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3/25/2024, 10/8/24, 1/2/25, 1/6/25

Community Assistance Planning Report No. 345

MILWAUKEE COUNTY HAZARD MITIGATION PLAN UPDATE: 2024-2029

Chapter 5

HAZARD MITIGATION STRATEGIES

5.1 PLANNING FOR HAZARD MITIGATION MEASURES

Hazard mitigation planning systematically evaluates the nature of vulnerability to existing hazards while developing continued actions that reduce or eliminate the long-term risks and their effects. Specific purposes of hazard mitigation include eliminating loss of life, lessening danger (or risk) to human health and safety, minimizing monetary damage or impacts to private and public property, reducing the cost of utilities and services, minimizing disruption in community affairs, and to increase community capability, resiliency, and equity. Hazard mitigation also involves avoiding the intensification of existing hazards and the creation of new hazards.

The preparation of the Milwaukee County hazard mitigation plan update involved developing and evaluating alternative mitigation measures, or actions to reduce risks, and to select the most effective elements of the alternatives to formulate an integrated plan. For planning purposes, the alternative mitigation measures for most hazards are separated into three categories: 1) **Nonstructural** and/or **Nature-Based Solutions**, 2) **Structural**, and 3) **Public Informational and Educational Programming**.

The mitigation measures identified in each hazard category were evaluated based on the relative cost and likely benefits (direct and indirect), as indicated in the cost-benefit analysis summary tables at the end of each reported hazard. Consideration was also given to the likelihood of occurrence of each hazard, as outlined in the Hazard Prioritization Analysis section of Chapter 3. The highest priority is recommended for the mitigation measures that directly or indirectly result in minimized loss of life or injury.

Estimated Cost of Implementation

Where possible, the cost-benefit analysis table for each reported hazard includes a summary of the estimated capital cost and average annual operation and maintenance cost for each mitigation measure. Many mitigation measures exist, other than for flooding, where a direct monetary cost was impossible or impractical to develop. Therefore, mitigation measures were also classified as low-, moderate-, or high- cost to categorize the relative expense of implementing the measure.

Low-Cost (less than $100,000)

- Educational and informational programming
- Ongoing enforcement of ordinances
- Plan development
- Continued coordination/mutual aid/interagency agreements

Moderate-Cost (greater than $100,000 and less than $1,000,000)

- Addition of new staff
- Additional staff hours budgeted
- Additional equipment
- New ordinance development
- New programs/task force

High-Cost (greater than $1,000,000)

- Major construction
- New buildings and infrastructure)
- Capital programs

This cost assessment allows the mitigation measures to be prioritized with particular regard to cost-effectiveness by comparing the estimated low-, moderate-, and high-costs to the number of both direct and indirect benefits identified.

Benefits (Direct and Indirect)

The benefits of implementing a mitigation measure can be classified as direct (or measurable) and as indirect (or intangible). **Direct benefits** were defined as enhanced preparedness/protection of individuals or communities, reduced property damage, reduced injuries, and reduced mortalities. Although the exact number or amount of such benefits are often unknown, these would directly result from implementing a particular mitigation measure. In contrast, **indirect benefits** represent a range of potential benefits that may result from implementing specific management actions, such as increased environmental and recreational benefits and ecosystem services, and reduced loss of life and injury and the associated benefits for economic productivity. For this hazard mitigation plan, direct and indirect benefits are combined into one category within each cost-benefit analysis table for the profiled hazard.

Communities/Jurisdictions Affected

The cost-benefit analysis tables for each profiled hazard also indicate a list of the communities affected for each hazard and corresponding priority mitigation measure.

Some of the mitigative measures described are ongoing or committed actions which do not require the assessment of alternative measures but are still suggested to be incorporated into this mitigation plan. In other instances, applicable viable alternatives may be described and evaluated. This Chapter describes the hazard mitigation actions considered to resolve the identified hazard problems within Milwaukee County that were described in Chapter 3.

In preparing updates to the Plan, Commission staff, Milwaukee County Office of Emergency Management (OEM) and the Milwaukee County Hazard Mitigation Plan Local Planning Team (LPT) reviewed and reevaluated the current and past County and City of Milwaukee hazard mitigation plan goals and objectives (see Chapter 4). This review considered if those past and more recent goals were still applicable and whether additional goals should be added. In addition, hazard conditions within the County were reviewed and reevaluated (see Chapter 3). This review and reevaluation included the following.

- Updating the profile data of each hazard (i.e., extent and severity of hazard events)

- Reassessment of the vulnerability and risk associated with each hazard

- Reevaluation of potential changes in hazard severity and risk under future conditions

This review and reassessment process served as the basis for formulating viable mitigation measures to reduce vulnerability to hazards and to select priority mitigation actions recommended to address such hazards.

Vulnerable Populations

With more frequent and intense weather events, people and property are becoming increasingly vulnerable to natural disaster impacts (i.e., structural and/or vehicle damage and/or loss; injury, death, disruption to communication devices and infrastructure, etc.), most notably low-income, elderly, disabled, weak, under educated, and minority populations. Therefore, as part of this Plan update, individuals or populations deemed vulnerable (or at a higher risk) to natural disaster impacts within Milwaukee County, (see in Chapter 2 and Appendix D), played an integral part when formulating the following recommended mitigation alternatives and priority actions for each of the identified hazards.

5.2 HAZARD MITIGATION PLAN COMPONENT FOR MULTIPLE HAZARD TYPES

One of the bedrock principles of emergency management is to approach issues from a multi-hazards perspective. This is generally very cost-effective because it accomplishes mitigation goals and preparedness for *several* types of hazards with *one* resource or strategy. As such, this plan component includes mitigation strategies, actions, projects, or programs for multiple types of hazards. This approach helps reduce the repeating of similar mitigation measures that would otherwise be recurring for several or all of the hazards reported in this Plan. Mitigation measures that apply to multiple hazards are presented below.

Nonstructural

- Encourage the periodic review, updating, and/or exploration of new municipal and County development regulations and guidelines, especially in known hazard areas.

- Continue to enforce State building code regulations that aim to improve the ability of structures to withstand or become more resilient to the increasingly harsh weather conditions.[1]

- Encourage local municipalities to participate in the National Weather Service's (NWS) *StormReady* program.[2] Requirements for this program include:

  - Establishing a 24-hour warning point and emergency operations center

  - Having multiple ways to receive severe weather warnings and forecasts to alert the public

  - Promoting the importance of public readiness through community seminars

  - Developing a formal hazardous weather plan, which includes training severe weather spotters and holding emergency exercises

- Continue to support and encourage the participation in weather safety preparedness and training, (e.g., Milwaukee County SkyWarn[3] severe weather spotter training program).

- Continue to integrate and expand, along with periodic review and updating, of hazard mitigation planning into other County and local planning efforts (i.e., comprehensive, watershed, park, and local land use planning).

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[1] *The State Uniform Dwelling Code (UDC) is a statewide regulation that sets standards for fire safety; structural strength; energy conservation; erosion control; heating, plumbing, and electrical systems; and general health and safety in dwellings constructed or altered after 1980. The UDC applies uniformly throughout the State, and local governments may not adopt a more or less stringent code. Consequently, should review of local ordinances reveal that a change in building code would be a viable mitigation measure, the County and the municipalities within the County would need to pursue a change in the UDC at the State level.*

[2] *The **NWS StormReady program** helps communities with the communication and safety skills needed to save lives and property--before, during and after the event. The Program includes communities, counties, Indian nations, universities and colleges, military bases, government sites, commercial enterprises and other groups. As of this plan the Village of Bayside and the University of Wisconsin-Milwaukee participate in the NWS StormReady program.*

[3] ***SKYWARN®** is a volunteer program with trained severe weather spotters that help keep local communities safe by providing timely and accurate reports of severe weather to the National Weather Service.*

- Continue to collaborate and coordinate with other County and municipal departments (i.e., public health and human services, community outreach/public event planners, emergency management/public safety, public works), local and regional volunteer groups, and NGOs on up-to-date emergency preparedness and response procedures.

- Promote and expand training through the Southeastern Wisconsin Community Organizations Active in Disaster (COAD) program.[4]

- Create and enhance local funding opportunities and mechanisms for hazard mitigation.

- Continue to update a list of potential funding sources associated with hazard mitigation planning.

Structural

- Continue to regularly maintain and update, as necessary, the County public early warning systems and communication networks, particularly the recently upgraded multi-governmental interoperable OASIS radio and communication system.

- Continue to regularly educate, train, and implement the use of various early public warning and safety communication techniques and devices to ensure adequate safety and warning is equally provided to all County residents, notably the elderly, homeless, disabled, hard of hearing, deaf, visually impaired, and/or to those that lack transportation or communication devices before and/or during a hazardous event.

- Continue to bury and protect power and utility lines, where feasible, to prevent damage from hazardous weather conditions.

- Promote the installation and maintenance of emergency on-site back-up power generation systems at critical community facilities and utility locations.

[4] *The **COAD** program brings together leaders from emergency management, public safety, local government, volunteer organizations, and the private sector to collaboratively prepare for, respond to, and recover from emergencies or disasters impacting Southeast Wisconsin (sewicoad.org).*

- Continue to increase public awareness and resources on the availability and location of emergency shelters before, during, and after extreme weather events (see Appendix B).

    - Collaborate with key stakeholders to strengthen community-partner relationships in developing and enhancing a reliable and accessible emergency shelter network to increase their capabilities in the County.

    - Consider the establishment of community resilience hubs.[5] Resilience hubs are community-serving facilities designed to support and provide residents, including those most vulnerable, with an accessible, reliable, and safe physical space (i.e., community center, recreation facility, or multi-family housing building) to gather for either: shelter/safety during a severe weather event, a community engagement/collaboration event, information and education resources on environmental or community health and safety resources, including mitigation recommendations.

- Establish safe and appropriate locations for temporary debris disposal sites.

- Routinely trim and maintain the health of trees, especially those near vulnerable infrastructure (i.e., utility lines and roads) and critical community facilities. Communities should also encourage private landowners to routinely inspect and remove dead or infected trees.

Public Informational and Educational Programming

- Maintain and regularly update County and community websites and other online resources with information related to extreme weather events and risk reduction measures (Appendix B).

- County and all public safety personnel should identify at-risk (or vulnerable) individuals or communities to better anticipate the needs and provisions of information and resources required before, during, and after disasters.

- Encourage and expand County and municipal collaboration and coordination efforts on public outreach programs and events that inform, educate, and assist County residents of all social, economic, physical, and educational backgrounds on the planning and preparation of severe weather events.

[5] *resilience-hub.org.*

- Increase local and community partnerships and collaborations with government agencies, organizations and nonprofits, businesses, and local citizens to improve and enhance community resources and capability efforts before, during and after emergencies.

- Encourage and assist residents of all social, economic, and educational backgrounds to develop Severe Weather Emergency Preparedness Plans and Tool Kits (see Appendix H).

- Reach out and educate, as well as encourage *all* County residents, especially those that are vulnerable, on the installation and use of severe weather warning applications (apps.) and devices, such as FEMA's *ready.gov* app. and/or the *MKEALERT* app (Figure 5.1).[6]

- Continue to distribute information and educational resources and programs to County residents of all social, economic, and educational backgrounds on flood insurance as well as federal or state grant funding opportunities to assist during and after a severe weather event.

Current Programs and Ongoing Projects

Federal and State Programs

FEMA funds several programs that assist State and local governments with hazard mitigation efforts that are administered through WEM in the State of Wisconsin. Two of these programs fit best in this "multiple hazards" section because they address a broad array of hazard events. These programs include FEMA's Hazard Mitigation Grant Program (HMGP) and Building Resilient Infrastructure and Communities (BRIC) Program. These programs provide funding for both pre-disaster planning and on-the-ground projects and will be discussed in further detail in the hazard mitigation funding sources in Chapter 6. FEMA and WEM also provide additional online resources and tool kits, including *Climate.gov*, the Climate Risk and Resilience Portal (ClimRR), the FEMA National Risk Index (NRI), Grant Equity Threshold Tool (GETT), and the FEMA Resilience Analysis and Planning Tool (RAPT). These tools can assist the public in extreme weather preparedness, safety, and recovery.[7]

A number of additional federal and state agencies also have programs that offer awareness and educational resources and tools to enhance State and local hazard mitigation efforts, including the Department of

[6] ***MKEALERT*** *is a free, emergency alert system designed to keep the residents and visitors of the City of Milwaukee informed during potential hazards.*

[7] *www.fema.gov/about/reports-and-data/resilience-analysis-planning-tool.*

Homeland Security's Ready Campaign (*Ready.gov*) program. This is a national public service advertising campaign that provides educational resources on disaster preparedness, response, and mitigation measures for disasters.[8] Similarly, WEM developed *ReadyWisconsin*, with information, materials, and resources customized to Wisconsin's state, regional and local emergency preparedness landscape including Wisconsin's weather awareness events. These include Tornado Week April 8-12; Heat Awareness Day June 5; Lightning Safety Awareness Day June 18; and Winter Weather Awareness Week November 18-22.

NOAA's NWS also has extensive public information to educate local officials and residents about the dangers of severe weather, including data on associated damages, deaths, and injuries. The NWS issues warnings, watches, and advisories when there is a threat of severe weather conditions. Further, the NWS *StormReady* Program encourages communities, including Milwaukee County, to take a proactive approach to improving local hazardous weather operations by providing emergency managers with guidelines on how to improve their hazardous weather operations. Also The NWS-Milwaukee Weather Support for Outdoor Events Program provides free education and training to county and local officials and event coordinators in severe weather monitoring, alerting, and evacuation protocols.

Wisconsin Department of Health Services (DHS), WEM, and other State and local government agencies provide the public with various information, resources, and educational material on severe weather preparedness, including recommended emergency supplies and toolkits, different emergency alerting systems and mobile applications ("apps"), and available public federal, state, or local programs and resources that can assist during and after a severe weather event (see Appendix H).

Various federal, state, and local agencies and/or programs, including those in the state of Wisconsin and Milwaukee County, include data and information related to social and economic (socioeconomic) disparities such as vulnerable or at-risk individuals and populations into planning and policy programs to better ensure equitable services. The primary federal agency that provides information and resources related to vulnerable populations is the U.S. Department of Health and Human Services (HHS), which includes the Centers for Disease Control and Prevention (CDC). As noted in Chapter 2, and Appendix D, this Plan update utilized the CDC's online Social Vulnerability Index (SVI) database and mapping tool to identify and quantify communities experiencing social vulnerability within Milwaukee County. This information can help County

[8] *Department of Homeland Security's* ***Ready Campaign*** *was launched in February 2003 as a National public service campaign designed to educate and empower citizens to prepare for, respond to, and mitigate emergencies, including natural and man-made disasters. Go to Ready.gov to download the mobile app.*

and local public health and emergency officials better prepare for and respond to hazardous events. The CDC also developed an Environmental Public Health Tracking Program, in which it collects, integrates, analyzes, and disseminates health, environmental, and socio-economic data from various sources to help improve and enhance community health, equity, and resiliency.[9]

In 2004, the Department of Homeland Security set forth the National Incident Management System (NIMS) as a directive to increase efficiency and effectiveness in emergency incident management. The NIMS provides a set of standardized organizational structures, such as the Incident Command System (ICS), multi-agency coordination systems, and public information systems, as well as requirements for processes, procedures, and systems designed to improve interoperability among jurisdictions and disciplines in various areas. This includes training, resource management, personnel qualification and certification, equipment certification, communications and information management, technology support, and continuous system improvement. The NIMS integrates existing best practices into a consistent, nationwide approach to domestic incident management that is applicable at all jurisdictional levels and across functional disciplines in an "all hazards" context in terms of preparing for, preventing, responding to, and recovering from domestic incidents, regardless of cause, size, or complexity, including weather-related incidents. As of 2007, Federal preparedness assistance funding for State, territorial, local, and tribal jurisdictions is conditioned on full compliance with NIMS.

Local Programs

Milwaukee County OEM is responsible for developing, implementing, and managing the County's disaster prevention, preparedness, and response, recovery, and mitigation efforts. Milwaukee County and its communities provide educational material via flyers, brochures, printed media, broadcasted media, social media, and/or local websites on disaster preparedness, safety, and recovery resources. Milwaukee County and its municipalities also participate in a number of public outreach events to promote, inform, and educate on different hazardous events and available resources (Appendix B).

As detailed in Chapter 2, there are many modes of communication in which the residents of Milwaukee County are able to receive severe weather warnings including outdoor warning sirens, NOAA Weather Radios, local television and radio broadcasts, digital mobile alert systems, social media platforms, and even door-to-door notifications in certain situations. Milwaukee County also has the capability to issue emergency alerts through its Integrated Public Alert and Warning System (IPAWS). IPAWS provides the

[9] *www.cdc.gov/environmental-health-tracking.*

County with an effective way to alert and warn the public about emergencies using the Emergency Alert System (EAS), Wireless Emergency Alerts (WEA), NOAA Weather Radios, and other public alerting systems from a single interface. In addition to IPAWS, Milwaukee County has the ability to alert the public through reverse-9-1-1, Teletypewriter (TTY), and several subscription-based mobile alert text and email messaging application systems (i.e., "Notify-Me," "E-Notify," and "Hyper-Reach"). The City of Milwaukee also maintains and provides a free mobile alert notification app. called "*MKEALERT*" for missing persons, road closures, extreme weather, public health warnings, and more. Functional needs groups receive extreme weather alerts or warnings through door-to-door for the handicapped, visually and hearing impaired; foreign language media messaging, and/or close-caption (EAS television messaging). Maintaining and updating these public alerting services and the infrastructure that supports them is a vital component in hazard mitigation planning.

The County's updated multi-government shared early public safety radio system OASIS (Organization of Affiliated Secure Interoperable Radio Frequency (RF) Subsystems) provides critical and interoperable communications for public safety agencies and first responders throughout Milwaukee and Waukesha counties. In 2024, the OASIS interoperable radio and communication system was upgraded with the transition to the Wisconsin Public Safety Network (WiPSN). The transition allowed Milwaukee and Waukesha Counties to update and replace the radio system and infrastructure (tower support systems) that was outdated or at its end-of-life functionalities, including the upgrade of the OASIS 800 MHz microwave backhaul system and design, towers and supporting systems, and other operational updates. Ultimately this major upgrade eliminates the risk of system-wide failure and ensures constant communication capability for emergency responders and public safety officials. The completed cost of this project was $1.8 million (2023 dollars).

Milwaukee-Waukesha Counties Amateur Radio Emergency Service (Milwaukee-ARES) / Radio Amateur Civil Emergency Service (RACES), consists of licensed amateur radio operators (hams) that provide backup auxiliary communications for the County during a planned or emergency event if the County loses some, or all, of its radio communication systems. Volunteers are also trained in NIMS.

In addition, and as described in Chapter 1, Milwaukee County has developed a comprehensive emergency management plan (CEMP)[10] which sets forth an all-hazards action plan. Similarly, many of the local units of government have developed emergency operations plans and/or programs that complement the County's

[10] *Milwaukee County Office of Emergency Management*, Comprehensive Emergency Management Plan (CEMP)*, 2021*.

plan and also set forth procedures and actions to deal with a range of situations and events. To that end, this Plan recommends that Milwaukee County OEM and local units of government continue to regularly collaborate to review and update emergency plan components to ensure that all involved personnel are aware of plan recommendations, procedures, and tasks before, during, and after an emergency event.

Multi-Jurisdictional Considerations

The hazards addressed by mitigation measures in this multi-hazard plan component include multiple weather hazard events. These events have the potential to impact all municipalities within Milwaukee County and may cause damage or loss to a variety of assets including infrastructure (i.e., transmission lines, communication lines, and transportation routes), buildings (i.e., homes, businesses, critical facilities), and property. Hence, Milwaukee County, its municipalities, and relevant businesses and organizations should continue to coordinate hazard mitigation planning activities and procedures through a cooperative County and local government and organization partnership. Furthermore, when adapting to climate change, county and local officials must consider the priorities, needs, and challenges of vulnerable communities as a priority for hazard mitigation planning.

Evaluation of Alternatives and Identification of Priority Mitigation Measures

The best way to mitigate vulnerability to many hazards is to avoid them all together, when possible. Life and property are vulnerable to hazard events when they are in or near known hazard areas. For this reason, an important aspect to any hazard mitigation plan is continuing to enforce, review, and when necessary, enact new regulations and ordinances. The County and its municipalities should continue to review building code regulations and ordinances with consideration of future hazard events and the effects of a changing climate.

The continued use of various platforms (printed material, radio/tv broadcast, websites, social media, public outreach) to communicate with *all* Milwaukee County residents on the seriousness of severe weather events, associated impacts, and different preparedness recommendations is an integral part of this Milwaukee County hazard mitigation plan. Also, educational outreach events and programs should be conducted in a County-community partnership with Federal, State, and local officials to improve local networking and provide resources related to hazard mitigation planning and projects.

Furthermore, providing the public with advanced warning of an imminent hazard event is a major component of Milwaukee County mitigation planning. It is imperative that the County continue to use multiple means of communication to alert *all* citizens to the threat of various hazards, and to maintain and

improve these early warning systems as means of effective and reliable public safety measures. The Milwaukee County OEM continued participation and coordination in disaster and emergency preparedness with other local, State, and Federal organizations is another key component of public safety mitigative action in order to help protect all citizens and assets of Milwaukee County.

Based upon the foregoing evaluation and consideration of risk, and review by the Milwaukee County Hazard Mitigation Plan LPT, there are 20 mitigation measures that apply to multiple types of hazards and were considered to be priority actions as part of this hazard mitigation plan update. These priority mitigation measures, along with a general cost-benefit summary are presented in Table 5.1.

5.3 HAZARD MITIGATION PLAN COMPONENT FOR FLOODING AND ASSOCIATED STORMWATER DRAINAGE PROBLEMS

As noted in Chapter 3, flooding and related stormwater drainage (or urban flooding) problems represent one of the most common and damaging types of hazards affecting Milwaukee County. Generally, the amount of damage from flooding is a direct consequence of the contributing drainage (or watershed) area land use. It is likely that flooding and related stormwater drainage problems will continue to be a major source of damage affecting the County in the future. As such, the following section describes alternative and priority flooding and stormwater mitigation strategies to consider for hazard mitigation planning in Milwaukee County.

Identification of Alternative Mitigation Strategies

Various structural, nonstructural (including nature-based solutions), and educational/informational measures are available for mitigating the impacts of flooding and stormwater drainage concerns in Milwaukee County. **Nonstructural measures** are most effective when the flooded structures are scattered throughout the watershed. In contrast, **structural measures** typically are most effective where impacted buildings are concentrated, such as in urban areas. **Educational and informational** flood mitigation-related material is effective for communities, homeowners, landowners, businesses, and local officials who repeatedly experience riverine and stormwater flooding events.

For purposes of organizing this extensive Plan component, flood mitigation strategies are grouped into four sub-plan elements:

- Preservation of Floodplains, Open Space, and Environmentally Sensitive Lands

- Floodplain Management

- Stormwater Management

- Public Information and Education Outreach

Preservation of Floodplain, Open Space, and Environmentally Sensitive Lands Plan Element

As mentioned in Chapter 2, natural landscape features such as floodplains, wetlands, and undeveloped (i.e., open space, forested, etc.) areas are essential for storing water and ultimately reducing the impact of flood events. With increasing urbanization, it is critical that these lands be preserved, protected from development, and enhanced when possible. The following sections detail recommended management actions to help preserve and maintain these essential open space lands within Milwaukee County.

Preservation of Floodplains and Wetlands

As detailed in Chapter 1, and listed in Table 1.1, municipalities within Milwaukee County have several pertinent floodplain management guidelines in place, most notably zoning regulations and ordinances. The floodplain zoning ordinances, described under Section 87.30 of the *Wisconsin Statutes* and Chapter NR 116, are intended to preserve the floodwater conveyance and storage capacity of floodplain areas and to prevent the addition of new flood-damage-prone development in flood hazard areas. Implementing and enforcing these ordinances on an ongoing basis is an integral part of flood mitigation.

With the increase of intense rain events, more restrictive floodplain zoning ordinances should be considered to enhance flood storage preservation throughout the County. Currently, floodplain zoning ordinances only apply to the Federal Emergency Management Agency's (FEMA) special flood hazard area (SFHA) or 1-percent-annual-probability floodplain. The FEMA 0.2-percent-annual-probablity floodplain (or 500-year floodplain) should be considered for new development or redevelopment to maintain or create additional flood storage areas and protect existing assets within the County. The effective FEMA 0.2-percent-annual-probability floodplains in Milwaukee County are shown in green on Map 5.1, which provides a larger floodplain footprint compared to the FEMA SFHA.

In relation to floodplain regulations and also described in Chapter 1 and listed Table 1.1, municipalities within Milwaukee County have relevant wetland management regulations in place, most notably in the form of shoreland-wetland zoning. The shoreland-wetland zoning ordinance, under Chapter NR 117 of the *Wisconsin Administrative Code,* is to help maintain the stormwater and floodwater storage capacity of

wetlands and prohibits certain land uses detrimental to wetlands. Implementing and enforcing this regulation on an ongoing basis is essential to County and local flood mitigation.

Protection of Environmentally Sensitive Lands and Open Space Areas

Protecting environmentally sensitive lands, which may include environmental corridors, natural areas, and open space sites can help prevent increased flood flows and associated problems. As detailed in Chapter 2, and shown on Map 5.2, environmental corridors in Milwaukee County are primarily located along major stream valleys and along the Lake Michigan shoreline. These lands contain almost all of the best remaining woodlands and wildlife habitat areas, including significant floodplains and wetlands.

The regional land use and transportation plan[11] and park and open space plan[12] also carry forward fundamental land use recommendations, including reducing and containing urban sprawl and protecting and preserving environmentally sensitive lands, such as environmental corridors, open space lands, and isolated natural resource areas. These regional plans form the framework for ongoing local land use planning and plans carried out by local government units and Milwaukee County. As detailed in Chapter 4, the Milwaukee County park and open space plan[13] and the various local land use plans refine, detail, and extend on these regional plans.

