 – On January 29th, a surge of historically cold arctic air settled over southern WI. Windy conditions and low temperatures in the -20s to -30s Fahrenheit resulted in wind chill temperatures of 35 below to 55 below zero for much of this period. Widespread government, school, and business closings were common on January 30-31st. The United States Postal Service suspended mail delivery on January 29-30th. Many water main breaks and power outages occurred. A man was found frozen in his garage in Milwaukee and had collapsed after shoveling snow. Another man was found frozen in the snow in Cudahy and died from hypothermia.

Vulnerability and Community Impact Assessment

Similar to extreme heat, extreme cold is primarily a public health concern, with the poor and elderly being much more susceptible to extreme temperature-related deaths and injury. Pets and livestock can also suffer from prolonged exposure to excessive cold. Severe cold temperatures can cause breaks in water mains that can interrupt water supply. The impacts of a water main break depend on the size and location of the main. Frozen service laterals can also interrupt water supply to individual buildings. Water main breaks can be costly to municipalities. In the first three months of 2014 alone, the City of Racine responded to 103 water main breaks, costing nearly $450,000 to repair.

Property and crop damages have occasionally been reported as resulting from extreme cold events. Table 3.16 shows that between 2011 and 2021, extreme cold events have been reported as causing about $91,335 in crop damages in Racine County. On average, there are about 1.4 extreme cold events per year in Racine County.

A review of the community assets described in Chapter 2 indicate the potential for extreme cold hazard events to impact: 1) residents at a countywide level, especially the poor, elderly, and sick, 2) agricultural croplands; 3) pets and livestock; 4) municipal water and electric utilities; and 5) natural surface and groundwater reserves. No specific cost data are estimated for extreme cold events, because the nature of such events does not readily permit direct cost analysis.

Future Changes and Conditions

As mentioned previously, Racine County can expect to experience an average of 1.4 extreme cold events per year. It should be noted that the historical record shows considerable variation among years in the numbers of these events that occurred. While it would be expected that in some years the County will experience either fewer events or more events than the average number, the average annual number of events is not expected to change over the five-year term of this plan update.

The projections based on downscaled results from climate models indicate that there will likely be substantial changes in the frequencies of extreme cold events over the 21st century.[23] The frequency of extreme cold events may decrease by the middle of the century. The projected warming trends are expected to be greatest during the winter. Average winter temperatures in Racine County are projected to increase by about 7.5°F. This may result in a reduction of some risks associated with extreme cold.

Multi-Jurisdictional Risk Management

Based upon a review of the historic patterns of extreme cold events in Racine County, there are no specific municipalities that have unusual risks. Rather, the events are of a uniform countywide concern.

Lake Michigan Coastal Hazards

As mentioned in Chapter 2, the Lake Michigan coastline encompasses portions of five local units of government, including the City of Racine and the Villages of Caledonia, Mount Pleasant, Wind Point, and North Bay. The portion of the Lake Michigan shoreline lying within the jurisdiction of each of these general-purpose local units of government is shown in Table 3.17. There are three types of Lake Michigan coastal hazards of concern that pose risk to Racine County:

[23] *Wisconsin Initiative on Climate Change Impacts, 2021, op. cit.*

- **Erosion of Coastal bluffs, beaches, and near shore lake beds**

- **Coastal Flooding** from high Lake Michigan levels and/or storm surge and storm-induced waves (i.e., wave run-up) causing damage to structures such as residences, businesses, and public facilities

- **Damage and failure of shoreline protection structures** (revetments[24], seawalls, and groins[25]) from wave action, storm surge, and varying lake levels

The main focus of this vulnerability assessment will be on the first two types of coastal hazards noted above: erosion of coastal bluffs and beaches and coastal flooding from high Lake levels and/or storm surge. With regard to the third hazard listed above—damage and failure of shoreline protection structures—there is little available information about the amount, location, and condition of shoreline protection structures in the County, particularly on privately owned coastal parcels. For this reason, this hazard will not be addressed at length in this assessment.

It is important to note that shoreline protection structures have been known to contribute to coastal problems by decreasing, or preventing, natural erosion of littoral material (lake bottom near shore) such as sand and gravel from existing shorelines. Additionally, these structures can disrupt the natural flow and deposition of those sediments along the lake shore, affecting beach ecosystems. Some shoreline protection structures may redirect wave energy to adjacent shorelines, which can increase the potential for erosion at neighboring sites.[26]

Nearly 80 percent of Wisconsin's Lake Michigan shoreline is affected by coastal erosion and bluff recession to some degree, and recurring erosion presents a significant risk in almost every coastal county. The terms recession and erosion are often used interchangeably. Recession is the landward movement of a land

---

[24] *Revetments are sloping structures placed on banks or cliffs in such a way as to absorb the energy of incoming water (i.e., wave impact). Many materials may be used such as wooden piles, loose-piled boulders (i.e., riprap), concrete shapes, or geotextile fabric sandbags.*

[25] *A groin is a narrow structure (i.e., breakwater and/or jetty) built out into the water from a beach in order to prevent beach erosion or to trap and accumulate sediments that would otherwise drift along the beach face. A groin can be successful in stabilizing a beach on the up-drift side, but erosion tends to be aggravated on the down-drift side.*

[26] *University of Wisconsin Sea Grant,* Great Lakes Coastal Shore Protection Structures and Their Effects on Coastal Processes, *2013.*

feature, such as a bluff crest, while erosion is the wearing away of land. Recession is expressed as distance or a change in distance, while erosion is expressed as a volume or change in volume. Recession can be thought of as a consequence of erosion. Shoreline recession rates are usually determined by comparing aerial photographs taken on different dates.

The rate at which coastal erosion occurs is dependent on a variety of factors including Lake Michigan level fluctuations, disruption of the transport of beach-building sediments, elevated groundwater levels, storms, and surface stormwater runoff. Additional contributing factors to coastal erosion can include soil composition, vertical cracks in the upper slope of the soil, shoreline ice cover, freezing and thawing cycles, shoreline orientation, beach composition, beach width and slope, the presence or absence of shore protection, and the type of shore protection.[27] Shores that have cohesive materials, such as clay, till, and bedrock have strong binding forces. Shores that have non-cohesive materials, such as sand and/or gravel have weak or no binding forces. Like most of the Great Lakes Region, the soils in Racine County are composed of sand, gravel, clay, and clay-like material known as glacial till. Much of the bluffs along the Racine County coast are relatively high (50-200 feet) and are prone to landslides, slumping, surface rill erosion, and soil creep[28].

Lake Level Fluctuations

Lake level can be a significant factor in determining the rate of erosion along Wisconsin's coasts. As mentioned above, high Lake levels and increased wave action can worsen both coastal erosion and coastal flooding issues. As lake levels rise, bluff recession rates can also increase. Major storm events can also lead to high erosion rates because of increased wave action on the shoreline. The effects of wave-induced erosion are usually greater during periods of high Lake levels. Conversely, low Lake levels pose problems for facilities that are dependent on constant access to water, such as ports, marinas, and nearshore water utility intakes. Low water levels can also cause problems with shore protection structures, such as normally submerged timber pilings being exposed to air.

Water levels in the Great Lakes fluctuate seasonally, annually, and over multi-decade cycles. Seasonally, the lakes are at their lowest levels during the winter, when much of the precipitation is held on land in the form

---

[27] *U.S. Army Corps of Engineers-Detroit District, University of Wisconsin Sea Grant,* Living on the Coast: Protecting Investments in Shore Property on the Great Lakes, *2003.*

[28] *Soil creep (also known as downhill creep, or creep) is the slow and subtle downward progression of rock and soil down a low grade slope.*

of snow and ice, and evaporation occurs over open water. The highest seasonal levels are during the summer when snowmelt from the spring thaw and summer rains contribute to the Lake water supply. For Lake Michigan in the 30-year-period between 1991-2021, the average difference between summer high water levels and winter low water levels has been about one foot.[29] Long-term variations in Lake levels (over multi decades) depend on climatic factors such as precipitation, the presence or absence of ice cover on the Lake during the winter, and evaporation of water from the Lake.

Coastal hazard problems have been most evident in southeastern Wisconsin and Racine County during high water periods. These have occurred in recent history on Lake Michigan in the early 1950s, the early 1970s, and the mid-1980s, with water levels in 2019 approaching the record set in 1986. As of November 2021, Lake Michigan water levels continued their seasonal decline, decreasing by about 3 inches from October to November. Though Lake Michigan is about 25 inches below the highest monthly water level recorded for November in 1986, the Lake is still about 13 inches above the long-term average water level as of November 2021. Water levels are expected to continue their seasonal decline through the early winter but remain above the long-term average.[30]

Shoreline Recession and Bluff Stability Conditions

An inventory of the shoreline conditions and bluff stability within the entire Southeastern Wisconsin Region was conducted in 1977[31] by a number of coastal technical consultants under the Wisconsin Coastal Management Program (WCMP) and again in 1995 for a study published in 1997 by SEWRPC in conjunction with the WCMP.[32] The study found nine feet per year of shoreline recession over the period 1963 to 1995, with an average of 1.8 feet per year. Similarly, bluff erosion rates of up to eight feet per year, with an average of 1.1 feet per year were found for the period 1975 to 1995. With 20 of the 34 sites evaluated, the study found Racine County's bluff conditions to be mostly stable in 1995. The areas with unstable bluffs are limited to the northern part of the County, which is considered part of the City of Racine. In general, the 1995 survey

[29] *This is a calculated average from monthly water levels obtained from the National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory.*

[30] *Collaborative Action for Lake Michigan (CALM) Coastal Resilience Monthly Newsletter, November 2021.*

[31] *D.M. Mickelson, L. Acomb, N. Brouwer, T.B. Edil, C. Fricke, B. Haas, D. Hadley, C. Hess, R. Klauk, N. Lasca, and A.F. Schneider,* Technical Report, Shoreline Erosion and Bluff Stability Along Lake Michigan and Lake Superior Shorelines of Wisconsin, *Wisconsin Coastal Management Program, February 1977.*

[32] *SEWRPC Technical Report No. 36,* Lake Michigan Shoreline Recession and Bluff Stability in Southeastern Wisconsin: 1995, *December 1997.*

generally found bluff stability had improved compared to 1977 conditions. This is likely due to the construction of shoreline protection measures in areas of development.

Wisconsin Shoreline and Oblique Photo Viewer

WCMP, the Association of State Floodplain Managers (ASFPM), and Geo-Professional Consultants, LLC have developed a web mapping tool to view shoreline conditions along most of Wisconsin's Great Lakes coast. The Wisconsin Shoreline Inventory and Oblique Photo Viewer (shoreline viewer tool)[33] can be used to view and compare assessments on shoreline protection and shore and bluff conditions. Shoreline characteristics and conditions were derived from interpretation of oblique aerial photography of the Lake Michigan coastline taken in 1976 and 2007, performed by David M. Mickelson.[34] It should be noted that these interpretations represent conditions on the date that these photographs were taken and are limited by what can be seen in the photos.

In addition, geotagged oblique images can be viewed and compared on the shoreline viewer tool from 1976, 2007, 2010, 2017, 2018, 2019, 2020, and 2021. These images can be used with the interactive mapping tool to understand and evaluate how bluffs along the Racine County coast have changed over time.

The shoreline viewer tool also provides insight into current general conditions of Lake Michigan bluffs in 2021, as shown in Map 3.8. In 2021, 28.5 percent of Racine County's shoreline was considered to have moderately unstable to unstable/failing bluffs (as shown in black and red on Map 3.8).

<u>Types of Shore Protection in Racine County</u>

Table 3.18 summarizes an assessment of the types of shore protection in the County in 2018-2019, as provided on the shoreline viewer tool. About 30 percent of the shoreline in Racine County was unprotected in 2018-2019. The most common type of shore protection in the County was revetment (42.8 percent).

<u>Types of Bluff Failure in Racine County</u>

Table 3.19 specifies the types of bluff failure that was occurring at the time of the 2018-2019 assessment. Shallow slides were the most common observed type of bluff failure, occurring at 29.7 percent of the

---

[33] *Floodatlas.org*

[34] *Mickleson, D and Stone J,* Wisconsin's Lake Superior and Lake Michigan Shoreline Oblique Photography: Analysis of Changes 1976 (78) to 2007 (08), A Report to the Wisconsin Coastal Management Program, *2012*.

assessed County shoreline. This is relatively low considering that 64.3 percent of the coastline showed no obvious failures.

Long-Term (1956-2015) and Short-Term (1995-2015) Bluff Toe and Bluff Crest Recession

A recent analysis by the University of Wisconsin-Madison Coastal Sustainability and Environmental Fluid Mechanics Laboratory is also available to view on the shoreline viewer tool. The study measured long-term (1956-2015) and short term (1995-2015) bluff toe recession, bluff crest recession, and general shoreline recession along the shores of Kenosha, Milwaukee, Ozaukee, and Racine Counties.[35] Bluff recession distances were measured from historical aerial photos in Geographic Information Systems (GIS) software. The bluff crest, bluff toe, and shoreline were carefully traced on each aerial photo. The bluff crest is identified as the break in slope between the upland and the bluff slope; the bluff toe is identified as the break in slope between the bluff slope and the beach; and the shoreline is defined as the location that appears as the interface between the water and land at the time the photo was taken (see Figure 3.4). Data in Maps 3.9 through 3.12 show recession distances that have been spatially averaged along 300-foot sections of coast. The data therefore represent average recession over a distance wider than a typical parcel or shoreline frontage and should not be interpreted as recession at a specific property.

This recession analysis can provide useful insights into the historic migration of the Lake Michigan coast in Racine County. It should be noted that bluff recession can be sporadic. A bluff crest that remained unchanged for decades can recede many feet almost instantly due to a bluff collapse. This analysis represents how the bluffs have responded to historical environmental conditions and human actions over a specific time period. There will always be uncertainty in how bluff and shoreline recession will respond to future conditions.

Long-Term Bluff Toe and Crest Recession

As shown in Map 3.9, about 52.2 percent of the bluff toe in Racine County has experienced at least some recession in the 59-year long term period from 1956 to 2015. Furthermore, about 20.5 percent of the County's bluff toe was estimated to have experienced significant recession of at least 20 feet to more than 60 feet. The most severe long term bluff toe recession has occurred in the City of Racine (see Map 3.9). It is estimated that about 47.8 percent of the bluff toe in the County has either experienced no recession or has moved towards the Lake. It should be noted that accretion or small bluff toe recession distances may

---

[35] *This study was funded by the Wisconsin Coastal Management Program and the National Oceanic and Atmospheric Administration, Office for Coastal Management.*

represent areas where the bluff crest has slumped towards the shoreline or where the construction of shore protection structures has advanced the bluff toe lakeward.

Map 3.10 shows long term bluff crest recession distances in the County. About 11.6 percent of the bluff crest in Racine County has experienced at least some recession, with 2.6percent experiencing at least 20 feet of retreat. The largest bluff crest recession distances have occurred in the City of Racine. About 88.3 percent of the bluff crest in the County has had no recession or has experienced accretion, possibly due to fill added to the bluff in slope stabilization projects.

Short-Term Bluff Toe and Crest Recession

As shown in Map 3.11, about 20.9 percent of the bluff toe in Racine County has experienced at least some recession in the 20-year short term period from 1995 to 2015, with most of that percentage experiencing 0 to 10 feet of bluff toe retreat. It is estimated that 79.1 percent of bluff toe in the County has had no recession or has experienced accretion. Again, it should be noted that bluff toe accretion may represent areas where material has slumped from the bluff crest above or where the construction of shore protection structures has advanced the bluff toe lakeward.

Map 3.12 shows short term bluff crest recession distances in Racine County. About 8.1 percent of bluff crest data collected in the County has shown at least some recession in the 20-year short term period,. Bluff crest recession distances greater than 20 feet have occurred in the City of Racine and the Village of Caledonia. Conversely, 92 percent of the bluff crest in Ozaukee County has either experienced no recession or accretion during this short term period.

Coastal Flooding

Coastal flooding tends to be most serious in the low-lying areas.[36] The risk of coastal flooding is reduced when lake levels are low, however other factors such as storm-induced winds and wave run-up can cause or exacerbate coastal flooding. Likewise, when lake levels are high, storm surge, wave height, and wave run-up also influence the severity of coastal flooding. Communities positioned on low terraces are at a medium-risk of flooding, whereas communities in the County located on high bluff areas are not vulnerable to coastal flooding.[37]

---

[36] *State of Wisconsin Hazard Mitigation Plan, December 2016, op. cit.*

[37] *Ibid.*

Racine County's mid-shoreline, located in the City of Racine, is low-lying with beaches. Based on SEWRPC's parcel-based analysis, there are no structures identified within Lake Michigan's 100-year recurrence interval floodplain (special flood hazard area).

The Great Lakes Coastal Flood Study (GLCFS)—an on-going collaboration between FEMA and the U.S. Army Corps of Engineers (USACE)—will soon complete mapping for coastal flood velocity zones (V Zones) for the Great Lakes. At this time, the Lake Michigan coast has flood Zones A or AE along much of its coast, including Racine County.[38] Zones A and AE are typically inland (i.e., lakes and rivers) flood zones that do not account for wave action greater than 3 feet or storm surge. Zones V and VE represent the area along the coast that is subject to inundation by the 1-percent-annual-probability flood with additional hazards associated to wave run-up greater than 3 feet above the base flood elevation (BFE). Note, Zones AE and VE have detailed hydraulic studies to determine the BFE (i.e., elevation data), while Zones A and V do not and are approximate flood Zones. Digital Flood Insurance Rate Maps (DFIRMs) showing the new coastal V and VE Zones for the Great Lakes should be available for Southeast Wisconsin within the life span of this plan.[39]

Recent Events

2013 – Lake Michigan water levels are up an average of more than three feet since January 2013, its highest level since 1998 according to the National Weather Service. The large amount of ice cover in the winters of 2013 and 2014 has led to less evapotranspiration, contributing to rising Lake levels.

2015 – Beginning in 2015, residents in the Lake Park neighborhood of the Village of Mount Pleasant, whose homes reside on a bluff overlooking Lake Michigan, have experienced significant erosion and bluff recession issues. The erosion has been caused by a combination of wave action reaching up to the bottom of the bluff and groundwater seepage from the top of the bluff. Some property owners have reported losing 40 feet or more of land due to the erosion.

2016 – One home on Sheridan Road needed to be removed in April 2016, while another 10 to 12 homes are threatened by the receding bluff. In addition, public utilities and roads are at risk. In addition, several homes in the Village of Caledonia were also at risk due to Lake Michigan bluff erosion. As of June 2016, a project was underway to stabilize and reinforce the shoreline on a private property on Waters Edge Road.

[38] Note that the Ozaukee County FIS indicates that the Lake Michigan coastal AE Zone floodplain elevations were based on wave run-up calculations.

[39] State of Wisconsin Hazard Mitigation Plan, December 2016, op.cit.

On Novak Road erosion had undercut the bluff where a home resides, and the home's deck was at risk of falling into the Lake.

In May 2016 the Racine County Executive issued a declaration of emergency to better position the County to receive State and Federal assistance as well as to make personnel and resources available to assist affected residents. Several public meetings were hosted in the Village of Mount Pleasant in the summer of 2016 that included local, County, State, and Federal officials. The meetings provided information for property owners on temporary actions they can take to stabilize the bluff while more permanent solutions are explored. Long term solutions to stabilize bluffs could cost property owners tens of thousands of dollars, or more.[40]

2018 – On April 15th, a prolonged period of strong and gusty onshore northeast winds resulted in high waves crashing into the western shore of Lake Michigan from overnight of April 13th through the 14th, into the early morning of April 15th. Northeast winds were persistent 20 to 30 mph with frequent gusts of 35 to 45 mph for about a 24 hour period. Waves were estimated to reach 15 feet as they crashed into shore. These waves and high lake levels resulted in areas of lakeshore erosion and damage from Port Washington south to Kenosha with the most erosion in the Racine and Kenosha County lake shore areas. A prolonged period of strong winds and high waves caused erosion damage to the beach at the Wind Point Lighthouse. Erosion damage was also noted at Sam Myers Park in Racine.