Milwaukee County has primary responsibility for parks and related open space areas within the County. The County has taken an active role in preserving environmentally sensitive lands and currently owns approximately 6,767 acres of park, parkway, and open space lands located in 159 sites, with the remaining 10 sites of 938 acres being state-owned. The current locations of these major parks, primary and secondary environmental corridors, and isolated natural resource areas[14] are shown on Map 5.3 and listed in Appendix F. As indicated by the maps, many of Milwaukee County Parks and environmental corridors are located along the streams of Milwaukee County. This Plan therefore recommends that these parks,

[11] *Southeastern Wisconsin Regional Planning Commission Planning Report No. 55 (2nd Edition),* VISION 2050: A Regional Land Use and Transportation Plan for Southeastern Wisconsin *(June 2020).*

[12] *Southeastern Wisconsin Regional Planning Commission Planning Report No. 27,* A Regional Park and Open Space Plan for Southeastern Wisconsin: 2000*, November 1977.*

[13] *Southeastern Wisconsin Regional Planning Commission Community Assistance Planning Report No. 132,* A Long-Range Park and Open Space Plan for Milwaukee County (2nd edition)*, February 2022.*

[14] *Isolated natural resource areas are physically separated from environmental corridors by intensive urban or agricultural land uses and are at least five acres in size.*

parkways, and environmentally sensitive areas be preserved and maintained for flood mitigation efforts in Milwaukee County.

Participation in Milwaukee Metropolitan Sewerage District (MMSD) Greenseams® Program

In 2001, MMSD, with the assistance of The Conservation Fund, initiated the Greenseams® program. This Program was developed based on recommendations in the MMSD Conservation Plan[15] and Greenway Connection Plan.[16] The aim of the Greenseams® program is to protect significant lands, particularly those containing water-absorbing soils, to help prevent future flooding and water pollution, as well as manage wildlife habitat and recreational lands within watersheds contributing to the MMSD service area.[17] As shown on Map 5.4, approximately 611 acres of land in Milwaukee County has been acquired as part of this Program. This Plan recommends the continued support of Milwaukee County communities in the Greenseams® program for flood mitigation purposes.

Floodplain Management Element

Implementing floodplain management measures is a fundamental element of hazard mitigation planning. The identification, analysis, and recommendation of possible methods of mitigating flooding problems within the Region, including Milwaukee County, has been the subject of various planning efforts. As detailed in Chapter 4, current flood management efforts within Milwaukee County are being carried out under the Milwaukee Metropolitan Sewerage District (MMSD) Watercourse System and Flood Management Planning Program.[18] With the assistance of the Southeastern Wisconsin Regional Planning Commission (Commission), County and local partners, this MMSD Planning Program has become a vital element in flood risk reduction efforts in the Region, especially for at-risk structures and critical community infrastructure located within the 1-percent-annual-probability flood hazard areas. Map 5.5 illustrates the MMSD service area and the major watersheds and watercourses within the District and Milwaukee County. Table 5.2 also lists the MMSD jurisdictional streams by watershed. This Plan considers the ongoing and planned flood risk reduction

[15] *The Conservation Plan identified land parcels recommended to be protected for multiple purposes, including flood reduction potential and stormwater management benefits.*

[16] *Southeastern Wisconsin Regional Planning Commission Memorandum Report No. 152,* A Greenway Connection Plan for the Milwaukee Metropolitan Sewerage District, *December 2002.*

[17] *mmsd.com.*

[18] *As a regional agency, MMSD is the most appropriate entity to address watershed issues that involve multiple municipalities. The District's authority to reduce the risk of flooding is documented in* Wisconsin Statutes, *sec. 200.31(1).*

efforts by MMSD, and its partners as described below as priority mitigation measures for Milwaukee County flood hazard mitigation.

Milwaukee Metropolitan Sewerage District (MMSD) Watercourse and Floodplain Management Project Recommendations

As watershed boundaries do not necessarily follow municipal boundaries, reducing the risk of flooding requires looking at the watershed as a whole, including the complete river system and its tributaries. The MMSD Watercourse Planning Program was developed using the watershed-based approach and the following major projects from that Program are recommended for this Plan element. All of these projects and estimated costs are listed in Table 5.3 and the major efforts are discussed in the sections below. The projected Watercourse Program total cost for floodplain projects planned through 2035 is about $242 million (2023 dollars).

Milwaukee River Watercourse

- Milwaukee River Estabrook Dam Removal Follow Up Efforts

  The 81-year-old Estabrook Dam was removed in May 2018 due to deterioration and with the intent of restoring the natural functions of the river. Removing the dam also slightly reduced water levels immediately upstream of the dam location as well as improved water quality, instream and riparian habitat, and recreational opportunities. Currently updated hydraulic and hydrologic modeling and floodplain mapping updates are being done to reflect the dam removal, which will impact areas of the Cities of Glendale and Milwaukee.

- Milwaukee River and Lake Michigan Estuary Study

  This study aims to develop mitigation alternatives to reduce flood risk to structures in the City of Milwaukee located in the 1-percent-annual-probability floodplain of the Milwaukee River Estuary using the updated Lake Michigan water-levels. Individual structure evaluations by private subcontractors may be considered for this plan.

Menomonee River Watercourse

- Menomonee River of Western Milwaukee (Phase 2B)

  This particular project, which ties together several other Menomonee River watercourse projects, will protect structures from the 1-percent-annual-probability flood along the Menomonee River in the Cities of Wauwatosa and Milwaukee (see Figure 5.2). These projects are a component of the *Phase II Watercourse Management Plan for the Menomonee River Watershed*, which identified overbank

flooding in the vicinity of West State Street on the west side of Milwaukee. The project entails the design and construction of a levee and floodwall along West State Street to tie into the east end of a previously constructed levee.

- Menomonee River Levee System Accreditation
  This particular measure is to ensure the levees constructed along the Menomonee River in Hart Park and Valley Park meet WDNR NR 116 and FEMA 44 CFR 65.10 levee requirements.[19] This will allow identified structures within flood hazard areas to no longer be mapped in the Menomonee River SFHA.

- Sewer Rehabilitation for FEMA Levee Accreditation
  This project is intended to repair and rehabilitate certain points along the storm and sanitary sewer systems that penetrate the Hart Park and the Western Milwaukee Levee System on the Menomonee River. This measure is required to fulfill FEMA's accreditation requirements for certification of the levee system.

Kinnickinnic River (KK) Watercourse

- The KK River Watershed Watercourse and Flood Management Plan
  This includes two Preliminary Engineering (PE) studies and analysis work for portions of the KK River watershed. The purpose of this effort is to ultimately reduce flood risks to numerous residential and commercial structures located in the 1-percent-annual-probability floodplain in the KK River watershed. The first PE study refines the KK River Watershed Flood Management Plan (KKRWFMP)[20] recommendations for the Jackson Park and 43rd Street Ditch projects. The second PE study improves the KKRWFMP recommendations for the Wilson Park Creek, Villa Mann Creek, and Lyons Park Creek projects.

[19] *For purposes of the NFIP, FEMA only recognizes levee systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the flood hazard from the 1-percent-annual-probability flood.*

[20] *GRAEF, Hey and Associates, Inc., and CDM Smith,* Kinnickinnic River Watershed Flood Management Plan*, May 2017.*

- Pulaski Park Project (Figure 5.3)

  This major project was recently constructed by MMSD to reduce flood risk for a number of residential and commercial structures located in the KK River 1-percent-annual-probability floodplain between South 6th and 16th Streets in the City of Milwaukee and improve public safety (reduce drowning risk) from the high velocity concrete-lined KK River channel. To date, MMSD in partnership with Milwaukee County Parks and others, have removed over 1,700 feet of concrete lining from the KK River mainstem, constructed flood storage areas, and reconstructed the W. Cleveland Avenue bridge within Pulaski Park. This project will allow for slower stream velocities and reduce overall flood risks within this area.

- Jackson Park Project

  This major watercourse project will reduce structural flood risk, improve public safety, as well as alleviate increased flood flows from future concrete channel lining removal projects on the KK River mainstem, Lyons Park Creek, and the S. 43rd Street Ditch. This project consists of acquiring properties, relocating the businesses and removing structures, creating flood storage, lowering and reshaping parkland and recreational fields, and dredging the park to enhance flood storage.

Oak Creek Watercourse

- Oak Creek Structural Acquisition and/or Floodproofing Study

  As of 2019, there are three identified structures remaining in the regulatory floodplain. The current proposal is to refine the Oak Creek Watercourse and Flood Management study to include structure acquisition, removal, or floodproof recommendations for the identified structures within the 1-percent-annual-probability floodplain.

Root River Watercourse

- Floodplain Modeling and Mapping Updates

  This effort will complete the Root River floodplain modeling and mapping efforts initiated under the Milwaukee County MCAMLIS (now MCLIO)[21] mapping program. Mapping updates for the upper part of the Root River mainstem and 27 tributaries in Milwaukee and Waukesha County will enhance the identification of structures at-risk of flooding from the 1-percent annual-probability event.

[21] *MCAMLIS is now called the* Milwaukee County Land Information Office (MCLIO).

Lake Michigan Drainage Area-MMSD Facilities

- Impact of Water Levels on the MMSD Facilities and Assets Study

  The purpose of this Study is to determine the effects of high and low water surface elevations (Lake Michigan and the Milwaukee River) on the MMSD Water Reclamation Facilities and conveyance assets, including flood and stormwater protection measures. It is intended to provide alternatives to reduce risks and provide cost estimates for each identified alternative. From this effort the two major projects listed below are envisioned.

  - MMSD's Jones Island Water Reclamation Facility (WRF) Project(s)

    The purpose of this project is to reduce the risk of flood damage to the Jones Island WRF and its assets, as well as confirm that staff will have safe access to and from the facility during a potential future flooding event.

  - Flood Protection at the MMSD South Shore Water Reclamation Facility Project(s)

    The goal for this study is to mitigate flooding risks in low lying areas of the MMSD South Shore WRF. It is outlined to mitigate risks to safety, ongoing flood event repair costs, and operational effectiveness at the treatment plant.

Because floodplain modeling and mapping updates were in various stages during the drafting of this Plan, property owners of at-risk structures (Map 3.2) should consider additional on-site surveys from a private subcontractor or engineer to confirm the structure is indeed at risk to flooding. Subsequently, if confirmed, voluntary floodproofing or acquisition decisions should be made in collaboration with the local municipality and be consistent with the MMSD Flood Risk Reduction policy. Reducing structural risks, especially to critical community facilities and/or infrastructure, should be considered a high priority for flood risk reduction projects. Additionally, MMSD and its partners should continue to consider populations and assets most vulnerable to flooding impacts when developing mitigation projects.

<u>Actions to Address Structures Located in High-Risk Areas Based on Parcel-Based Analysis</u>

In addition to the above MMSD Watercourse and Flood Management efforts, it is important to address the structures identified in the parcel-based analysis as potentially being in the 1-percent-annual-probability floodplain, as well as structures identified by FEMA that experience repetitive flooding issues.

As mentioned in Chapter 3, there are currently 1,483 insurable structures estimated to be located within the 1-percent-annual-probability flood hazard areas of Milwaukee County (see Tables 3.8 and 3.9), including

four critical community facilities and 16 FEMA designated repetitive loss structures. The amount and general location of these insurable structures are shown on Map 3.2. The 16 repetitive loss structures are primarily residential along with three commercial structures. The combined estimated fair market value of these repetitive loss structures is $2.91 million (2022 dollars). The damages to the four critical community facility properties resulting from a 1-percent-annual-probability flood is estimated to be about $4.35 million (2022 dollars).

The following priority mitigation measures are recommended for the 1,483 at-risk structures identified in the parcel-based analysis:

- **Voluntary acquisition and removal** of up to 1,260 **residential structures** identified in the parcel-based analysis as potentially being in the 1-percent-annual-probability floodplains. Note, of the 1,260 structures, 28 are identified to be within the Lake Michigan coastal floodplain (see Map 3.12). These structures include single-family residential buildings, apartment buildings, and condominiums (note, manufactured homes were examined separately as these structures are considered highly vulnerable during extreme weather events). Following the demolition of the structures, the land should be kept as an open space for recreational and natural flood storage purposes. For any structure, this recommendation should be implemented following confirmation that the structure is indeed located within the 1-percent-annual-probability floodplain with additional in-field surveys. Again, this plan element is presented as a voluntary option, subject to the preference of the individual property owner. Also, voluntary acquisition should be in collaboration with the local municipality and consistent with the MMSD Flood Risk Reduction policy. As indicated in Table 5.4, the damages these properties would experience from a 1-percent-annual-probability flood are estimated to be about $76.1 million (2022 dollars). The estimated cost of acquiring and removing all 1,260 structures is approximately $508 million (2022 dollars).

    - As indicated in Chapter 3 and shown on Map 3.2 and in Table 3.9, the Cities of Glendale and Milwaukee and the Village of Fox Point have a significant number of parcels with structures located within the flood hazard areas of Milwaukee County. Further, Map 3.2 and Table 5.5 shows that the majority of these structures, specifically residential, are within the **Kinnickinnic** (530), **Milwaukee** River (515) and **Root** River (157) watersheds. With a significant amount of at-risk structures within the same vicinity (i.e., clusters), homeowners, municipalities, and MMSD should utilize the most up-to-date floodplain mapping and work together on the best flood mitigation alternatives. These would include voluntary structural acquisition and removal to provide for open

space (i.e., floodplain), park, and/or recreational opportunities. Potential 1-percent-annual-probablity flood damages to structures by watershed are listed in Table 3.8.

- **Voluntary removal** of 16 **manufactured homes and acquisition of the land** in the City of Franklin, as identified by the parcel-based analysis as being located in the 1-percent-annual-probability floodplains of the East Branch Root River. Following the removal of the manufactured homes, the land should be kept in open-space use. This recommendation should be implemented following confirmation with recent floodplain mapping updates and completing in-field surveys of the structures. This recommendation is presented as a voluntary option, subject to the preference of the individual property owner. The estimated cost of acquiring the land and relocating all 16 manufactured homes is about $3.52 million (2022 dollars).

- **Voluntary floodproofing**[22] of up to 207 **nonresidential structures**, including commercial, critical community facilities, park, and utility structures identified in the parcel-based analysis as potentially being in the 1-percent-annual-probability floodplains. This mitigation measure should only be implemented following further confirmation of the structure's location in relation to the flood hazard area. This can be done with additional in-field surveys by an engineer or surveyor.[23] Note, this plan element is presented as a voluntary option, subject to the preference of the individual property owner. Listed in Table 5.4, the damages these properties would experience from a 1-percent-annual-probability flood are estimated to be nearly $89.8 million (2022 dollars). The estimated cost of floodproofing all 207 structures is approximately $96.8 million.

    - Table 5.5 lists the number of nonresidential structures estimated to be within 1-percent-annual-probability floodplains by watershed. As indicated in Table 5.5, the **Kinnickinnic** River, **Menomonee** River, and **Root** River watersheds have the greatest amount of at-risk nonresidential

*[22] **Floodproofing** is a combination of structural and non-structural changes or adjustments made to the building that reduces or prevents flood damage to the structure and/or its contents. There are three main types of floodproofing: elevation, dry floodproofing, and wet floodproofing**. Elevation** is raising the first floor of the building above the 1-percent-annual-probability flood elevation, often with a factor of safety, and removing the use of the basement. **Dry floodproofing** is the practice of making a building watertight or substantially impermeable to floodwaters up to the expected floodwater height. **Wet floodproofing** reduces damage from flooding in three ways: allowing floodwater to enter and exit a structure to minimize structural damage, use of flood damage-resistant materials, and elevating important utilities. (FEMA, 2008).*

[23] It is anticipated that the results of the floodplain map updating efforts, and the field surveys may reduce the number of structures that are confirmed to be in the flood hazard area and that may require floodproofing.

structures in Milwaukee County. Potential damages to structures by watershed are listed in Table 3.8.

- Priority mitigation measures to protect and floodproof **critical community facilities**, infrastructure, and utilities from flood hazard events is highly recommended for Milwaukee County. Based upon the parcel-based analysis and shown on Map 5.6, there are four identified critical community structures potentially located within the 1-percent-annual-probability floodplain. These structures include an adult day service facility and St. Lukes hospital located in the Kinnickinnic watershed within the City of Milwaukee; College Park Elementary School located in the Root River watershed in the Village of Greendale; and the Lake Express High-Speed Ferry terminal in the City of Milwaukee near the Lake Michigan shoreline. Listed in Table 5.4, the damages these properties would experience from a 1-percent-annual-probability flood are estimated to be about $4.35 million (2022 dollars). The estimated cost of floodproofing the four structures is approximately $4.95 million.

Actions to Address Flooding Hazards to Vulnerable Populations

Hazardous and extreme weather events including flooding are known to disproportionately impact communities of color, low-income, and disadvantaged populations, hence increasing their vulnerability to impacts caused by such events. As described in Chapter 2 of this Plan, the CDC created a Social Vulnerability Index (SVI) of every U.S. census tract. As indicated in Figure 2.1, the overall SVI for Milwaukee County ranges from high to low. Although socially vulnerable individuals live throughout the County, there are high concentrations of socially vulnerable residents in denser urban areas, specifically within and around the City of Milwaukee. Because of this, Milwaukee County and local community officials and agencies should work together on designing and implementing appropriate and beneficial flood mitigation measures within these denser urban areas to create a more resilient community.

Additional vulnerability assessments done within Milwaukee County that are highly recommended to use to implement this Plan are highlighted below.

The Milwaukee Flood and Health Vulnerability Assessment (MFHVA) Tool[24]

Described previously in Chapter 3, Groundwork Milwaukee, along with academia professionals and state partners, put together an interactive online mapping (or storymap) and data tool to help identify communities across the City of Milwaukee where exposure to urban flooding may disproportionately impact vulnerable populations due to socioeconomic and health conditions. The effort used a surface runoff model called CityCAT,[25] FEMA's 1-percent-annual-probability flood hazard zone, and U.S census tract data, with a focus on health, socioeconomic, and housing data to create an overall Flood Vulnerability Index (FVI) tool. As shown in Figure 5.4 (A), the FVI results indicate that overall, the majority of the City of Milwaukee is vulnerable to flooding, however the highest vulnerability values are concentrated in the City's central location. Census data gathered from this assessment was also used to generate flood exposure and vulnerability "hotspots." Locations identified as hotspots, shown in Figure 5.4 (B-D), should be considered priority locations to reduce the impacts of flooding as these are considered the most vulnerable communities.

Milwaukee County Climate Action 2050 Plan Vulnerability Assessment[26]

During the drafting of this Plan, Milwaukee County conducted a comprehensive vulnerability assessment on the effects of climate change on Milwaukee County operations and residents. The assessment conducted a public survey for Milwaukee residents and when asked about their extreme weather concerns, community survey respondents reported road closures, damaged vehicles, sewage overflows, and flooded basements to be most impactful in their communities. The assessment also analyzed FEMA floodplains with the CDC SVI data and concluded there are four waterways which may disproportionately impact vulnerable communities due to a hazardous flooding event. These four streams include Wilson Park Creek, the Menomonee River, Lincoln Creek, and the Milwaukee River. These vulnerable communities in particular face strenuous economic challenges, exacerbating the risks associated with extreme flooding and ultimately impacting community resilience. Additionally, the assessment found high-priority assets deemed vulnerable or at-risk in the event of a 100- or 500-year flood. These sites are listed in Table 5.6.

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[24] *Groundwork Milwaukee, Wisconsin Health Professionals for Climate Action, Medical College of Wisconsin, and the City of Milwaukee,* Milwaukee Flood and Health Vulnerability Assessment*, July 2023*.

[25] *The CityCAT model was used to compute the flow of water in real time accounting for infiltration based on the distribution of pervious and impervious surfaces for a 100-year, 1-hour storm in the City of Milwaukee.*

[26] *Milwaukee County,* Milwaukee County Climate Action 2050 Plan Vulnerability Assessment*, July 2023*.

Actions to Address and Protect Vulnerable Infrastructure from Flooding Events

In addition to structural flooding, infrastructure such as major roadways and bridges within the County have been reported to experience frequent flooding problems. Flooding can have significant impacts on County and community infrastructure (such as transportation networks, building structures, and utility systems), including the disruption of travel (emergency vehicle response, public transportation routes or public mobility to access a safe location) and critical utility services (electricity, heat, power plants, water treatment facilities, etc.). For those reasons, this Plan recommends that community development or redevelopment plans incorporate resilient infrastructure designs to withstand the impacts of a 1-percent-annual-probability flood event.

Table 5.7 highlights specific areas within the County known to or mapped as overtopping during a heavy rain event.[27] A roadway is often considered impassable when flood depths reach one foot. Because of this, roadway flooding can pose a significant safety risk to residents of Milwaukee County, (i.e., driving through the flooded portion of the road not knowing water depths and/or velocity) as well as impede roadway accessibility for residents and emergency responders. This Plan recommends that known roadway flooding locations be evaluated for alternatives to reduce future flooding risks. It is further recommended that evaluations of flood risk be conducted on all major transportation systems including roadways, bridges, railroads, and airports in Milwaukee County that are located within or near the 1-percent-annual-probability floodplain. In doing so, County and local government officials, emergency responders, and public transportation and utility personnel will be provided with better information to help prepare and plan for alternate routes and facilities to use during hazardous flooding events.

Participation in the National Flood Insurance Program (NFIP)
and Floodplain Mapping Revisions and Updates

Based on a detailed countywide Flood Insurance Study (FIS), FEMA produces Digital Flood Insurance Rate Maps (DFIRMs) to identify areas in the county that are subject to flooding. Through FEMA's Map Modernization program,[28] Milwaukee County's effective countywide FIS was completed in September 2008

[27] *Southeastern Wisconsin Regional Planning Commission Memorandum Report No. 259,* A Watercourse System Plan for Honey Creek: Milwaukee, Wisconsin, *October 2022; Southeastern Wisconsin Regional Planning Commission Community Assistance Planning Report No. 330,* A Restoration Plan for the Oak Creek Watershed*, December 2021; Milwaukee County Parks.*

[28] *In 2003, FEMA implemented* the **Map Modernization program***. This program was intended to upgrade and distribute FIRMs into a digital format, rather than on paper (i.e., Digital Flood Insurance Rate Maps or "DFIRMs"). This program used state-of-the-art technology and advanced engineering to increase the quality, reliability, and availability of flood hazard maps and data and employed a collaborative process to involve state, regional and local partners in mapping tasks.*

(see Table 5.8). As a result, Milwaukee County and communities are able to participate in the FEMA National Flood Insurance Program (NFIP), allowing residents impacted by flood events to purchase government backed flood insurance. As such, this Plan calls for homeowners in and near flood-prone areas to purchase flood insurance to provide some financial relief for flood losses. Hence, Milwaukee County and its communities should continue to participate in the NFIP and, as necessary, request that FEMA revise the FIS to reflect new flood hazard data. Finally, as recommended flood control measures are implemented, the impacted communities should submit map revisions to FEMA. Current FEMA effective floodplain maps for Milwaukee County are available and can be viewed on the FEMA, WDNR, and Milwaukee County websites.

As part of modernizing Milwaukee County's mapping, a cooperative agreement in 1990 was executed between Milwaukee County and three local utility companies for the development and maintenance of a Milwaukee County Automated Land Information System (MCAMLIS). Under that program, large-scale digital topographic mapping was prepared for all of Milwaukee County. The MCAMLIS Steering Committee also requested that the Commission carry out a digital floodplain mapping program. Hydrologic and hydraulic analyses and mapping completed under the MCAMLIS effort are now being refined for local zoning and FEMA flood insurance purposes. These more recent mapping modifications and updates are being incorporated in the DFIRMs through the Letter of Map Revisions (LOMR)[29] process. Current floodplain modeling and mapping updates that are underway include the Root River, portions of the Menomonee River mainstem and several of its tributaries, and Fish Creek.

As documented in Chapter 2, during the drafting of this Plan various floodplain modeling and mapping updates were ongoing or near completion through the FEMA process. As such, the floodplains used in this Plan consisted of a combination of the FEMA effective floodplains, the Commission developed floodplains on certain streams, Menomonee River and Estabrook Dam LOMRs, and maps on certain streams developed by WDNR as part of the Risk MAP effort.[30] It should be noted that updated Milwaukee County DFIRMs and an FIS report will become effective on October 24, 2024.

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[29] **A Letter of Map Revision (LOMR)** *is FEMA's modification to an effective Flood Insurance Rate Map (FIRM). Letter of Map Revisions are generally based on the implementation of physical measures that affect the hydrologic or hydraulic characteristics of a flooding source and thus result in the modification of the existing regulatory floodway, the effective Base Flood Elevations (BFEs), or the Special Flood Hazard Area (SFHA). The LOMR officially revises the Flood Insurance Rate Map (FIRM) and modifies data in the Flood Insurance Study (FIS) report.*

[30] *In 2010, FEMA began its new* **Risk Mapping, Assessment, and Planning (Risk MAP) program**. *This refined program provides communities with both flood information and tools and updated DFIRMs that communities can use to make better informed decisions and to take action to reduce risk to life and property.*

Participation in Community Rating System

The NFIP's Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions meeting the three goals of the CRS:

- Reduce flood damage to insurable property
- Strengthen and support the insurance aspects of the NFIP
- Encourage a comprehensive approach to floodplain management

During the drafting of this Plan update, there were no municipalities within Milwaukee County participating in the CRS program. Therefore, it is recommended that Milwaukee County and its municipalities consider participating in the CRS program to directly provide a benefit to residents for flood hazard mitigation efforts.