2019 – On October 21st, Pershing Park Drive in the City of Racine was closed due to rocks and debris being thrown onto the roadways by high waves. The gravel parking area adjacent to the park will need to be re-graded due to the debris. Time included is when the duration of the strongest onshore winds at the Racine airport (KRAC). A period of strong east to southeast onshore winds caused high waves at the Lake Michigan shoreline for several hours. These conditions resulted in an enhanced risk of lakeshore erosion and flooding. The strongest onshore winds occurred between 10 am CDT and 4 pm CDT Monday, October 21st.

2020 – On January 11th, Lakeshore erosion at Carre Hogel Park (200' shoreline), Pershing Drive (900' shoreline), North of Zoo Beach (260' embankment/bluff and shoreline erosion), and Shoop Park (50' erosion). Strong low pressure passing by to the southeast resulted in an extended period of strong north to northeast winds along the Lake Michigan shoreline of southeast and east central Wisconsin. Wind gusts at Milwaukee Mitchell Field gusted 40 to 50 knots at time from 9 pm CST the evening of January 10 through

[40] *Mark Schaaf, "'Significant' Erosion Due to Lake Surge," Racine Journal Times, August 23, 2015.*

3 pm CST the afternoon of January 11. The persistent strong onshore winds combined with near record high Lake Michigan water levels produce severe lakeshore flooding and erosion at the Port of Milwaukee as well as at spots all along Lake Michigan from Kenosha to Sheboygan. Wave heights were estimated to be in the 10 to 18 foot range at the height of the event the morning of January 11th.

On April 30th, A slow moving low pressure area brought several inches of rain to far eastern WI over a 24-40 hour period. River and lake flooding occurred along with some road flooding. Almost all of North Beach in Racine was underwater due to lakeshore flooding and record high water levels on Lake Michigan.

Vulnerability and Community Impact Assessment

In 2021, Wisconsin Emergency Management (WEM) conducted a county-level coastal erosion risk and vulnerability assessment for the State as part of the Threat and Hazard Identification and Risk Assessment (THIRA). WEM used the statewide parcel inventory (Wisconsin Statewide Parcel Database) as the basis for estimating the existing potential losses from Lake Michigan coastal erosion. Each parcel contained information such as total parcel value, improvement value, and property class. A GIS buffer analysis was conducted to identify parcels within one-quarter and one-half mile of the Lake Michigan coastline. Parcels within one-quarter of a mile from the coast were considered to be in a High Risk Erosion Zone, while parcels within one-half mile were considered to be in a Low Risk Erosion Zone. As a result, in Racine County a total of 11,688 parcels were determined to be within the coastal risk erosion zones (see Table 3.20). Of those 11,688 total identified parcels, 10,860 were classified as residential, 789 as commercial, and 39 as manufacturing. The low-risk zone has an estimated value of improvements of more than $1.2 billion, while the high-risk zone has a value of improvements of more than $669 million, for a combined total value of improvements around $1.89 billion. It should be noted that the high and low risk coastal zones are solely based on distance from the Lake Michigan shoreline. Steps already taken, such as shoreline protection structures, likely have reduced the coastal hazard risk to many of these structures.

In addition, the analysis described above has highlighted particular areas along the Racine County coast that are of particular concern due to bluff toe and crest recession over time. These communities include the City of Racine, Village of North Bay, and Village of Wind Point.

Some low lying areas in the central portion of the County, where bluffs are not present, have been susceptible to recent beach erosion. The North Beach, Zoo Beach, and Samuel Myers Park in the City of Racine have seen significant impact due to recent high lake levels, such as consistent flooding that has caused erosion of the sand and trails.

A review of the community assets described in Chapter 2 indicate the potential for coastal hazard impacts to: 1) flood prone residential, commercial, and other developed land uses; and 2) agricultural lands. A review of the mapping of critical community facilities, emergency service facilities, and historic sites in the County indicate that there are seven childcare facilities, 23 adult care facilities, two government buildings, five public schools, five private schools, three emergency service buildings, one health clinic, and six historic sites within the 1/2 mile low risk coastal hazard zone. Critical facilities within the 1/4 mile high risk coastal hazard zone include six childcare facilities, two adult care facilities, six government buildings, two private schools, three emergency service buildings, one health clinic, and 26 historic sites (including one shipwreck in Lake Michigan). The names of these critical facilities within the high risk coastal zones are included in Appendix C. As noted above, the high and low risk coastal zones are solely based on distance from the Lake Michigan shoreline. Steps already taken, such as shoreline protection structures, likely have reduced the coastal hazard risk to many of these structures.

A review of the Lake Michigan coastal erosion conditions within Racine County indicates that there is a significant potential community impact as a result of the potential loss of land improvements and infrastructure in selected areas due to lakeshore erosion. A review of coastal flooding conditions within Racine County indicates that there is little to no potential community impact as indicated from the lack of structures within the 1-percent-annual-probability flood hazard area along the coast of the County. However, it should be noted that community impact for coastal flooding should be assessed when v zones become effective. At the time of this plan development, v zones are still preliminary and not included as part of this analysis.

Future Changes and Conditions

Changes in land use can have an impact on the potential for coastal erosion hazards to occur. Such changes relate to the potential future increase in development within the erosion hazard areas, particularly when not accompanied by proper shore protection measures. Enforcement of the current zoning procedures that are in place in the coastal communities of Racine County call for the use of shoreline protection, bluff stabilization structural measures, and bluff setbacks for new development along portions of the Lake Michigan shoreline where urban shoreline development exists, or is envisioned, and provides for a larger setback for development in areas where structural protection is not envisioned to be used due to limited planned urban development.

As discussed in the sections above, Lake Michigan is about 13 inches above the long-term average water level as of November 2021, causing some residents in the City of Racine, and Villages of Caledonia and

Mount Pleasant to experience significant erosion and bluff recession issues. In addition, climate change may lead to more drastic fluctuations in Lake Michigan water levels. Over the five-year period covered by this plan update, Lake Michigan water levels are expected to continue to fluctuate. Potential future fluctuations in Lake Michigan water levels could lead to continued bluff failures, particularly in areas that have no shoreline protection, where shoreline protection structures are not maintained adequately, or where shoreline protection structures are not built to sufficient specifications to protect against fluctuating water levels. Mitigation measures to protect areas along the Lake Michigan coast are described further in Chapter 5.

Changes over the 20th century and projections based on downscaled results from climate models indicate that there will likely be changes affecting coastal conditions over the 21st century. Coastal areas have experienced, and are projected to experience, increases in air temperatures, increases in precipitation, especially during fall, winter, and spring months, and increases in the frequency of heavy precipitation events.[41] Wind strengths have increased over the Great Lakes and are expected to continue increasing into the future.[42] In addition, wind patterns over Lake Michigan have altered. Prevailing winds during summer months shifted from coming from the southwest during the 1980s to coming from the east after 1990.[43] These climatic changes are expected to influence lake levels, coastal erosion, flooding, and shoreline stability, sometimes in complex ways. According to the NOAA Office for Coastal Management in 2015, "recent climate studies, along with the large spread in existing modeling results, indicate that projections of Great Lakes water levels represent evolving research and are still subject to considerable uncertainty."

For example, Lake Michigan is likely to be impacted by trends that act both to increase and to decrease water levels. Increased precipitation will increase water contributions to the Lake. At the same time, increases in temperatures will lead to increases in evaporation of water from the Lake. The temperature increase will also result in reduced ice cover over the winter. This affects evaporation because ice cover on the Lake acts as a cap, reducing evaporation by preventing water vapor from escaping into the air. As a result of both of these processes, evaporation from the Lake is projected to increase.[44] It should be noted that water levels

---

[41] *Wisconsin Initiative on Climate Change Impacts, 2021, op. cit.*

[42] *Desai, Austin, Bennington, and McKinnley, 2009, op.cit.*

[43] *James T. Waples and J. Val Klump, "Biophysical Effects of a Decadal Shift in Summer Wind Direction over the Laurentian Great Lakes," Geophysical Research Letters, Volume 29, pages 43-1 through 43-4, 2009.*

[44] *Wisconsin Initiative on Climate Change Impacts, 2021, op. cit.*

in the Lake vary widely around their average, with high-water and low-water decades occurring. This variability is expected to continue.

While the hazard impacts associated with water level variations should be similar in type to those impacts currently resulting from water level variations, there may be some increase in the magnitude of these impacts. While low water levels may allow beaches and beach ridges to build and beach-anchoring vegetation to move toward the Lake, they may also adversely impact shipping, power generation, and tourism. It should be noted that long periods of low water levels may lead to erosion of the lakebed, which may allow storm-generated waves to reach farther inland when water levels rise. While high water levels may benefit communities, businesses, and industries that depend upon Great Lakes waters for commercial shipping, hydro power, recreational boating, and tourism, higher water levels with increased storm frequency and intensity could increase shoreline and bank erosion. This could increase damages to lakefront property and reduce the area of beaches.

Several other elements of climate change may also act to intensify shoreline erosional processes. Increases in wind strength over the Lake and changes in prevailing wind direction would be likely to lead to greater offshore wave development. This would produce higher waves along the coast. Changes in several elements of climate may affect the stability of bluffs along the lakeshore. The amount of water contained in bluff soils is an important factor determining their stability. Friction between soil particles hold them in place. As water fills the spaces between these particles the friction between soil particles decreases, causing the soil to become more fluid and less stable. Higher lake levels and increases in 1) precipitation, 2) the frequency of heavy storms, and 3) the number of freeze-thaw cycles will all contribute to shoreline bluffs becoming less stable and more susceptible to slumping. Prolonged dry periods and droughts may also contribute to reduced stability of coastal bluffs. As bluff soils dry out, cracks in the soil can form, weakening the surface soil. During long-term droughts, these cracks can develop into deep fractures. Such fractures can allow surface water to penetrate deep into bluff soils. If heavy rainfall events occur following a drought, they may cause rapid saturation of dry, fractured bluff soils. This could cause a long-term major slope failure.

Multi-Jurisdictional Risk Management

Shoreline erosion, bluff failure, and coastal flooding, when combined, present a moderate risk in Racine County. As discussed above, coastal hazard risks are present in all five local units of government in Racine County along Lake Michigan. Areas of recent active erosion have been identified within the City of Racine and the Villages of Caledonia, Mount Pleasant, and Wind Point. In addition, there is a need for continued surveillance of coastal conditions in the Villages of North Bay and Wind Point.

Severe Winter Storms (Heavy Snowstorm, Blizzard, Ice Storm)

Winter storms can vary in size and strength and include heavy snowstorms, blizzards, freezing rain, sleet, ice storms, and blowing and drifting snow conditions. Extremely cold temperatures accompanied by strong winds can result in wind chills that cause bodily injury, such as frostbite and death. A variety of weather phenomena and conditions can occur during winter storms. For clarification, the following are National Weather Service approved descriptions of winter storm elements:

- **Heavy Snowfall**—The accumulation of six or more inches of snow in a 12-hour period or eight or more inches in a 24-hour period.

- **Blizzard**—An occurrence of sustained wind or frequent gusts 35 mph or higher accompanied by falling or blowing snow, and visibilities of one-quarter mile or less, for three or more hours.

- **Ice Storm**—An occurrence of rain falling from warmer upper layers of the atmosphere to the colder ground, freezing upon contact with the ground and exposed surfaces, resulting in ice accumulations of one-quarter inch or more within 12 hours or less.

- **Freezing Drizzle/Freezing Rain**—The effect of drizzle or rain freezing upon impact on objects that have a temperature of 32°F or below.

- **Sleet**—Solid grains or pellets of ice formed by the freezing of raindrops or the refreezing of largely melted snowflakes. This ice does not cling to surfaces.

- **Wind Chill**—An apparent temperature that describes the combined effect of wind and low air temperatures on exposed skin.

Much of the snowfall in Wisconsin occurs in small amounts of between one and three inches per occurrence. Heavy snowfalls that produce at least eight to 10 inches of widespread accumulation happen on the average only once per winter season across southern Wisconsin. In addition, a snowfall event of six to eight inches usually occurs once per winter. The southwestern and southeastern portions of Wisconsin receives most of its snow during mid-winter. Snowfall amounts in Racine County average 38 inches per season in the far southwest corner to about 45 inches near Lake Michigan.

Lake Michigan can have both an enhancement effect and a dampening effect on snowfall totals in the County. Warmer water temperatures in the Lake can keep winter air temperatures on land near the lakeshore warm enough for precipitation to fall as rain where it may fall as snow only a mile further inland. On the other hand, lake effect snow bands can drop significant amounts of snow on nearshore communities, while areas slightly further inland may see none. Lake effect snow occurs when cold air moves across the relatively warm open waters of Lake Michigan, causing warm air and moisture to transfer into the lowest portion of the atmosphere, forming snow producing clouds.

Blizzard-like conditions often can occur during heavy snowstorms when gusty winds cause severe blowing and drifting of snow, even if the conditions did not last long enough to be considered a true blizzard. True blizzards are not common in Wisconsin. However, when they do occur, they tend to affect the eastern counties near Lake Michigan. Due to less frictional drag over Lake Michigan, northwest windstorms can reach higher speeds. According to the National Climatic Data Center (NCDC) and shown in Table 3.21, Racine County has experienced two blizzard events from 2011 to 2021.

Freezing rain, ice, and sleet storms can occur at any time from October into April. In a typical winter season, there are three to five light freezing rain events in the southeastern Wisconsin region. On average, a major ice storm occurs about once every other year somewhere in the State and once every seven years over southeastern Wisconsin. If one-half inch of rain freezes on trees and utility wires, extensive damage can occur, especially if accompanied by high winds that compound the effects of the added weight of the ice. There are also between three and five instances of glazing (less than one-quarter of an inch of ice) throughout the State during a normal winter.

Recent Events

Generally, the winter storm season in Wisconsin runs from October through March. Severe winter weather has occurred, however, as early as September and as late as the latter half of April and into May in some locations in the State. The average annual duration of snow cover in Racine County is approximately 85 days. Table 3.21 lists the recent winter storm events that have occurred in Racine County from 2011 to 2021. A few examples of recent events from Table 3.21 are noted below.

2011 – During the overnight hours of February 1 to February 2, 2011, a powerful low pressure center passing south of Wisconsin produced blizzard conditions across much of southern Wisconsin (the Groundhog Day Blizzard of 2011). Snow associated with the system began in the mid-afternoon hours in far southern Wisconsin and pushed northward into the State through the evening. Twenty-four hour snowfall totals were between 20 and 26 inches, with 24 inches of snow reported at the Racine Wastewater Treatment Plant, setting a one-day record. This was in addition to several inches of snow that had fallen on January 31. In the City of Racine, this storm set new two-day and three-day snowfall records, with snowfall totals of 26 inches. Very strong winds were associated with this storm for an extended period of time. Sustained northeast winds of 30 to 40 mph were common through the event, with peak wind gusts between 45 and 65 mph. Strong wind gusts were reported near Lake Michigan, with the lakeshore observation site at Kenosha reporting a gust of 64 mph. The combination of high winds and heavy snow created widespread sustained visibilities of less than one-quarter mile, with frequent whiteout conditions and near zero visibilities. Many locations saw blizzard conditions beginning early during the evening of February 1 and continuing through the early morning hours of February 2. Snow drifts of four to 12 feet were common, with reports of some drifts reaching up to 15 feet in open rural areas. Drifting snow closed county highways and roads with many stranded motorists having to be rescued from vehicles buried in the drifting snow. The Racine Fire Department responded to 150 emergency calls related to the storm. About 100 National Guardsman were mobilized statewide in response to the Governor's emergency declaration for 29 counties. At the height of the storm, We Energies reported 5,200 customers were without power across southeastern Wisconsin. A Yorkville woman died from exposure when she became disoriented in the whiteout conditions, after she was dropped off by a tow truck driver at her driveway and was unable to find her way into her home. An estimated $1.4 million was spent in Racine County for snow removal. Trucks were forced to dump snow cleared from roadways at Pershing Park, where snow piles reached 70 feet in height. A Presidential disaster declaration was issued for 11 Wisconsin Counties, including Racine County, as a result of the Groundhog Day Blizzard of 2011. Racine County received almost $825,000 in public assistance under this declaration.

2015 – Intensifying low pressure tracked from the central Great Plains to southeast Indiana the night of January 31st into the evening of February 1st. This resulted in a long duration winter storm and blizzard over portions of southern Wisconsin. Snowfall of 6 to 14 inches accumulated over far southern and eastern Wisconsin. Winds gusted from 30 to 40 mph with blizzard conditions, including frequent whiteouts from heavy and blowing snow, in Racine and Kenosha Counties. Vehicle slide-offs and accidents were prevalent. The Milwaukee County Medical Examiner Office reported the death of three men who died after collapsing from shoveling snow.

Vulnerability and Community Impact Assessment

Between 2011 and 2021, 93 winter weather events have affected Racine County. Based on this, it is estimated that Racine County experiences an average of 9.3 winter weather events per year. It should be noted that during this time period there has been considerable variation around this average, with the County experiencing as few as four winter storm events in some years and as many as 13 winter storm events in other years (Table 3.21).

The NCDC database contains few reports of property damages and crop damages for winter storms. For Racine County, records of crop insurance indemnities from the U.S. Department of Agriculture Risk Management Agency show that about $406,330 have been paid out between 2011 and 2021 due to damage caused by winter related weather, such as frost, freeze, or snow. In addition, since 2001, about $20,000 in property damages have been reported as having been caused by winter weather events in Racine County. Given that the County received almost $825,000 in public assistance under the disaster declaration related to the Groundhog Day blizzard of 2011, the reported damages in the NCDC database clearly represent an underestimate of the potential damages associated with severe winter storms impacting Racine County.

Winter storms can present a serious threat to the health and safety of affected citizens and can result in significant damage to property. Snow and ice are the major hazards associated with winter storms and are the eighth most destructive natural hazard in Wisconsin. Snow and ice can cause traffic accidents, bring down telephone and power lines, damage trees, impede transportation, burst water pipes, and can tax the public's capabilities for snow removal during heavy storms. A major winter storm can have a serious impact on a community. Loss of heat and mobility are key complications that contribute to winter storm fatalities.

Ice storms and freezing rain are less common than snow but produce road conditions that can make travel hazardous. Even fog or mist on cold roads can produce a glaze of ice that makes travel slippery and dangerous. Accumulated ice can cause the structural collapse of buildings, bring down trees and power lines, causing property damage, loss of power, and isolate people from assistance or services.

Future Changes and Conditions

Based upon recent historical data from the period 2011-2021, Racine County can expect to experience an average of 9.3 winter storm events per year. It should be noted that the historical record shows considerable variation among years in the numbers of these events that occurred. While it would be expected that in some years the County will experience either fewer events or more events than the average number, over the five-year term of this plan update the average annual number of events is not expected to change.

Changes in the 20th century and projections based on downscaled results from climate models indicate that there will likely be changes in winter storm conditions affecting Racine County over the 21st century. It is projected that by 2055, the average amount of precipitation that Racine County receives during the winter will increase by about 0.5 to 1.0 inch (measured as water), an increase of about 25 percent.[45] Due to increasing winter temperatures, the amount of precipitation that falls as rain during the winter rather than as snow is projected to increase significantly. It is also projected that freezing rain will be more likely to occur.