Documentation of the Extent of Future Floods

It is recommended that when flooding occurs in Milwaukee County, the County and affected municipalities document the extent of the floods as well as damages incurred by the flood. A number of methods could be used to accomplish this, including aerial, satellite, or ground-based photography showing locations of flooded areas; surveying and mapping of the elevation of debris lines resulting from floods; or other documentation techniques. Data developed from documenting the extent of future floods can be used to periodically refine the hydrologic and hydraulic simulation models used to develop the DFIRMs and FIS. In addition, such data may also be useful in bridge and culvert design and in water quality management planning. A current example to reference is the ongoing MMSD Watercourse Corridor Study, in which time-lapse imaging is used to document the impacts caused during and after an intense rainfall event on stream conditions and the adjacent environment.

MMSD Watercourse Corridor Study

MMSD, the U.S. Geological Survey (USGS), and the University of Wisconsin-Milwaukee School of Freshwater Sciences are conducting a long-term study on the hydrologic, geographic, physical, biological, and chemical properties of the major waterways within the MMSD service area. Currently, the study is in its sixth phase (2021-2025), which involves refining the earlier information and data collection methods, including streamflow. Streamflow measurements are being collected at seven sites, in which six of the sites are using

time-lapse image capabilities using a mounted camera continuously capturing a photo at pre-set intervals. Stream monitoring sites with time-lapse imaging include the following.

- Little Menomonee River near Freistadt Road
- Little Menomonee River upstream of the confluence with the Menomonee River
- Honey Creek upstream of the confluence with the Menomonee River
- Menomonee River at 16th Street
- Milwaukee River at its mouth at Jones Island
- Root River at Grange Avenue

Employing this technique provides the ability to visually document and analyze real-time effects of an extreme rainfall event on stream channel and riparian conditions (example: Figure 5.5).[31] This available information, which is accessible on the USGS Water Data for the Nation (WDFN) website, should be considered for Milwaukee County flood hazard mitigation planning. Further, Milwaukee County and/or MMSD should consider deploying additional monitoring sites using the same capabilities (i.e., mounted cameras) within all the major watersheds of Milwaukee County. These additional monitoring sites can provide MMSD and the County with supplementary insight on the effects of rainfall and timing of flooding events, allowing for better flood mitigation planning.

MMSD Study on 1000-Year Storm Model

To evaluate stormwater ponding areas in the County, MMSD is working with a consultant to utilize hydrologic and hydraulic models with high resolution digital elevation models (DEMs) to analyze the potential impacts from larger storms events (i.e., 1000-year storm) within the MMSD service area. The intent of this modeling effort is to identify potential "hot spots" with a high stormwater flooding risk.

[31] *MMSD,* Watercourse Corridor Study: Continuous Real-Time Streamflow | *U.S. Geological Survey (usgs.gov).*

Stream Channel Maintenance Activities and Project Recommendations

As mentioned in Chapter 2 and shown on Map 2.6, sections of urban watercourses within MMSD's jurisdiction were channelized and lined with concrete to improve conveyance capacity. This practice has caused negative impacts including increases to flow velocities, increases to the severity of flooding downstream, reductions in flood storage, streambed and streambank erosion, decreases in water quality, and the loss of riverine and riparian habitat. Additionally, during flooding events the concrete lined channels experience a rapid increase in stream flows and velocities, which creates a major public safety concern (injury or drowning). In response to the negative impacts of concrete-lined channels, this Plan calls for MMSD, the communities, and Milwaukee County to continue their ongoing and planned efforts of restoring the Region's channels to more natural stream conditions and in turn, reducing flood risks within the County.

As indicated in Table 5.3 and highlighted below are major ongoing or planned MMSD channel concrete removal projects which play a critical role in flood risk reduction and are therefore considered a priority mitigation alternative for this Plan. Costs for implementing the planned concrete-channel removal projects are listed in Table 5.3.

Menomonee River Watershed

- Honey Creek Watercourse-Reach 1 Concrete Removal

  This watercourse plan includes removing approximately 3,900 feet of concrete-lined Honey Creek channel from W. Wisconsin Avenue to W. Fairview Avenue extended (Reach 1). It also includes constructing a more naturalized channel on nearly 1,100 feet of concrete channel and approximately 3,700 feet of heavily eroding natural channel from Wisconsin Avenue downstream to the Menomonee River.

- Underwood Creek Watercourse-Reach 1, Phase 2

  This watercourse project includes design and construction to remove about 4,400 feet of concrete-lined channel, lower the floodplain, and replace the concrete channel with bioengineered material. It is also planned to include a series of pools, riffles, and wetlands to enhance the natural functions of Underwood Creek. This effort plans to lower the floodplain which will require a LOMR to be submitted to FEMA. This is a U.S. Army Corps of Engineers (USACE)-led effort with MMSD's assistance.

Kinnickinnic River (KK) Watershed

- KK River Mainstem Watercourse-Jackson Park

  This project involves the removal of about 1,400 feet of concrete channel and enclosed culverts, lowering the floodplain, and naturalizing the channel. This project was part of a recommended alternative from the KK River Watershed Preliminary Engineering study.

- KK River Mainstem Watercourse-Pulaski Park

  To improve safety as well as stream and riparian habitat, this plan includes removing about 1,900 feet of concrete-lined channel within Pulaski Park. Additionally, this project will involve the removal of residential structures and widening of the channel to improve flood flows.

In addition to concrete-removal mitigation measures, this Plan recommends MMSD, Milwaukee County, and local municipalities remove objects (i.e., woody debris or trash) within the stream channel or culverts observed to be obstructing and/or potentially impounding flood flows.

It should be noted, that while MMSD would address the most severe problems associated with channel obstructions (i.e., blocking the floodplain), MMSD does not address the obstruction of storm sewer outlets. Those problems will need to be addressed by the County and its municipalities as appropriate. Overall, all stream channel maintenance projects, including concrete-removal, should be considered a priority mitigation measure for Milwaukee County hazard mitigation planning.

<u>Lending Institution and Real Estate Agent Policies</u>

The plan calls for lending institutions to continue their practice of determining the flood-prone status of properties before mortgage transactions. The principal sources of flood hazard information will be the most recent available studies for the watersheds and subwatersheds located partly or wholly within the County. Furthermore, real-estate brokers and salespersons are to continue to inform potential purchasers of property of any flood hazard that may exist at the site being traded in accordance with Chapter 707, "Disclosures by Owners of Real Estate," of the *Wisconsin Statutes*.

Installation and Continued Maintenance of U.S. Geological Survey (USGS)
Stream Gages on Streams and Rivers of Milwaukee County

As listed in Table 5.9, Milwaukee County currently has 17 active USGS stream flow gages within its boundaries.[32] These gages are located on the Milwaukee River, Menomonee River, Kinnickinnic River, Oak Creek, and Root River mainstems, as well as on Holmes Avenue Creek, Honey Creek, Lincoln Creek, the Little Menomonee River, Underwood Creek, and Wilson Park Creek. Additionally, there are six active USGS gages monitoring flows for streams flowing into and out of the County (see Map 5.7). Streamflow data can act as an early warning for potential flooding events for those downstream by indicating rising water levels which ultimately can provide information to emergency responders about which areas may experience the worst flood conditions.

As part of this Plan update, it is proposed to maintain the current USGS stream gages and to consider installing at least one additional gage in the upper portion of the Milwaukee River watershed. Continuous flow data collected at this additional location would provide information necessary to develop more precise floodplain modeling and more accurate flood event forecasting. The cost to install one USGS stream gage with all new equipment is about $15,000 (2023 dollars). After installation, operation and maintenance costs are about $13,000 per year.

Actions to Manage the Potential Flood-Related Impacts of Dam Failure

Flooding can also occur as a result of a dam failure. Dam failure flooding may occur when flood flows exceed the hydraulic capacity of the dam spillways, resulting in water overtopping the dam or abutments or when structural failure of the dam occurs. The potential impacts of such failure are related both to the size and configuration of the dam and to the amount, types, and locations of development downstream of the dam. The most at risk location for a dam failure is immediately downstream of a dam. Therefore, assessing the potential for loss in the event of a dam failure is an important part of flood hazard mitigation.

As discussed in Chapter 3 of this Report, the WDNR lists nine existing dams located in Milwaukee County (see Table 3.6 and Map 3.1) Based on the dam locations within Milwaukee County, The Milwaukee County Grounds dam on the County Grounds impoundment has been assigned a high hazard rating by the WDNR, indicating the potential for loss of human life as well as economic loss, environmental damage, or disruption of lifelines during failure or misoperation of the dam. The remaining dams in Milwaukee County are County-, MMSD-, or privately-owned low hazard rating dams.

[32] *waterdata.usgs.gov/wi/nwis.*

The following mitigation measures are recommended to address the risk of flooding due to dam failure in Milwaukee County:

- All dams in Milwaukee County should be regularly inspected and maintained. Chapter 31, "Regulation of Dams and Bridges Affecting Navigable Waters," of the *Wisconsin Statutes*, requires inspection of dams by a professional engineer with experience in dams at a frequency based upon the dam's hazard rating. High hazard dams are required to be inspected every two years, significant hazard dams are required to be inspected every three to four years, and low hazard dams are required to be inspected every 10 years. In addition, it is recommended that owners and operators of dams inspect their dams both on a regular basis and following any high-water event.

- Owners or operators of dams should continue to monitor their dams during high water events.

- MMSD as the owner and operator of the high hazard dam should develop, maintain, and periodically update the emergency action plan for this dam.

- Owners and operators of dams of any hazard rating should consider developing, maintaining, and periodically updating emergency action plans for their dams. Requirements for emergency action plans as well as guidance and templates for developing such plans are available from the WDNR. Such a plan should include:

    - Procedures to be followed to warn the public in the event that a dam failure is likely to occur.

    - Procedures for evacuating areas likely to flood as a result of failure of the dam.

    - An identification of road closings and rerouting is needed to keep traffic and people out of danger areas in the event of flooding due to failure of the dam.

    - Dam failure analyses should be completed for those dams for which they are required and have not been done.

    - Hydraulic shadows from available dam failure analyses should be accessible and added to County and local government websites within their GIS map layers. Local units of government within the

County should regulate and zone the hydraulic shadow areas as floodway, unless the shadow area is specifically mapped as floodway and flood fringe for the dam hazard designation.

Recent projects and plans associated with dam work within Milwaukee County include the following. Project costs can be found in Table 5.3.

Estabrook Dam Removal

MMSD removed the Estabrook Dam from the Milwaukee River in 2018. As a result, the water levels immediately upstream of the former dam site lowered and altered the regulatory floodplain. As result, the City of Glendale, with MMSD assistance, is preparing to revise the floodplain delineation near the former dam location. Updating the floodplains to reflect the dam removal should be considered a priority as part of this Plan update. This work will improve the estimated damages and structure count associated with a 1-percent-annual-probability event, particularly in the Cities of Glendale and Milwaukee.

South Milwaukee Mill Pond Dam Sediment Analysis and Mitigation Alternatives

As part of the Commission's comprehensive watershed restoration plan for Oak Creek (Report),[33] the Mill Pond and dam were analyzed for flooding, water quality, habitat, and recreational access. For this Plan, information related to flood mitigation is the main focus. The maintenance sluice gate for the dam is inoperable, and the WDNR is requiring the gate be repaired or other options be considered for the dam location. The Report concluded that the Mill Pond was not designed to provide flood storage but instead created for recreational and aesthetic purposes. Additionally, the Report states that under the current configuration of the dam, the regulatory FEMA floodplain overtops the adjacent Oak Creek Parkway and bypasses the dam abutments. The Report evaluated five alternatives for the dam and pond location, as well as an emergency spillway design to improve safety and lower flood elevations in the pond area. Additional dam alternatives to consider for flood mitigation, as listed in the Report, include sluice gate repair, sediment dredging to enhance the pond, or dam removal. Estimated costs of implementing the different dam alternatives can be found in the Report. In 2022 Milwaukee County performed sediment core sampling in the Mill Pond and the lab analysis indicated high metal levels are present. This result will modify dredging costs that are in the Commission's report. Currently Milwaukee County is working with a consultant to get public input on a few alternatives from the Commission's planning report.

[33] *Southeastern Wisconsin Regional Planning Commission Community Assistance Planning Report No. 330*, A Restoration Plan for the Oak Creek Watershed (Volume 1-3), *December 2021*.

Ice Jams and Mitigation Measures

Ice jams occur when floating river ice accumulates at a natural or man-made structure that impedes the progress of the ice downstream with the river current. Ice jams can significantly block the flow of a river causing upstream flooding. Ice jam flooding events are not uncommon on the Milwaukee River in particular; therefore, it is recommended that the County and potential impacted communities implement mitigation measures to prevent potential ice jam impacts. Ice jam mitigation measures include:

- Development and maintenance of an ice jam event database such as:
    - Historical and recent records of ice jam events
    - Site-specific ice jam event data, including real time-lapse imagery, duration of freeze-up and ice cover breakup, and damage estimates
- Implement the use of the U.S. Army Corps of Engineers (USACE) Cold Regions Research and Engineering Laboratory (CRREL) database.[34]

Stormwater Management Element

With the expansion of impermeable surfaces in urban areas and alterations to the natural landscape, notably in Milwaukee County, many of the natural functions of floodplains and natural areas have been greatly reduced or even lost. Increases in urbanization and the accompanying impervious surfaces prevent rainwater from infiltrating into the ground, leading to increased surface runoff, and potentially flash flood events. Also, rainfall will accumulate in low-lying areas, causing ponding and inundation. Furthermore, the combination of urbanization and climate change has been shown to increase the number of extreme rainfall events, increasing the vulnerability of communities to experience small-scale (or "localized") flooding impacts. Because of this, stormwater management plays an integral part of flood hazard mitigation planning in Milwaukee County.

Enforcement and Updating of Stormwater Plans, Programs, and Regulations

As detailed in Chapter 1 and listed in Table 1.1, all Milwaukee County communities and Milwaukee County have stormwater management plans and/or regulations (i.e., ordinances) per *Wisconsin Administrative Code* Chapters NR 151 and 216, designed to minimize the adverse impacts caused by urban development. In

[34] *Department of the Army, U.S. Army Corps of Engineers,* Engineering and Design ICE ENGINEERING*, October 30, 2002.*

addition, Chapter NR 216 requires larger municipalities with separate storm sewer systems (MS4s) to obtain a Wisconsin Pollutant Discharge Elimination System (WPDES) stormwater discharge permit to manage the quantity and quality of stormwater runoff before it enters a waterbody. All Milwaukee County communities meet this criterion, therefore are required to obtain and regularly update a WPDES MS4 stormwater discharge permit (listed in Table 1.2).

Also described in Chapter 1, communities within the MMSD service area are required to comply with MMSD's Chapter 13 , "*Surface Water and Storm Water Rules,*" in which governmental units under the MMSD service area are to do the following.

- Manage land use and activities in their jurisdictions to minimize debris and sediment from creating obstructions at outfalls or other structures in watercourses

- Remove debris and sediment that obstructs stormwater outfalls or other drainage structures

- Submit annual reports to the District that provide watershed, drainage, and development information

- Establish which developments and redevelopments must comply with the peak runoff management requirements set forth in Section 13.302 of the MMSD stormwater management rules

- Submit stormwater management plans for all eligible development and redevelopment projects

This Plan calls for Milwaukee County and its communities to continue to update, maintain, and enforce their stormwater management plans and regulations as a means of reducing stormwater flooding impacts and creating a more resilient community.

<u>Stormwater Facilities and Conveyance Systems Maintenance</u>

The effectiveness of stormwater management conveyance and detention facilities and other management measures can be sustained only if proper operation, repair, and maintenance procedures are carefully followed. Important maintenance procedures include the periodic repair of storm sewers, clearing of sewer obstructions, maintenance of open channel vegetation, clearing of debris and sediment from open channels, maintenance of detention facility inlets and outlets, maintenance of detention basin vegetative cover, and periodic removal of sediment accumulated in detention basins. This Plan calls for these maintenance activities to be carried out on a continuing basis to maximize the effectiveness of the stormwater

management facilities and measures, and to protect the capital investment in the facilities. With more intense rainfall events predicted, it is recommended that Milwaukee County and its municipalities identify specific locations where major stormwater management systems are inadequate to handle the runoff from the 1-percent-annual-probablity (or greater) events and prepare stormwater management systems to address those deficiencies.

As described in the previous "Stream Channel Maintenance Activities" section, MMSD will only address the most severe problems associated with channel obstructions, and MMSD does not address storm sewer system problems, such as the obstruction of storm sewer inlets, outlets, or sediment and debris accumulation in sewers or open channels.

The MMSD North 30th Street Corridor Wet Weather Relief Project[35]

Because of repetitive stormwater flooding experienced within the 30th Street Corridor, this project in progress is an integral element of urban flood mitigation within the City of Milwaukee. The project encompasses the area within W. Townsend Street, W. Hampton Avenue, N. 27th Street, and N. 41st Street in the City of Milwaukee (see Figure 5.6). Historical flooding within this area has caused substantial property damage and significant disruption to the operation of MMSD facilities. To reduce future flooding impacts, the project includes three stormwater basins (East Basin, West Basin, and North Basin), of which the East and North Basins are built. The estimated costs of completing this major stormwater project is listed in Table 5.3.

Green Infrastructure (or Nature-Based) Integration

Certain green infrastructure (GI) practices manage smaller rainfall events to help reduce peak flows downstream. Bioretention can reduce flows into nearby streams by providing some stormwater storage and gradually releasing the water into groundwater through infiltration through the soil media underneath. Similarly, bioswales can hold back stormwater and slowly release it to surface water or groundwater drainage systems to reduce peak flows. Rain barrels and rain gardens can also help manage smaller rain events by capturing some stormwater for garden use. Permeable pavement also increases infiltration and reduces runoff. These practices can also provide additional benefits of improving water quality, providing resilience to climate change, and increasing aesthetics when they are properly maintained. In addition to providing reductions in the volume of stormwater runoff, these practices can help reduce urban heat island

[35] *See the Milwaukee Metropolitan Sewerage District website for detailed project information (mmsd.com).*

effects (through shading and convective shading) thereby improving the quality of life to those living in densely urbanized communities.

Green infrastructure practices can be used at the site or building scale, neighborhood scale, or County-wide scale. Examples of GI practices are listed below.

- Bioretention areas, such as plantings in parking lot islands
- Green roofs
- Downspout disconnections into rain barrels, planter boxes and permeable areas
- Rain gardens
- Streets and alleys with permeable surfacing
- Bioswales
- Native plantings
- Wetland and floodplain preservation and restoration
- Conservation and protection of open lands, natural areas and green spaces
- Permeable and porous pavements and paved surfaces
- Urban tree canopy protection and restoration, tree planter boxes and tree trenches

Together the City of Milwaukee and MMSD, with assistance from organizations including the 1000 Friends of Wisconsin, Milwaukee Environmental Collaboration Office, HOME GR/OWN, Reflo, Groundwork Milwaukee, and Clean Wisconsin play a major role in the implementation of green infrastructure practices in Milwaukee County. These efforts include implementing codes and ordinances; hosting education and informational workshops; distribution of educational and informational material, including program and funding resources; and assisting in community projects (see Appendix I for example of Milwaukee GI

resources and projects). Actions associated with GI practices should be considered as a priority mitigation measure as a means to reduce localized (or concentrated) stormwater flooding and improve the health and well-being of residents.

Key green infrastructure practices, regulations, programs, and plans in Milwaukee County are highlighted below.

- 1000 Friends of Wisconsin along with a private planning and designing firm assisted MMSD and the Milwaukee County Environmental Office to address the barriers to green infrastructure practices in community codes and ordinances including all the municipalities in the MMSD service area. The project addressed the concern that municipal codes and ordinances limit the implementation of green infrastructure.

- Under MMSD*'s* Chapter 13, "Surface Water and Storm Water Rules," *section 13.303* of "Site Development: Stormwater and Green Infrastructure Plans" municipalities under MMSD jurisdiction must submit a Green Infrastructure Plan during any new development or redevelopment project and conform within the guidelines associated with stormwater runoff.

- In 2018, the City of Milwaukee revised a city ordinance to require all large developments and redevelopments of an acre or more to capture at least the first 1/2 inch of rainfall using green infrastructure.

- Major green rooftops installments within the City of Milwaukee include: (see Appendix I).

    - Milwaukee Public Art Museum

    - Milwaukee Public Library

    - Rockwell Automation

    - Global Water Center

    - UWM School of Freshwater Sciences

- Alverno College
- Northwestern Mutual Building

- Milwaukee Public School's Green Schoolyards Program
- City of Milwaukee Green Streets Stormwater Management program and projects, which include:
  - N. 92nd Street Greet Street - W. Capitol Drive to W. Good Hope Road
  - W. Grange Avenue Green Street - S. 19th Street to S. 27th Street
  - N. 27th Street Green Street - W. Capitol Drive to W. Roosevelt Drive
- City of Milwaukee Green Infrastructure Geographic Information Services (GIS) Tool
- Milwaukee Harbor and North Avenue Redevelopment projects
- The "13th District Green Corridor" project
- MMSD Green Infrastructure Initiatives and Programs:
  - Fresh Coast Guardians program and Green Infrastructure Resource Center
  - Green Solutions program-incentivizing municipalities within the District to implement green infrastructure
  - Green Infrastructure for Schools guidebook
  - Green Highways program
  - Green Luminary Award recognizes projects that use green infrastructure to help protect rivers and Lake Michigan

- MMSD Fresh Coast Guardians and Resources Center program

- Numerous GI plans completed by the City of Milwaukee and MMSD are listed in Appendix I.

Public Information and Education Outreach Element

Public information, education, and participation constitute an integral aspect of Milwaukee County's flood and stormwater mitigation efforts. This element includes activities, namely accessible public education and information outreach and resources for flood and stormwater management risk reduction purposes. Material related to education and informational resources is provided in Appendix H.

Current Federal, State, and Local Educational and Informational Activities

As discussed in the multiple hazards plan element, FEMA, the National Weather Service (NWS), and WEM provide many online resources and social media toolkits to assist the public with hazardous weather preparedness, safety, and recovery. FEMA's website provides a number of resources related to flooding hazards, flood insurance, and flood mitigation assistance programs (i.e., Hazard Mitigation Grant Program (HMGP), Building Resilient Infrastructure and Communities (BRIC) Program, and the Flood Mitigation Assistance (FMA) Program). As previously described, Milwaukee County is currently participating in FEMA's Hazard Mitigation Grant Program (HMGP), RiskMAP, and National Flood Insurance Program (NFIP) programming efforts. Continued outreach and educational efforts in promoting the importance of obtaining flood insurance through the NFIP program (*FloodSmart.gov* home of the NFIP), including to those not within the mapped flood hazard zones, is an important part of flood hazard mitigation. Further, it is encouraged that Milwaukee County, and its municipalities consider participating in the FEMA's Community Rating System (CRS) program.

FEMA's website also provides flood risk mapping services. The FEMA Flood Map Service Center (MSC) is the official online source for flood hazard information produced under the NFIP. All flood mapping products, such as Digital Flood Insurance Rate Maps (DFIRMs), Letter of Map Changes (LOMC), Letter of Map Revisions (LOMR), countywide Flood Insurance Studies (FIS), and National Flood Hazard Layer (NFHL) geodatabases are online and available to view and download.[36] FEMA has also produced an interactive online National Risk Index (NRI) mapping tool and application. The NRI is a user-friendly interactive tool that shows which communities are most at risk of natural hazards (i.e., flood events) with data on expected annual losses, social vulnerability, and community resilience at the county and Census tract level. Also, FEMA's Ready.gov

[36] *msc.fema.gov/portal/resources.*

provides a Flood Safety Social Media Toolkit with a number of additional resources and links on flood safety and preparedness.

Other good resources for flood hazard outreach include the Centers for Disease Control and Prevention (CDC) and the National Weather Service (NWS). The CDC website has additional information on how to prepare for a flood, stay safe during a flood, and protect your health after a flood. The NWS website also provides a number of informational and educational resources and links including an interactive flood map, description on types of flooding events, warning and safety resources, and available flood-related programs.

The U.S. Army Corps of Engineers (USACE) website provides informational and educational resources and links related to flood risk preparedness and management. The USACE National Flood Risk Management (NFRM) program was established to integrate and coordinate USACE flood risk management programs and activities with FEMA and other Federal, state, regional, and local agencies. The USACE NFRM program maintains and constructs public flood control structures such as dams, reservoirs, levees, floodwalls, and diversion channels. The USACE Disaster Preparedness program provides emergency management organization, planning, training, supplies, tools and equipment, and inspection for non-Federal flood risk management projects. The USACE website also has past, present (or daily), and forecasted Great Lakes water levels which can be used by Milwaukee County and its coastal municipalities for coastal flooding mitigation planning. Additionally, the USACE Cold Regions Research and Engineering Laboratory (CRREL) provides advanced science and engineering expertise to study complex environments, materials, and processes such as ice jam events. The CRREL ice jam database provides information and educational resources as well as known locations and descriptions of historical and current ice jam events.[37] This information may be useful for Milwaukee County and its municipalities to protect valuable and potentially vulnerable community assets along the major waterways within the County.

The Wisconsin Department of Health Services (DHS) has prepared a flooding toolkit for citizens. The toolkit provides general flood information, preparedness tips, and guidelines on clean up after a flood has occurred. In addition to providing flood preparedness information and resources, the Wisconsin DHS and its partners created an interactive online mapping tool called the Risk Assessment Flood Tool (RAFT, formerly the Wisconsin Flood Risk Map Application) to help local, regional, and state agencies prepare for and respond to floods. As indicated in Appendix H, the interactive map includes GIS layers of FEMA

[37] *www.crrel.usace.army.mil/icejams.*

floodplains, locations of emergency management and medical services, social vulnerability census data, as well as live rainfall information.[38]

The University of Wisconsin-Extension, WEM, *ReadyWisconsin,*[39] and WDNR provide educational information on flooding preparedness (i.e., emergency toolkits), response, and recovery as well as examples of different flood management practices to help reduce flooding impacts. The WDNR website also provides an interactive mapping tool with FEMA floodplains and the FEMA mapping process.