It should also be noted that the likelihood of lake effect snow occurring could be affected by climate change. A lack of ice cover over Lake Michigan during the winter promotes the development of lake effect snow. Rising temperatures during the winter will reduce the frequency and extent of ice cover over the Lake. Because the increase in temperature may also result in some of this precipitation falling as rain, it is not clear whether this will lead to an increase in the frequency of lake effect snow events.

Multi-Jurisdictional Risk Management

Based upon a review of the historic patterns of winter storm events in Racine County, there are no specific municipalities that have unusual risks. Rather, the events are of a uniform countywide concern.

Drought

Drought is the result of a natural decline in the expected precipitation over an extended period of time, and occurs in virtually every climate on the planet, including areas of high and low precipitation. The severity of drought can be aggravated by other climatic factors, such as prolonged high winds, high temperatures, and low relative humidity. Drought is a complex natural hazard which is reflected in the following four definitions commonly used to describe it:

1. Meteorological drought: The degree of dryness, expressed as a departure of actual precipitation from expected average or normal amount, based on monthly, seasonal, or annual time scales

2. Hydrological drought: The effects of precipitation shortfalls on streamflow, reservoir, lake, and groundwater levels

3. Agricultural drought: Soil moisture deficiencies relative to water demands of crop life

[45] *Wisconsin Initiative on Climate Change Impacts, 2021, op. cit.*

4. Socioeconomic drought (or water management drought): Occurs when the demand for water exceeds the water supply, resulting in a water shortage.

A drought's severity depends on several factors, including its duration, its intensity, its geographic extent, and the demands for water for use by both humans and vegetation.

Drought can be difficult to define in exact terms. This is partly due to its multi-dimensional nature and partly due to the ways it differs from other natural hazards. There is no exact and universally accepted definition of what constitutes a drought. The onset and end of a drought are difficult to determine due to the slow accumulation of its impacts and the lingering of its effects after its apparent end. The impacts of drought are less obvious than those of some other hazards and may be spread over a larger geographic area. These characteristics have hindered the preparation of drought contingency or mitigation plans by many governments and can make it difficult to perform an accurate risk assessment analysis.

Droughts can have several impacts. They can reduce water levels and flows in surface waterbodies and groundwater. This can cause shortages of water for human and industrial consumption, hydroelectric power, recreation, and navigation. Water quality may also decline, and the number and severity of wildfires may increase during a drought. Severe droughts may result in reduced yields or the loss of agricultural crops and forest products, undernourished wildlife and livestock, and lower land values.

One method to measure the magnitude of a drought is by using the Palmer Drought Severity Index. This method considers factors like temperature, soil moisture, and precipitation, which are entered into an algorithm that returns results between -4 (extreme drought) and 4 (extremely moist) with zero being normal conditions. The U.S. Drought Monitor uses the Palmer Index, along with other indicators, to rate drought conditions into categories, as described below in Figure 3.5.

Wisconsin is vulnerable to agricultural drought. The State has approximately 14.2 million acres of farmland on 64,100 farms.[46] Even small droughts of limited duration can significantly reduce crop growth and yields, adversely affecting farm incomes and local economies. Droughts significantly increase the risk of forest fires and wildfires. Additionally, the loss of vegetation in the absence of sufficient water to maintain it can result in increased flooding and soil erosion, even from average rainfall.

[46] *State of Wisconsin Department of Agriculture, Trade and Consumer Protection, 2022 Wisconsin Agricultural Statistics.*

Estimates of agricultural losses experienced in Racine County due to drought over the period 2011 to 2021 are shown in Table 3.22. Due to inconsistent reporting with NCDC data, these estimates come from records of indemnities paid to agricultural operators by Federal crop insurance programs.[47] The loss estimates reflect several factors. First, crop losses often go unreported. Second, Federal crop insurance policies offer coverage to only certain types of crops in any particular year. Third, agricultural operators generally insure only a portion of their crops when purchasing Federal crop insurance. Thus, loss estimates are likely to represent underestimates of actual losses. It should be noted that indemnities for drought related losses were paid out in most years. This probably reflects variability in rainfall causing localized crop losses. Based on these sources, it is estimated that Racine County experienced crop damages in excess of $1.9 million between 2011 and 2021. Based on this, average annual crop losses due to drought in Racine County are estimated to be about $176,037.

Small droughts of shortened duration have occurred in Wisconsin at an interval of about once every 10 years since the 1930s. Extended, widespread droughts have been infrequent in Wisconsin. The five most significant droughts, in terms of severity and duration, are 1929-1934, 1948-1950, 1955-1959, 1976-1977, and 1987-1988.

The 1929-1934 drought probably was the most significant in Wisconsin history considering its duration, as well as its severity. This drought affected a large majority of the United States and contributed to the Dust Bowl period that greatly damaged agriculture throughout the County (see Figure 3.6). Wisconsin experienced at least a 75-year recurrence drought interval in most of the State and over 100-year recurrence drought interval in certain areas. The severe economic impact of the Depression compounded its effects. The drought continued with somewhat decreased effect until the early 1940s in some parts of the State.

Recent Events

The only drought event that has occurred recently between 2011 and 2021 took place in 2012. A lack of rain over south central and southeastern Wisconsin during June 2012 allowed a drought to slowly develop. The intensity of this drought increased rapidly. By July 3, conditions in Racine County had progressed from abnormally dry to moderate drought. By July 17, Racine County was experiencing extreme drought. The drought was moderated by several rounds of thunderstorms that moved through the area during the latter half of July; however, this rain came too late for much of the corn crop which had passed the critical pollination stage. In addition, not enough precipitation was deposited by these storms to end the drought.

---

[47] *Payments of crop insurance indemnities are reported by the U.S. Department of Agriculture Risk Management Agency.*

Severe drought conditions continued in Racine County until late August and moderate drought conditions persisted until the end of October. Conditions remained abnormally dry in Racine County into March 2013. The drought reduced crop yields. Agricultural operators in Racine County received over $1.21 million in crop insurance indemnities in 2012 due to drought (Table 3.22). The drought also forced sell offs of some dairy and beef cattle herds. Farmers also reported that heat impacts to cows reduced milk production, in some instances by as much as 20 percent. In response to this drought, the Governor declared a drought emergency and authorized the WDNR to expedite permit applications for water withdrawals from lakes and streams for the purpose of watering crops.

Vulnerability and Community Impact Assessment

Racine County is vulnerable to agricultural drought. There are about 111,884 acres of farmland on 611 farms.[48] Even small droughts of limited duration can significantly reduce crop growth and yields, adversely affecting farm income. More substantial events can decimate croplands and result in total loss, hurting the local economy. Due to the importance of agriculture to the Racine County economy and the potential for large crop losses, drought is a major natural hazard threat. There are also 101 miles of major streams, five major and numerous smaller lakes, and over 19,000 acres of wetlands which can also be negatively impacted due to drought conditions. In addition, groundwater levels can be affected by drought conditions. This is most important in the portion of the County west of IH 94, as well as limited areas of development east of IH 94, which rely on groundwater as a source of water supply. Severe droughts may only happen on average once every 25 or 50 years, but the 1976 drought proves that, while severe droughts are rare, they can be devastating to agriculture, damaging to the local economy, and negatively impact the natural surface water system and groundwater supply system.

In 2017, the most recent year for which data are available, the market value of agricultural products sold by farms in Racine County was about $86.4 million. This was comprised of about $64.6 million in crops and $21.7 million in livestock, poultry, and their products.[49] Based on the current average estimate of $176,037 in crop losses per year, it can be expected that approximately 1.8 percent of the market value of all crops, or about 1.3 percent of the market value of all agricultural products sold by farms in the County, will be lost to drought each year. It is also expected that there will be considerable variation among years in the number of losses experienced.

---

[48] *United States Department of Agriculture, National Agricultural Statistics Service, 2017 Census of Agriculture.*

[49] *U.S. Department of Agriculture National Agricultural Statistics Service op. cit.*

The ample supply of fresh water available in the Great Lakes and the Mississippi River basins help to minimize water supply problems in Racine County. However, during a severe drought some wells, mainly private wells, will go dry. It is agriculture that is most vulnerable to drought, as many farms in Racine County do not irrigate.

A review of the community assets described in Chapter 2 indicate the potential for drought hazard events to impact: 1) residents at a countywide level, 2) agricultural croplands, 3) livestock, 4) municipal water utilities, and 5) natural surface and groundwater reserves.

Future Changes and Conditions

Some of these episodes are likely to be of short duration. The statewide historical record indicates that severe droughts can be expected to occur at roughly 10-year intervals. As can be seen in Figure 3.7, southeastern Wisconsin regularly experienced drought to at least a moderate level two to three times every ten years from 1895 to 2022.[50] It is not expected that the probability of drought will change during the five-year term of this plan update.

Historical changes over the 20th century and projections based on downscaled results from climate models indicate that there will likely be changes in drought conditions affecting Racine County over the 21st century. By mid-century, average temperatures are projected to rise, leading to longer summers and shorter winters. The temperature increase will also lead to a longer growing season and increased rates of evapotranspiration during summer and early fall months. While the amount of rain during the summer is not projected to change, a greater proportion of precipitation is projected to fall in heavy rainfall events. This will result in a greater number of dry days during the summer. More dry days, coupled with higher summer temperatures and increases in evapotranspiration rates, will increase the likelihood of summer droughts occurring.[51]

Multi-Jurisdictional Risk Management

Based upon a review of the potential impacts of droughts in Racine County, the areas most susceptible to hazard conditions are the agricultural communities, the municipalities served by public water supply which use groundwater as a source of supply, and those communities which have the largest numbers of private wells. This includes all of the communities in the County, except the City of Racine and the Villages of

---

[50] *University of Wisconsin-Madison, Atmospheric and Oceanic Sciences, www.aos.wisc.edu.*

[51] *Wisconsin Initiative on Climate Change Impacts, 2021, op. cit.*

Elmwood Park, North Bay, Sturtevant, and Wind Point. The events are of a uniform countywide concern, with those communities with largely agricultural land uses being the most vulnerable to risk.

SEWRPC Community Assistance Planning Report No. 266 (4th Edition)

RACINE COUNTY HAZARD MITIGATION PLAN UPDATE: 2023-2028

Chapter 3

ANALYSIS OF HAZARD CONDITIONS

TABLES

#263192 – Racine Co HMP Table 3.1
500-1147
JED/KMM/mid
1/5/23; 7/19/2022

Table 3.1
Perceived Risks of Hazards as Determined by Hazard Vulnerability and Risk Assessment Survey: 2022

Hazard[a]	Probability *Likelihood this will occur*	Human Impact[b] *Possibility of death or injury*	Property Impact[b] *Physical losses and damages*	Business & Agency Impact[b] *Interruption of services*	Preparedness[b] *Mitigation or pre-planning*	Total Risk[c] *Relative threat*	Rank[d]
Tornado	2.094	2.531	2.576	2.469	2.182	11.294	1
Stormwater Flooding	2.406	1.844	2.242	1.970	2.182	9.322	2
Ice Storm	2.387	2.094	1.788	2.250	2.273	9.212	3
High Straight-Line Wind	2.531	2.000	2.030	1.879	2.364	8.974	4
Heavy Snowstorm	2.719	1.875	1.636	2.303	2.576	8.805	5
Riverine Flooding	2.313	1.906	2.212	1.727	2.061	8.753	6
Blizzard	2.469	2.063	1.667	2.364	2.576	8.683	7
Extreme Cold	2.656	2.156	1.545	1.818	2.273	8.625	8
Lake Michigan Bluff Failure	2.129	1.594	1.938	1.364	1.061	8.163	9
Extreme Heat	2.406	2.219	1.455	1.636	2.030	7.891	10
Lake Michigan Erosion	2.281	1.484	1.697	1.273	1.152	7.533	11
Thunderstorm	2.719	1.875	1.697	1.576	2.485	7.240	12
Hail	2.452	1.594	1.879	1.364	2.212	6.433	13
Drought	2.219	1.719	1.364	1.303	1.697	5.965	14
Lightning	2.563	1.688	1.636	1.394	2.424	5.877	15
Wildfire	1.323	1.594	1.758	1.515	1.303	4.713	16
Dam Failure	1.219	1.688	1.806	1.697	1.394	4.628	17
Fog	2.406	1.375	1.182	1.152	1.909	4.329	18
Lake Michigan Coastal Flooding	1.469	1.219	1.333	1.061	1.212	3.526	19
Land Subsidence	1.419	1.156	1.182	1.094	1.152	3.237	20
Inland Lake Flooding	1.281	1.219	1.563	1.242	1.576	3.136	21
Earthquake	0.906	1.250	1.364	1.375	0.939	2.763	22
Inland Landslide	1.031	1.156	1.121	1.182	0.848	2.692	23
Dust Storm	1.031	1.000	1.030	0.970	1.121	1.938	24

Note: Ranking is based on the weighted average of the number of votes received for each score of low, moderate, or high.

[a] *Score/Ranking for Each Hazard from Survey123: High (3); Moderate (2); Low (1); N/A (0)*

[b] *Severity = Sum of Impact – Preparedness*

[c] *Total Risk = Probability x Severity*

[d] *Perceived threat/rank increases with weighted average and percentage.*

Source: SEWRPC

#263911 – Racine Co HMP Table 3.2
500-1147
JED/KMM/mid
1/5/2022; 7/19/2022

Table 3.2
Summary of Hazards to be Considered in the Racine County Hazard Mitigation Plan

Hazard	Risk of Occurrence	Damage to Property	Threat to Life Safety	Duration of Impact	Size of Area Affected
	(high, medium, or low)			(long, moderate, or short)	(large, medium, or small)
Inland Flooding (stormwater, riverine, inland lake, dam failure)	High	High	Medium	Moderate	Large
Severe Thunderstorms Combined (thunderstorm, high straight-line winds, hail, lightning)	High	Medium	Medium	Long	Large
Tornadoes	Low	High	High	Short	Small
Severe Winter Storms (heavy snowstorm, blizzard, ice storm)	High	Low	Medium	Moderate	Large
Temperature Extremes (extreme heat, extreme cold)	High	Low	Medium	Long	Large
Drought	Medium	Low	Medium	Long	Large
Lake Michigan Coastal Hazards (erosion, recession, flooding)	High	Medium	Medium	Long	Medium

Source: SEWRPC

#263905 – Racine Co HMP Table 3.3
500-1147
JED/KMM/mid
12/29/2022; 7/19/2022

Table 3.3
Summary of Estimated Disaster Damages and Assistance in Racine County for Federally Declared Disaster Emergencies: 2001-2021

Date of Disaster and Event(s)	Estimated Property and Crop Damages ($)	Public Assistance[a] ($)	Individual Assistance[b] ($)
2001 – Snow (DR-3136)	--	5,380,816	--
2001 – Severe Storms, Flooding, & Tornadoes (DR-1369)	65,000	19,743,137	--
2002 – Severe Storms & Flooding (DR-1429)	--	2,158,899	--
2002 – Severe Storms, Flooding, & Tornadoes (DR-1432)	--	3,547,202	--
2004 – Severe Storms & Flooding (DR-1526)	6,622,000	10,868,369	6,568,870
2005 – Hurricane Katrina Evacuation (DR-3249)	--	1,236,260	--
2007 – Severe Storms & Flooding (DR-1719)	2,580,000	10,250,605	8,012,383
2008 – Record Snow & Near Record Snow (DR-3285)	--	8,596,849	--
2008 – Severe Storms, Flooding, & Tornadoes (DR-1768)	3,778,000	48,563,081	56,679,489
2010 – Severe Storms, Flooding, & Tornadoes (DR-1933)	46,000	4,019,463	--
2010 – Severe Storms & Flooding (DR-1944)	6,000	8,143,719	--
2011 – Severe Winter Storm & Snowstorms (DR-1966)	--	11,708,670	61,762,768
2012 – Severe Storms & Flooding (DR-4076)	10,000	8,488,330	--
2013 – Severe Storms & Flooding (DR-4141)	--	5,934,364	--
2016 – Severe Storms & Flooding (DR-4276)	--	11,488,732	--
2016 – Severe Storms & Flooding (DR-4288)	--	9,108,327	--
2017 – Severe Storms, Straight-Line Winds, & Flooding (DR-4343)	--	8,928,512	--
2018 – Severe Storms, Straight-Line Winds, & Flooding (DR-4383)	7,000	7,620,232	--
2018 – Severe Storms, Straight-Line Winds, Flooding, & Tornadoes (DR-4402)	--	36,974,388	8,902,520
2019 – Severe Storms, Straight-Line Winds, Flooding, & Tornadoes (DR-4459)	3,000	17,892,260	--
2020 – Severe Winter Storm & Flooding (DR-4477)	4,000,000	5,168,656	--
Total	17,117,000	245,820,871	141,926,030

[a] *Public assistance includes assistance to local units of government and nonprofit organizations.*

[b] *Individual assistance includes disaster assistance through FEMA programs and disaster loans from the U.S. Small Business Administration to individuals, households, and businesses.*

Source: National Climatic Data Center, U.S. Department of Agriculture Risk Management Agency, Wisconsin Emergency Management, Racine County Office of Emergency Management, and SEWRPC

Table 3.4
Historical Hazard Events Recorded in Racine County: 2001-2021

Event	Number of Events	Deaths	Injuries	Property Damages ($)	Crop Damages ($)
Drought	18	0	0	0	525,000
Tornadoes	7	0	3	6,122,000	11,000
Severe Thunderstorms Combined (thunderstorm, high straight-line winds, hail, lightning)	250	1	10	4,543,000	35,000
Flooding (stormwater, riverine, coastal, inland lake, dam failure)	34	1	0	32,543,000	8,876,000
Temperature Extremes (extreme heat, extreme cold)	31	1	0	5,000	0
Severe Winter Storms (heavy snowstorm, blizzard, ice storm)	161	1	0	20,000	0
Total	567	4	13	43,233,000	9,447,000

Source: The National Climatic Data Center (NCDC), National Oceanic and Atmospheric Administration (NOAA), and the National Environmental Satellite, Data and Information Service (NESDIS), and the U.S. Department of Agriculture Risk Management Agency

#263908 – Racine Co HMP Table 3.5
500-1147
JED/KMM/mid
12/29/2022; 7/19/2022

Table 3.5
Racine County Severe Weather History: 2001-2021

Year	Flash Flood Warning	Flood Warning	Severe Thunderstorm		Tornado	
			Watch	Warning	Watch	Warning
2001	0	0	10	7	1	1
2002	0	0	7	6	1	0
2003	1	0	9	4	3	0
2004	4	0	15	16	5	0
2005	0	0	11	5	0	3
2006	2	0	19	19	3	0
2007	4	3	2	11	3	0
2008	6	15	9	19	5	4
2009	3	7	8	8	1	2
2010	1	7	7	9	8	7
2011	0	1	10	17	2	0
2012	0	0	7	11	0	0
2013	0	8	5	8	2	4
2014	1	1	8	11	1	1
2015	1	1	5	15	2	2
2016	1	0	7	8	0	0
2017	2	6	10	15	2	0
2018	0	12	4	6	1	0
2019	2	8	8	4	0	0
2020	1	6	5	8	2	3
2021	0	0	4	7	0	1
Total	29	75	170	214	42	28

Source: National Oceanic and Atmospheric Administration, National Weather Service, and Iowa State University College of Agriculture – Department of Agronomy, "Iowa Environmental Mesonet"

#263913 – Racine Co HMP Table 3.6
500-1147
JED/KMM/mid
1/3/23; 7/19/2022

Table 3.6
Enhanced Fujita Scale Characteristics

EF-Scale	Wind Speed (miles per hour)[a]	Character of Damage	Relative Frequency (percent)
EF0 (weak)	65-85	Light	53
EF1 (weak)	86-110	Moderate	32
EF2 (strong)	111-135	Considerable	11
EF3 (strong)	136-165	Severe	3
EF4 (violent)	166-200	Devastating	1
EF5 (violent)	> 200	Incredible (rare)	<1

[a] *Equivalent wind speeds associated with the Enhanced Fujita Scale represent a three-second gust of wind.*

Source: National Oceanic and Atmospheric Administration

#263914 – Racine Co HMP Table 3.7
500-1147
JED/KMM/mid
1/5/23; 7/19/2022

Table 3.7
Areal Extent of 1-Percent-Annual-Probability Floodplain by Community in Racine County: 2022

Community	Area (acres)
Cities	
Burlington	727.0
Racine	620.2
Villages	
Caledonia	1,721.5
Elmwood Park	0.0
Mt. Pleasant	1,327.3
North Bay	1.7
Raymond	1,722.2
Rochester	738.3
Sturtevant	74.3
Union Grove	48.5
Waterford	124.3
Wind Point	62.9
Yorkville	1,684.2
Towns	
Burlington	5,213.3
Dover	2,088.4
Norway	7,672.0
Waterford	3,157.4
Total	26,983.4

Source: Federal Emergency Management Agency and SEWRPC

#263915 – Racine Co HMP Table 3.8
500-1147
JED/KMM/mid
1/5/23; 7/19/2022

Table 3.8
Wisconsin Department of Natural Resources Dam Inventory Information: 2021

Map ID	Community	Dam Name		Owner Organization	Size	Structural Height (ft.)	Hazard Potential
		Official	Local				
1	Racine	Horlick Dam	--	Racine County	Large	19.0	Low
2	Waterford	Waterford	Buena Lake Dam	Racine County	Large	10.0	Significant
3	Spring Prairie	Honey Lake[a]	Sugar Creek	Honey Lake Protection & Rehabilitation District	Large	12.0	Low
4	Burlington	Burlington	Echo Lake Dam	City of Burlington	Large	10.0	Significant
5	Vernon	Reischl[b]	--	Norris, Inc.	Large	13.0	Low
6	Rochester	Rochester	--	Racine County	Large	9.0	Low
7	Dover	Eagle Lake	Eagle Lake Property Owners Association	Racine County	Large	8.0	Low
8	Norway	Wind Lake	--	Racine County	Large	7.0	Low
9	Norway	Lake Denoon	Riparians	Riparians	Small	2.0	Low
10	Norway	Waubeesee	--	Town of Norway	Large	6.5	Low
11	Burlington	Browns Lake	Even J. Sells	Even J. Sells	Small	4.0	Low
12	Burlington	Bohner Lake	WDNR	Racine County	Small	5.0	Low
13	Burlington	Long Lake	--	Riparians	Small	2.0	Low
14	Norway	Lake Kee Nong A Mong	--	Town of Norway	Small	4.0	Low
15	Mt. Pleasant	Colonial Park Environmental Center	--	City of Racine	Small	6.0	Low
16	Waterford	Joseph Shaffer	--	--	Small	13.0	Low
17	Burlington	Bohner Pond	--	Racine County	Small	12.0	Low
18	Yorkville	Hickory Lake	Dremel	--	Large	20.0	Significant
19	Mt. Pleasant	Pleasant Valley Lake	--	--	--	--	Low

[a] *Dam is located in Walworth County immediately west of the Racine County Line.*

[b] *Dam is located in Waukesha County immediately west of the Racine County Line.*

Source: Wisconsin Department of Natural Resources and SEWRPC

#263916 – Racine Co HMP Table 3.9
500-1147
KMM
7/19/2022

Table 3.9
Recent Flood Events in Racine County: 2011-2021

Date	Location	Type	Deaths	Injuries	Property Damages ($)	Crop Damages ($)
9/26/2011	Ives Grove	Flood	1	--	6,000.00	1,000.00
4/18/2013	Burlington	Flood	--	--	10,000.00	1,000.00
4/18/2013	Kneeland	Flood	--	--	3,000.00	1,000.00
5/12/2014	Bohners Lake	Flash Flood	--	--	--	--
7/12/2017	Honey Lake	Flash Flood	--	--	300,000.00	15,000.00
7/12/2017	Honey Lake	Flood	--	--	23,500,000.00	1,000.00
2/20/2018	Caldwell	Flood	--	--	5,000.00	--
10/1/2018	Kneeland	Flood	--	--	--	5,000.00
10/6/2018	Kneeland	Flood	--	--	--	1,000.00
10/6/2018	Burlington	Flood	--	--	1,000.00	--
3/14/2019	Rochester	Flood	--	--	1,000.00	--
4/29/2020	Kneeland	Flood	--	--	1,000.00	--
5/1/2020	Kneeland	Flood	--	--	1,000.00	--
5/17/2020	Kneeland	Flood	--	--	5,000.00	--
5/18/2020	Downtown Racine	Flood	--	--	5,000.00	--
8/10/2020	Wind Point	Flash Flood	--	--	1,000.00	--
		Total	1	0	23,839,000.00	25,000.00

Source: The National Climatic Data Center (NCDC), National Oceanic and Atmospheric Administration (NOAA)

Table 3.10
Estimated Flood Damages for a 1-Percent-Annual-Probability Flood in Racine County

Community	Number of Structures in Floodplain	Flood Damages		
		Direct ($)	Indirect ($)	Total ($)
Cities				
Burlington	33	838,710	172,390	1,011,100
Racine	166	4,548,880	1,140,730	5,689,610
Villages				
Caledonia	7	153,150	37,940	191,090
Elmwood Park	0	--	--	--
Mt. Pleasant	46	1,546,880	376,650	1,923,530
North Bay	0	--	--	--
Raymond	6	195,340	30,080	225,420
Rochester	13	298,910	73,250	372,160
Sturtevant	1	26,160	10,460	36,620
Union Grove	0	--	--	--
Waterford	13	688,720	122,670	811,390
Wind Point	0	--	--	--
Yorkville	17	400,270	114,270	514,540
Towns				
Burlington	67	529,510	114,350	643,860
Dover	28	488,190	90,900	579,090
Norway	207	5,650,830	941,810	6,592,640
Waterford	44	646,770	99,700	746,470
Total	648	16,012,320	3,325,200	19,337,520

Note: Estimated damages are based on assessed improvement values in 2022.

Source: Wisconsin Department of Natural Resources and SEWRPC

#263919 – Racine Co HMP Table 3.11
500-1147
JED/KMM/mid
1/9/2023; 7/19/2022

Table 3.11
Recent Severe Thunderstorms Combined Events in Racine County: 2011-2021

				Reported Damages			
Date	**Location**	**Event Type**	**Magnitude**	Deaths	Injuries	Property Damages ($)	Crop Damages ($)
February 18, 2011	Racine County	Strong Wind	30 mph	--	--	2,000.00	--
April 15, 2011	Racine County	Strong Wind	36 mph	--	--	3,000.00	--
May 11, 2011	Bohners Lake	Hail	0.88 in.	--	--	--	--
May 15, 2011	Racine County	Strong Wind	46 mph	--	--	5,000.00	--
May 22, 2011	Burlington	Thunderstorm Wind	81 mph	--	--	150,000.00	--
May 22, 2011	Union Grove	Thunderstorm Wind	60 mph	--	--	--	--
June 8, 2011	Burlington	Thunderstorm Wind	65 mph	--	--	--	--
June 8, 2011	Sturtevant	Thunderstorm Wind	65 mph	--	2	--	--
June 21, 2011	Burlington	Hail	1.25 in.	--	--	--	--
June 30, 2011	Wind Pt	Thunderstorm Wind	82 mph	--	--	100,000.00	--
August 2, 2011	Downtown Racine	Thunderstorm Wind	65 mph	--	--	--	--
September 29, 2011	Racine County	Strong Wind	47 mph	--	--	2,000.00	--
October 19, 2011	Racine County	High Wind	73 mph	--	--	10,000.00	--
November 13, 2011	Racine County	Strong Wind	30 mph	--	--	1,000.00	--
November 29, 2011	Racine County	Strong Wind	53 mph	--	--	1,000.00	--
January 1, 2012	Racine County	Strong Wind	45 mph	--	--	1,000.00	--
March 12, 2012	Kansasville	Hail	1 in.	--	--	--	--
March 12, 2012	Union Grove	Hail	1 in.	--	--	--	--
March 12, 2012	Caledonia	Hail	1.75 in.	--	--	--	--
April 16, 2012	Racine County	Strong Wind	30 mph	--	--	1,000.00	--
April 16, 2012	Racine County	Strong Wind	47 mph	--	--	1,000.00	--
June 18, 2012	Racine County	Strong Wind	45 mph	--	--	10,000.00	--
July 18, 2012	Downtown Racine	Thunderstorm Wind	65 mph	--	--	--	--
July 31, 2012	Waterford	Thunderstorm Wind	65 mph	--	--	--	--
July 31, 2012	Downtown Racine	Hail	1 in.	--	--	25,000.00	--
September 4, 2012	Tichigan	Thunderstorm Wind	65 mph	--	--	10,000.00	--
September 4, 2012	Wind Lake	Thunderstorm Wind	60 mph	--	--	5,000.00	--
November 11, 2012	Racine County	Strong Wind	46 mph	--	--	3,000.00	--
January 18, 2013	Racine County	Strong Wind	45 mph	--	--	5,000.00	--
January 19, 2013	Racine County	Strong Wind	51 mph	--	--	5,000.00	--

Table continued on next page.

Table 3.11 (Continued)

Date	Location	Event Type	Magnitude	Reported Damages			
				Deaths	Injuries	Property Damages ($)	Crop Damages ($)
April 11, 2013	Racine County	Strong Wind	47 mph	--	--	10,000.00	--
July 21, 2013	Waterford	Thunderstorm Wind	58 mph	--	--	--	14,000.00
August 21, 2013	Waterford	Hail	0.88 in.	--	--	--	--
August 21, 2013	Waterford	Hail	1 in.	--	--	--	--
November 17, 2013	Racine County	Strong Wind	55 mph	--	--	5,000.00	--
May 6, 2014	Franksville	Hail	0.75 in.	--	--	--	--
May 6, 2014	Husher	Hail	0.75 in.	--	--	--	--
May 12, 2014	Bohners Lake	Hail	2 in.	--	--	--	--
May 12, 2014	Bohners Lake	Thunderstorm Wind	70 mph	--	--	30,000.00	--
May 12, 2014	Union Grove	Hail	0.88 in.	--	--	--	--
May 12, 2014	Burlington	Thunderstorm Wind	58 mph	--	--	2,000.00	--
May 12, 2014	Bohners Lake	Hail	2 in.	--	--	--	--
May 12, 2014	Ives	Hail	0.75 in.	--	--	--	--
May 12, 2014	Sturtevant	Thunderstorm Wind	58 mph	--	--	1,000.00	--
May 12, 2014	Sturtevant	Hail	1.25 in.	--	--	--	--
May 12, 2014	Gatliff	Hail	1 in.	--	--	--	--
May 12, 2014	Downtown Racine	Hail	1.5 in.	--	--	--	--
May 12, 2014	Downtown Racine	Hail	2.5 in.	--	--	--	--
June 1, 2014	Caldwell	Thunderstorm Wind	60 mph	--	--	5,000.00	--
October 31, 2014	Racine County	Strong Wind	48 mph	1	--	5,000.00	--
April 9, 2015	Burlington	Hail	0.88 in.	--	--	--	--
April 9, 2015	Wind Lake	Hail	0.88 in.	--	--	--	--
July 18, 2015	Downtown Racine	Thunderstorm Wind	63 mph	--	--	20,000.00	--
August 2, 2015	Racine County	Strong Wind	50 mph	--	--	5,000.00	--
August 2, 2015	Wind Lake	Thunderstorm Wind	58 mph	--	--	15,000.00	--
August 2, 2015	Wind Lake	Hail	2.75 in.	--	--	--	--
August 2, 2015	Union Grove	Hail	1 in.	--	--	--	--
August 2, 2015	Waterford	Hail	1 in.	--	--	--	--
August 2, 2015	Franksville	Hail	1 in.	--	--	--	--
August 2, 2015	Downtown Racine	Hail	1 in.	--	--	--	--
August 10, 2015	Ives Grove	Thunderstorm Wind	69 mph	--	--	5,000.00	--
December 23, 2015	Racine County	Strong Wind	56 mph	--	--	1,000.00	--
February 19, 2016	Racine County	High Wind	60 mph	--	--	75,000.00	--
March 16, 2016	Racine County	High Wind	58 mph	--	--	8,000.00	--
March 31, 2016	Elmwood Park	Hail	1 in.	--	--	--	--
March 31, 2016	Downtown Racine	Hail	1 in.	--	--	--	--

Table continued on next page.

Table 3.11 (Continued)

Date	Location	Event Type	Magnitude	Reported Damages			
				Deaths	Injuries	Property Damages ($)	Crop Damages ($)
March 31, 2016	Downtown Racine	Hail	1 in.	--	--	--	--
June 5, 2016	Caddy Vista	Thunderstorm Wind	65 mph	--	--	10,000.00	--
June 5, 2016	Franksville	Thunderstorm Wind	58 mph	--	--	10,000.00	--
June 5, 2016	Elmwood Park	Thunderstorm Wind	58 mph	--	--	7,000.00	--
March 8, 2017	Racine County	High Wind	58 mph	--	--	40,000.00	--
March 23, 2017	Husher	Hail	0.75 in.	--	--	--	--
April 10, 2017	Sturtevant	Hail	1 in.	--	--	--	--
April 20, 2017	Burlington	Thunderstorm Wind	59 mph	--	--	--	--
April 20, 2017	Kneeland	Thunderstorm Wind	81 mph	--	--	50,000.00	--
April 20, 2017	Thompsonville	Thunderstorm Wind	70 mph	--	--	7,500.00	--
April 20, 2017	Gatliff	Thunderstorm Wind	60 mph	--	--	5,000.00	--
May 17, 2017	Waterford	Hail	1 in.	--	--	--	--
June 14, 2017	Browns Lake	Hail	1 in.	--	--	--	--
July 6, 2017	Waterford	Thunderstorm Wind	65 mph	--	--	4,000.00	--
July 6, 2017	Union Grove	Thunderstorm Wind	58 mph	--	--	3,000.00	--
December 4, 2017	Racine County	High Wind	58 mph	--	--	7,000.00	--
June 18, 2018	Tichigan	Thunderstorm Wind	58 mph	--	--	7,000.00	--
October 20, 2018	Racine County	Strong Wind	51 mph	--	--	20,000.00	--
February 24, 2019	Racine County	Strong Wind	52 mph	--	--	1,000.00	--
June 24, 2019	Downtown Racine	Hail	1 in.	--	--	--	--
July 2, 2019	Horlick Racine	Thunderstorm Wind	58 mph	--	--	5,000.00	--
July 17, 2019	North Cape	Thunderstorm Wind	65 mph	--	--	3,000.00	--
November 27, 2019	Racine County	Strong Wind	52 mph	--	--	10,000.00	--
April 29, 2020	Union Grove	Heavy Rain	--	--	--	500.00	--
April 29, 2020	Racine County	Strong Wind	45 mph	--	--	1,000.00	--
July 9, 2020	Racine Batten Airport	Thunderstorm Wind	68 mph	--	--	--	--
July 9, 2020	Midway Park	Thunderstorm Wind	58 mph	--	--	500.00	--
July 9, 2020	Midway Park	Thunderstorm Wind	58 mph	--	--	1,000.00	--
August 10, 2020	Union Grove	Thunderstorm Wind	58 mph	--	--	2,000.00	--
August 10, 2020	Elmwood Park	Thunderstorm Wind	58 mph	--	--	8,000.00	--
August 10, 2020	Downtown Racine	Thunderstorm Wind	58 mph	--	--	6,000.00	--
August 10, 2020	North Bay	Thunderstorm Wind	58 mph	--	--	3,000.00	--
November 10, 2020	Burlington	Thunderstorm Wind	65 mph	--	--	25,000.00	--
November 10, 2020	Rochester	Thunderstorm Wind	75 mph	--	--	25,000.00	--
August 11, 2021	Statewide	Thunderstorm Wind	58 mph	--	--	8,000.00	4,000.00
October 24, 2021	Racine County	Strong Wind	47 mph	--	--	5,000.00	--

Table continued on next page.

Table 3.11 (Continued)

				Reported Damages			
Date	**Location**	**Event Type**	**Magnitude**	Deaths	Injuries	Property Damages ($)	Crop Damages ($)
December 15, 2021	Racine County	High Wind	63 mph	--	--	10,000.00	--
			Total	1	2	811,500.00	18,000.00

[a] *Deaths, injuries, and property damages reported were based upon a geographic area impacted by the hazard event, which affected Racine County and, in some cases, a larger area of impact than the County itself, generally within the southeast regional area of Wisconsin.*

[b] *Dollar values were adjusted to year 2014 by using the average annual Consumer Price Index (CPI) values from the U.S. Department of Labor, Bureau of Labor Statistics.*

Source: The National Climatic Data Center (NCDC), National Oceanic and Atmospheric Administration (NOAA), and the National Environmental Satellite, Data and Information Service (NESDIS), and the U.S. Department of Agriculture Risk Management Agency

Table 3.12
Extreme Temperature and Departure from Average Temperature Within Racine County: 2011-2021

	Burlington Inland Site				Racine Lakeshore Site			
Year	High Temperature (°F)	Low Temperature (°F)	Average Annual Temperature (°F)	Departure from Average Temperature (°F)	High Temperature (°F)	Low Temperature (°F)	Average Annual Temperature (°F)	Departure from Average Temperature (°F)
2011	97.0	-14.0	46.4[a]	+0.2	100.0	-8.0	48.1[a]	+0.2
2012	102.0	-4.0	48.6[a]	+2.4	104.0	-1.0	51.1[a]	+3.2
2013	94.0	-10.0	44.2[a]	-2.0	96.0	-6.0	N/A	N/A
2014	87.0	-19.0	42.6	-3.6	90.0	-1.0	43.9	-4.0
2015	91.0	-15.0	46.4	+0.2	92.0	-10.0	47.3	-0.6
2016	91.0	-14.0	48.1	+1.9	94.0	-10.0	49.8	+1.9
2017	92.0	-10.0	45.9	-0.3	90.0	-6.0	49.0	+1.1
2018	93.0	-13.0	45.7	-0.5	91.0	-9.0	46.6	-1.3
2019	94.0	-27.0	45.0	-1.2	92.0	-24.0	45.6	-2.3
2020	92.0	20.0	47.4	+1.2	95.0	14.0	47.9	0.0
2021	92.0	-16.0	47.9	+1.7	94.0	-8.0	49.4	+1.5
Average	93.2	-11.1	46.2	--	94.4	-6.3	47.9	--

Note: N/A indicates data not available.