As indicated in Appendix B, the Milwaukee Metropolitan Sewerage District has prepared and distributed various public information and educational materials, including materials oriented toward local homeowners, local government agencies, and educators designed to help them consider and potentially undertake actions to mitigate damage caused by riverine and stormwater flooding as well as sanitary sewer backups. Additionally, the MMSD Fresh Coast Guardians program offers residents, educators, organizations, vendors, and municipalities within the District's service area a variety of information and resources on stormwater management including green infrastructure practices, programs, plans, and assistance for individual, group, and community members. This Plan encourages Milwaukee County and its residents to consider looking into these provided resources to help reduce potential flood risks.

The Milwaukee County Office of Emergency Management prepares and distributes, via the County website and social media platforms, a number of public educational materials and resources on extreme weather event preparedness and assistance, including flood events. The OEM also provides informational in-person learning and outreach sessions and educational resources for local property owners on preventive measures for homeowners to mitigate flood damages. Such resources also provide basic information about flood warnings, as well as the National Flood Insurance Program (NFIP) and various Federal and State aid programs that may be available to flood victims. In addition, the Milwaukee County Office of Emergency Management website provides an interactive online map of the FEMA effective 1-percent-annual-probability-floodplain layer.

Most of Milwaukee County city and village websites provide information on federal and state flood resources for flooding and stormwater impacts and preventative measures (i.e., emergency preparation toolkits, links to multiple federal and state resources, educational material, related ongoing projects, and

[38] *This can be accessed at: www.dhs.wisconsin.gov/flood.*

[39] *readywisconsin.wi.gov/default.asp.*

funding opportunities). Also, most municipalities have online interactive municipal maps with FEMA floodplain layers.

Together, Root-Pike WIN and the Southeastern Wisconsin Watersheds Trust, Inc. (Sweet Water) developed the Respect Our Waters (ROW) program. This program educates area residents on stormwater best management practices, such as actions to improve water quality and quantity from a rainfall event. The ROW Program is supported by 50 municipalities across southeastern Wisconsin, including those within Milwaukee County. Educational and information outreach is presented at community or County events, in which native plants, rain barrels and Milorganite fertilizer are often distributed. Sweet Water also assists many of Milwaukee County communities with MS4 compliance by documenting best management practices and educational outreach material and instruction on stormwater-related management.

Multi-Jurisdictional and Watershed Considerations

According to the parcel-based analysis, structures within flood hazard areas have been identified in 14 of the 19 Milwaukee County municipalities and within all six major watersheds (see Tables 3.8 and 3.9). Based on the analysis, the jurisdictions with the greatest amount of vulnerable populations (i.e., identified parcels with structures in flood hazard areas) comprise the Cities of Glendale and Milwaukee and the Village of Fox Point (Map 3.2), including several structures located within the Lake Michigan coastal flood zone (Map 3.12). Note, information related to Lake Michigan coastal flooding is further discussed in the "Hazard Mitigation Plan Component for Lake Michigan Coastal Hazards" section of this Chapter. Also, there is one manufactured home park with 16 homes in the flood hazard area in the City of Franklin. As mentioned in Chapter 3, the structures in this parcel-based analysis that are at risk of flooding during the 1-percent-annual-probabillty (100-year recurrence interval) event were identified by MMSD and used by Commission staff to compute flood damages.

As previously mentioned in this Plan, the City of Milwaukee was found to have a high socio-economic vulnerability index (SVI) score (see Appendix D). as well as high risk to flooding impacts (see Figure 5.4), notably within the northern and central portions of the City. Because of this, Milwaukee County and MMSD should consider implementing certain flood mitigation activities and projects aimed to benefit the different types of vulnerable populations and communities identified within the City of Milwaukee. Such flood mitigation activities may include more accessible educational and informational material and outreach activities as well as projects designed to remove/reduce impervious surfaces, thereby creating additional flood storage, green space, and recreational opportunities.

From a watershed-based approach, and as indicated in Map 3.2 and Table 5.5 the majority of flooded structures, specifically residential, are within the Kinnickinnic (530), Milwaukee River (515), and Root River (141) watersheds. Additionally, as shown in Table 5.5, these same watersheds (Kinnickinnic River, Menomonee River, and Root River) have the greatest amount of nonresidential structures at-risk to flooding within Milwaukee County.

Evaluation of Alternatives and Identification of Priority Mitigation Measures

The goal of flood mitigation activities is to reduce, in a cost-effective manner, the loss of lives and property due to these events. A full range of nonstructural and structural approaches were considered in the initial assessment of potential mitigation measures and their alternative approaches for reducing flooding impacts in Milwaukee County.

An important factor in selecting priority mitigation measures is to consider incorporating recommendations from other related County and local planning efforts (i.e., Milwaukee County's park and open space plan,[40] regional transportation and land use plan,[41] land and water resource management plan,[42] and comprehensive emergency management plan,[43] and the various watershed and flood management planning efforts, including the current MMSD Watercourse And Flood Management Program) that may help prevent flooding or act to mitigate the impacts of flooding when it occurs. Including such recommendations in this hazard mitigation plan furthers the goal of integrating the elements of the various plans that seek to provide guidance to the County for a variety of issues. Similarly, it was judged important that the set of priority mitigation measures incorporate existing regulations, programs, resources, and efforts that reduce the exposure of people and property to flood risks or that act to mitigate the impacts of flooding when it occurs. Examples of such programs include floodplain zoning, existing stormwater management policies and guidelines, continued and expanded participation in the National Flood Insurance Program (NFIP), updating of DFIRM maps, and educational and informational outreach programs.

[40] *Southeastern Wisconsin Regional Planning Commission Community Assistance Planning Report No. 132 (2nd Edition),* A Long-Range Park and Open Space Plan for Milwaukee County, *February 2022*

[41] *Southeastern Wisconsin Regional Planning Commission Planning Report No. 55,* VISION 2050: A Regional Land Use and Transportation Plan for Southeastern Wisconsin*, June 2020*

[42] *Southeastern Wisconsin Regional Planning Commission Community Assistance Planning Report No. 312 (2nd Edition),* A Land and Water Resource Management Plan for Milwaukee County: 2022-2031, *December 2021.*

[43] *Milwaukee County Office of Emergency Management,* Milwaukee County Hazard Mitigation Plan*, October 19, 2017.*

Flood damages can be mitigated by limiting or restricting how development occurs in high-risk areas. These measures can limit the County's and municipalities' future vulnerability to flooding impacts and should be considered a primary element in any flood mitigation effort. Measures to implement this type of mitigation include incorporating recommendations from other related County and local planning efforts, enforcing regulations such as floodplain and wetland-shoreland zoning guidelines, and enforcing local and MMSD development and redevelopment policies and guidelines.

Another important measure that is strongly recommended for Milwaukee County is the preservation and conservation of open space and environmentally sensitive lands. This preservation can help improve and increase flood storage capabilities and functions, wildlife habitat, recreational opportunities and potentially improve the health and well-being of residents.

Another important flood mitigation component should be to focus on existing development located within high-risk areas, with an emphasis on vulnerable populations and critical community facilities and infrastructure. Recurring economic losses and distress from flooding can be reduced by either removing structures from the floodplain or by modifying and maintaining them to resist flood damage. This priority element includes acquisition and demolition, floodproofing, and retrofitting of structures located in high-risk areas. This component also includes further analysis and inventory on roadway flooding concerns throughout Milwaukee County.

Because Milwaukee County is heavily urbanized, actions that address stormwater conveyance and storage are vital for flood mitigation planning. Such actions include the improvement and maintenance of current and planned stormwater infrastructure, removing and rehabilitating concrete-lined channels, and increasing and maintaining green infrastructure or nature-based stormwater practices.

These priority mitigation measures, along with a general cost benefit summary are presented in Table 5.10.

5.4 HAZARD MITIGATION PLAN COMPONENT FOR SEVERE WEATHER EVENTS (THUNDERSTORMS, STRONG WINDS, HAIL, AND LIGHTNING)

Thunderstorms, high-winds, hail, and lightning are natural hazard events of significant concern to be considered in the Milwaukee County hazard mitigation plan. This section describes alternative and selected priority strategies to mitigate these types of hazards. As part of the updating process, these strategies were

reviewed and reevaluated by the Milwaukee County Hazard Mitigation LPT in light of the updated hazard conditions and hazard mitigation goals documented in Chapters 3 and 4.

Identification of Alternative Mitigation Strategies

All thunderstorms and related hazard events are potentially dangerous and are common within Milwaukee County. Although there are about 100,000 thunderstorms each year in the U.S., only about 10 percent reach "severe" levels.[44] Severe thunderstorm fronts can often be tracked, providing ample warning for potentially affected areas to take precautionary actions. In addition, when severe thunderstorms and related hazard events occur, they generally last for short periods.

While it may not be possible to accurately identify specific areas where there is significant risk from thunderstorm-related hazard events or non-thunderstorm high-wind events, measures can be taken to reduce the potential damage caused wherever they may occur in the County. High-wind events associated with windstorms and thunderstorms are similar to tornadoes, except they are more common and usually less powerful.

Hailstorms tend to occur in conjunction with severe thunderstorms. A severe thunderstorm weather advisory or advance warning system may indicate that large or damaging hail is imminent. Personal safety is the first priority during a hailstorm, and people should seek shelter and stop driving to avoid accidents. Advance warning systems may allow some actions to reduce hail damage to vehicles and some property, but little can be done to protect structures or crops in the field.

Personal protection is paramount for lightning safety—many people suffer injuries or are killed due to misinformation and inappropriate behavior during lightning storms. A few simple precautions can reduce many of the dangers posed by lightning. The individual is ultimately responsible for their safety and should take appropriate action when threatened by lightning. Little can be done beyond electrical grounding to protect property from lightning strikes.

Through review by the Milwaukee County Hazard Mitigation LPT, the following measures to reduce vulnerability to thunderstorm winds, non-thunderstorm high-winds, hail, and lightning have been identified as viable for this Plan update. In addition to the measures listed below, mitigation strategies that address

[44] *www.nssl.noaa.gov.*

multiple hazard types, including thunderstorms and related events, are discussed in the "Multiple Hazard Mitigation" section in this Chapter.

Nonstructural

- Continue to maintain and regularly update local fire department equipment to help detect or mitigate lightning-related fires, such as thermal imaging devices

- Maintain compliance with the National Incident Management System (NIMS)

- Enforce existing local ordinances requiring adequate electrical grounding in newly constructed buildings

- Continue to work with local fair/festival/entertainment district planning officials to create and regularly update emergency plans in the case of severe weather

- Provide information and urge the use of fire-resistant materials and surge protectors on critical electronic equipment

Structural

- Work with municipalities and businesses to explore installation or upgrading of community safe rooms and hardening projects[45] for public buildings, community facilities, major industrial and manufacturing sites, large businesses, manufactured home parks, neighborhoods with a concentrated amount of outdated and poor condition housing units, and fairgrounds/large outdoor public gathering locations to ensure adequate shelter from thunderstorm and high-wind hazards.

- Install and routinely update lightning grade surge protection devices for critical electronic components used by government, public service, and public safety facilities, such as warning systems, control systems, communications, computers, and data networks

[45]*FEMA defines "hardening" as project-specific specialized design and construction methods which are applied to one or more rooms within a building and/or to an entire building envelope to allow portions of and/or the entire structure to resist wind pressures and windborne debris impacts during an extreme wind event and are capable of providing life-safety protection to the occupants of the room or structure.*

Public Informational and Educational Programming

- Continue to enhance and expand public education and awareness of the potential severity of thunderstorms and related hazards with up-to-date emergency preparedness information to all County residents. Educational efforts should include promoting safety guidelines to reduce the risk of lightning hazards and the potential severity of hailstorms

Current Programs and Ongoing Projects

Federal and State Programs

The NWS issues warnings, watches, and advisories when there is a threat of severe weather conditions. Several categories of warnings, watches, and advisories apply to thunderstorms and associated hazards. The NWS Storm Prediction Center in Norman, Oklahoma will issue a severe thunderstorm watch when conditions are favorable for the development of severe thunderstorms in and close to the watch area.

The NWS Milwaukee/Sullivan office will issue a *severe thunderstorm* warning when:

- A thunderstorm is producing winds equal to or exceeding 58 miles per hour (mph).
- Hail of one inch or larger in diameter.
- A severe thunderstorm is detected by Doppler radar.

The NWS Milwaukee/Sullivan office will issue a *high wind* warning when:

- Sustained winds of 40 mph are expected to occur for an hour or more.
- Wind gusts of 58 mph or more are expected to occur.

The NWS Milwaukee/Sullivan office will issue a *wind* advisory when:

- Sustained winds of 30 mph are expected to occur for an hour or more.
- Wind gusts of 45 mph to 57 mph are expected to occur.

As mentioned in the "Multiple Hazards" section of this Chapter, a number of Federal and state programs include awareness and educational efforts and provide online resources including links to various networks and/or agencies as well as to different social media outlets with additional resources/programs, including toolkits or interactive mapping data to assist on hazardous weather preparedness, safety, and recovery. As such, the NWS has an extensive public information program to educate and to train citizens and emergency managers (via the *StormReady* program) to be aware of and spotting thunderstorms and related dangers. Also, the Wisconsin Department of Health Services (DHS) developed a severe thunderstorm and tornado toolkit to provide information to local governments, health departments, and citizens about preparing for and responding to severe thunderstorms and tornadoes. Similarly, WEM has educational resources regarding thunderstorms and related hazards including prerecorded radio public service announcements, scripts for radio public service announcements, social media announcements and information, short online educational videos, printed fliers, and educational materials for children. In addition, numerous other organizations including the American Red Cross, provide public safety information regarding lightning.

Local Programs

As discussed in detail in the multiple hazards plan component, Milwaukee County has a variety of methods to warn residents of emergencies, including thunderstorms and thunderstorm-related events. Severe thunderstorms watches, warning bulletins, and advisories are disseminated throughout Milwaukee County by the NWS[46] to the general public through its OASIS public warning safety radio network, local television and radio stations, cable television systems, cell phone apps, and NOAA weather radios. It is important that all County residents are able to receive or have access to such warnings or alerts.

In addition, the Milwaukee County OEM has various printed and online resources available for the public on severe weather safety and other general emergency management-related topics. Milwaukee County OEM participates in all State sponsored severe weather awareness campaigns.

Multi-Jurisdictional Considerations

Thunderstorms and their related hazards can potentially impact all municipalities within the County. In addition, these severe events can potentially cause multiple damages to a variety of infrastructure including transmission lines, communication lines, and transportation routes due to flooding, as well as damage to buildings from flooding, hail, and/or high winds. Hence, Milwaukee County, its municipalities, relevant

[46] *The NWS operates two 24-hour weather radio transmitters that serve all or portions of Milwaukee and Waukesha Counties.*

businesses, and other organizations should continue to coordinate hazard mitigation activities through a cooperative County and local government partnership in countywide disaster planning and response. Such measures are already well underway through the comprehensive emergency management planning program involving the Milwaukee County OEM and coordinated local community emergency operations programs and should be continued.

Evaluation of Alternatives and Identification of Priority Mitigation Measures

Based upon the foregoing evaluation, consideration of risk and review and action by the Milwaukee County Hazard Mitigation LPT as part of the updating process (see Appendix A), the following mitigation measures related to thunderstorms, high-wind, hail, and lightning events are included in the Milwaukee County hazards mitigation plan:

Based upon review of the above and the risk analysis given in Chapter 3, continuation and refinement of current early warning system programs represents a major component of the planned mitigation action for thunderstorm-related hazards and high-wind events. The existing warning systems should continue to rely upon the use of multiple means of communication to alert people to the threat of severe weather. In addition, informing the public of the significance of thunderstorm watches and warnings so that they take these events seriously, know where to seek shelter in emergency situations, and are prepared should such a storm cause a disaster is an important component for minimizing the risks associated with these natural hazards. Community-based informational programs should also continue to be conducted by the County and its communities in partnership with Federal, State and local authorities.

Providing and notifying, through various modes of communication, of adequate safe places for people to seek shelter, notably those that are most vulnerable, during severe storms constitutes an additional approach to mitigating impacts of severe storms in Milwaukee County. As detailed in Chapter 2 and shown on Map 2.1, there are 15 manufactured home parks in Milwaukee County, with the majority containing at least 50 homes. As these residents are highly vulnerable to high wind events, it is highly encouraged to investigate the need for community safe rooms. Implementing this recommendation constitutes an important element of this hazard mitigation plan.

Severe thunderstorm related events can also cause economic losses, especially to agricultural producers through damage to crops. Continuing to provide agricultural producers with information regarding Federal crop insurance programs and encouraging them to purchase crop insurance provides some protection against such losses. Other feasible mitigation actions include:

- Enforcement of building code regulations that improve the ability and reliability of structures to withstand severe wind and surge protection for sensitive electronic equipment

- On-site emergency backup power generation for critical infrastructure

- Other precautions that will limit possible injuries, deaths, or property damages due to severe weather events

The majority of these measures are currently in place to varying degrees, indicating an ongoing need for informational programming and enforcement.

Based upon the foregoing evaluation and consideration of risk and review by the Milwaukee County Hazard Mitigation LPT (see Appendix A), there are 5 actions determined to be priority mitigation measures for this hazard mitigation plan update that are specifically related to thunderstorm winds, non-thunderstorm high-winds, lightning and hail events.[47] These priority mitigation measures, along with a general cost-benefit summary are presented in Table 5.11.

5.5 HAZARD MITIGATION PLAN COMPONENT FOR TORNADOES

Tornadoes are natural hazard events of moderate concern to be considered in this update of the Milwaukee County hazard mitigation plan. This section describes alternative and selected priority strategies to mitigate tornado events. As part of the updating process, these strategies were reviewed and reevaluated by the Milwaukee County Hazard Mitigation LPT in light of the updated hazard conditions and hazard mitigation goals documented in Chapters 3 and 4.

Identification of Alternative Mitigation Strategies

All tornadoes are potentially dangerous hazards within Milwaukee County as discussed in Chapter 3. However, as indicated in Table 3.13, tornadoes have been shown to impact Milwaukee County about once every three years and these are most likely to be an EF1 (or F1) magnitude or less. In addition, when tornadoes and related hazard events occur, they generally last for short periods of time and impact relatively

[47] *Priority mitigation measures that apply to multiple hazard types including thunderstorm winds, non-thunderstorm high-winds, lightning and hail events, are presented in the "Hazard Mitigation Plan Component for Multiple Hazard Types" section in this Chapter.*

small areas of the County. However, when strong tornadoes do strike, they can cause extensive property damage, injuries, and death.

While it may not be possible to accurately identify specific areas where there is significant risk from tornado events, or the number or severity of the events, measures can be taken to reduce the potential damage caused by tornado-related hazards wherever they may occur in the County. Based upon review by the Milwaukee County Hazard Mitigation LPT, the following measures to reduce the vulnerability to tornadoes have been identified as practical for this hazard mitigation Plan update. In addition to the measures listed below, mitigation strategies that address multiple hazards, including tornadoes, are discussed earlier in the "Multiple Hazard Mitigation Measures" section of this Chapter.

Nonstructural

- Continue to monitor and update the usage policies and procedures of the County's public outdoor warning systems to improve public safety and warning effectiveness.

    - Promote the use of "Wisconsin Outdoor Warning Siren Best Practices" recommendation guidelines.[48]

- Require construction regulations for safe rooms in new schools, daycares, nursing homes, hospitals, community centers, and large business/industrial facilities, and encourage the establishment of safe rooms in existing structures such as those listed that do not have basements.

- Regularly conduct an inventory and inspection of municipal and County community facilities to ensure the quality, quantity, and accessibility of reliable and adequate tornado shelters are provided.

Structural

- Consistently inspect and monitor the operational and structural functions of all 58 Milwaukee County outdoor tornado warning sirens to ensure of their effectiveness and reliability

- Routinely inspect manufactured homes and/or parks to ensure they are securely anchored or have adequate and accessible safety material (i.e., tie-downs) in case of a tornado or extremely strong wind event

[48] *S. Ziegler, G. Goodchild, and D. Janda, Wisconsin Outdoor Warning Siren Best Practices, 2019.*

- Recommend municipalities and businesses install or upgrade community safe rooms and hardening projects[49] for public buildings, community centers, major industrial and manufacturing sites, large businesses, manufactured home parks, beaches, fairgrounds, and large outdoor public gathering spaces

Public Informational and Educational Programming

- Increase public education and awareness of the potential severity of tornadoes and continue to produce and expand updated emergency preparedness information (e.g., the steps that should be taken when hearing a tornado siren), especially to those that are most vulnerable

- Make information available and understandable on where to go during a tornado event for those visiting a public open space such as a park or a beach

Current Programs and On Going Projects

Federal and State Programs

The NWS issues tornado watches when conditions are favorable for the development of thunderstorms that have a strong capability of producing tornadoes and issues tornado warnings when a tornado has been spotted by a trained observer or Doppler radar has indicated a developing tornado.

Federal and State programs for tornados include awareness and education efforts. NOAA's National Severe Storms Laboratory (NSSL) website has educational material on severe weather, including tornadoes. In addition, the NWS has an extensive public information program to educate people about the dangers of tornadoes and related hazards that assist in preventing related deaths and injuries. WEM, in conjunction with the NWS and State and local government agencies, provides both preparedness information and severe weather information to the public. Similarly, WEM has produced several educational resources regarding tornadoes including prerecorded radio public service announcements, scripts for radio public service announcements, fliers, and educational materials for children.[50] The Wisconsin Department of Health

[49] FEMA defines "hardening" as project-specific specialized design and construction methods which are applied to one or more rooms within a building and/or to an entire building envelope to allow portions of and/or the entire structure to resist wind pressures and windborne debris impacts during an extreme wind event and are capable of providing life-safety protection to the occupants of the room or structure.

[50]These can be accessed at Wisconsin Emergency Management's ReadyWisconsin website located at: ready.wi.gov/Resources/Manager_Resources.asp.

Services has developed a severe thunderstorm and tornado tool kit to provide information to local governments, health departments, and citizens in Wisconsin about preparing for and responding to severe thunderstorms and tornadoes.[51] In addition, numerous other organizations, including the American Red Cross, provide public safety information regarding tornadoes.

Local Programs

Programs within Milwaukee County primarily include those conducted by the Milwaukee County OEM. Milwaukee County provides various printed (i.e., brochures, booklets, and pamphlets) and online material and resources available for the public on tornado safety and other general emergency management-related topics. Milwaukee County OEM participates in State sponsored severe weather awareness campaigns including Wisconsin Best Outdoor Siren Practices.

As discussed in detail in the Multiple Hazards section, Milwaukee County has a variety of methods to warn residents of emergency situations, including its 58 outdoor warning sirens, In 2018 Milwaukee County OEM upgraded the then 57 County- and municipal-owned tornado sirens with new encryption technology to keep the sirens safe from cybersecurity threats. This upgrade caused adverse impacts on a number of the tornado sirens existing equipment. As a result, in 2024, Milwaukee County OEM, with the assistance of ARPA Covid-19 funds,[52] was able to fully update and/or replace all 58 now County-owned tornado sirens (24 being completely replaced). The cost of implementing this project was about $1.8M (2024 dollars)[53]

Multi-Jurisdictional Considerations

Tornadoes and their related hazards can potentially impact all municipalities within the County. In addition, these events can potentially cause severe damage to a variety of infrastructure including transmission lines, communication lines, and transportation routes due to high winds and debris. Public and private buildings can also be destroyed. Hence, Milwaukee County, its municipalities, relevant businesses, and other organizations should coordinate tornado mitigation activities through a cooperative County and local government partnership in countywide disaster planning and response. Such measures are already well underway through the comprehensive emergency management planning program involving the Milwaukee County OEM and coordinated local community emergency operations programs and should be continued.

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[51] *Wisconsin Department of Health Services,* Wisconsin Severe Thunderstorm and Tornadoes Toolkit, op. cit.

[52] ***The American Rescue Plan Act****, signed into law on March 11, 2021, provides direct funding to cities, towns and villages throughout the United States in response to and recovery from the COVID-19 public health emergency.*

[53] *Milwaukee County,* 2024 Recovery Plan Performance Report, State & Local Fiscal Recovery Funds*, July 2024.*

Evaluation of Alternatives and Identification of Priority Mitigation Measures

The best place to be during a tornado event is a building or room specifically designed to withstand the impacts of a tornado event (i.e., tornado shelters or community safe rooms). If lacking such shelters, taking refuge in a basement near supporting walls or pillars, and away from windows is appropriate. If there is no basement in a building, taking shelter in smaller interior, windowless rooms, such as hallways or closets, can offer some protection and is the next best option. Cars, manufactured homes, garages, and outbuildings are not safe shelters from tornadoes. Thus, promoting adequate and reliable safe places to seek shelter during tornadoes constitutes an additional approach to mitigating impacts of severe storms in Milwaukee County. Residents living in manufactured homes or poorly built residential conditions, in particular, represent a segment of the County's population that often lack access to adequate shelters. Because of this, these communities or individuals bear additional risks from tornadoes. Encouraging and promoting the construction of adequate and reliable community safe rooms that provide shelter from tornadoes to County residents, especially those most vulnerable, constitutes an important element of this hazard mitigation plan.

In addition, informing the public of the significance of tornado watches and warnings so that they take tornado warnings seriously and know where to seek shelter, especially those that are the most vulnerable, are important, ongoing components for minimizing the risks associated with natural hazards. Community- and school-based informational programs on tornadoes should continue to be conducted and enhanced by the County and its communities in partnership with Federal, State and local authorities to ensure all county residents are receiving equal and reliable tornado safety information.