[a] *Average and/or total values computed with one to nine daily values missing.*

Source: National Weather Service and National Oceanic and Atmospheric Administration NOWData

Table 3.13
Level of Risk for Persons in High Risk Groups Associated with the Heat Index

Heat Index (°F)	Category	Possible Heat Disorders for Persons in High-Risk Groups
80-90	Caution	Fatigue possible with prolonged exposure and/or physical activity
90-105	Extreme Caution	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity
105-129	Danger	Sunstroke, muscle cramps and/or heat exhaustion likely. Heatstroke possible with prolonged exposure and/or physical activity
130 or above	Extreme Danger	Heat stroke or sunstroke likely

Source: National Weather Service

#263922 – Racine Co HMP Table 3.14
500-1147
JED/KMM
1/9/2023; 7/19/2022

Table 3.14
Recent Extreme Heat Events in Racine County: 2011-2021

Date	Type	Deaths	Injuries	Property Damage ($)	Crop Damage ($)
July 17, 2011	Heat	0	0	--	--
July 20, 2011	Heat	0	0	--	--
June 28, 2012	Heat	0	0	--	--
July 3, 2012	Excessive heat	0	0	--	--
July 16, 2012	Heat	0	0	--	--
July 23, 2012	Heat	0	0	--	--
July 25, 2012	Heat	0	0	--	--
July 16, 2013	Heat	0	0	--	--
August 30, 2013	Heat	0	0	--	--
July 21, 2016	Heat	0	0	--	--
June 17, 2018	Heat	0	0	--	--
June 29, 2018	Excessive heat	0	0	--	--
July 1, 2018	Excessive heat	0	0	--	--
July 4, 2018	Heat	0	0	--	--
July 19, 2019	Excessive heat	0	0	--	--
	Total	0	0	--	--

Source: National Climatic Data Center

#263923 – Racine Co HMP Table 3.15
500-1147
JED/KMM/mid
1/9/2023; 7/19/2022

Table 3.15
Wind Chill Temperatures[a]

Wind	Temperature (°F)																	
(mph)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

[a] *Wind Chill (°F) = 35.74 + 0.6215T - 35.75($V^{0.16}$) + 0.4275T($V^{0.16}$), where T = air temperature (°F) and V = wind speed (mph). The wind chill temperature is only defined for temperatures at or below 50°F and wind speeds above 3 mph. Bright sunshine may increase wind chill temperature by 10°F to 18°F.*

Frostbite times associated with wind chills:

30 minutes

10 minutes

5 minutes

Source: National Weather Service

#263924 – Racine Co HMP Table 3.16
500-1147
JED/KMM
1/9/2023; 7/19/2022

Table 3.16
Recent Extreme Cold Events in Racine County: 2011-2021

Date	Type	Deaths	Injuries	Property Damage ($)	Crop Damage ($)
January 21, 2011	Cold/wind chill	0	0	--	12,045
January 21, 2013	Cold/wind chill	0	0	--	--
January 6, 2014	Extreme cold/wind chill	0	0	--	39,645
January 27, 2014	Extreme cold/wind chill	0	0	--	39,645
January 7, 2015	Cold/wind chill	0	0	--	--
January 9, 2015	Cold/wind chill	0	0	--	--
December 14, 2016	Cold/wind chill	0	0	--	--
December 18, 2016	Cold/wind chill	0	0	--	--
December 25, 2017	Cold/wind chill	0	0	--	--
January 1, 2018	Cold/wind chill	0	0	--	--
February 5, 2018	Cold/wind chill	1	0	--	--
January 29, 2019	Extreme cold/wind chill	0	0	--	--
February 7, 2021	Cold/wind chill	0	0	--	--
February 13, 2021	Cold/wind chill	0	0	--	--
	Total	1	0	--	91,335

Source: National Climatic Data Center and U.S. Department of Agriculture Risk Management Agency

#263925 – Racine Co HMP Table 3.17
500-1147
JED/KMM/mid
1/10/2023; 7/19/2022

Table 3.17
Length of Lake Michigan Shoreline Within Racine County Communities

Community	Lake Michigan Shoreline Length (miles)	Percent of County Total
Village of Caledonia	4.47	30.2
Village of Mt. Pleasant	2.53	17.1
Village of Wind Point	2.40	16.3
Village of North Bay	0.63	4.2
City of Racine	4.76	32.2
Total	14.79	100.0

Source: SEWRPC

#263888 – Racine Co HMP Table 3.18
500-1147
JED/KMM/mid
1/10/2023; 11/22/2022

Table 3.18
Shore Protection in
Racine County: 2018-2019

Type of Shore Protection	Percent of County Shoreline
Public Marina	5.5
Seawall/Bulkhead	3.1
Revetment	42.8
Poorly Organized Rip-Rap/Rubble	18.3
No Protection	30.2
Total	100.0

Source: SEWRPC

#263889 – Racine Co HMP Table 3.19
500-1147
JED/KMM/mid
1/10/2023; 11/22/2022

Table 3.19
Bluff Failure in Racine County: 2018-2019

Type of Bluff Failure	Percent of County Shoreline
Shallow Slides	29.7
Creep	5.5
No Obvious Failures	64.3
No Bluff	0.5
Total	100.0

Source: SEWRPC

#264197 – Racine Co HMP Table 3.20
500-1147
JED/KMM/mid
1/10/2023; 8/10/2022

Table 3.20
Parcels Within the Low and High Risk Coastal Erosion Zones in Racine County: 2021

	Improved Parcels in Erosion Risk Zone				Value of Improvements ($)			
Racine County	Residential	Commercial	Manufacturing	Total	Residential	Commercial	Manufacturing	Total
Low-Risk Zone (within 0.5 miles)	7,300	550	31	7,881	958,820,700	206,358,150	52,690,600	1,217,869,450
High-Risk Zone (within 0.25 miles)	3,560	239	8	3,807	530,551,000	119,447,850	19,781,000	669,779,850
Total	10,860	789	39	11,688	1,489,371,700	325,806,000	72,471,600	1,887,649,300

Source: Wisconsin Emergency Management

#263927 – Racine Co HMP Table 3.21
500-1147
JED/KMM/mid
1/10/2023; 7/19/2022

Table 3.21
Recent Winter Events in Racine County: 2011-2021

Date	Type	Deaths	Injuries	Property Damages	Crop Damages
January 17, 2011	Winter Weather	--	--	--	--
February 1, 2011	Blizzard	1	--	--	--
February 6, 2011	Winter Weather	--	--	--	--
February 21, 2011	Winter Weather	--	--	--	--
December 29, 2011	Winter Weather	--	--	--	--
January 12, 2012	Winter Weather	--	--	--	--
January 17, 2012	Winter Weather	--	--	--	--
January 20, 2012	Winter Weather	--	--	--	--
February 23, 2012	Winter Weather	--	--	--	--
March 2, 2012	Winter Storm	--	--	--	--
January 27, 2013	Winter Weather	--	--	--	--
January 30, 2013	Winter Weather	--	--	--	--
February 7, 2013	Winter Storm	--	--	--	--
February 22, 2013	Winter Weather	--	--	--	--
February 26, 2013	Winter Storm	--	--	--	--
March 5, 2013	Winter Storm	--	--	--	--
March 18, 2013	Winter Weather	--	--	--	--
November 25, 2013	Winter Weather	--	--	--	--
December 8, 2013	Winter Weather	--	--	--	--
December 19, 2013	Winter Weather	--	--	--	--
December 22, 2013	Winter Storm	--	--	--	--
December 31, 2013	Winter Weather	--	--	--	--
January 1, 2014	Winter Weather	--	--	--	--
January 10, 2014	Winter Weather	--	--	--	--
January 14, 2014	Winter Weather	--	--	--	--
January 24, 2014	Winter Weather	--	--	--	--
January 26, 2014	Winter Weather	--	--	--	--
January 26, 2014	Winter Weather	--	--	--	--
February 4, 2014	Winter Weather	--	--	--	--
February 13, 2014	Winter Weather	--	--	--	--
February 17, 2014	Winter Storm	--	--	--	--
March 4, 2014	Winter Weather	--	--	--	--
November 22, 2014	Winter Weather	--	--	--	--
January 8, 2015	Winter Weather	--	--	--	--
February 1, 2015	Blizzard	--	--	--	--
February 25, 2015	Winter Weather	--	--	--	--
March 3, 2015	Winter Weather	--	--	--	--
November 20, 2015	Winter Storm	--	--	--	--
December 28, 2015	Winter Storm	--	--	--	--
February 29, 2016	Winter Weather	--	--	--	--
March 1, 2016	Winter Weather	--	--	--	--
March 24, 2016	Winter Weather	--	--	--	--
April 2, 2016	Winter Weather	--	--	--	--
April 8, 2016	Winter Weather	--	--	--	--
December 4, 2016	Winter Weather	--	--	--	--
December 10, 2016	Winter Storm	--	--	--	--
December 16, 2016	Winter Storm	--	--	--	--
January 10, 2017	Winter Weather	--	--	--	--

Table continued on next page.

Table 3.21 (Continued)

Date	Type	Deaths	Injuries	Property Damages	Crop Damages
January 11, 2017	Winter Weather	--	--	--	--
January 16, 2017	Winter Weather	--	--	--	--
February 24, 2017	Winter Weather	--	--	--	--
March 12, 2017	Lake-Effect Snow	--	--	--	--
January 7, 2018	Winter Weather	--	--	--	--
January 14, 2018	Winter Weather	--	--	--	--
January 22, 2018	Winter Storm	--	--	--	--
February 3, 2018	Winter Weather	--	--	--	--
February 5, 2018	Winter Weather	--	--	--	--
February 8, 2018	Winter Storm	--	--	--	--
February 11, 2018	Winter Weather	--	--	--	--
March 5, 2018	Winter Weather	--	--	--	--
April 3, 2018	Winter Weather	--	--	--	--
April 15, 2018	Winter Weather	--	--	--	--
April 18, 2018	Winter Weather	--	--	--	--
November 25, 2018	Winter Storm	--	--	--	--
December 28, 2018	Winter Weather	--	--	--	--
January 18, 2019	Winter Storm	--	--	--	--
January 22, 2019	Winter Weather	--	--	--	--
January 27, 2019	Winter Storm	--	--	--	--
February 5, 2019	Winter Weather	--	--	--	--
February 7, 2019	Winter Weather	--	--	--	--
February 11, 2019	Winter Storm	--	--	--	--
February 17, 2019	Winter Weather	--	--	--	--
February 26, 2019	Winter Weather	--	--	--	--
April 14, 2019	Winter Storm	--	--	--	--
April 27, 2019	Winter Weather	--	--	--	--
October 30, 2019	Winter Weather	--	--	--	--
November 10, 2019	Winter Weather	--	--	--	--
January 11, 2020	Winter Weather	--	--	--	--
January 17, 2020	Winter Weather	--	--	--	--
January 24, 2020	Winter Weather	--	--	--	--
January 31, 2020	Winter Weather	--	--	--	--
February 9, 2020	Winter Weather	--	--	--	--
February 12, 2020	Winter Weather	--	--	--	--
December 29, 2020	Winter Storm	--	--	--	--
January 1, 2021	Winter Weather	--	--	--	--
January 25, 2021	Winter Storm	--	--	--	--
January 30, 2021	Winter Storm	--	--	--	--
February 4, 2021	Winter Weather	--	--	--	--
February 11, 2021	Winter Weather	--	--	--	--
February 13, 2021	Winter Weather	--	--	--	--
February 15, 2021	Winter Storm	--	--	--	--
March 15, 2021	Winter Weather	--	--	--	--
December 28, 2021	Winter Weather	--	--	--	--
	Total	1	0	--	--

Note: The data presented in this table only accounts for damages, injuries, and deaths that are directly caused by each winter storm event. Damages, injuries, and deaths that occur indirectly as the result of traffic accidents, slips and falls, or health issues associated with winter storms are not included in this table.

Source: National Climatic Data Center

#263928 – Racine Co HMP Table 3.22
500-1147
JED/KMM/mid
1/10/2023; 8/3/2022, 7/19/2022

Table 3.22
Estimates of Crop Losses Due to Drought in Racine County: 2011-2021

Year	Crop Insurance Indemnity Paid ($)
2011	58,901
2012	1,211,969
2013	60,947
2014	5,556
2015	24,774
2016	185,385
2017	1,228
2018	2,349
2019	0
2020	8,372
2021	376,930
Total	1,936,411

Source: National Climatic Data Center (NCDC), the U.S. Department of Agriculture Risk Management Agency, and SEWRPC

SEWRPC Community Assistance Planning Report No. 266 (4th Edition)

RACINE COUNTY HAZARD MITIGATION PLAN UPDATE: 2023-2028

Chapter 3

ANALYSIS OF HAZARD CONDITIONS

FIGURES

#263662 – Racine Co HMP Figure 3.1
500-1147
KMM/mid
6/28/2022

Figure 3.1
July 12, 2017, Flooding: Fox River in the City of Burlington

Source: Burlington Standard Press, myracinecounty.com

#263886 – Racine Co HMP Figure 3.2
500-1147
KMM/mid
7/19/2022

Figure 3.2
Heat Index Chart

Relative Humidity (%)	Temperature (°F)															
	80	82	84	86	88	90	92	94	96	98	100	102	104	106	180	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

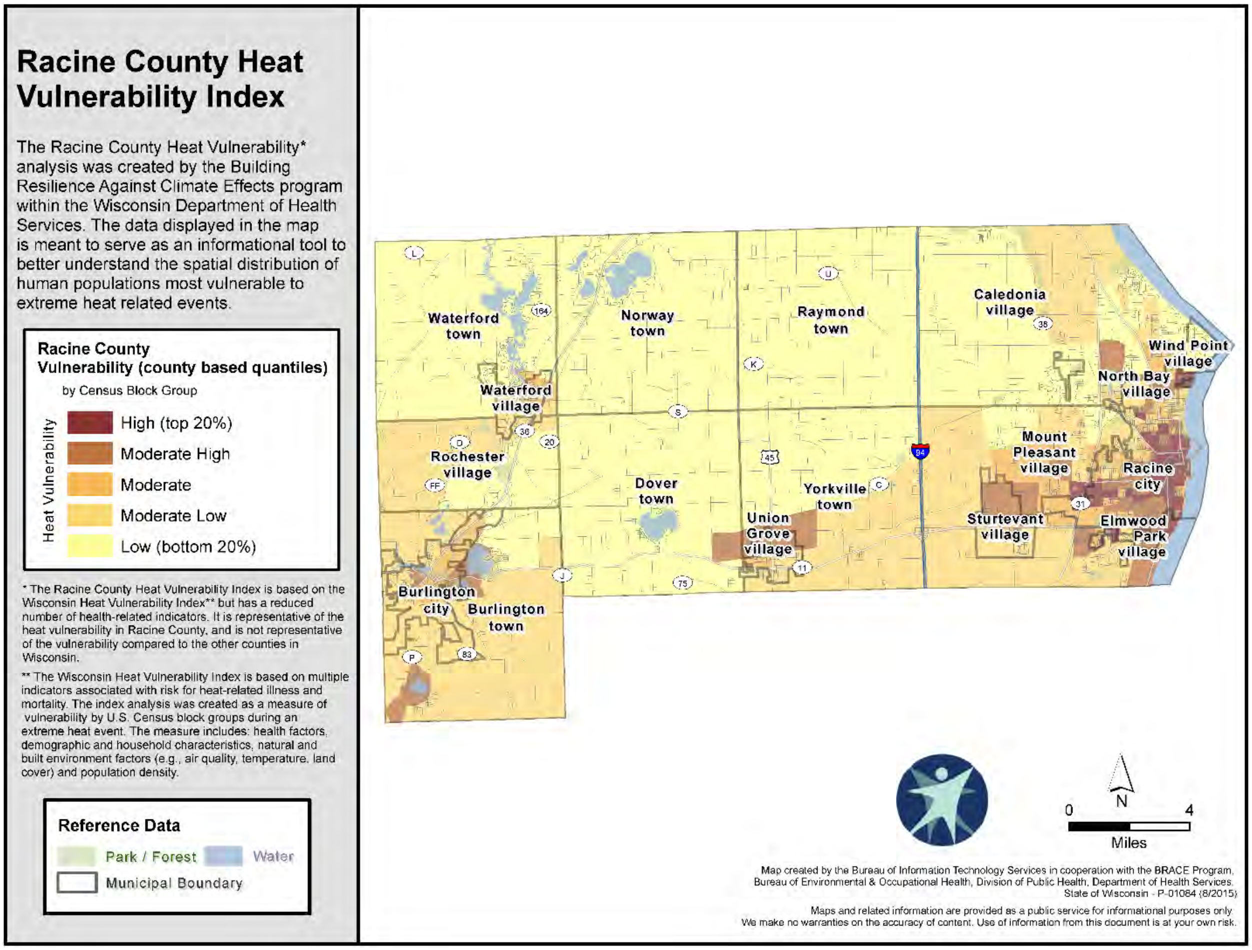
Likelihood of heat disorders with prolonged exposure or strenuous activity:

- Caution
- Extreme Caution
- Danger
- Extreme Danger

Source: National Weather Service and SEWRPC

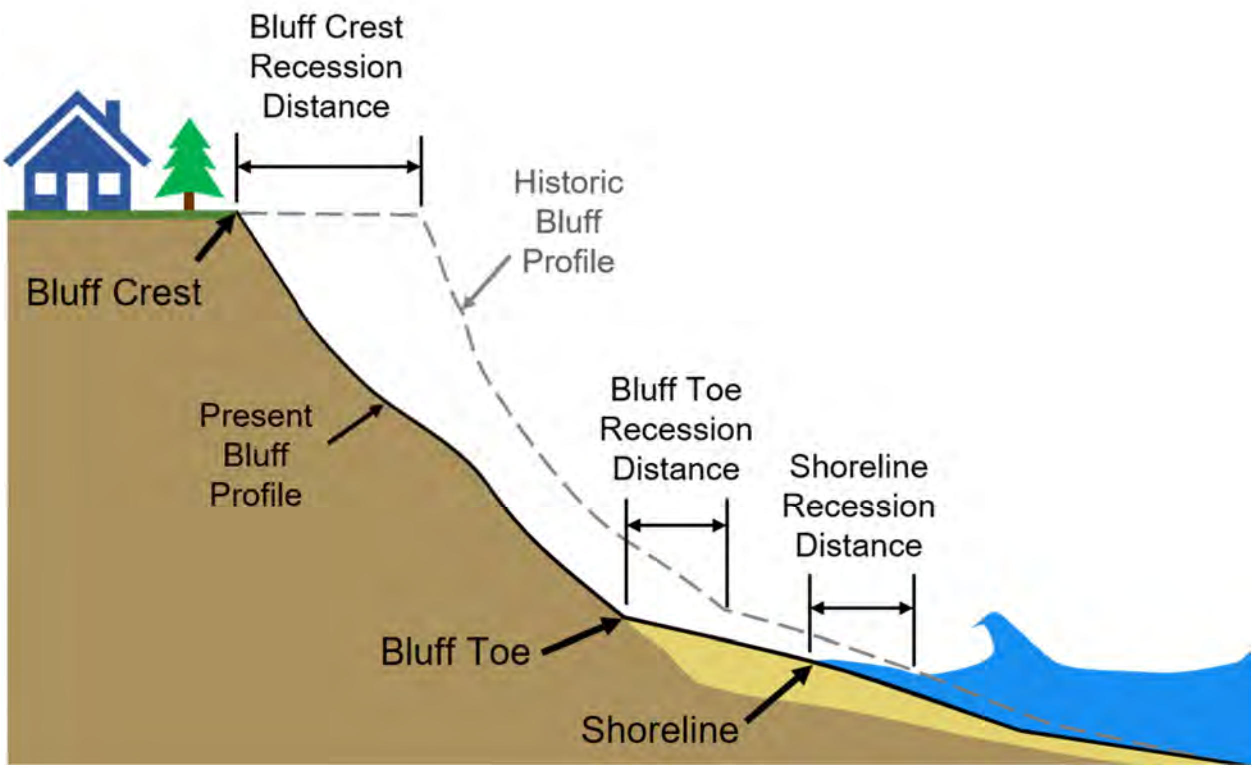
#263887 – Racine Co HMP Figure 3.3
500-1147
KMM/mid
7/19/2022