Finally, other feasible mitigation actions include enforcing building code regulations that improve the ability of structures to withstand severe wind and increasingly harsh weather conditions, on-site emergency backup power generation for critical community facilities and infrastructure and utility systems; and providing information and educational resources and material that is easily accessible for all County residents. The majority of these measures are currently in place to varying degrees, indicating an emphasis on informational programming and enforcement.

Based upon the foregoing evaluation and consideration of risk and consideration by the Milwaukee County Hazard Mitigation LPT (see Appendix A), there are 7 actions determined to be priority mitigation measures

as part of this hazard mitigation plan update that are specifically related to tornado events.[54] These priority mitigation measures, along with a general cost-benefit summary are presented in Table 5.12.

5.6 HAZARD MITIGATION PLAN COMPONENT FOR WINTER STORMS

Winter storms are natural hazard events of moderate concern to be considered in the Milwaukee County hazard mitigation plan. This section describes alternative and selected priority strategies to mitigate this type of hazard. As part of the updating process, these strategies were reviewed and reevaluated by the Milwaukee County Hazard Mitigation Plan LPT in light of the updated hazard conditions and hazard mitigation goals documented in Chapters 3 and 4.

Identification of Alternative Mitigation Strategies

Severe winter weather can include blizzards, freezing rain, sleet, ice, and dangerous combinations of temperatures and wind. Winter storms may last a few hours or days, completely shutting down businesses and government, while isolating residents in their homes.

Impacts of heavy snow and ice accumulations include slippery roads and walkways; collapsed roofs from heavy ice and snow loads; and damaged trees, telephone poles and lines, electrical wires, and communications towers.[55] Additionally, indirect injuries and fatalities may occur , especially to those considered vulnerable (i.e., elderly, young, disabled, sick/weak, and/or low-income), from activities associated with winter storms such as heart attacks while shoveling snow, carbon monoxide poisoning, hypothermia, frostbite, automobile accidents, and improper use of space heaters. Severe winter storm fronts can often be tracked, which generally provides ample warning for potentially affected areas to take preventative actions.

While it may not be possible to accurately predict the number or severity of winter storm events, measures can be taken to reduce the potential damage caused by winter storms and their related hazards whenever they may occur in the County. High-wind, freezing rain, sleet, ice, and snow may be associated with a winter storm. Reviewed by the Milwaukee County Hazard Mitigation LPT as part of the updating process, the

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[54] Priority mitigation measures that apply to multiple hazard types, including tornado events, are presented in the "Hazard Mitigation Plan Component for Multiple Hazard Types" section in this Chapter.

[55] Wisconsin Department of Emergency Management and Military Affairs, State of Wisconsin Hazard Mitigation Plan, *December 2016.*

following measures to reduce vulnerability to these dangers have been identified as viable for this Milwaukee County hazard mitigation plan update. This section will present structural, nonstructural, and public outreach mitigation measures as well as current programs that apply to winter storm hazards. In addition to the measures listed below, mitigation strategies that were found to address multiple hazard types, including winter storm events, are discussed in the "Multiple Hazard Mitigation" plan component in this Chapter.

Nonstructural

- Review the energy efficiency and winter readiness of critical community facilities and utility systems throughout the County

- Continue to work with agencies, such as the American Red Cross, to establish and maintain short-term community sheltering units, particularly for those most vulnerable during harsh winter conditions

- Pursue additional funding opportunities to assist with budgeting for overtime hours and extra governmental personnel needed during extreme winter events.

- Ensure that the necessary amount of snow removal, anti-icing, and deicing equipment is available and routinely maintained.

Structural

- Work with utility companies to assess and improve, as needed, electric service system dependability and/or redundancy and backup systems.

- Continue to ensure reliable and resilient back-up emergency power sources at community warming centers.

- Continue to promote and highly encourage the installation or purchase of back-up power systems at homes and businesses.

Public Informational and Educational Programming

- Continue to maintain and promote, via various modes of communication, winter hazard awareness and resources for all County residents, including home and travel safety measures, such as avoiding

travel during winter storms; having a shovel, sand, warm clothing, food, and water in the vehicle if travel cannot be avoided; and installing a back-up heating system in at least one room in the home.

- Promote the availability of low-income energy assistance programs.

Current Programs and Ongoing Projects

Federal and State Programs

Federal and State winter storm programs include awareness and education activities. The Department of Homeland Security's *Ready.gov* campaign provides online resources on snowstorms and extreme cold awareness and preparedness.

The NWS Storm Prediction Center provides or issues smaller, more targeted information, including warnings, watches, and advisories on rapidly approaching intense, heavy winter precipitation to the public, private sector meteorologists, and state and local governments. Several categories of warnings, watches, and advisories apply to winter weather conditions and associated hazards.

The Milwaukee/Sullivan office will issue a winter storm warning when one or more of the following weather events are expected to occur over a period of 12 or fewer hours:

- Snowfall greater than six inches
- Sleet accumulations of two or more inches
- Intermittent blowing snow that reduces visibility below one-half mile with winds of 25 to 34 mph
- Less than one-quarter inch of freezing rain accompanied by another winter event

The NWS Milwaukee/Sullivan office will issue a winter weather advisory when one or more of the following weather events are expected to occur within 12 to 36 hours:

- Snowfall of three to six inches
- Sleet accumulations of less than two inches

- Intermittent blowing snow that reduces visibility below one-half mile with winds of less than 25 mph

- Less than one-quarter inch of freezing rain accompanied by another winter event

The NWS office will also issue an advisory or warning for blizzard, ice storm, and lake effect snow events.

In November each year, Winter Awareness Week focuses on informing and educating people concerning the hazards presented by severe winter weather and information on preparation for extreme weather conditions during winter. The Wisconsin Department of Health Services (DHS) has developed a weather tool kit to provide information to local governments, health departments, and citizens in Wisconsin about preparing for and responding to winter storm events.[56] Similarly, WEM has produced several educational resources regarding winter weather, including prerecorded radio public service announcements, scripts for radio public service announcements, fliers, and educational materials for children.[57]

The Wisconsin Building Code specifies design requirements to minimize vulnerability to winter storms by setting the load capacity of roofs by region based on likely maximum snowfall. The U.S. Department of Transportation reports that 24 percent of weather-related vehicle crashes occur on snowy, slushy or icy pavement and 15 percent happen during snowfall or sleet, therefore, listening to weather advisories and avoiding travel during winter storms would significantly reduce risk.

Local Programs

Winter safety information is prepared and distributed to the public by Milwaukee County OEM during Winter Awareness Week in November. Preparedness information is also provided in County and municipal community buildings, such as the County courthouse and safety building, health and human services, library, the Milwaukee City Hall, libraries, as well as the other village or city halls, and police and fire departments structures within Milwaukee County.

In addition, Milwaukee County, its communities, and local emergency departments provide information via social media on winter road conditions in and around the County. The Milwaukee County website also

[56] *Wisconsin Department of Health Services,* Wisconsin Winter Weather Toolkit, op. cit.

[57] *These can be accessed at Wisconsin Emergency Management's ReadyWisconsin website located at ready.wi.gov/Resources/Manager_Resources.asp.*

provides residents with numerous links and resources pertaining to extreme temperature safety, preparedness, and education including public shelter locations throughout the county.

Community strategies for winter storms in Milwaukee County include snow removal, salting and sanding roads, maintaining the health of urban trees to minimize damage from ice storms, promoting and maintaining community warming shelters. Also, during a storm, the public is advised via local radio, television, and NOAA weather alert radios on up-to-date winter weather forecasts.

Furthermore, as described in Chapter 2, Milwaukee County has developed a comprehensive emergency management plan, which sets forth an all-hazards action plan. The Plan provides for coordination of public safety support agencies such as the American Red Cross and for additional resources provided during winter emergencies. Note, many of the local units of government have developed emergency operations plans and/or programs which complement the County plan.

Multi-Jurisdictional Considerations

Winter storms and their related hazards can potentially impact all municipalities within the County. In addition, these severe events can potentially cause multiple damages to a variety of infrastructure including transmission lines, communication lines, and transportation routes due to whiteout conditions, snow accumulations, and ice. Milwaukee County, local units of government, and relevant businesses need to coordinate hazard mitigation activities through local government participation in countywide disaster planning and response mechanisms.

Evaluation of Alternatives and Identification of Priority Mitigation Measures

Analysis of the vulnerability of humans, infrastructure, and economic production to winter storms and related hazard events demonstrates that providing advanced weather forecasts and warning systems, as well as public informational and educational programming, are the most important mitigation actions to be considered. In addition, informing the public of the significance of winter storm watches and warnings so that they take these events seriously and know where to seek shelter is important. Forming a neighborhood outreach program to locate isolated, vulnerable or special-needs populations likely to be affected by winter storms is an important element in ensuring that these groups are protected during these events. Community and school based informational programs are currently being conducted by the County and its communities in partnership with Federal, State and local authorities.

Based upon the foregoing evaluation and consideration of risk and consideration by the Milwaukee County Hazard Mitigation LPT there are 7 actions determined by the Milwaukee County Hazard Mitigation LPT to be priority mitigation measures as part of this hazard mitigation plan update that are specifically related to winter storm events.[58] These priority mitigation measures, along with a general cost-benefit summary are presented in Table 5.13.

5.7 HAZARD MITIGATION PLAN COMPONENT FOR EXTREME TEMPERATURE

Extreme temperatures are natural hazard events of reasonable concern to be considered in the Milwaukee County hazard mitigation plan. Extreme temperatures can cause disruption of normal activities for the population and even the loss of life, particularly among more vulnerable populations (i.e., urban heat island effect). More vulnerable populations for extreme temperatures include young children, the elderly, underprivileged, undereducated, pregnant, and those in poor health or have chronic health conditions. This section describes alternative and selected priority strategies to mitigate this type of hazard. As part of the updating process, these strategies were reviewed and reevaluated by the Milwaukee County Hazard Mitigation Plan LPT in light of the updated hazard conditions and hazard mitigation goals documented in Chapters 3 and 4.

Identification of Alternative Mitigation Strategies

Extreme heat and cold events combined are the number one most deadly natural type of weather in Wisconsin and is therefore considered a serious concern to Milwaukee County. Furthermore, as detailed in Chapter 3, and depicted in Figure 3.4, because of its high population density, high social vulnerability index rating,[59] and urban heat island effect, Milwaukee County has even a higher vulnerability to extreme heat events and has experienced many heat-related fatalities (Table 3.4). As shown in Figure 3.4, the largest area of high heat vulnerability identified in the Milwaukee County Hazard Vulnerability Index (HVI) map[60] is the inner core of the City of Milwaukee.

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*[58] Priority mitigation measures that apply to multiple hazard types, including winter storm events, are presented in the "*Hazard Mitigation Plan Component for Multiple Hazard Types*" section in this Chapter.*

[59] Includes people who do not have health insurance, people without transportation or funds to reach a hospital, people with disabilities, and low-income and racially marginalized people.

*[60] The Wisconsin DHS **heat vulnerability index** is based on multiple indicators associated with risk for heat-related illnesses and mortality including health factors, demographic and household characteristics, socioeconomic factors, natural and built environment factors, and population density.*

Based upon review by the Milwaukee County Hazard Mitigation LPT as part of the updating process, the following measures to reduce the vulnerability to extreme temperature events have been identified as viable for this update of the Milwaukee County hazard mitigation plan. In addition to the measures listed below, mitigation strategies that address *multiple* hazard types, including extreme temperature events, are discussed in the "Multiple Hazard Mitigation" section in this Chapter.

Nonstructural

- Organize and/or enhance reliable neighborhood outreach groups or networks that reach out and look after vulnerable individuals and populations during extreme temperature conditions

- Continue support of the Milwaukee Heat Task Force

- Continue to provide special arrangements for payment of heating and cooling bills for customers unable to pay due to financial restraints

- Continue to designate or update adequate sites to be used as public cooling/warming shelters throughout extreme temperature events. In addition:

    - Conduct an inventory and inspection of these facilities to ensure their quality, quantity, and accessibility for use as heating and/or cooling shelters

    - Extend hours at these sites during extreme temperature events

    - Promote transportation options to assist members of highly vulnerable populations to reach these sites during extreme temperature events

- Reschedule public events to avoid large outdoor gatherings during periods of extreme heat or cold

- Extend public swimming pool hours to increase the accessibility during extreme heat events

- Establish and promote a donation program of functional window air conditioner units and fans that are no longer in use and distribute these items to vulnerable populations

- Promote and expand winter weather clothing drives (coats, hats, mittens) where people can drop off gently used winter clothing for distribution to vulnerable populations

Structural

- Take measures to reduce heat island effects in dense urban areas. Examples of such measures include:
    - Increase the amount of green space throughout urban areas
    - Increase tree plantings around buildings, parking lots, and along public right-of-way to shade surfaces that contribute to heat island formation
    - Encourage the use of "cool roofing" products made of highly reflective and emissive materials
- Maintain warming and cooling public shelter sites

Public Informational and Educational Programming

- Continue to increase and enhance public education and awareness, especially to those with limited accessibility or at high-risk, (i.e., elderly, impoverished/low-income, disabled, or lacking communication or travel devices) of the potential severity and danger of extreme temperature events and distribute emergency preparedness information related to these types of events
- Increase public awareness of community cooling/warming shelters that are available during extreme temperature events through municipal, County, and public health department websites and interactive maps, use "2-1-1," and by sharing with appropriate local media outlets
- Produce and distribute emergency preparedness information related to the safe operation of generators, space heaters, fireplaces, and wood stoves
- Ensure those that are living in poor conditions with minimal resources are aware of different local, State, and/or Federal assistance programs and toolkits related to extreme temperature safety and risk prevention

Current Programs and Ongoing Projects

Federal and State Programs

The NWS issues warnings, watches, and advisory statements to media, emergency management, and public health officials when there is a threat of severe weather conditions. Several categories of warnings, watches, and advisories apply to both extreme heat and extreme cold conditions and the associated hazards. The conditions necessary for each of these categories are presented in detail in Chapter 3 of this Report. Heat waves cannot be prevented; therefore, it is important to provide notice of adverse conditions so that the public can anticipate and avoid health-threatening situations. Excessive heat alert thresholds specific to major metropolitan centers are determined based on research results that link unusual amounts of heat-related deaths to city-specific meteorological conditions. The NWS also has a HeatRisk forecast tool that provides a color and numeric value for the level of heat concern for a specific location. HeatRisk considers factors like how much higher than normal the temperatures are, the time of year, and the duration of unusual heat. In addition, the NWS provides a Wet Bulb Globe Temperature (WBGT) which is an effective indicator of heat stress for active populations such as outdoor workers and athletes by using temperature, humidity, wind, solar radiation, and other weather parameters.

The Occupational Safety and Health Administration (OSHA) recommends protective measures for outdoor work:

- Acclimatize workers starting the first day working in the heat and after any extended absences
- Provide shade for outdoor work sites
- Schedule work earlier or later in the day
- Use work/rest schedules
- Limit strenuous work (e.g., carrying heavy loads)
- Use relief workers when needed

State programs include various awareness and education efforts. WEM, in conjunction with the National Weather Service and State and local government agencies, provide both preparedness and severe weather information to the citizens of Wisconsin. Prepared information is provided during three severe weather

awareness campaigns conducted during the year, each focusing on the prevalent weather hazard at that time. The Wisconsin Department of Health Services (WI DHS) has developed an extreme heat tool kit to provide information to local governments, health departments, and citizens in Wisconsin about preparing for and responding to extreme heat events.[61] Also, as detailed in Chapter 3, WI DHS developed a Building Resilience Against Climate Effects (BRACE) Program, which includes a geo-spatial analysis of heat-related vulnerability in the State by County (see Figure 3.4). Further, WI DHS developed a winter weather toolkit to provide information about winter weather, including extreme cold.[62] WEM has produced several educational resources regarding extreme heat and winter weather, such as extreme cold, including prerecorded radio public service announcements, scripts for radio public service announcements, fliers, and educational materials for children.[63] In addition, numerous other organizations, such as the American Red Cross, provide public safety information related to extreme temperatures.

Wisconsin 211 is a free 24-hour hotline (dial 2-1-1) and online database/dashboard of information on local or regional resources and services available such as utility assistance, emergency housing during extreme weather events, available resources during extreme temperatures, food, elder care, or crisis intervention. For southeastern Wisconsin counties, including Milwaukee, "IMPACT 211" is the regional central access point for local resources and information.

Local Programs

The Milwaukee County OEM has information available for the public on extreme temperatures and other general emergency management-related topics. The Milwaukee County OEM participates in State sponsored severe weather awareness campaigns.

The City of Milwaukee Health Department (MHD) maintains an updated list and interactive map of cooling/heating centers with available air-conditioned or heated environments to prevent adverse effects. In addition, MHD leads the Milwaukee Metropolitan Area Heat Task Force which is a coordinated effort committed to reducing the public health threat from heat waves. The Heat Task Force is comprised of members from the Milwaukee County OEM, the Milwaukee/Sullivan regional office of the NWS, the Milwaukee County Department on Aging, as well as interested parties from local government and

[61] *Wisconsin Department of Health Services,* Wisconsin Extreme Heat Toolkit, *Publication P00632, March 2014.*

[62] *Wisconsin Department of Health Services,* Wisconsin Winter Weather Toolkit, *Publication P00652, April 2014.*

[63] *These can be accessed at Wisconsin Emergency Management's ReadyWisconsin website located at: ready.wi.gov/Resources/Manager_Resources.asp.*

community organizations. The Milwaukee Heat Task Force partnership collaborated on and instituted a plan for excessive heat conditions.[64] This plan outlines the roles and responsibilities of each participating group during excessive heat conditions. This plan includes a list of public cooling sites and essential recommendations and additional considerations for organizations offering to publicize their facilities as cooling centers.

Finally, a variety of methods to warn the residents of Milwaukee County of emergency situations, including extreme temperatures, are described in detail in the "multiple hazards" plan component earlier in this Chapter.

Multi-Jurisdictional Considerations

Extreme temperature events are primarily a public health concern for all communities and can affect all individuals within the County; however, they are particularly dangerous for those that most vulnerable, including the elderly, sick or unhealthy, mentally ill, poor, and homeless. In addition, vulnerable residents living in portions of the City of Milwaukee are at a greater risk to extreme heat events and associated impacts due to the urban heat island effect. A coordinated effort involving the Milwaukee County OEM, local health departments, local community organizations, NGO, and local safety and emergency programs will be needed to identify and protect individuals vulnerable to temperature-related hazards.

Evaluation of Alternatives and Identification of Priority Mitigation Measures

Based upon review of the above, the ongoing informational and educational programs related to extreme temperatures represent a major component of the planned mitigation action. Milwaukee County and its communities should continue to promote and enhance basic strategies to reduce injuries and fatalities, hazard awareness, and community involvement. Temperature hazards are experienced by Milwaukee County residents annually and the ability to make positive decisions concerning exposure limits will depend on hazard safety awareness. Analysis of the vulnerability of humans, infrastructure, and economic production caused by extreme temperature events demonstrates that providing advanced weather forecasting systems; providing early warning systems to alert the public of extreme temperature situations; the availability of adequate shelter from the heat and cold in public buildings, major industrial sites, and other large businesses or complexes; and public informational and educational programming are the most important mitigation actions to be considered. Public service announcements regarding avoiding heat

[64] *City of Milwaukee Health Department and Milwaukee Metropolitan Area Heat Task Force,* "Excessive Heat Event Coordination Plan," *June 2018*.

stress help to minimize exposure. Milwaukee County supports measures presently implemented by the NWS; Federal, State, and local health organizations; and the media preceding and during excessively hot and cold weather. Outreach to poor and homeless populations to inform them of the availability and location of warming and cooling shelters and available resources within the County is also an important component to keeping these vulnerable populations safe. Community and school-based informational programs and networks for extreme temperature awareness should continue to be conducted and improved in partnerships with other local organizations and Federal, State and local authorities.

Based upon the foregoing evaluation and consideration of risk and review by the Milwaukee County Hazard Mitigation LPT (see Appendix A), there are 8 actions determined to be priority mitigation measures as part of this hazard mitigation plan update that are specifically related to extreme temperature events.[65] These priority mitigation measures, along with a general cost-benefit summary are presented in Table 5.14.

5.8 HAZARD MITIGATION PLAN COMPONENT FOR DROUGHT

Droughts are natural hazard events of minor to moderate concern to be considered in the Milwaukee County hazard mitigation plan. This section describes alternative and selected priority strategies to mitigate this type of hazard. As part of the updating process, these strategies were reviewed and reevaluated by the Milwaukee County Hazard Mitigation Plan LPT in light of the updated hazard conditions and hazard mitigation goals documented in Chapters 3 and 4.

Identification of Alternative Mitigation Strategies

A drought is a prolonged period of unusually constant dry weather that persists long enough to cause deficiencies in water supply (surface or groundwater). When drought events do occur, they often impact a relatively large area. The effects of drought are often grouped as economic, environmental, and social. Over time droughts can severely affect crops, municipal water supplies, recreational resources, human health, and wildlife. If drought conditions extend over a number of years, the direct and indirect impacts can be significant.[66]

[65] *Priority mitigation measures that apply to multiple hazard types, including extreme temperature events, are presented in the "Hazard Mitigation Plan Component for Multiple Hazard Types" section in this Chapter.*

[66] *FEMA,* Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards*, January 2013*.

Because Milwaukee County has very little agriculture (see Tables 2.9 and 2.10) and is positioned on Lake Michigan, which serves as its main source of drinking water, overall, it is less susceptible to droughts. However, certain stresses on the water resources of Milwaukee County such as increased competition for available water, loss of groundwater recharge areas due to development, and the potential effects of a changing climate may make drought conditions worse.

Although nothing can prevent a drought, certain measures should be considered and implemented to help reduce potential impacts. As reviewed by the Milwaukee County Hazard Mitigation Plan LPT, the following are considered as part of this Plan update to reduce drought vulnerability. In addition to the measures listed below, mitigation strategies that address *multiple* hazard types, including drought events, are discussed in the "Multiple Hazard Mitigation" section in this Chapter.

Nonstructural

- Encourage the development and maintenance of drought emergency plans for local water utilities and private well users. Such plans should include:
    - Development of criteria for triggering drought-related actions
    - Development of agreements for secondary water sources that may be used during drought conditions
    - Specification of water use regulations during drought conditions
- Encourage the development of local water conservation programs.[67] Such programs may include provisions such as:
    - Water supply system efficiency actions including meter testing, leak detection and repair, water main maintenance and replacement, water system audits, and water production system refinement
    - Public information and education programming and distribution of educational materials

[67] *Southeastern Wisconsin Regional Planning Commission Planning Report No. 52,* A Regional Water Supply Plan for Southeastern Wisconsin*, December 2010*.

- Outdoor watering reduction measures such as the use of rain barrels/cisterns or implementation of lawn and landscape plant watering restrictions when a severe drought is occurring

- Development and use of water conservation rate structures

- Fixture and plumbing system retrofits

- Promote regional activities to protect groundwater recharge areas within and outside of the County

- Identify areas with potential groundwater level problems and inspect wells in those areas for adequate depth and construction.

- Allow and encourage the use of drought-resistant landscaping practices using native plantings.

- Promote the use of green infrastructure and other stormwater management practices that facilitate aquifer recharge, such as rain gardens, permeable pavement, and soil amendments.

- Support ordinances to prioritize or control water use during drought conditions.

- Design and plan for water supply infrastructure systems that are not vulnerable to drought events.

Structural

- Consider implementing the recommendations made in the regional water supply plan for additional water supply facilities and programs to meet forecast water use demands[68]

- Continue operation and monitoring of stream gaging stations and groundwater monitoring wells by the WDNR, U.S. Geological Survey, NWS, and U.S. Army Corps of Engineers.

[68] *See recommendations for Milwaukee County in Table 194 from Southeastern Wisconsin Regional Planning Commission Planning Report No. 52,* A Regional Water Supply Plan for Southeastern Wisconsin*, December 2010. These recommendations were made for water utilities to meet a "reliable capacity" based on forecast water use demands in the design year 2035.*

Current Programs and Ongoing Projects

Federal Programs

Interagency/Collaborative Efforts

The National Oceanic and Atmospheric Administration's (NOAA) National Integrated Drought Information System (NIDIS) Act is a comprehensive interagency program that coordinates and integrates drought research by building upon existing federal, tribal, State, and local partnerships in support of creating a national drought early warning information system. In addition, the NIDIS website[69] serves as the primary drought portal and clearinghouse for drought related resources. The NIDIS website provides regional drought early warning systems (DEWS)[70] links to research and resources for drought planning and preparedness, as well as links for recovery, education, news about drought, regional webinars and upcoming drought-related events. In addition, the website has a number of maps, tools, social media updates, and data related to drought at both the national and regional scale.

The National Drought Resilience Partnership (NDRP), a federal partnership between the U.S. Department of Agriculture (USDA), the U.S. Department of Energy (U.S. DOE), the U.S. Department of the Interior (U.S. DOI); and federal sub-agencies including NOAA, NWS, NIDIS, USGS, National Aeronautics and Space Administration (NASA), the Assistant Secretary of the Army for Civil Works, FEMA, and the U.S Environmental Protection Agency (EPA), provides technical and financial Federal resources on efforts to build, protect, and sustain long-term drought resilience capacity at regional and basin-level scales.

The National Drought Mitigation Center (NDMC) assists local officials, organizations, and institutions to build resilience to drought through monitoring and planning. The NDMC website offers abundant information on drought research, education, planning, and monitoring and is host of the U.S. Drought Monitor (USDM) map.[71] The NDMC assists State, Federal, regional, tribal, and local governments as well as individual ranchers and farmers involved in drought and water supply planning, mitigation, and policy making.