Figure 3.3
Racine County Heat Vulnerability Index: 2015



#263890 – Racine Co HMP Figure 3.4
500-1147
JED/KMM/mid
1/10/2023; 7/19/2022

Figure 3.4
Bluff Recession Schematic



Source: Wisconsin Coastal Management Program and SEWRPC

#263892 – Racine Co HMP Figure 3.5
500-1147
JED/KMM/mid
1/10/2023; 7/19/2022

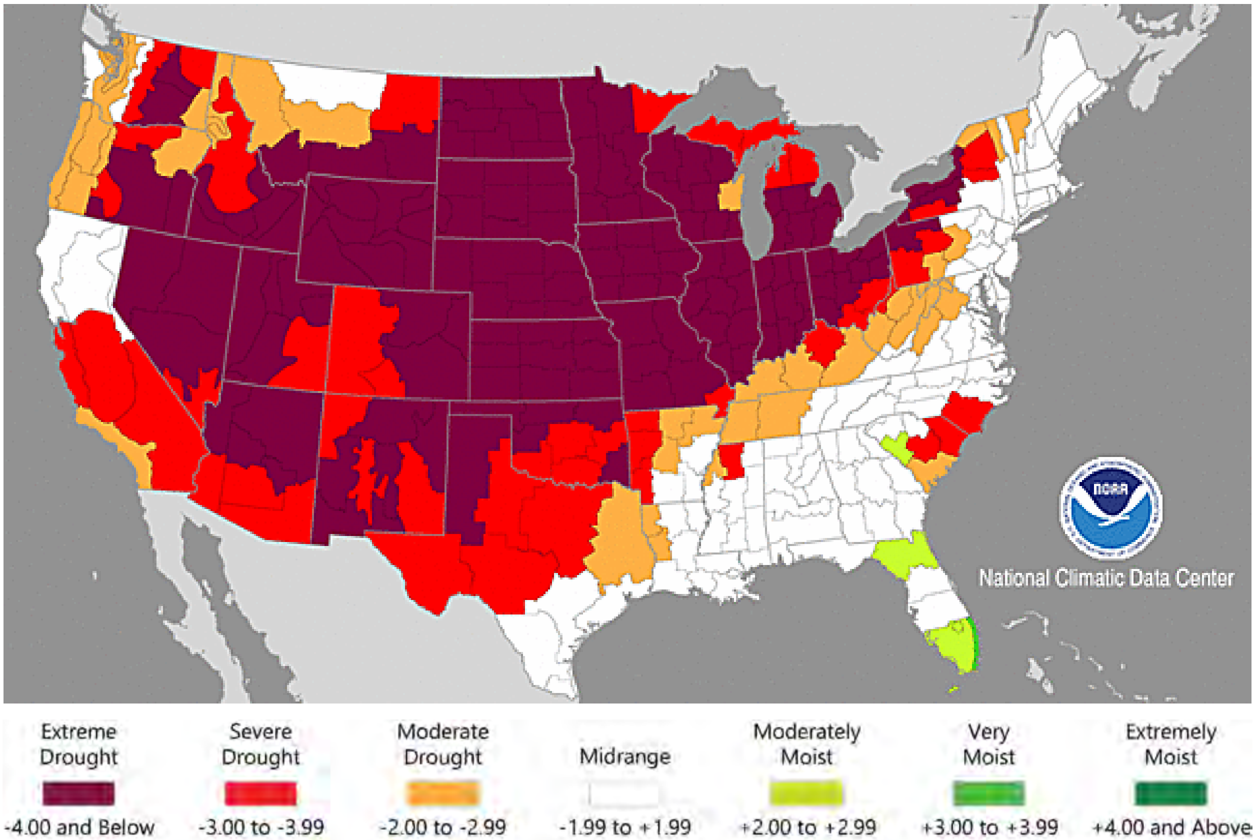
Figure 3.5
U.S. Drought Monitor Classifications

Category	Description	Possible Impacts	Ranges: Palmer Drought Severity Index (PDSI)	Ranges: CPC Soil Moisture Model (Percentiles)	Ranges: USGS Weekly Streamflow (Percentiles)	Ranges: Standardized Precipitation Index (SPI)	Ranges: Objective Drought Indicator Blends (Percentiles)
D0	Abnormally Dry	Going into drought: • short-term dryness slowing planting, growth of crops or pastures Coming out of drought: • some lingering water deficits • pastures or crops not fully recovered	-1.0 to -1.9	21 to 30	21 to 30	-0.5 to -0.7	21 to 30
D1	Moderate Drought	• Some damage to crops, pastures • Streams, reservoirs, or wells low, some water shortages developing or imminent • Voluntary water-use restrictions requested	-2.0 to -2.9	11 to 20	11 to 20	-0.8 to -1.2	11 to 20
D2	Severe Drought	• Crop or pasture losses likely • Water shortages common • Water restrictions imposed	-3.0 to -3.9	6 to 10	6 to 10	-1.3 to -1.5	6 to 10
D3	Extreme Drought	• Major crop/pasture losses • Widespread water shortages or restrictions	-4.0 to -4.9	3 to 5	3 to 5	-1.6 to -1.9	3 to 5
D4	Exceptional Drought	• Exceptional and widespread crop/pasture losses • Shortages of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less	0 to 2	0 to 2	-2.0 or less	0 to 2

Source: U.S. Drought Monitor Drought Classification (droughtmonitor.unl.edu/About/AbouttheData/DroughtClassification.aspx)

#263893 – Racine Co HMP Figure 3.6
500-1147
JED/KMM/mid
1/10/2023; 7/19/2022

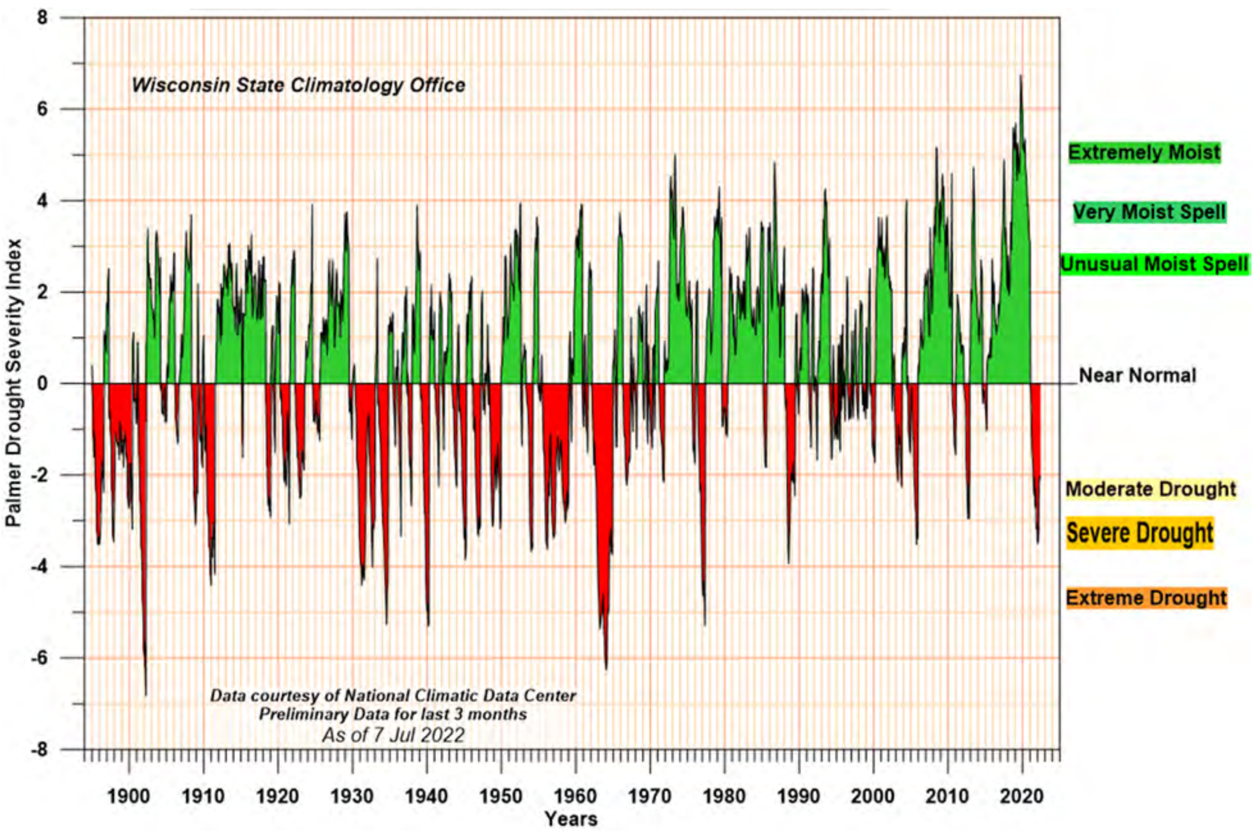
Figure 3.6
Palmer Drought Severity Index for July 1934



Source: National Climatic Data Center

#263978 – Racine Co HMP Figure 3.7
500-1147
JED/KMM/mid
1/10/2023; 7/21/2022

Figure 3.7
Palmer Drought Severity Index for Southeastern Wisconsin: 1895-2022



Source: University of Wisconsin Atmospheric and Oceanic Sciences, Wisconsin State Climatology Office

SEWRPC Community Assistance Planning Report No. 266 (4th Edition)

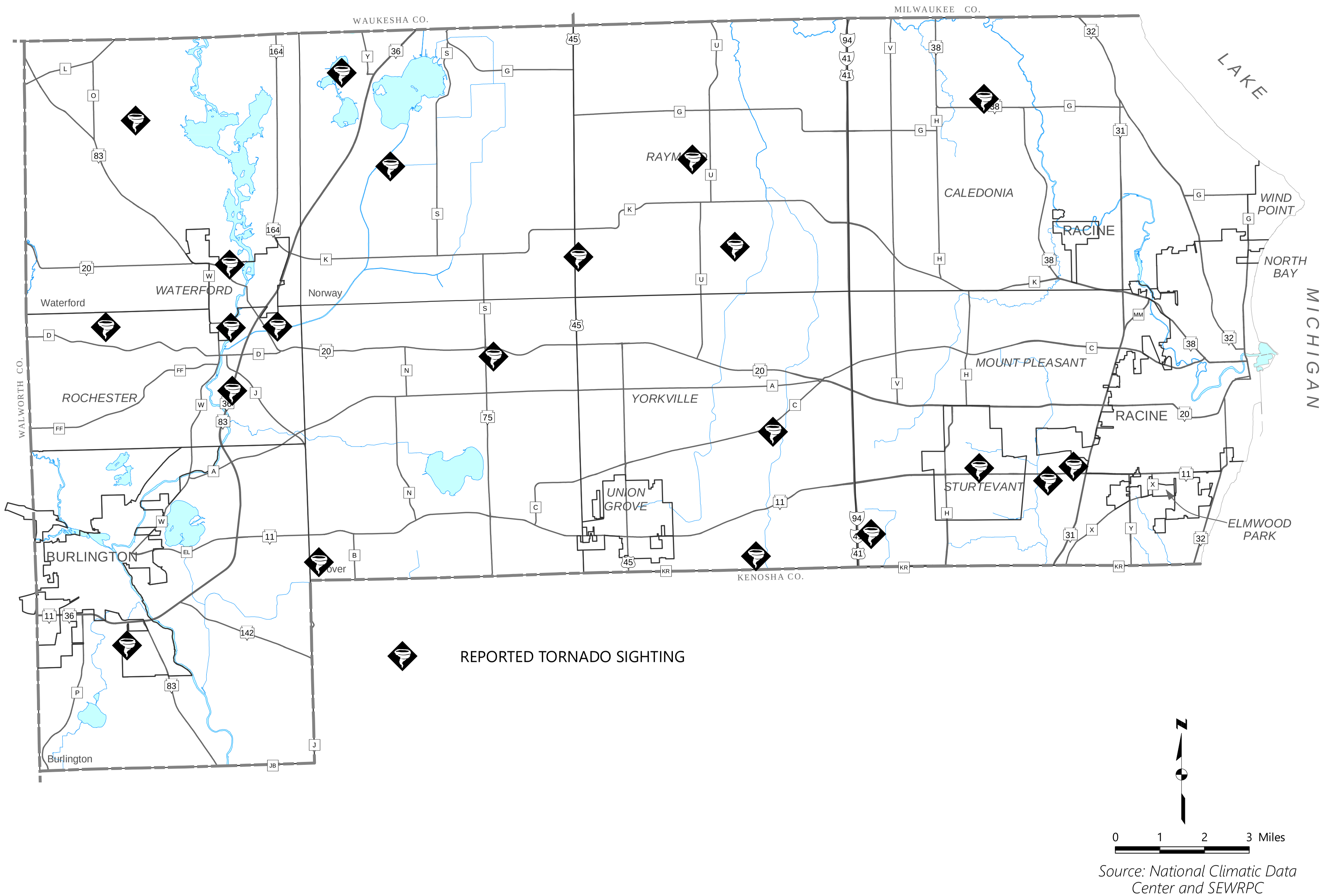
RACINE COUNTY HAZARD MITIGATION PLAN UPDATE: 2023-2028

Chapter 3

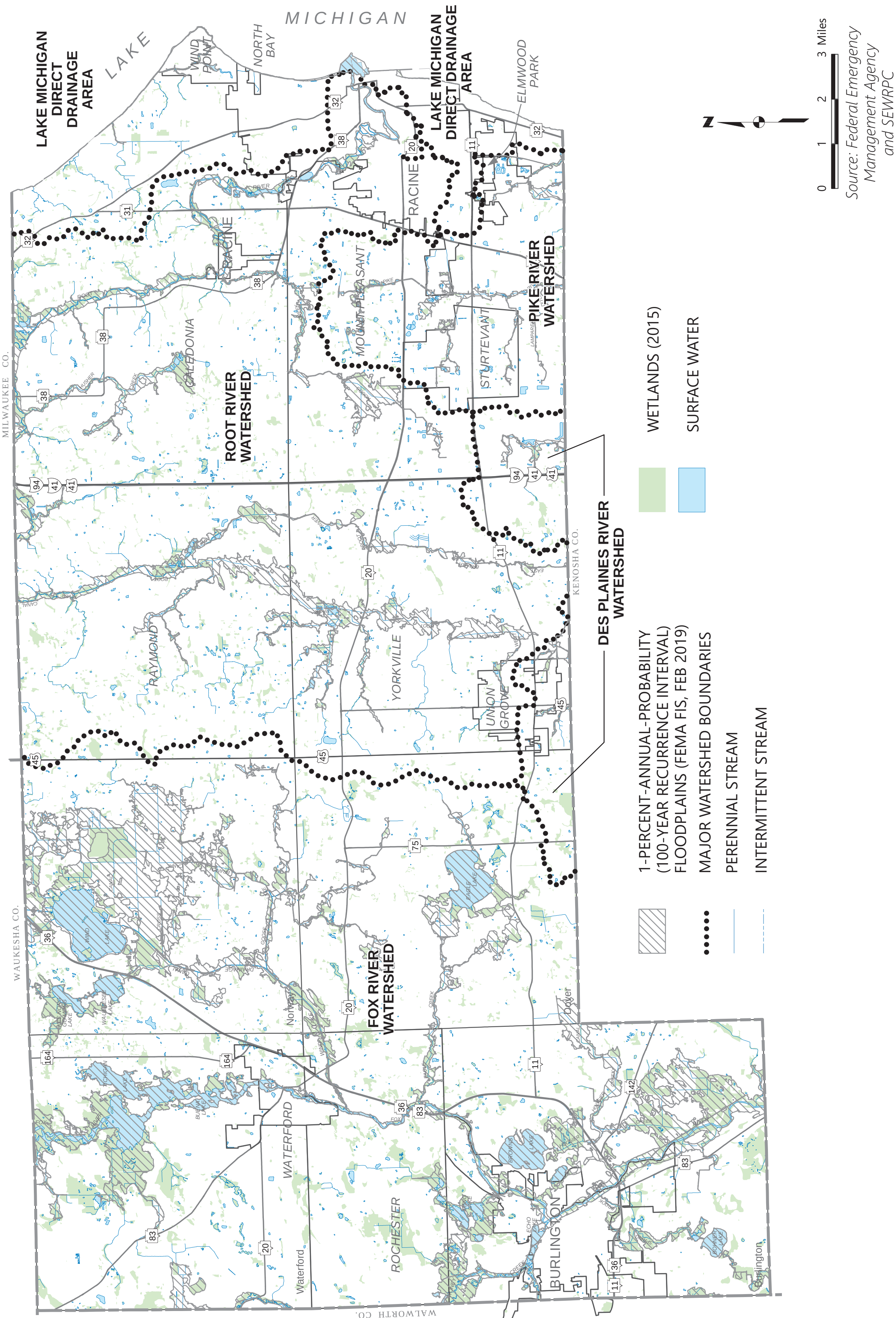
ANALYSIS OF HAZARD CONDITIONS

MAPS

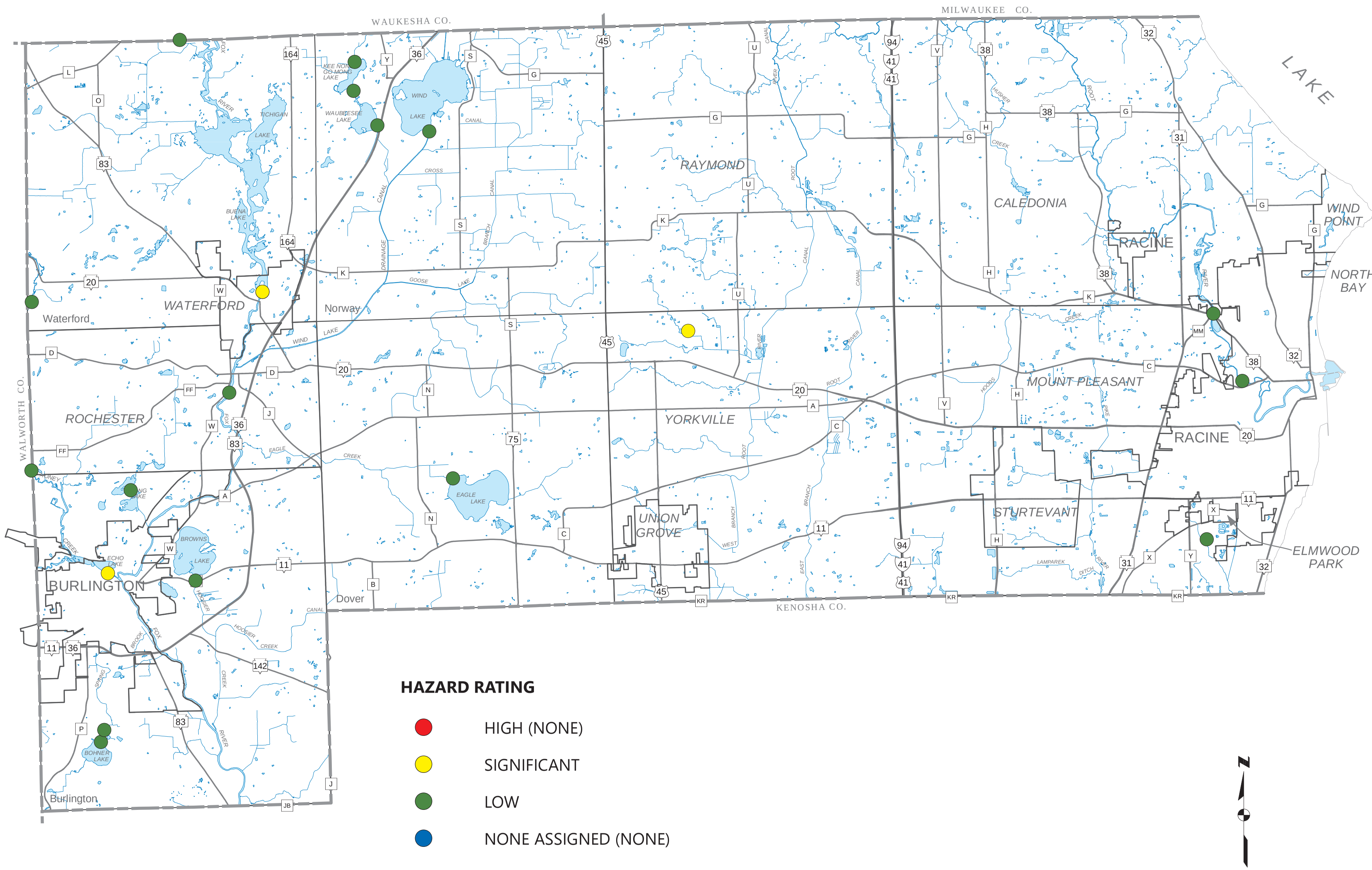
Map 3.1
Historic Tornado Events Reported in Racine County: 1950-2021