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[69] *The NIDIS website can be found at www.drought.gov.*

[70] *The Drought Early Warning System (DEWS) utilizes new and existing networks of federal, tribal, State, local, and academic partners to make climate and drought science accessible and useful for decision makers. It also aims to improve the capacity of stakeholders to monitor, forecast, plan for, and cope with the impacts of drought.*

[71] *The **U.S. Drought Monitor (USDM),** a partnership between the NDMC, USDA, and NOAA, produces a weekly interactive online map and informational on current drought conditions. USDM provides an updated map every week with a general summary of current drought conditions, various indices, outlooks, field reports, and news accounts.*

The U.S. Geological Survey (USGS) also monitors, assesses, studies, and presents information on water resources and associated conditions such as streamflow, groundwater, water quality, and water use and availability. The USGS website provides water quality and water level data through a number of interactive maps, such as, "Drought Watch", "Water Watch", and "Groundwater Watch." In addition, the website offers a number of additional drought-related resources and links available for public information and education.

Also, the USDA and the Natural Resources Conservation Service (NRCS) both provide information and educational resources on conservation practices as well as a number of financial, technical, agricultural, and natural resources programs that should be considered during and after a severe drought event.

The NWS also provides a number of informational and educational online resources related to drought and drought monitoring, including the NWS Climate Prediction Center, the National Climatic Data Center Drought Monitoring, and NOAA's experimental drought monitoring and early warning guidance tool known as Evaporative Demand Drought Index.[72]

Additional Federal Programs and Mitigation Resources

FEMA provides drought mitigation assistance through its Hazard Mitigation Grant Program (HMGP) and Building Resilient Infrastructure and Communities (BRIC) mitigation program as well as drought-related informational and educational resources and links available on the FEMA website. NASA's Gravity Recovery and Climate Experiment (GRACE) satellite integrates groundwater and soil moisture storage observations with modeling to generate drought indicators based on cumulative distribution of wetness conditions.[73] In 2013, the American Planning Association (APA), in collaboration with NDMC and NIDIS, published a guide to help decision-makers, resource managers, public agencies, land owners, local officials, and policy-makers assist communities for drought preparedness and mitigation.[74]

[72] *Evaporative Demand Drought Index (EDDI) can offer early warning of agricultural drought, hydrologic drought, and fire-weather risk by providing near-real-time information. EDDI can capture signals of water stress at weekly to monthly timescales, which makes it a strong tool for drought preparedness.*

[73] *Drought.gov.*

[74] *James C. Schwab, American Planning Association-Planning Advisory Service Report No. 574,* "Planning and Drought," *October, 2013.*

State Programs

The Wisconsin Geological and Natural History Survey (WGNHS), in collaboration with USGS, and WDNR, provide interactive online maps of statewide monitoring wells that include groundwater elevation and conditions.

Additionally, the Wisconsin DHS has developed a drought toolkit to provide information to local governments, health departments, and citizens in Wisconsin about preparing for and responding to drought events.[75] Similarly, *ReadyWisconsin* Drought provides drought-related information and resources to assist individuals and communities prior to and during a drought.[76] Also, Chapter NR 852, "Water Conservation and Water Use Efficiency," of the *Wisconsin Administrative Code* establishes mandatory water conservation and efficiency measures for withdrawals in the Great Lakes Basin and water loss approvals throughout the State.

Local Programs

As described in Chapter 1, Milwaukee County has developed a comprehensive emergency management plan that sets forth an all-hazards action plan, including instances of drought related events. In addition, the City of Milwaukee helps water users in identifying and eliminating leaks in internal plumbing systems; the City of Oak Creek has implemented water treatment plant modifications to help reduce water usage; and the City of Franklin has instituted water sprinkling restrictions from May through September. Further, while not specifically reported, all County utilities strive to improve efficiency and minimize water losses within their systems, including meter testing for accuracy, leak detection programs, and repair of water main breaks and leaks. In general, most Milwaukee County municipalities have adopted water usage regulations during drought conditions and offer resources related to water conservation and drought related preparedness practices.

Multi-Jurisdictional Considerations

Ultimately, all areas in the County are at a uniform risk of drought events and associated impacts, as droughts occur regionally and not within specific locations, in which all vulnerable populations within the County would be impacted. In 2005 the Commission completed the regional water supply plan,[77] which

[75] *Wisconsin Department of Health Services,* Wisconsin Drought Toolkit, *Publication P00884, revised May, 2019.*

[76] *Ready.gov/wisconsin.*

[77] *Southeastern Wisconsin Regional Planning Commission Planning Report No. 52,* A Regional Water Supply Plan for Southeastern Wisconsin, Vol. I, *2010.*

included an inventory of all water supply sources in Milwaukee County. That plan indicated that over 100 private groundwater well systems existed in the county in 2005. These private well systems included over 50 high-capacity wells and served residential, industrial, commercial, institutional, recreational, and governmental land uses. In 2005 the majority of these private groundwater well systems were located in the Cities of Franklin and Oak Creek and the Villages of Bayside and River Hills. Also to note is that the majority of residents in the Village of River Hills have individual private wells as of 2024. Assuming all these areas still contain groundwater well systems, certain risk reduction measures should be considered during prolonged drought events.

Evaluation of Alternatives and Identification of Priority Mitigation Measures

Drought can have economic, environmental, and social impacts, especially to those populations and communities considered vulnerable, which include the elderly, low income, and/or disabled. Aside from the noted locations above, Milwaukee County receives its drinking water from Lake Michigan. Nevertheless, it is still important to consider the adverse impacts of drought within and around the County. Mitigation of the potential impacts of drought should be addressed through a multi-faceted approach. Important elements of such an approach include developing plans for responding to drought conditions for local communities and utilities; protecting local water supply sources that use groundwater as the main source; water conservation efforts; and encouraging residents to take advantage of Federal programs.

Based upon the foregoing evaluation and consideration of risk and consideration by the Milwaukee County Hazard Mitigation LPT (see Appendix A), there are 7 actions determined to be priority mitigation measures for this hazard mitigation plan update related to drought events.[78] These priority mitigation measures, along with a general cost-benefit summary are presented in Table 5.15.

5.9 HAZARD MITIGATION PLAN COMPONENT FOR LAKE MICHIGAN COASTAL HAZARDS

The Great Lakes coastline is a dynamic environment with shoreline conditions continually changing over time. Today, with the effects of a changing climate, these dynamic conditions are often exacerbated with the already erodible unconsolidated Lake Michigan shoreline material, human activity, and different shoreline management practices. And because of this, people, property, and structures along the Lake

[78] *Priority mitigation measures that apply to multiple hazard types including drought events, are presented in the "*Hazard Mitigation Plan Component for Multiple Hazard Types*" section in this Chapter.*

Michigan Milwaukee County coastline are becoming increasingly vulnerable to the impacts of the coastal hazards of shoreline erosion/recession, bluff failure, coastal flooding, storm surge, and ice shove.

To increase coastal resiliency in Milwaukee County and to protect shoreline assets, this Plan calls for the implementation of the following recommended alternative and priority mitigation measures which are both structural and nonstructural.

Identification of Alternative Mitigation Strategies

As reported in Chapters 2 and 3, a number of studies and planning programs have been carried out related to Lake Michigan coastal processes, including bluff failure and beach or shoreline erosion impacts. A review of those plans and programs comprise material developed under the Wisconsin Coastal Management Program (WCMP) and the University of Wisconsin Sea Grant Institute (WSGI). These plans include a range of alternative bluff, beach, and shoreline erosion control and flood mitigation measures that are considered priority coastal hazard mitigation measures for this Plan update.

As such, the recommended coastal mitigation measures are presented in five main categories for coastal Milwaukee County hazard mitigation planning.

- Coastline Regulations and Policy Measures
- Bluff Top and Ravine Mitigation Measures
- Bluff Face, Bluff Toe and Shoreline Mitigation Measures
- Coastal Flooding Measures
- Informational and Educational Outreach and Resources

Coastline Regulations and Policy Measures

The shores of the Great Lakes are subject to a multitude of federal, state, and local laws and standards.[79] Shoreline or coastal policies (i.e., zoning ordinances) and management guidelines often include development (or structural) setback regulations,[80] building relocation requirements, bluff, beach, and shoreline best management practices and guidelines, regulations for implementing shoreline protection structures/devices, and requirements for engineering or geotechnical analyses of proposed shoreline site modifications. Implementing, maintaining, and enforcing these coastal management guidelines and regulations is essential for Milwaukee County and its coastal communities in hazard mitigation planning efforts.

Federal Regulations

Because the Great Lakes are navigable waters of the United States, permits are required from the U.S. Army Corps of Engineers (USACE) for the placement of piers, wharves, jetties, breakwaters, revetments, and similar shoreline structures.

State Regulations and Management Guidelines

A permit for coastal work is required from the Wisconsin Department of Natural Resources (WDNR) pursuant to Chapter 30 of the *Wisconsin Statutes*. Also, under *Wisconsin Administrative Code*, Chapter NR 115, the statewide setback in the shoreland zone is 75 feet from the Ordinary High Water Mark (OHWM).[81] On coastal bluffs, the OHWM is generally the toe of the bluff (see Figure 5.7) and is often inadequate for safe shoreline development, especially at the top of the bluff.

- In response to the State setback standard mentioned above, the Wisconsin Coastal Management Program (WCMP), UW-Wisconsin Sea Grant Institute (WSGI), and WDNR developed recommendations to go above and beyond the State requirement, including a minimum setback

[79] *Alan R. Lulloff, P.E., CFM, Science Services Program Director - Association of State Floodplain Managers and Philip Keillor, P.E., Coastal Engineer,* Wisconsin Coastal Management Program: Managing Coastal Hazard Risks On Wisconsin's Dynamic Great Lakes Shoreline, *2015*.

[80] *The distance from the edge of a coastal bluff or bank (or other reference point) to a building or other structure is called a* ***setback distance*** *(Source UW-Wisconsin Sea Grant Institute).*

[81] ***OHWM****, as defined by the WDNR is "the point on the bank or shore up to which the presence and action of water is so continuous as to leave a distinct mark either by erosion, destruction of terrestrial vegetation or other easily recognized characteristic."*

distance for the structure(s) to be set back from the bluff *crest* or calculated stable slope instead of the OHWM (or the bluff toe). See Figure 5.8 as example.[82]

- Based on bluff setback recommendations developed by WSGI and others, the Commission drafted a model ordinance for Lake Michigan bluff setbacks (see Figure 5.9 and Appendix J.1). This model ordinance is intended to help protect structures and properties from bluff erosion and failure without reliance on shore protection measures. The model ordinance includes a bluff top setback distance based on a 60-year bluff recession, a stable bluff face slope, and an additional 100-feet. Milwaukee County coastal communities that have yet to adopt coastal setback regulations should consider implementing them for coastal hazard mitigation.

Local Regulations and Management Guidelines

- Milwaukee County coastal communities including the City of Oak Creek, and the Villages of Bayside, Fox Point, Shorewood, and Whitefish Bay have developed their own coastline management strategies and regulations to protect existing and proposed development from potential bluff instability and erosion/recession hazards. These local coastal regulations and guidelines include bluff setback requirements, regulations for conducting site specific bluff stability analyses, and provisions for implementing shoreline protection structures (see Appendix J.2).[83] For coastal hazard mitigation purposes, this Plan encourages and recommends that these communities continue to maintain and enforce these regulations and guidelines.

- To prevent or reduce future damage to county-owned assets along the Lake Michigan coastline, Milwaukee County, with the assistance of Commission staff, developed and adopted coastline management regulations and guidelines which are to be enforced within the designated Coastline Management Zone (CMZ), as indicated on Map 5.8.[84] These management guidelines and regulations include coastal bluff and ravine setbacks requirements (see Figure 5.10), guidance on shoreline vegetation and best management practices, viewshed management, recommended bluff stabilization

[82] *Wisconsin Coastal Management Program,* Managing Coastal Hazard Risk on Wisconsin's Dynamic Great Lakes Shoreline*, 2015.*

[83] *Some municipalities' lake bluff regulations also relate to the bluffs of ravines that are tributary to Lake Michigan.*

[84] *Southeastern Wisconsin Regional Planning Commission Memorandum Report No. 248,* Milwaukee County Coastline Management Guidelines*, February 2021.*

techniques, and stormwater management practices and regulations.[85] This Plan calls for Milwaukee County to promote and continue to enforce these guidelines and regulations as they relate directly to coastal hazard mitigation measures. Additionally, the Milwaukee County coastal municipalities are encouraged to adopt similar coastal goals and guidelines for future coastal work.[86]

Bluff Top and Ravine Mitigation Measures

The bluff top is where coastal assets like homes, businesses, and infrastructure are often located, and is greatly influenced by human activity (Figure 3.9). Bluff top management practices such as land use, surface water runoff, groundwater infiltration, and vegetation management play an important role in the overall stability of the bluff and therefore are an important element in coastal hazard mitigation planning. Note that a large portion of the Milwaukee County coastline is currently designated as environmental corridors and isolated natural resource areas (see Map 5.9 (North Half) and (South Half). Most of these uses are in parks, which means the risk to buildings and infrastructure is relatively small for the County. Nevertheless, the recommended bluff top and ravine practices below will provide additional protection from coastal impacts.

- Land use management – As recommended in the previous "Coastline Regulations and Policy Measures" section, structures should be an adequate distance away from the bluff top edge (or bluff crest) to reduce the risks of structural impacts from bluff failure hazards.

    - It is encouraged that Milwaukee County, and its coastal communities develop and promote bluff top best management practices (BMPs) along the Milwaukee County bluff shoreline. Implementing these practices is of particular priority in areas where significant bluff crest recession has been observed. As discussed in Chapter 3, and indicated on Maps 3.9 and 3.11, the largest bluff crest recession within the long-term period (1956-2015) were observed in the Cities of Milwaukee, St. Francis, Whitefish Bay, and Oak Creek, with both St. Francis and Oak Creek also experiencing the greatest amount of short-term (1995-2015) bluff crest recession.

[85] *On February 4, 2021, the Milwaukee County Board of Supervisors authorized adoption of the coastline management guidelines for implementation by the County Parks Department for all pertinent land use actions, both County-initiated as well as third party projects.*

[86] *Milwaukee County requires proposals for a scope of work for all land-disturbing activities within the designated Lake Michigan Coastline Management Zone.*

- Consider relocating buildings determined to be at high-risk for sustaining damages from bluff recession and/or failure. Detailed studies by a licensed engineer would be needed to determine if a building should be considered for relocation. This plan element is presented as an option, subject to the preference of the individual property owner.

- For coastal risk reduction measures, it is suggested to avoid adding excess weight or other disturbances near the bluff-top edge.

- As described in Chapter 3 and detailed in Table 3.22, WEM conducted a county-level coastal erosion risk and vulnerability assessment using a statewide parcel inventory database. Parcels within one-quarter of a mile from the coast were considered within the High-Risk Erosion Zone, while parcels within one-half mile were considered to be in a Low-Risk Erosion Zone. Of the 23,869 total parcels identified in Milwaukee County to be at risk (low and high), 6,457 were considered to be in the High-Risk Zone. For hazard mitigation purposes, this Plan calls for the structures identified within the High Risk Zone and/or near the coastal bluff edge to be further evaluated for coastal hazard risk.

- In circumstances where buildings cannot be relocated safely or economically onsite, or where bluff recession has progressed to the point where the risk of catastrophic failure of the slope is imminent, or where there is an imminent threat of failure within five years, acquisition and demolition of the structures should be considered. Note, this plan element is presented as an option, subject to the preference of the individual property owner.

- Surface or stormwater management – Stormwater runoff can contribute to bluff and ravine destabilization and erosion. Paved surfaces and structures on the top of the bluff can prevent water from infiltrating into the soil, which may increase sheet and concentrated flows of water over the bluff crest causing erosion. It is recommended to limit or minimize the use of impervious surfaces and to have a well-designed and properly constructed drainage system to eliminate stormwater from flowing over the edge and down the face of the bluff.[87] These bluff top stormwater BMPs include the following.

[87] *A. Mangham, D. Hart, A. Belche, G. Clark, D. Peroff, J. Noordyk, B. Stitt, and L. Stitt, University of Wisconsin Sea Grant Institute,* Adapting to a Changing Coast, Options and Resources for Lake Michigan Property Owners, *August 2017.*

- Positioning stormwater ditches and roof gutters to *direct flow away* from the bluff-top edge

- Use rain barrels to capture roof runoff

- Route water into existing stormwater systems that move water away from the coastal bluff

- Continue to monitor and maintain stormwater drainage systems and outfalls

- Stormwater infrastructure that discharges (or outfalls) into Lake Michigan, such as those shown on Map 5.10 (North Half) and (South Half), can potentially damage the shoreline or become damaged from coastline impacts. Further, coastal damage can be exacerbated during extreme rainfall events with the higher volume and velocity of discharges increasing the risk of erosive impacts within and along coastal bluffs and shorelines. Also, stormwater infrastructure is also susceptible to potential coastal damage impacts, particularly during high water levels in that natural debris from the Lake or a storm may damage the outfall or the area around the outfall. Milwaukee County and its coastal communities are encouraged to continue to monitor, maintain, and improve (as needed), their stormwater infrastructure systems, specifically during high Lake Michigan water levels.

Bluff Face, Bluff Toe and Shoreline Mitigation Measures

Bluff face, bluff toe, and shoreline protection measures (see Figure 3.9) are often managed concurrently as many of the physical processes that affect these coastal features are connected. For example, addressing bluff toe problems frequently corresponds with stabilizing the bluff face. Therefore, bluff stabilization and shoreline protection highlighted within this Plan element are considered as mitigation alternatives for Milwaukee County and its coastal communities for its coastal hazard planning efforts.

- As mentioned in Chapters 2 and 3, a number of studies and assessments have been conducted on the Milwaukee County coastal characteristics and condition(s) including shore erosion and bluff stability. From the various assessments and reports, potential bluff hazards within Milwaukee County are highlighted below. Priority coastal mitigation measures should be considered for these locations.

- According to the 2020 Milwaukee County Coastal Resources Inventory report, detailed in Chapter 3, the vulnerability and risk assessment reported that the bluffs along Warnimont Park, Grant Park, Sheridan Park, Bay View Park, Big Bay Park, and Doctors Park have both a high vulnerability and risk rating.

- In 2019 unstable Lake Michigan bluff conditions existed in the Cities of Cudahy, South Milwaukee, and St. Francis (Map 3.6). Moderately unstable bluffs were found in the City of Oak Creek and the Village of Fox Point.

- A few examples of 2024 erosion areas along the Milwaukee County bluffs can be found in Figure 5.10. These photos were taken from the Wisconsin Shoreline Inventory and Oblique Photo Viewer which can be used by communities to review current bluff conditions.

- Groundwater saturation can weaken the soil matrix, causing landslides or slumps on the bluff face. Where groundwater saturation is known to be weakening bluff soils, it is recommended to investigate the suitability of installing a well-designed, appropriately located underground drainage system to help dewater the subsurface bluff soils. This system would help reduce groundwater saturation and increase bluff stability.

- Vegetation on coastal bluff slopes can stop surface erosion and may prevent shallow slides. Combining a variety of plants and root structures increases the strength and cohesion of soil even during saturated conditions, thus implementing this technique can slow stormwater runoff, reduce erosion, and increase bluff top and face stability. Guidance on selecting suitable plant species for bluff stabilization can be found in "A Property Owner's Guide to Protecting Your Bluff".[88] Recommendations from this guide include limiting substantial digging or other ground disturbances near the bluff-top edge and avoiding unnecessary compaction of soil on the bluff top during landscaping or construction.

- For mitigation purposes, Milwaukee County and its coastal communities should consider using visual cues to potentially help reduce or prevent future impacts caused by coastal bluff hazards. Visual signs on the bluff face or toe that indicate potential bluff instability include the following.

    - The formation of **rills or gullies** into the bluff face causing erosion on the bluff face.

    - **Groundwater** seepage in the middle of an otherwise dry bluff face indicates saturated soils which can reduce bluff slope stability.

[88] *L. Salus, A. Bechle, J. Noordyk, G. Clark, and D. Carter, University of Wisconsin Sea Grant and Southeastern Wisconsin Regional Planning Commission,* A Property Owners Guide to Protecting Your Bluff, September 2021.

- **Tilted or curved trees/shrubs** signifies that the slope is unstable and beginning to move slowly toward the lake.

- **Slides or slumps** on the bluff face indicates a recent slope movement and that a large bluff failure event is likely.

- **Loss of vegetation** on the bluff face is another indication of recent slope movement. Furthermore, a completely bare bluff face implies erosion is too rapid for plants to establish.

- **Steep, near-vertical slopes** at the base of the bluff (i.e., "scarps") caused by waves eroding the bluff toe can destabilize the bluff slope and ultimately lead to bluff failure.

- Milwaukee County and its coastal communities are encouraged to review and implement up-to-date geotechnical engineering studies and assessments that include variables (i.e., soil, groundwater conditions, maximum groundwater levels, vegetative cover, surface drainage, bluff height, slope angle, and previous studies) to help determine bluff stability and shoreline recession concerns.

  - Bluff slope stability analyses should be based upon the highest groundwater conditions (when the bluff is most likely to fail), and safety factors appropriate for the consequences of failure.[89]

- If determined to be necessary by a licensed engineer, maintain bluff stability by regrading and terracing the angle of the bluff face to create a less steep slope between the top and toe of the bluff. Any bluff regrading project would need to be designed and overseen by a geotechnical engineer trained in slope stabilization and a qualified contractor should be involved throughout the project.[90]

- With the assistance of a certified engineer and/or a marine contractor, Milwaukee County and its coastal communities are encouraged to routinely inspect, monitor, and update an inventory and assessment of the condition and effectiveness of all shoreline protection structures, such as shoreline revetments, breakwater walls, commercial and industrial docks and marinas, and bulkhead/seawalls

[89] Ibid.

[90] Ibid.

(see Map 3.5 and Map 5.11 (North Half) and (South Half). Note, a certified engineer and/or qualified marine contractor will be required if a new or reconstructed shoreline protection project is needed.[91]

As discussed below, there are a number of coastal mitigation projects planned or in progress in Milwaukee County and its coastal communities.

- With assistance from NOAA and the Fund for Lake Michigan, the City of Oak Creek is planning to conduct bluff toe and slope stabilization and habitat rehabilitation along a city-owned bluff that is on the Peter-Cooper brownfield site . The design includes construction of a revetment wall at the bluff toe, bluff slope regrading, and a drainage layer at the bluff face to stabilize the bluff slope. The 2,200 foot long revetment will be built from the seawall at the MMSD South Shore Water Reclamation Facility (WRF) to the existing revetment at the City of Oak Creek's water intake site. The goal of the revetment is to limit wave erosion at the base of the bluff. It should be noted that nature-based toe protection options were explored during the design phase of this project, however, with the high wave environment and sediment starvation from nearby shoreline protection structures, these options were impractical. The project also includes bluff regrading to mitigate bluff collapse and to allow public access.

- Another shoreline project considered a priority mitigation measure for Milwaukee County is the renovation work on the northern portion of the South Shore Breakwater wall. This breakwater structure protects the Milwaukee County coastal assets of Cupertino, South Shore, and Bay View Parks. It also protects the shore along the Oak Leaf Trail and Milwaukee's South Shore Yacht Club and boat launch. In 2020, after severe winter storms the breakwater structure was damaged, most likely due to undersized rocks. In 2023, several gaps within the structure had to be repaired, and beginning in 2024 sections of the northern breakwater wall began to be reconstructed. The renovated breakwater wall is designed to be 15 feet above the waterline, whereas now it is seven feet, in order to better protect County coastal assets. Construction is scheduled to be complete in 2025.

- The combination of the 2019-2020 high Lake Michigan water levels along with severe storms that included big waves, debris accumulation, and flooding, caused significant damage to portions of the Village of Fox Point. Shoreline impacts included extensive shoreline erosion and infrastructure exposure and damage. In 2020, the Village began a major shoreline protection and resiliency project

[90] Ibid.

along portions of Beach Drive. The project included the design of a robust and resilient revetment structure, the implementation of green infrastructure, the updating and replacement of existing stormwater outfalls, and the construction of more robust protection at existing sanitary sewer manholes. The project was completed in 2024 at a cost of $3.6 million.

- Milwaukee County and its coastal communities are encouraged to develop and/or maintain long-term protection measures for critical community, utility, and historical facilities located on the Lake Michigan shoreline.

- Milwaukee County and the City of Milwaukee are to ensure the breakwater walls and piers within and around the Milwaukee Harbor, which includes the Jones Island WRF and the Port of Milwaukee, are routinely maintained and up-to-date to withstand the increasingly harsh conditions of extreme weather events in the Lake Michigan coastal environment (such as gale force winds, large waves, or flooding), particularly during periods high water levels.

- It is important that Milwaukee County and its coastal communities consider the adverse impacts that coastal processes can have on historic sites and districts (see Appendix F and Maps 5.12 (North Half) and (South Half)). This Plan calls for mitigative and protective measures to ensure that these sites and districts are safe from the hazardous and damaging impacts of coastal processes.

The following measures are recommended for Milwaukee County and its coastal communities prior to conducting shoreline protection projects.

- Structural shoreline protection measures (i.e. jetties, groins, seawalls, and revetments) should only be installed if other less invasive measures are inadequate in reducing shoreline erosion and if it can be shown that such measures will effectively reduce shoreline erosion while not adversely affecting adjacent sections of the Lake Michigan shoreline.

- To the degree practicable, landowners (private and public) along the Milwaukee County Lake Michigan coastline are encouraged to use nature-based shoreline protection measures, such as living revetments or seawalls, native plantings, dune and coastal wetland restoration, and beach replenishment over the use of traditional "hard" shoreline protection structures (i.e., jetties, groins, breakwaters, seawalls, and levees). Hard shoreline protection structures have been proven to intervene with natural coastal processes causing adverse impacts to nearby and downstream shoreline properties. Further, nature-

based shoreline management is less intrusive and more beneficial in the long-term both aesthetically and ecologically. Costs for implementing nature-based shoreline measures vary depending on the project scale and material used. Some considerations for nature-based solutions are listed below.