Map 3.2
Surface Waters, Wetlands, Watersheds, and Floodplains in Racine County

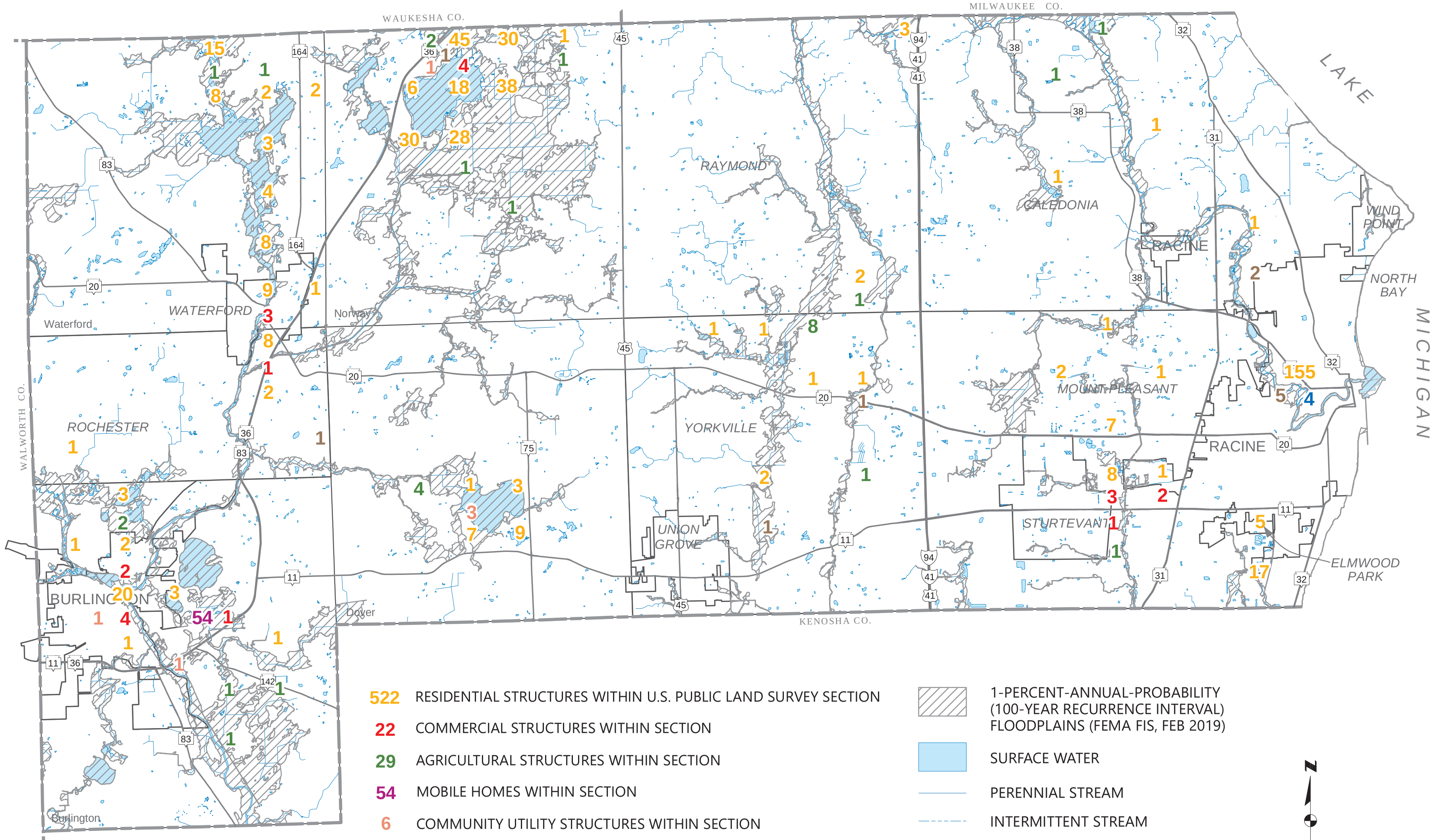


Map 3.3
Dams Located in Racine County: 2021



Source: Wisconsin Department of Natural Resources and SEWRPC

Map 3.4
Structures Located Within the 100-Year Floodplain: 2022



522	RESIDENTIAL STRUCTURES WITHIN U.S. PUBLIC LAND SURVEY SECTION
22	COMMERCIAL STRUCTURES WITHIN SECTION
29	AGRICULTURAL STRUCTURES WITHIN SECTION
54	MOBILE HOMES WITHIN SECTION
6	COMMUNITY UTILITY STRUCTURES WITHIN SECTION
4	GOVERNMENT STRUCTURES WITHIN SECTION
11	OTHER STRUCTURES WITHIN SECTION

1-PERCENT-ANNUAL-PROBABILITY (100-YEAR RECURRENCE INTERVAL) FLOODPLAINS (FEMA FIS, FEB 2019)

SURFACE WATER

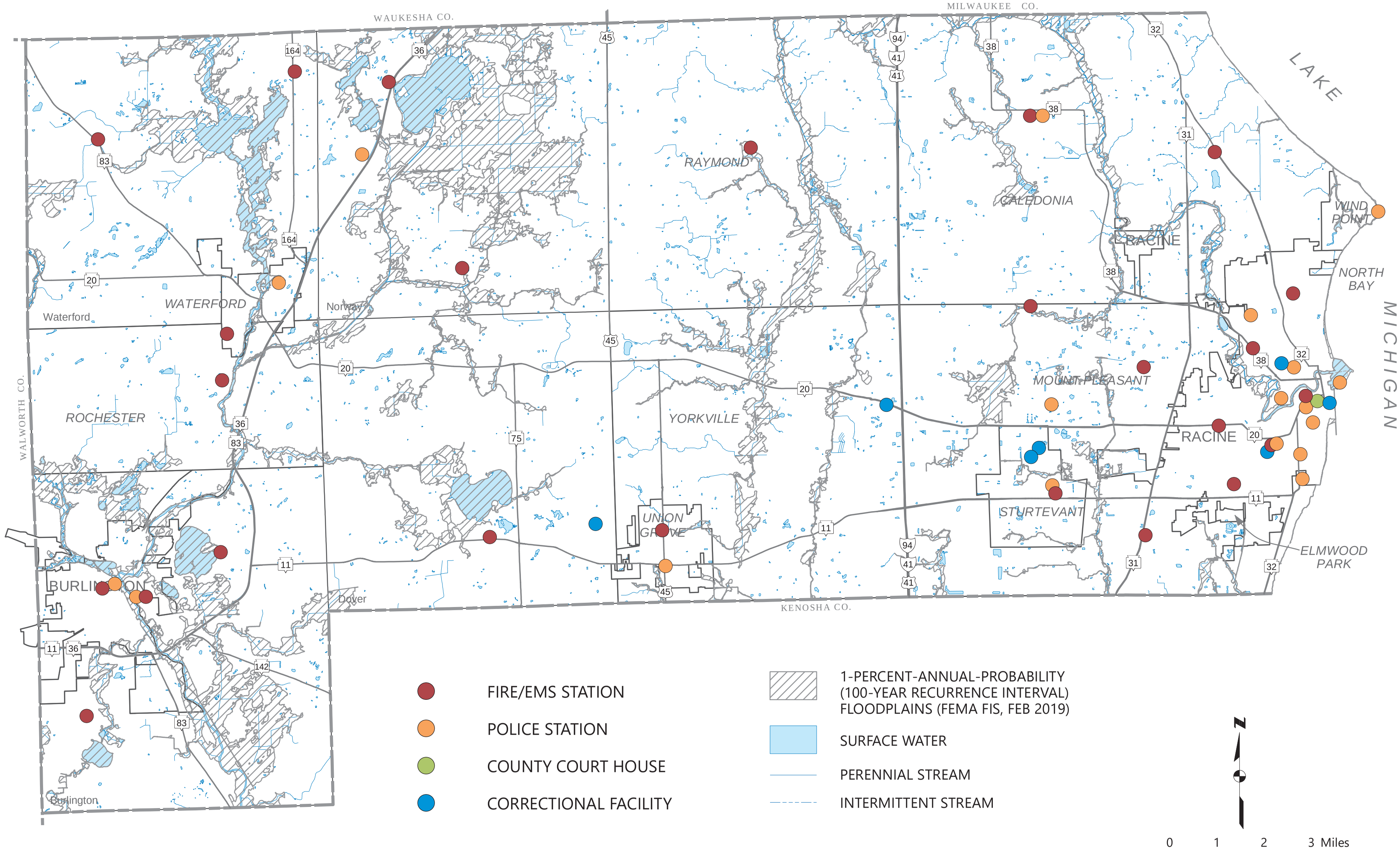
PERENNIAL STREAM

INTERMITTENT STREAM

0 1 2 3 Miles

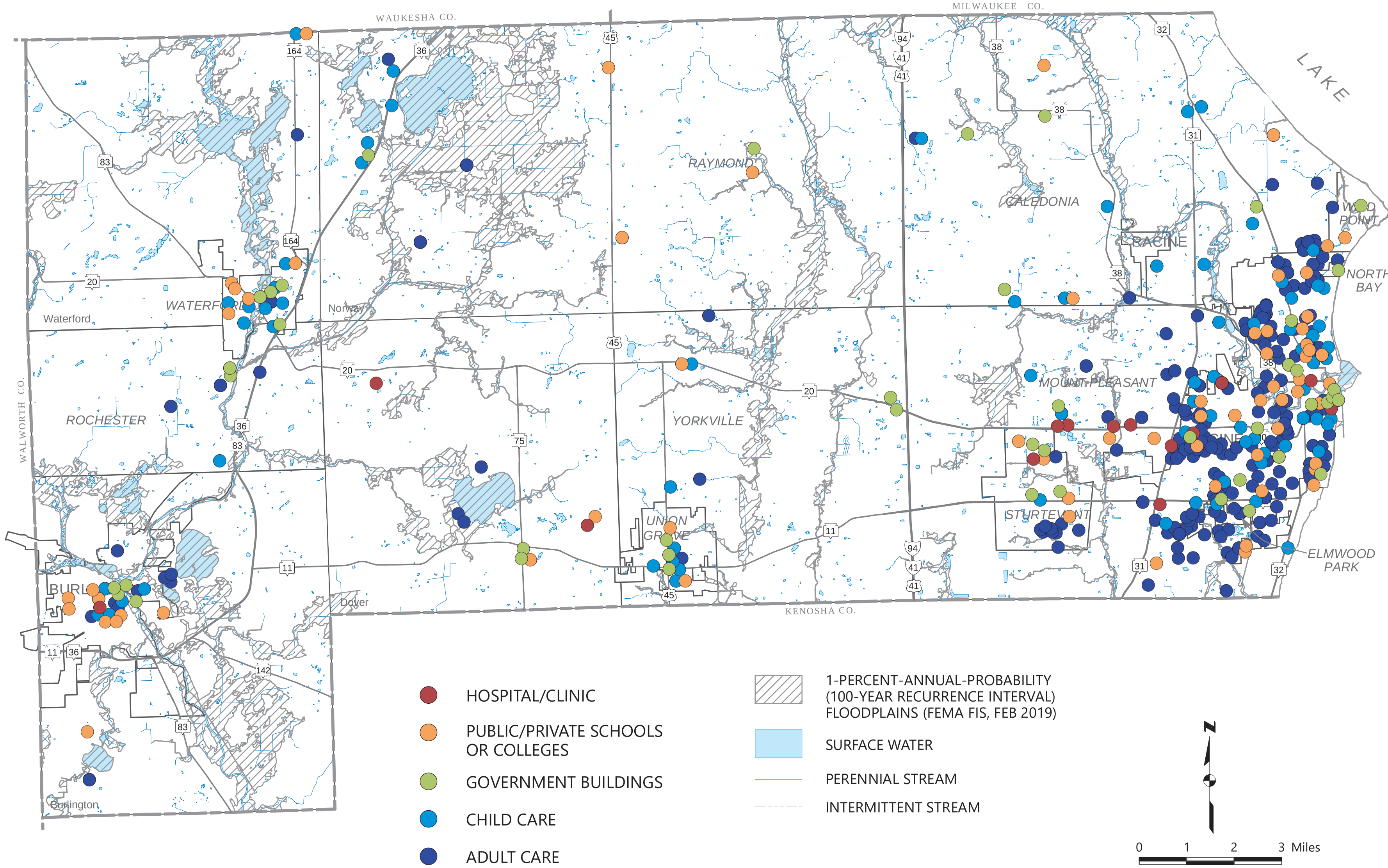
Source: Federal Emergency Management Agency, Racine County, and SEWRPC

Map 3.5
Emergency Service Structures in Relation to 100-Year Floodplains: 2022



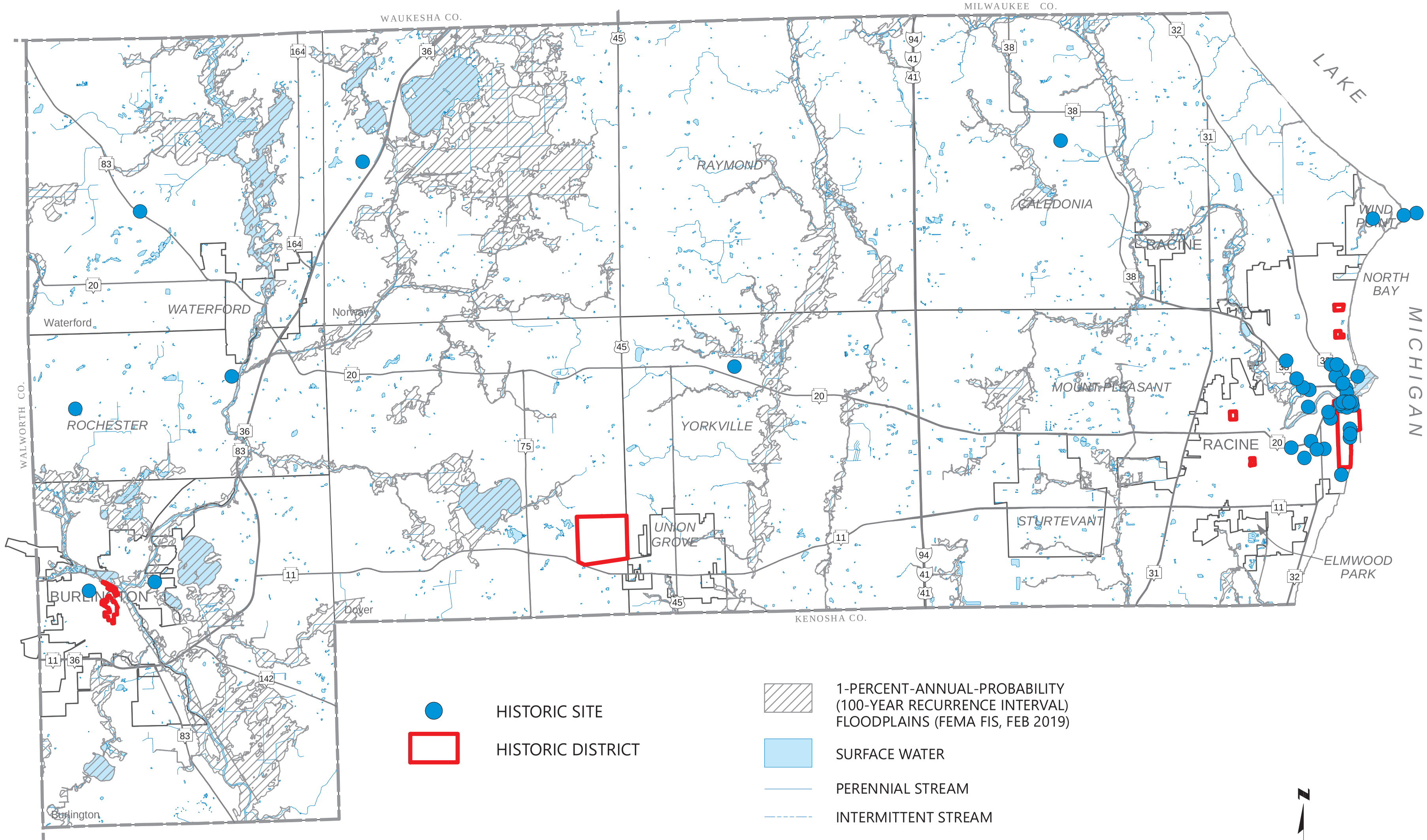
Source: Wisconsin Department of Justice (WILENET), Racine County Office of Emergency Management Department, Racine County, FEMA, and SEWRPC