- Fish and wildlife preservation measures should be considered and implemented to limit any adverse impacts during construction.

- It can often be more economical and effective to plan and implement shoreline protection or bluff stability projects in concert, with the design and implementation of projects along multiple neighboring properties and shorelines.[92]

- A 2015 coastal bluff analysis for the north shore of Milwaukee County is an example of the potential negative impacts of implementing hard-lined shoreline protection structures.[93] While the bluff analysis found that most bluffs along this reach were stable prior to 2013, it did reveal that some areas were beginning to experience bluff failure. The assessment concluded that these new bluff toe failures were a result of decreased beach widths and that these bluffs were failing in part because an adjacent property had constructed shoreline/bluff protection structures.

Coastal Flooding Measures

- Lower-lying shorelines are at a higher risk of being affected by the impacts of coastal flooding. In Milwaukee County there are small and scattered low lying shorelines along the coast, hence impacts to buildings and infrastructure are small. Nevertheless, Milwaukee County and its coastal communities are highly encouraged to continue to participate in the FEMA National Flood Insurance Program (NFIP). To note, Lake Michigan coastal V and VE flood hazard areas were added to the Milwaukee County regulatory floodplain maps in October 2024.[94]

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[92] Ibid.

[93] *University of Wisconsin Sea Grant Institute,* Integrated Assessment on Water Level Variability and Coastal Bluffs and Shores in Northern Milwaukee County and Southern Ozaukee County, Wisconsin, Interdisciplinary Synthesis of Existing Research*, November 2016*.

[94] *A Coastal High Hazard Area is identified as **Zone V** or **Zone VE** on FEMA flood maps where wave heights are larger than 3 feet. "**Zone VE**" means that a detailed study has been done for the area, whereas "Zone **V**" means that a detailed study has not been done, but wave hazards are still expected. Structures in areas mapped as Zone V and Zone VE are subject to stricter building requirements because of the higher risk of damage from strong winds and waves.*

- The Lake Michigan 1-percent-annual-probability floodplain, prior to the October 2024 update, was used by the Commission in the parcel-based flood analysis discussed in Chapter 3. As indicated in Table 3.8 and Map 3.12, the analysis identified 27 structures potentially within the 1-percent-annual-probability coastal floodplain. The risk to these 27 structures should be confirmed utilizing the October 2024 updated FEMA coastal mapping. To reduce the potential impacts of a coastal flood event, structural acquisition and removal or relocation measures should be considered by the at-risk property owners. This is a voluntary option and is subject to the preference of the individual property owner. Also, prior to structural removal or relocation, on-the-ground field surveys by a certified land surveyor or engineer is highly recommended to confirm the structure(s) in question are indeed located within the coastal flood hazard area. Shown in Table 5.16, the estimated cost of implementing this recommendation is $34.4 million (2022 dollars). Note, this cost is also included in the floodplain and stormwater management section of this Chapter.

- Critical community facilities and/or infrastructure and utilities within or near the Milwaukee County Lake Michigan 1-percent-annual-probability flood hazard zone, such as the MMSD Jones Island and South Shore WRFs, the Port of Milwaukee, the Lake Express Car Ferry, the U.S. Coast Guard facility, and the City of Milwaukee Water Works facility should consider implementing priority mitigation measures to reduce flood risks and hazardous impacts to these vital community lifeline facilities that serve Milwaukee County and its surrounding area.

  - The January 2020 event produced severe lakeshore flooding and erosion at the Port of Milwaukee, causing the Port and Car Ferry to shut down for two days. In addition, this event flooded nearly 70 percent of Jones Island, which impacted access to and from the MMSD Jones Island WRF and caused some structural damage. As a result of this event, MMSD initiated a major flood hazard mitigation study and project aimed to increase safety and reduce structural and infrastructure flooding impacts from Lake Michigan events. The cost of this study is listed in Table 5.3.

  - A number of public facilities within the City of Milwaukee (Discovery World, War Museum, Art Center, Riverfront boat launch, Veterans Park, McKinley Marina, South Shore Yacht Club) are also located within or near the Lake Michigan 1-percent-annual-probability flood hazard zone and are therefore encouraged to plan mitigation actions that will reduce the impacts caused by Lake Michigan extreme weather events, such as flooding.

Public Information and Educational Resources and Outreach

Coastal hazard information should continue to be readily available to the public. Coastal erosion hazard assessments and associated erosion hazard maps have been developed for Lake Michigan's coast.[95] It is recommended, as a part of this Plan update, to inform and encourage Milwaukee County and its coastal communities and landowners to use the Wisconsin Shoreline Inventory and Oblique Photo viewer mapping tool to better understand long- and short-term shoreline processes and the natural or man-made impacts on individual properties.

This Plan calls for Milwaukee County and its communities to continue to work with WCMP and University of Wisconsin-Sea Grant Institute (WSGI) on public outreach and education assistance to support bluff and shoreline best management practices. This plan also recommends reviewing and re-examining, as necessary, the current community and County zoning ordinances, regulations, and comprehensive plans related to coastal hazards and coastal community resiliency. Other recommended outreach and education activities are listed below.

- Continue to promote and provide information related to online interactive maps and resources that illustrate and detail specific sites or reaches related to shoreline erosion or coastal bluff hazards to serve as a "fair warning" guide for realtors, shoreline property owners, developers, community officials, lending institutions, and prospective buyers.

- Promote the awareness of flood insurance to residents along the County's low-lying coastline located within the Lake Michigan coastal flood hazard zone, such as those parcels and community parcels mentioned previously (see Map 3.12).

- Milwaukee County and its communities should enforce priority mitigation measures to those structures considered critical community facilities, infrastructure, or utilities as well as popular public venues, within the mapped Lake Michigan 1-percent-annual-probability floodplain.

[95] *Wisconsin Coastal Management Program*, Managing Coastal Hazard Risk on Wisconsin's Dynamic Great Lakes Shoreline*, Alan R. Lulloff, P.E., CFM, Science Services Program Director - Association of State Floodplain Managers and Philip Keillor, P.E., Coastal Engineer, 2011, updated in 2015.*

Current Programs and Ongoing Projects

Federal Programs

U.S. Army Corps of Engineers (USACE)

Since formalizing the Federal government's role in unifying and coordinating the coastal management efforts of multiple states with coastal resources, USACE has become a leading environmental preservation and restoration agency that maintains a rigorous research and development program in support of water resources. USACE's Chicago District now has jurisdiction for Wisconsin's Lake Michigan coastline, providing technical expertise and assistance to address coastline impacts like erosion and flooding.

The USACE exercises some control over lake levels through the use of controls such as locks and dams between the Great Lakes. However, these impacts are minimal compared to the lake level impacts due to climatic influence. The USACE provides current, past, and forecasted average daily and monthly mean water levels for the Great Lakes. The USACE also provides technical, direct, and advanced measures assistance. In addition, the UW Sea Grant and USACE Report, "Living on the Coast" provides informational and educational guidance for local officials and coastal property owners.[96]

FEMA offers information and resources related to coastal flooding, including recommended measures for those living within coastal flood hazard zones. Additionally, FEMA conducted a comprehensive storm and wind study for the Great Lakes basin titled "Great Lakes Coastal Flood Study" (GLCFS). This study includes information and data on updating coastal flood hazard information and DFIRMs for Great Lakes coastal communities, including Milwaukee County. The recently updated Milwaukee County floodplain maps (as part of the FEMA Risk MAP program) include results from the GLCFS effort for the Lake Michigan coast which now include coastal wave velocity zones (V, VE).

State Programs

Wisconsin Emergency Management (WEM) provides coastal hazard mitigation education and information in the State hazard mitigation plan.[97] In addition, WEM administers Federal programs within the State to assist coastal communities and local governments in preventing coastal hazards. These programs include the Hazard Mitigation Grant Program (HMGP) and the Building Resilient Infrastructure and Communities (BRIC) pre-disaster mitigation program.

[96] UW Sea Grant and USACE Detroit District, *Living on the Coast: Protecting Investments in Shore Property on the Great Lakes,* 2003.

[97] Ibid.

The University of Wisconsin Sea Grant is a statewide program of basic and applied research, education, outreach, and technology transfer dedicated to the stewardship and sustainable use of the Great Lakes. The Sea Grant staff has, over the years, provided substantial support to Milwaukee County and its communities in dealing with Lake Michigan shoreline management issues.

The Wisconsin Coastal Management Program (WCMP), which is part of the Wisconsin Department of Administration, Division of Intergovernmental Relations, oversees management of the State's coastal resources and strives to maintain a balance between preservation and economic needs. Established in 1978 under the Federal Coastal Zone Management Act, the WCMP works to preserve, protect, and wisely use the resources of the Lake Michigan and Lake Superior coastline for this and future generations. The WCMP provides guidance and grants to encourage the management and protection of Wisconsin's coastal resources and to increase public access to the Great Lakes.

The Southeast Wisconsin Coastal Resilience Project was a collaborative effort to enhance community capacity in southeastern Wisconsin and to build resilience to coastal hazards. The Coastal Resilience project developed educational and outreach materials for bluff best management practices, bluff slope vegetation practices that can improve bluff stability, nature-based shoreline protection specifically for Great Lakes shorelines, and resilient beach restoration practices that increase resistance to erosion. This project developed an online website which provides an excellent resource for local officials and residents living in coastal communities. The website contains informational and education programs, a blog, and social media outlets with updated news in regard to State and local coastal information.[98] This effort continued with the Collaborative Action for Lake Michigan (CALM) project. CALM aimed to continue the collaboration among Lake Michigan coastal communities and the WCMP and Wisconsin Sea Grant.

Local Programs

As stated previously in this report, Milwaukee County and some of its communities have adopted shoreland zoning ordinances that apply to the Lake Michigan coastal area (see Appendix J). A variety of methods are used to warn people in Milwaukee County of emergency situations, including Lake Michigan coastal hazards. These warning systems are described in the section of this chapter related to multiple hazards types.

[98] *sewicoastalresilience.org/about/project-overview.*

Multi-Jurisdictional Considerations

The plan element for Lake Michigan shoreline erosion and related problems corresponds only to the Lake Michigan coastal communities. These include Milwaukee County, the Cities of Cudahy, Milwaukee, Oak Creek, South Milwaukee, and St. Francis, and the Villages of Bayside, Fox Point, Shorewood, and Whitefish Bay.

Evaluation of Alternatives and Identification of Priority Mitigation Measures

Based upon the foregoing evaluation and consideration of risk, and review by the Milwaukee County Hazard Mitigation LPT (see Appendix A), there are 13 actions determined to be priority mitigation measures as part of this hazard mitigation plan update that are specifically related to Lake Michigan coastal hazard events.[99] These priority mitigation measures, along with a general cost-benefit summary are presented in Table 5.16.

5.10 HAZARD RISK ANALYSIS AND PRIORITIZATION: 2024

The major hazards that have been identified as potentially affecting Milwaukee County have been ranked by risk to assist in developing a mitigation plan. Additional description of hazards as well as the vulnerability assessment to these hazards have been identified and summarized in Chapter 3. These priority rankings were based upon the number of incidences per year, number of mortalities, number of injuries, property damage, and crop damage inventories also set forth in Chapter 3. Specifically, this prioritization is based upon the protection of Milwaukee County assets, including human life and property. Therefore, the major indicators of hazard severity used to rank these hazards are based upon the deaths and injuries versus economic losses as summarized in Tables 5.17 and 5.18, respectively. It should be noted that no data on injury, death, or economic losses due Lake Michigan coastal hazards were available for Milwaukee County.

As identified in the vulnerability assessment of hazards in Chapter 3, the magnitude and consequent risk of a particular hazard is dependent upon a number of factors that include, but are not limited to, time (e.g., time of year for thunderstorm events or time in terms of how long an event may last such as drought), size or scale, frequency of occurrence, population size potentially impacted, economic and/or social position of populations at risk, and amount of urban growth or development potentially impacted. These factors do not indicate that rural, or less urbanized areas are any more or less *important* than densely developed areas within the County; however, it does indicate that the more densely urbanized areas have a *greater chance*

[99] *Priority mitigation measures that apply to multiple hazard types, including Lake Michigan coastal hazard events, are presented in the "*Hazard Mitigation Plan Component for Multiple Hazard Types*" section in this Chapter.*

of loss in terms of human death, injury, and property damage per hazard event. It is also important to note, as identified in Chapter 3, that many disaster events are often compounded in nature and not the result of a single event, such as flooding during a severe thunderstorm event. Nonetheless, since the causes of disasters of the past will likely be the best predictor of future disasters, an attempt was made to normalize all of the hazard incidences to an annual average in order to understand the relative potential level of risk each hazard poses to Milwaukee County on an annual basis (see Tables 5.17 and 5.18).

Ranking Severity of Hazards

Death and Injury

Using the data from the various sources summarized in the vulnerability assessment of Chapter 3, the priority hazards identified in Table 3.4 were ranked with respect to their severity in terms of the sum of the number of annual death and injuries they caused and then by frequency of occurrence of each type of hazard event as shown in Table 5.17.

As shown in Table 5.17, four of the seven identified hazards have documented deaths or injuries. These hazards include temperature extremes, tornadoes, thunderstorms events (including hail, lightning, and strong winds), and flooding events. The vulnerability and community impact assessment indicate that the entire County is at risk from these hazards and these events are highly unpredictable in terms of exactly where they may occur and how powerful they might be. It is important to mention that these numbers represent an *annual average* of the recent 23 year period, hence the low results.

The remaining identified hazards have not been recorded as causing mortality or injury in Milwaukee County, based upon known data. These include winter storms, drought, and coastal hazards. Note, there are significant differences in the ranking of hazards depending upon whether the rankings are derived by comparing hazards based on their impacts upon human life and injury, or by comparing hazards based on damages to property and/or crop loss (see Property Damage section below).

Property Damage

Another way to assess the vulnerability of Milwaukee County to hazards is to examine the resultant property damage. Again, using the data from the various sources summarized in the vulnerability assessment of Chapter 3, hazards in Milwaukee County were ranked with respect to their severity in terms of the average annual sum of damage caused and by frequency of occurrence of each type of hazard event. As shown in Table 5.18, annual average estimates of property and/or crop damages were determined for six of the seven priority hazards which include flooding; thunderstorms events (high winds, hail, and lightning), tornadoes;

drought; winter storms; and extreme temperatures. Among these hazards, flooding was identified as resulting in the greatest amount of damage to property in Milwaukee County.

Because of the unpredictability of tornadoes and thunderstorm events, all buildings, infrastructure, community centers, and critical utilities and infrastructure within the County are considered at risk and therefore should be prioritized when planning implementation strategies and hazard priority hazard mitigation practices throughout Milwaukee County.

As summarized in the vulnerability and community impact assessment in Chapter 3, it is expected that for some years the County will experience more events than other years, but the average annual number is not expected to change over the span of this five year Plan. In addition, future changes in climate and land use are anticipated to worsen impacts due to flooding, extreme temperatures, and coastal events. Subsequently, such changes will also continue to adversely impact public health and safety, especially to vulnerable populations.

Community Assistance Planning Report No. 345

MILWAUKEE COUNTY HAZARD MITIGATION PLAN UPDATE: 2024-2029

Chapter 5

HAZARD MITIGATION STRATEGIES

TABLES

Table 5.1
Cost-Benefit Analysis for Hazard Mitigation Measures Within Milwaukee County: Multiple Hazards

Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Benefits						Community/ Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance	Low	Moderate	High	Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Nonstructural												
Continue to enforce State building code regulations that aim to improve the ability of structures to withstand hazardous weather conditions (i.e., strong winds hail, winter storms, extreme temps)	--[c]	--[c]	X			X	X	X	X			Milwaukee County and all local jurisdictions[d]
Encourage and enforce the periodic review of new and/or updated municipal and/or County development regulations, especially in known hazard areas	--[c]	--[c]	X			X	X	X	X			Milwaukee County and all local jurisdictions[d]
Encourage local municipalities to participate in the National Weather Service's (NWS) *StormReady* program	--[c]	--[c]	X			X						Milwaukee County and all local jurisdictions[d]
Continue the integration and expansion of hazard mitigation planning into other local planning efforts (i.e., comprehensive, watershed, and land use planning)	--[c]	--[c]	X			X						Milwaukee County and all local jurisdictions[d]
Create more local funding opportunities and programs for hazard mitigation	--[c]	--[c]		X		X						Milwaukee County and all local jurisdictions[d]
Continue to update a list of potential funding sources associated with hazard mitigation planning	--[c]	--[c]	X			X						Milwaukee County and all local jurisdictions[d]

Table continued on next page.

Table 5.1 (Continued)

Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Benefits						Community/ Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance	Low	Moderate	High	Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Nonstructural (continued)												
Continue to regularly work with community event/outreach organizers on up-to-date emergency plans and procedures in case of severe weather	--[c]	--[c]	X			X						Milwaukee County, NGOs, and all local jurisdictions[d]
Continue coordinating emergency response and operation plans among County and local governmental units and first responders	--[c]	--[c]	X			X						Milwaukee County and all local jurisdictions[d] and NGOs
Continue working with public departments, emergency personnel, volunteer groups, NGOs, and American Red Cross on natural weather hazard preparedness and procedures	--[c]	--[c]	X			X						Milwaukee County
Promote and expand training through the Southeastern Wisconsin COAD[e] program	--[c]	--[c]	X			X						Milwaukee County
Structural												
Regularly maintain and upgrade, as necessary, public early warning systems and communication networks (i.e., mobile apps, social media, broadcasting, etc.)				X		X						Milwaukee County and all local jurisdictions[d]
Continue to maintain and upgrade, as necessary, the County's shared interoperability radio communication network and infrastructure system "OASIS"	$3.6M (2023 dollars) OASIS upgrade	--[f]			X	X	X					Milwaukee County
Continue to bury and protect power and utility lines, where feasible and appropriate, to prevent damage from hazardous weather conditions	--[c]	--[c]			X	X		X	X			Milwaukee County and all local jurisdictions[d]
Promote and encourage emergency on-site back-up power generation at critical facilities and utility locations	--[c]	--[c]		X		X	X					Milwaukee County and all local jurisdictions[d]

Table continued on next page.

Table 5.1 (Continued)

Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Benefits						Community/ Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance	Low	Moderate	High	Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Structural (continued)												
Encourage residents and business owners to consider the purchase of backup power systems (i.e., generators) in case of hazardous conditions	--[c]	--[c]	X			X				X		Milwaukee County and all local jurisdictions[d]
Public Informational and Educational Programming												
Regularly update and maintain the County OEM website as well as other related county and local department and organization websites on hazardous weather events, preparedness, and resources	--[c]	--[c]	X			X						Milwaukee County and all local jurisdictions[d]
Continually increase participation in public outreach events that educate County residents, notably those in vulnerable situations, on severe weather events and preparedness resources	--[c]	--[c]	X			X						Milwaukee County and all local jurisdictions[d]
Encourage residents to develop a Family Emergency Preparedness Plan and Disaster Supply Kit (Appendix H).	--[c]	--[c]	X			X						Milwaukee County and all local jurisdictions[d]
Continue to publicize, through various modes of communication, to ensure all County residents, especially those that are most vulnerable, on the availability and accessibility of emergency shelter sites	--[c]	--[c]	X					X	X			Milwaukee County and all local jurisdictions[d]
Educate and encourage the use and importance of severe weather warning apps. (i.e., FEMA's *ready.gov* or Milwaukee's MKEALERT apps)	--[c]	--[c]	X			X						Milwaukee County and City of Milwaukee

Table continued on next page.

Table 5.1 (Continued)

Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Benefits						Community/ Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance	Low	Moderate	High	Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Public Informational and Educational Programming (continued)												
Continue to implement and train on the use of different alert/warning systems, so that those most vulnerable, such as hard of hearing, deaf, or blind are also provided with adequate and reliable warning before and during a hazardous event	--[f]	--[f]	X			X				X		Milwaukee County and all local jurisdictions[d]
Continue providing information on flood and severe weather insurance programs	--[f]	--[f]	X			X						Milwaukee County and all local jurisdictions[d]

[a] *All cost expressed in 2022 dollars unless otherwise noted.*

[b] *Cost of implementation is allocated among three categories of low (less than $100,000 dollars), moderate (greater than $100,000 and less than $1,000,000), and high (greater than $1,000,000) costs, which are generally defined as:*

Low	*Moderate*	*High*
Educational and informational programming	*Addition of new staff*	*Major construction*
Ongoing enforcement of ordinances	*Additional staff hours budgeted*	*New buildings (infrastructure)*
Plan Development	*Additional equipment*	*Capital programs*
Continued coordination/mutual aid/ interagency agreements	*New ordinance development*	
	New programs/task force	

[c] *Costs covered under ongoing activity.*

[d] *Jurisdictions include general purpose units of government—Cities and Villages—and special purpose units of government such as School Districts.*

[e] *COAD stands for the Southeast Wisconsin Community Organizations Active in Disaster program. This program is a coalition that brings together leaders from emergency management, public safety, local government, volunteer organizations, and the private sector to engage the community in preparedness efforts and disaster response.*

[f] *Costs are site-specific.*

Source: Milwaukee County and the Southeastern Wisconsin Regional Planning Commission

#274334 – CAPR-345 Table 5.2 Watersheds and Tribs within MMSD Jurisdiction
500-1151
MAS/LKH/mid
8/11/2024, 10/11/24

Table 5.2
Milwaukee Metropolitan Sewerage District (MMSD) Jurisdictional Watercourses

Milwaukee River	Menomonee River (Mn.)	Kinnickinnic River (KK)	Oak Creek	Root River (RR)	Lake Michigan Tributary Drainage
Beaver Creek	Burnham Canal	43rd Street Ditch	Mitchell Field Drainage Ditch	104th Street Branch	Fish Creek
Brown Deer Park Creek	Grantosa Creek	Edgerton Channel	North Branch Oak Creek	Crayfish Creek	Fish Creek Southwest Tributary
Indian Creek	Honey Creek	KK River Mainstem	Oak Creek Mainstem	East Branch RR	Fish Creek County Line Tributary.
Lincoln Creek	Little Mn. River	KK River Estuary		Hale Creek	
Milwaukee River Mainstem	Mn. River Mainstem	Lyons Park Creek		Lower Crayfish Creek	
Milwaukee River Estuary	Mn. River Estuary	Villa Mann Creek		North Branch RR	
Southbranch Creek	Schoonmaker Creek	Villa Mann Creek Tributary		Tess Corners Creek	
	South Branch Underwood Creek	Wilson Park Creek		West Branch RR	
	South Mn. Canal			Whitnall Park Creek	
	Underwood Creek				
	Woods Creek				

Note: Maps of the jurisdictional stream extents can be found on the MMSD website in the Chapter 13 Rules section.

Source: Milwaukee Metropolitan Sewerage District and the Southeastern Wisconsin Regional Planning Commission

Table 5.3
Major MMSD Watercourse Flood Mitigation Planning Projects and Studies in Milwaukee County: Up to Year 2035

Watershed	Watercourse Project or Study	2023 Estimated Cost (millions)
Milwaukee River	Indian Creek Flooding Improvements Study	0.31
	Milwaukee River Estabrook - Post Dam Removal Project	2.65
	N. 30th Street Corridor Project	15.14
	Milwaukee River/Lake Estuary Study	0.36
Menomonee River	Concordia Avenue Acquisition/Floodproof Project	5.17
	Menomonee River - Western Milwaukee (Phase 2B)	58.24
	Menomonee River - FEMA Levee System Accreditation	16.03
	Menomonee River - Levee Sewer Rehabilitation	11.73
	Underwood Creek Reach 1 - Concrete Removal Project (Phase 2)	7.45
	Honey Creek Reach 1 - Concrete Removal Project	6.44
	Honey Creek- State Fair Culvert Preliminary Engineering (Phase 1 and 2)	30.99
	Menomonee River/Lake Estuary Study	0.05
Kinnickinnic (KK) River	KK River Watershed Flood Management Plan (Wilson Creek, Villa Mann Creek, Lyons Creek, and 43rd Ditch Projects)	6.88
	KK River - Pulaski Park Project	39.00
	KK River - Jackson Park Project	73.93
Oak Creek	Oak Creek Flood Management Plan - Floodproofing/Acquisition	9.33
Root River	Root River Floodplain Flood Mapping Study	0.73
Lake Michigan Direct Drainage	Impacts of Lake and River Water Levels Study on MMSD Facility	1.04
	Coastal Flood Resiliency Improvements Projects (Jones Island and South Shore Water Reclamation Facilities)	4.48
All	Greenseams Projects 2025-2030	10.40
	Impact of 1000-year Flood	0.35
Totals	Floodplain-Related Projects	274.72
	Stormwater-Related Projects	25.89
	Total Project Costs	300.70

Note: Projects listed in table that focus more on stormwater management include the 30th Street Corridor Project, Greenseams, and 1000-year Flood Impact Study.