Map 3.6
Critical Community Facilities in Relation to 100-Year Floodplains: 2022



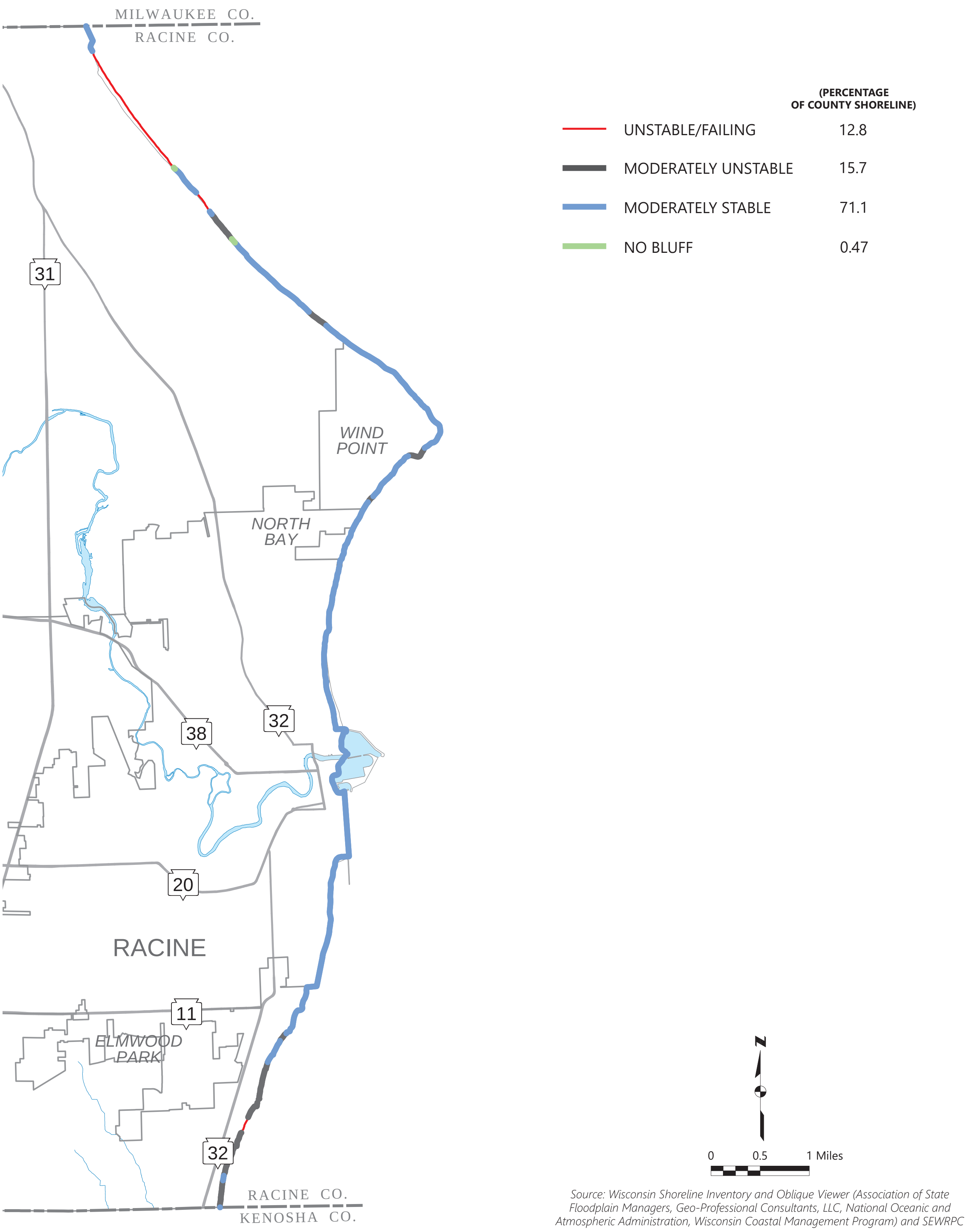
Source: Wisconsin Department of Children and Families, Wisconsin Department of Health and Social Services, Wisconsin Department of Public Instruction, Racine County, FEMA, and SEWRPC

Map 3.7
National and State Registers of Historic Sites and Districts in Relation to 100-Year Floodplains: 2022



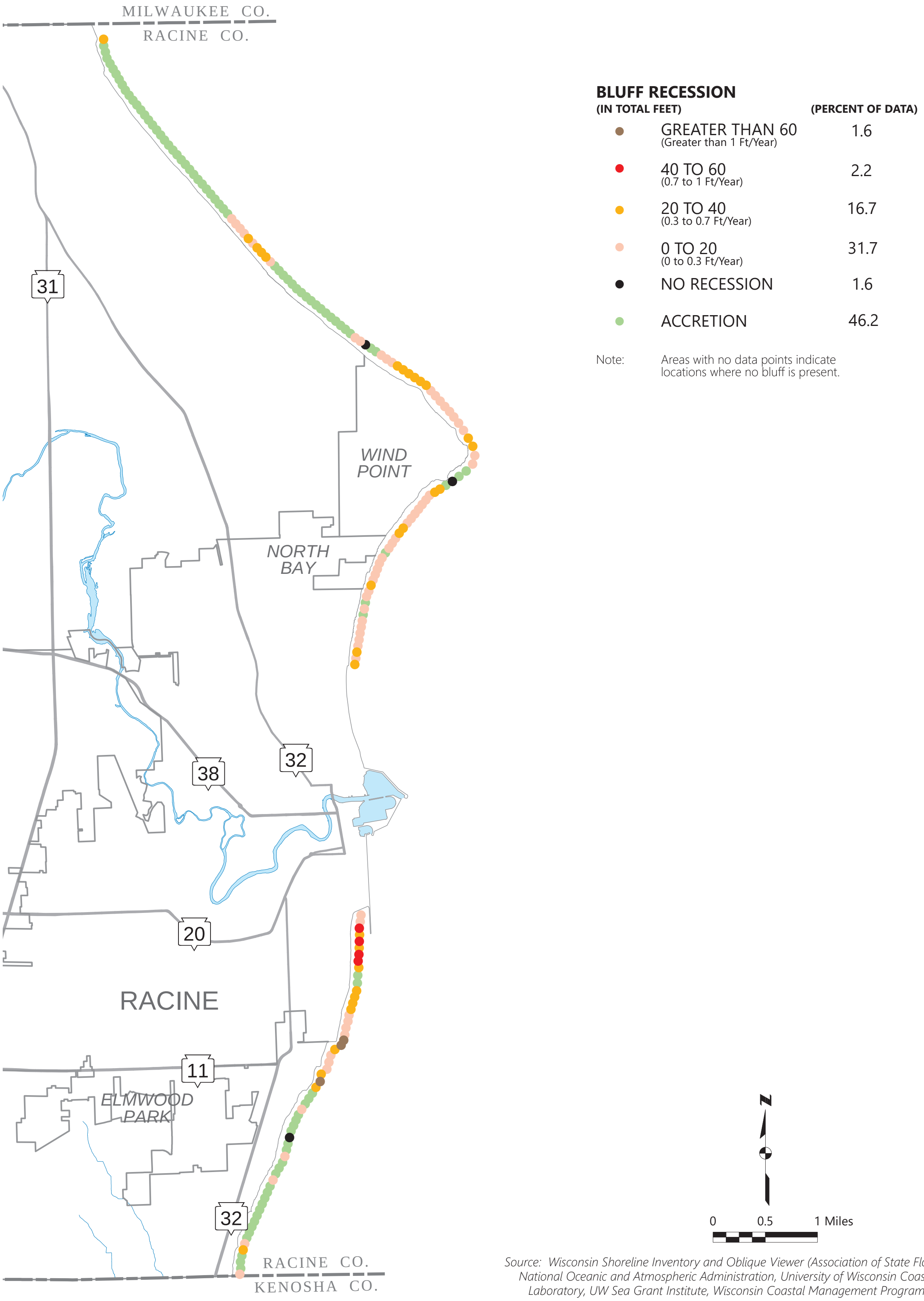
Source: FEMA and SEWRPC

Map 3.8
General Bluff Conditions in Racine County: 2018



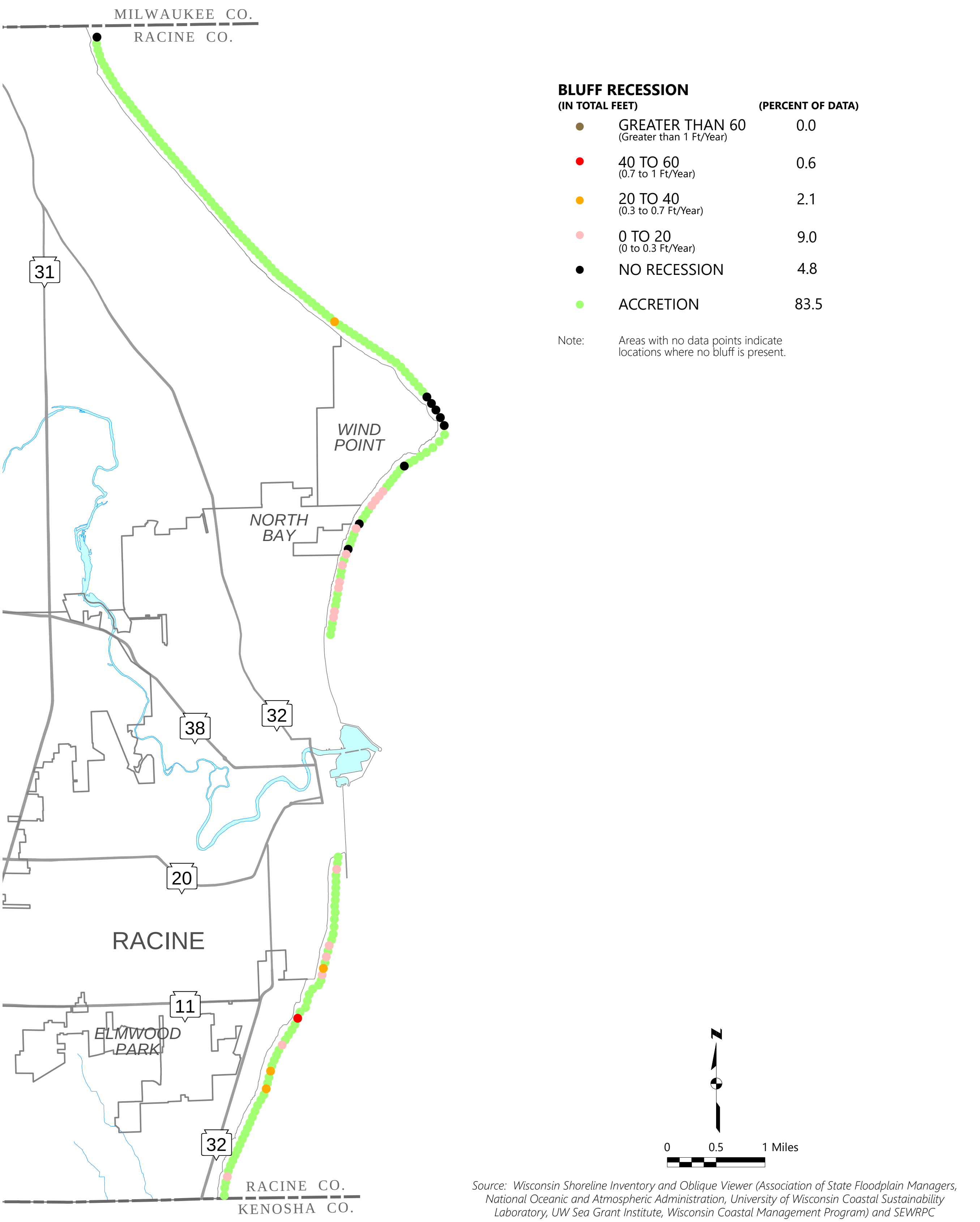
Source: Wisconsin Shoreline Inventory and Oblique Viewer (Association of State Floodplain Managers, Geo-Professional Consultants, LLC, National Oceanic and Atmospheric Administration, Wisconsin Coastal Management Program) and SEWRPC

Map 3.9
Long Term Bluff Toe Recession in Racine County: 1956-2015



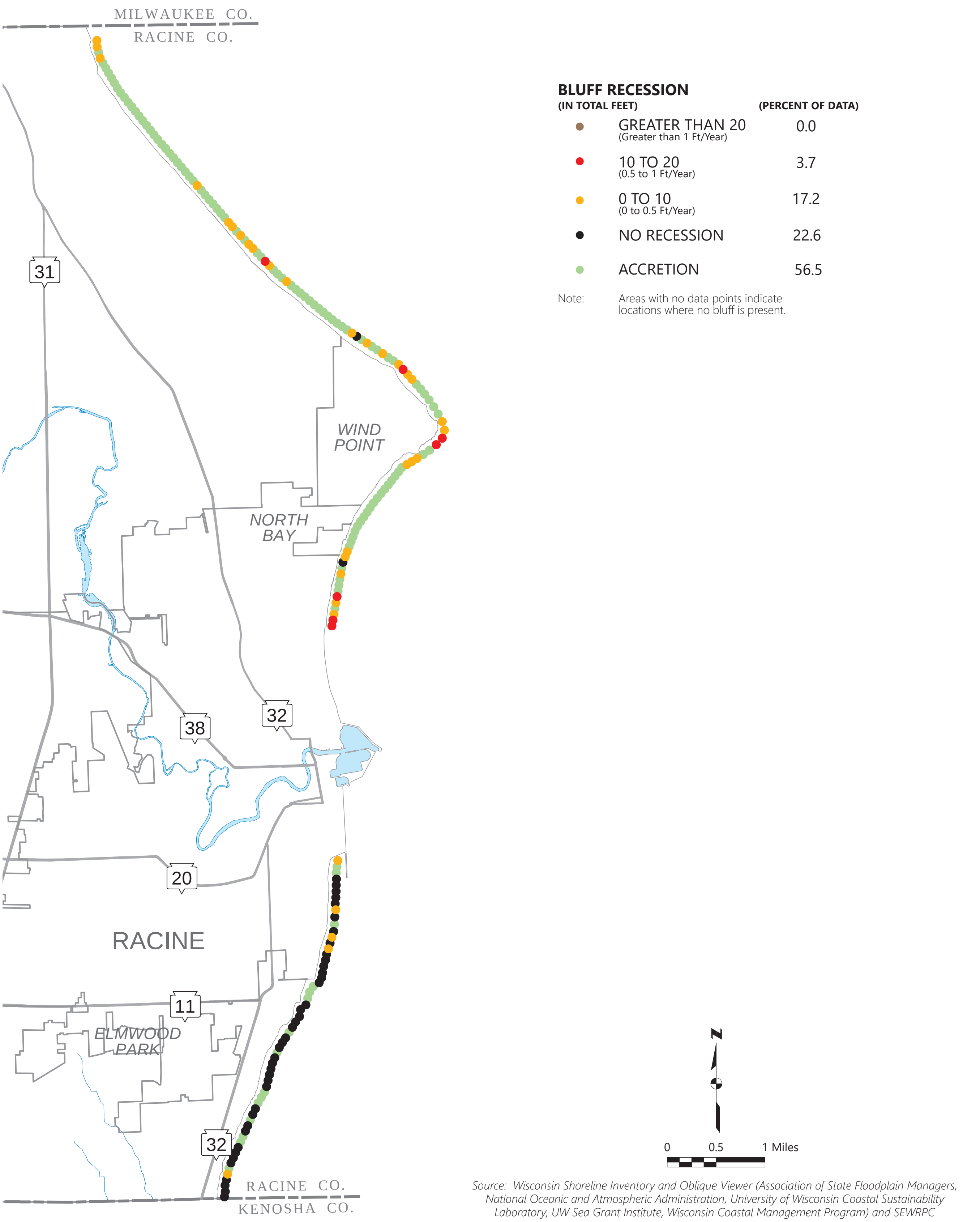
Source: Wisconsin Shoreline Inventory and Oblique Viewer (Association of State Floodplain Managers, National Oceanic and Atmospheric Administration, University of Wisconsin Coastal Sustainability Laboratory, UW Sea Grant Institute, Wisconsin Coastal Management Program) and SEWRPC

Map 3.10
Long Term Bluff Crest Recession in Racine County: 1956-2015



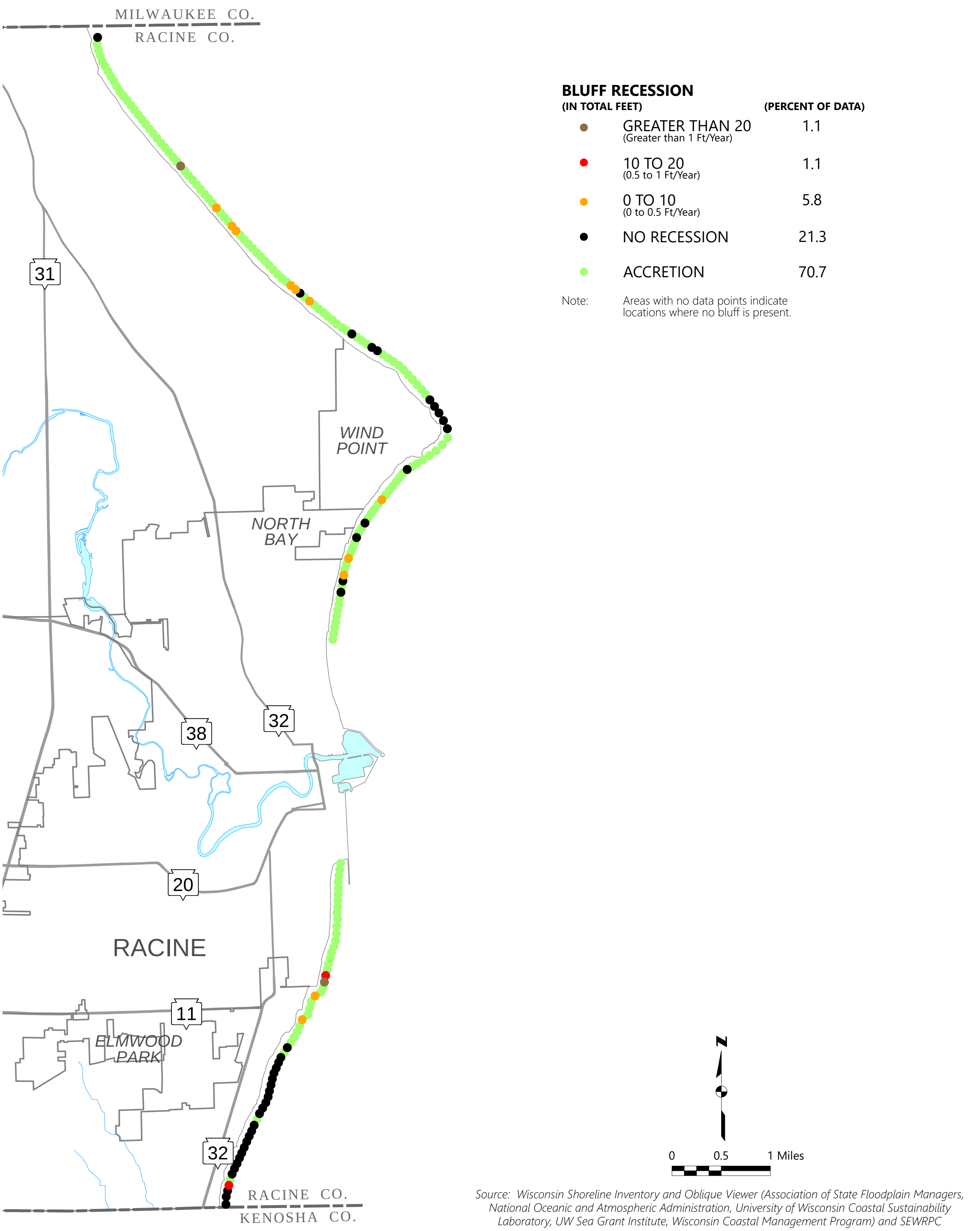
Source: Wisconsin Shoreline Inventory and Oblique Viewer (Association of State Floodplain Managers, National Oceanic and Atmospheric Administration, University of Wisconsin Coastal Sustainability Laboratory, UW Sea Grant Institute, Wisconsin Coastal Management Program) and SEWRPC

Map 3.11
Short Term Bluff Toe Recession in Racine County: 1995-2015



Source: Wisconsin Shoreline Inventory and Oblique Viewer (Association of State Floodplain Managers, National Oceanic and Atmospheric Administration, University of Wisconsin Coastal Sustainability Laboratory, UW Sea Grant Institute, Wisconsin Coastal Management Program) and SEWRPC

Map 3.12
Short Term Bluff Crest Recession in Racine County: 1995-2015



Source: Wisconsin Shoreline Inventory and Oblique Viewer (Association of State Floodplain Managers, National Oceanic and Atmospheric Administration, University of Wisconsin Coastal Sustainability Laboratory, UW Sea Grant Institute, Wisconsin Coastal Management Program) and SEWRPC

Map 3.16
Distressed Census Tracts in Racine County: 2017-2021