Source: Milwaukee Metropolitan Sewerage District and the Southeastern Wisconsin Regional Planning Commission

#274688 – CAPR-345 Table 5.4 Structures in the 1-Percent-Annual-Probability Floodplain in Milwaukee County by Structure Type: 2022
500-1151
MAS/mid
8/30/2024

Table 5.4
Structural Flood Damage Estimates From a 100-Year Flood Event in Milwaukee County

	Damages (2022 Dollars)		
Structure Type	Direct	Indirect	**Total**
Apartments	16,701,790	6,680,730	23,382,520
Commercial	60,875,080	24,350,060	85,225,140
Condominium	1,484,290	593,730	2,078,020
Critical Facility	3,104,410	1,241,770	4,346,180
Mobile Home	21,170	8,480	29,650
Parks	112,480	44,990	157,470
Residential	44,051,030	6,607,910	50,658,940
Utility	56,290	22,520	78,810

Source: Milwaukee Metropolitan Sewerage District and the Southeastern Wisconsin Regional Planning Commission

#274262 – CAPR-345 Table 5.5 Residential Structures Potentially located in 1-Percent Annual Flood by Watershed
500-1151
MAS/LKH/mid
08/16/2024, 10/11/24

Table 5.5
Estimated Number of Structures in the 1-Percent-Annual-Probability Floodplain by Watershed Within Milwaukee County

Major Watershed	Residential Structures	Nonresidential Structures
Kinnickinnic River	530	94
Lake Michigan Drainage Basin	27	1
Menomonee River	44	42
Milwaukee River	515	26
Oak Creek	3	7
Root River	141[a]	37
Total	1,260	207

[a] *The Root River residential structure total does not include the 16 manufactured homes in Franklin, as they were examined separately for this portion of the Report.*

Source: Milwaukee Metropolitan Sewerage District and the Southeastern Wisconsin Regional Planning Commission

Table 5.6
Milwaukee County Climate Action 2050 Plan Vulnerability Assessment on County Assets to Flood Risks

Watercourse	Flood Event		Vulnerable Asset At-Risk
	100-Year	500-Year	
Menomonee River	X		Hart Park
	X		Public Transit Bus Route 31
	X	X	W. State Street
	X		S. 35th Street
		X	City of Milwaukee Forestry Department
		X	Senior living facility
		X	Potawatomi Gas Plant
		X	Muskego Rain Yard and Watertown Subdivision rail
		X	Miller Coors Facilities and other various commercial and industrial sites
		X	Piggsville residential neighborhood and State Street industrial and commercial corridor
		X	N. Port Washington Road
Milwaukee River	X		Kletzsch and Lincoln Parks
		X	Glendale and River Hills residential neighborhoods
Beaver Creek	X		Brown Deer Village Park
		X	Brown Deer Village Hall
		X	Public Transit Bus Routes 76 and 88
		X	Brown Deer residential neighborhood around Hwy 57 and W. Joleno Drive
		X	Commercial Districts in Brown Deer
	X	X	N. Green Bay Road
		X	N. 51st Street
Lincoln Creek		X	Ascension Family Health Center
		X	Residential neighborhoods: W. Villard Avenue, Harriet Tubman Park, 60th Street and Custer, and West Mills Road Crossing
		X	W. Hampton Avenue
Root River		X	West Oklahoma Avenue

Source: Milwaukee County, Milwaukee County Climate Action 2050 Plan Vulnerability Assessment, *July 2023.*

#271505 – CAPR-345 Table 5.7 Milw. HMP-Roadway Flooding Concerns
500-1151
MAS/LKH/mid
12/18/23

Table 5.7
Roadway Flooding Concerns in Milwaukee County: 2024

Community	Roadway Flooding Locations	Resource
City of Franklin	Around Whitnall Park beer garden along Root River Parkway and College Avenue	Milwaukee County
City of Greenfield	The intersection of Layton Avenue and the Root River Parkway	Milwaukee County
	630-foot-long stretch of S. 43rd Street, just north of W. Edgerton Avenue	Southeastern Wisconsin Regional Planning Commission (Commission)
	W. Loomis Road crossing	Commission
	W. Layton Avenue crossing	Commission
	West of Honey Creek on S. Placid Drive just south of W. Allerton Avenue	Commission
	East of the Creek on W. Allerton Avenue just west of S. Honey Creek Drive	Commission
City of Milwaukee	Between Morgan Avenue and Howard Avenue on the Oak Leaf Trail	Milwaukee County
	Lincoln Park on Hampton Avenue on north side of the road, just west of Milwaukee River Parkway	Milwaukee County
	W. Ohio Avenue east and west of Honey Creek	Commission
	200-foot-long stretch of W. Honey Creek Drive and 500-foot-long stretch of S. Honey Creek Drive southwest of Honey Creek near S. 72nd Street	Commission
	1,170-foot-long stretch of S. 72nd Street intersecting Honey Creek	Commission
	600-foot-long stretch of W. Lakefield Drive north of Honey Creek	Commission
	490-foot-long stretch of N. Honey Creek Parkway east of Honey Creek, 610 feet south of W. Bluemound Road	Commission
City of Oak Creek	Stormwater pond adjacent to Howell Avenue (west side of road) floods during high rain events	Commission
City of South Milwaukee	Stormwater flooding under railroad tracks at College Avenue due to inadequate inlet capacity at street level	Commission
	Stormwater flooding along Rawson Avenue at the railroad tracks during extreme events	Commission
	Stormwater flooding occurs at Marquette Avenue and UP railroad overpass during heavy rain events	Commission
City of Wauwatosa	W. Wisconsin Avenue intersecting Honey Creek (bridge)	Commission
	1,490-foot-long stretch of N. Honey Creek Parkway east of Honey Creek, 670 feet southwest of Portland Avenue	Commission
	N. Honey Creek Parkway crossing, 250 feet southwest of Portland Avenue	Commission
	860-foot-long stretch of W. Honey Creek Parkway north of Honey Creek, 1,400 feet west of N. 70th Street	Commission
City of West Allis	Between Cleveland Avenue and Oklahoma Avenue on the west side	Milwaukee County
	Between National Avenue and Morgan Avenue	Milwaukee County
Village of Greendale	College Avenue across from College Park	Milwaukee County
	Intersection of College Avenue and 51st Street	Milwaukee County

Source: Milwaukee County Parks Department, Southeastern Wisconsin Regional Planning Commission MR No. 259, A Watercourse System Plan for Honey Creek, *2022 and Southeastern Wisconsin Regional Planning Commission CAPR No. 330,* A Watershed Restoration Plan for Oak Creek, *2014.*

#274022 – Table 5.8-Milw. Co. HMPU Participation in the NFIP
500-1151
MAS/LKH/mid
10/11/24

Table 5.8
Participation in the National Flood Insurance Program by Milwaukee County Jurisdictions

Community	Participating in Milwaukee County Hazard Mitigation Plan	Participating in National Flood Insurance Program	Date Initial Flood Hazard Boundary Map Identified	Date of Initial Flood Insurance Rate Map (FIRM)	Current Effective Map Date[b]	Entry Date into National Flood Insurance Program
Cities						
Cudahy	Yes	Yes	06/07/1974	12/15/1978	09/26/2008(M)	12/15/1978
Franklin	Yes	Yes	01/09/74	09/30/1977	09/26/2008	09/30/1977
Glendale	Yes	Yes	12/17/1973	06/01/1978	09/26/2008	06/01/1978
Greenfield	Yes	Yes	12/17/1973	08/15/1979	12/16/2015[d]	06/01/1978
Milwaukee	Yes	Yes	06/28/1974	03/01/1982	10/19/2023[d]	03/01/1982
Oak Creek	Yes	Yes	03/22/1974	09/29/1978	09/26/2008	09/29/1978
St. Francis	Yes	Yes	06/07/1973	07/07/1978	09/26/2008(M)	07/07/1978
South Milwaukee	Yes	Yes	12/28/1973	04/15/1980	09/26/2008	04/15/1980
Wauwatosa	Yes	Yes	12/21/1973	12/01/1978	09/26/2008	12/01/1978
West Allis	Yes	Yes	04/12/1974	04/15/1981	09/26/2008	04/15/1981
Villages						
Bayside[a]	Yes	Yes	02/22/1974	06/15/1977	07/31/2024[d]	06/15/1977
Brown Deer	Yes	Yes	12/17/1973	03/28/1980	05/19/2014(M)	12/17/1973
Fox Point	Yes	Yes	03/01/1974	05/16/1977	09/26/2008	05/16/1977
Greendale	Yes	Yes	12/28/1973	08/02/1982	09/26/2008	08/02/1982
Hales Corners	Yes	Yes	05/03/1974	06/15/1979	09/26/2008	06/15/1979
River Hills	Yes	Yes	12/17/1973	04/15/1980	09/26/2008	04/15/1980
Shorewood	Yes	Yes	12/14/1973	08/11/1978	09/26/2008(M)	08/11/1978
West Milwaukee	Yes	Yes	--	09/26/2008	(NSFHA)[c]	09/28/1978
Whitefish Bay	Yes	Yes	02/22/1974	05/01/1987	09/26/2008(M)	05/01/1987
County	Yes	Yes	--	09/26/2008	10/24/24	09/26/2008

[a] *The Village of Bayside is in both Milwaukee and Ozaukee Counties, because of this the Village has decided to participate in Milwaukee County's All Hazard Mitigation Plan.*

[b] *(M) No elevation determined- All zone A, C and X. Date will change to 10/24/24 when updated Countywide maps become effective.*

[c] *NSFHA stands for Non-Special Flood Hazard Area.*

[d] *Date of latest approved LOMR in the community*

Source: Federal Emergency Management Agency

Table 5.9
United States Geological Survey Active Stream Gage Locations in the Milwaukee County Area: 2023

Map 5.7 ID	Site Name	Site Number	Years of Operation	Watershed
1	Little Menomonee River at Milwaukee	4087070	2004 - Present	Menomonee River
2	Lincoln Creek at Sherman Boulevard at Milwaukee	40869416	2003 - Present	Milwaukee River
3	Milwaukee River at Milwaukee	4087000	1914 - Present	Milwaukee River
4	Menomonee River at 16th Street at Milwaukee	4087142	2008 - Present	Menomonee River
5	Menomonee River at Wauwatosa	4087120	1961 - Present	Menomonee River
6	Honey Creek at Wauwatosa	4087119	2004 - Present	Menomonee River
7	Underwood Creek at Wauwatosa	4087088	1980 - Present	Menomonee River
8	Wilson Park Creek at St. Lukes Hospital at Milwaukee	40871488	1997 - Present	Kinnickinnic River
9	Kinnickinnic River at 11th Street at Milwaukee	4087159	1982 - Present	Kinnickinnic River
10	Milwaukee River at Mouth at Milwaukee	4087170	2006 - Present	Milwaukee River
11	Wilson Park Creek at GMIA Outfall 7 at Milwaukee	40871475	1997 - Present	Kinnickinnic River
12	Holmes Avenue Creek Tributary at GMIA Outfall 1 at Milwaukee	40871476	1997 - Present	Kinnickinnic River
13	Wilson Park Creek at GMIA Infall at Milwaukee	40871473	1997 - Present	Kinnickinnic River
14	Oak Creek at South Milwaukee	4087204	1963 - Present	Oak Creek
15	Root River at Grange Avenue at Greenfield	4087214	2004 - Present	Root River
16	Root River near Franklin	4087220	1963 - Present	Root River
17	Root River at 60th Street near Caledonia	4087234	2016 - Present	Root River
18	Cedar Creek near Cedarburg	4086500	1990 - Present	Milwaukee River
19	Milwaukee River near Cedarburg	4086600	1981 - Present	Milwaukee River
20	Little Menomonee River near Freistadt	4087050	2007 - Present	Menomonee River
21	Root River Canal near Franklin	4087233	1963 - Present	Root River
22	Root River at Racine	4087240	1963 - Present	Root River
23	Menomonee River at Menomonee Falls	4087030	1979 - Present	Menomonee River

Source: United States Geological Survey and the Southeastern Wisconsin Regional Planning Commission

Table 5.10
Cost-Benefit Analysis for Measures Included in the Milwaukee County Hazard Mitigation Plan Update: Flood and Associated Stormwater Drainage Problems Hazards

Priority Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Estimated Benefits (dollars)[c]	Benefits						Community/Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance (thousands of dollars)	Low	Moderate	High		Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Floodland and Environmentally Sensitive Land Preservation Element													
Maintain and potentially update floodplain and wetland zoning regulations and ordinances[d]	--[e]	--[e]	X				X	X	X	X	X	X	Milwaukee County and all cities and villages
Continue to promote and improve the preservation and/or maintenance of environmentally sensitive, natural and open space lands[d]	--[f]	--[f]			X		X	X			X	X	Milwaukee County and all cities and villages
Continue participation in the MMSD Greenseams program	--[g]	--[g]			X		X	X			X	X	Milwaukee County and all cities and villages
Floodplain Management Element													
Implementation of MMSDs Watercourse and Flood Management Planning Program floodplain projects through planned year 2035 (see Table 5.2 for individual project costs)	$274.7M (2023 dollars)	--[f]			X		X	X	X	X	X	X	MMSD, Milwaukee County and all cities and villages
Remove up to 16 repetitive loss structures[d,j]	$2.9M (2022 dollars)	--[h]			X	$4.3M (per 100-yr flood event)	X	X	X	X	X	X	Milwaukee County and all affected communities
Surveys of up to 1,276 structures identified as being potentially located in flood hazard areas[d]	$2.6M[i] (2022 dollars)	--[h]			X	--	X						Milwaukee County and all affected communities
Floodproofing 207 structures identified as potentially located in flood hazard area[d, j]	$96.8M (2023 dollars)	--[h]			X	$89.8M (per 100-year flood event)	X	X	X	X	X	X	Milwaukee County and all affected communities
Acquisition and removal/demolition of 1,260 structures identified as being potentially located in flood hazard area[d]	$508M (2022 dollars)	--[h]			X	$76.1M (per 100-year flood event)	X	X	X	X	X	X	Milwaukee County and all affected communities

Table continued on next page.

Table 5.10 (Continued)

Priority Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Estimated Benefits (dollars)[c]	Benefits						Community/Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance (thousands of dollars)	Low	Moderate	High		Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Floodplain Management Element (continued)													
Removal of up to 16 manufactured homes identified as being potentially located in the flood hazard area.	$3.5M (2022 dollars)	--[h]			X	$29,000 (per 100-year flood event)	X	X	X	X	X	X	Milwaukee County and City of Franklin
Consider floodproofing and/or relocating critical facilities located within or nearby flood-prone areas (see Map 5.6)	$4.9M (2022 dollars)	--[h]			X	--	X	X	X	X	X	X	City of Milwaukee and Village of Greendale
Emphasize actions that address and protect vulnerable infrastructure (i.e., roadways and bridges) to flooding	--[h]	--[e]			X	--	X	X					Milwaukee County and all cities and villages
Continue participation in FEMA's National Flood Insurance Program and floodplain modeling and mapping updating efforts[d]	--[e]	--[e]	X			--	X	X					Milwaukee County and all cities and villages
Encourage County participation in FEMA's Community Rating System (CRS) Program	--[h]	--[h]		X		--	X	X				X	Milwaukee County and all cities and villages
Promote and encourage the implementation of using further documentation of the extent of future floods	--[h]	--[h]				--	X	X					Milwaukee County and all cities and villages
Continue and promote stream channel maintenance activities, including concrete and debris removal (see Table 5.2 for major channel concrete removal project costs)	--[e]	--[e]		X		--		X	X		X	X	Milwaukee County, MMSD, and all cities and villages
Lending institutions and real estate agent policies should continue and enforce their practice of determining and informing the public the floodprone status of properties before mortgage transactions are complete[d,e]	--[e]	--[e]	X			--	X	X					Milwaukee County and all cities and villages
Encourage the installation of new USGS stream gages, while maintaining and updating the current systems	$15,000[l] (2023 dollars)	$13,000[l] (2023 dollars)		X		--	X	X				X	Milwaukee County, MMSD, and all municipalities
Regularly inspect and maintain all dams within the County	--[e]	--[e]		X		--	X	X					Milwaukee County, MMSD, and private owners of the Kurtze Lake, Tuckaway County Club, and Northridge Lakes Residential Development dams
Continue to update and enforce the regular review of dam emergency action plans and procedures	--[h]	--[h]		X		--	X	X	X	X			All dam owners

Table continued on next page.

Table 5.10 (Continued)

Priority Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Estimated Benefits (dollars)[c]	Benefits						Community/Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance (thousands of dollars)	Low	Moderate	High		Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Stormwater Management Element													
Continue to develop and maintain stormwater management plans/programs[d]	--[e]	--[e]	X			--	X	X				X	Milwaukee County, MMSD, and all cities and villages
Continue to practice and enforce stormwater-related regulations, including installation of up-to-date stormwater drainage systems [d]	--[e]	--[e]	X			--	X	X				X	Milwaukee County, MMSD, and all cities and villages
Continue to participate and collaborate in MMSD's Watercourse and Flood Management Planning Program	$25.9M (2023 dollars)	--[f]			X	--	X	X	X		X	X	Milwaukee County, MMSD, and all cities and villages within the MMSD service area
Continue implementation and integration of green infrastructure and/or nature-based stormwater management practices	--[k]	--[k]	X			--	X				X	X	Milwaukee County, MMSD, and all cities and villages
Public Informational and Educational Element													
Continue to enhance public education and outreach activities on flood and stormwater management and safety/preparedness procedures	--[f]	--[f]	X			--	X						Milwaukee County and all cities and villages
Enhance the distribution of material related to Federal Flood Insurance Program (NFIP), including to those residents located outside the mapped floodplain	--[e]	--[e]	X			--	X	X					Milwaukee County and all cities and villages

[a] *All costs are expressed in 2022 or 2023 dollars unless otherwise noted.*

[b] *Cost of implementation is allocated among three categories of low (less than $100,000 dollars), moderate (greater than $100,000 and less than $1,000,000), and high (greater than $1,000,000) costs, which are generally defined as:*

Low
- *Educational and informational programming*
- *Ongoing enforcement of ordinances*
- *Plan development*
- *Continued coordination/mutual aid/ interagency agreements*

Moderate
- *Addition of new staff*
- *Additional staff hours budgeted*
- *Additional equipment*
- *New ordinance development*
- *New programs/task force*

High
- *Major construction*
- *New buildings (infrastructure)*
- *Capital programs*

[c] *The estimated benefits are based upon the reduction in flood damages during a 1-percent-annual-probability flood event. The damage estimates were developed by the Commission staff based upon structure values, flood stage, and depth of flooding as described in Chapter 3. Note, not all recommendations have a quantifiable benefit for the 100-yr floodplain, hence mitigation measures not having a cost associated to that column.*

[d] *This mitigation is related to, but not essential to, compliance with the requirements of the National Flood Insurance Program.*

[e] *Costs are covered under ongoing or day-to-day activities.*

Table continued on next page.

Table 5.10 (Continued)

[f] *Costs to be determined. Partially covered under ongoing programs.*

[g] *Budgeted capital costs for the Greenseams program are included under the MMSD Watercourse and Floodplain Management Planning Program.*

[h] *Costs are unknown.*

[i] *Survey costs were estimated using $2,000 per structure. Cost savings may be realized if surveys of clustered structures are done at the same time.*

[j] *Structure floodproofing, elevation, or removal will be evaluated on a site-by-site basis and be carried out at the discretion of property owners.*

[k] *Costs are site-specific, and additional investigation is needed for countywide estimate.*

[l] *Costs are estimates for installation and maintenance of one USGS stream gage.*

Source: Milwaukee County Division of Emergency Management and the Southeastern Wisconsin Regional Planning Commission

Table 5.11
Cost-Benefit Analysis for Measures Included in the Milwaukee County Hazard Mitigation Plan: Severe Thunderstorm and Thunderstorm-Related Hazards (High-Winds, Hail, and Lightning)

Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Benefits						Community/ Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance	Low	Moderate	High	Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Nonstructural												
Maintain and regularly update local fire department and/or first responder equipment to help detect or mitigate lightning-related fires, such as thermal imaging devices	--[c]	--[c]		X		X						Milwaukee County and all local jurisdictions[d]
Continue to enforce existing local ordinances requiring adequate electrical grounding in newly constructed buildings	--[e]	--[e]		X		X	X					Milwaukee County and all local jurisdictions[d]
Provide information and encourage the use of fire-resistant materials and surge protectors on critical electronic equipment	--[e]	--[e]	X			X	X					Milwaukee County and all local jurisdictions[d]
Structural												
Install lightning grade surge protection devices for critical electronic components used by government, public service, and public safety facilities	--[c]	--[c]		X		X	X					Milwaukee County and all local jurisdictions[d]

Table continued on next page.

Table 5.11 (Continued)

Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Benefits						Community/ Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance	Low	Moderate	High	Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Public Information and Educational Programming												
Increase public education and awareness, especially to those considered vulnerable, of the potential severity of thunderstorm related hazards and non-thunderstorm high-wind hazards and distribute emergency preparedness information related to thunderstorm hazards	--[e]	--[e]	X			X		X	X			Milwaukee County and all local jurisdictions[d]

[a] *All costs expressed in 2022 dollars unless otherwise noted.*

[b] *Cost of implementation is allocated among three categories of low (less than $100,000 dollars), moderate (greater than $100,000 and less than $1,000,000), and high (greater than $1,000,000) costs, which are generally defined as:*

Low	*Moderate*	*High*
Educational and informational programming	*Addition of new staff*	*Major construction*
Ongoing enforcement of ordinances	*Additional staff hours budgeted*	*New buildings (infrastructure)*
Plan Development	*Additional equipment*	*Capital programs*
Continued coordination/mutual aid/ interagency agreements	*New ordinance development*	
	New programs/task force	

[c] *Costs are site-specific.*

[d] *Jurisdictions include general purpose units of government—Cities and Villages—and special purpose units of government such as School Districts.*

[e] *Costs covered under day-to-day operations.*

Source: Milwaukee County and the Southeastern Wisconsin Regional Planning Commission

Table 5.12
Cost-Benefit Analysis for Measures Included in the Milwaukee County All-Hazards Mitigation Plan: Tornado Hazards

Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Benefits						Community/ Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance	Low	Moderate	High	Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Nonstructural												
Ensure usage policies/procedures of the County's public outdoor warning sirens are up-to-date and reflect the needs of public safety personnel (i.e., use of "Wisconsin Outdoor Warning Siren Best Practices")	--[c]	--[c]	X			X						Milwaukee County
Require and enforce construction regulations of safe rooms in new schools, daycares, community centers, hospitals, and nursing homes	--[d]	--[d]	X			X	X	X	X			Milwaukee County and all local jurisdictions[e]
Regularly conduct an inventory and inspection of municipal and County facilities to ensure the quality, quantity, and accessibility of tornado shelters	--[f]	--[f]	X			X		X	X			Milwaukee County and all local jurisdictions[e]
Structural												
Continue to maintain and upgrade the operational and structural functions of the County's outdoor warning sirens to ensure effective and resilient systems	--[d]	--[d]			X	X						Milwaukee County
Routinely inspect manufactured housing parks to ensure safety material (e.g., tie-downs) is provided and accessible during a tornado event	--[c]	--[c]	X			X	X	X				Milwaukee County and the Cities of Cudahy, Franklin, Milwaukee, Oak Creek, and West Allis

Table continued on next page.

Table 5.12 (Continued)

Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Benefits						Community/ Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance	Low	Moderate	High	Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Public Information and Educational Programming												
Increase public education and awareness of the potential severity of tornadoes and continue to produce and expand the distribution of emergency preparedness information related to tornado events, notably to those considered most vulnerable	--[f]	--[f]	X			X						Milwaukee County and all local jurisdictions[e]
Make readily available information on where to go during severe weather events at outdoor venues	--[f]	--[f]	X			X						Milwaukee County and all local jurisdictions[e]

[a] *All costs expressed in 2022 dollars unless otherwise noted.*

[b] *Cost of implementation is allocated among three categories of low (less than $100,000 dollars), moderate (greater than $100,000 and less than $1,000,000), and high (greater than $1,000,000) costs, which are generally defined as:*

Low	*Moderate*	*High*
Educational and informational programming	*Addition of new staff*	*Major construction*
Ongoing enforcement of ordinances	*Additional staff hours budgeted*	*New buildings (infrastructure)*
Plan Development	*Additional equipment*	*Capital programs*
Continued coordination/mutual aid/ interagency agreements	*New ordinance development*	
	New programs/task force	

[c] *Costs covered under ongoing activity*

[d] *Costs are site-specific.*

[e] *Jurisdictions include general purpose units of government—Cities and Villages—and special purpose units of government such as School Districts.*

[f] *Costs to be determined. Partially covered under ongoing programs.*

Source: Milwaukee County and the Southeastern Wisconsin Regional Planning Commission

Table 5.13
Cost-Benefit Analysis for Measures Included in the Milwaukee County Hazard Mitigation Plan: Winter Storms

Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Benefits						Community/ Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance	Low	Moderate	High	Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Nonstructural												
Review the energy efficiency and winter readiness of critical facilities/utilities and housing throughout the County	--[c]	--[c]	X			X				X		Milwaukee County and all local jurisdictions[d]
Continue to work with agencies (e.g., American Red Cross) and/or other organizations to establish reliable short-term sheltering of vulnerable populations	--[c]	--[c]		X		X		X	X	X		Milwaukee County and all local jurisdictions[d] and NGOs
Pursue additional funding opportunities to assist with budgeting for overtime hours and extra governmental personnel needed during extreme winter events	--[c]	--[c]		X		X		X	X	X		Milwaukee County and all local jurisdictions[d]
Ensure that the necessary amount of snow removal, anti-icing, and deicing equipment is available and operational	--[c]	--[c]		X		X				X		Milwaukee County and all local jurisdictions[d]
Structural												
Work with utility companies to assess and improve, as needed, electric service system dependability	--[e]	--[e]		X		X				X		Milwaukee County and all local jurisdictions[d]
Public Information and Educational Programming												
Continue to maintain and promote, via various modes of communication, winter hazard awareness and resources to all County residents, including home and travel safety measures	--[c]	--[c]	X			X						Milwaukee County

Table continued on next page.

Table 5.13 (Continued)

[a] *All cost expressed in 2022 dollars unless otherwise noted.*

[b] *Cost of implementation is allocated among three categories of low (less than $100,000 dollars), moderate (greater than $100,000 and less than $1,000,000), and high (greater than $1,000,000) costs, which are generally defined as:*

Low	Moderate	High
Educational and informational programming	*Addition of new staff*	*Major construction*
Ongoing enforcement of ordinances	*Additional staff hours budgeted*	*New buildings (infrastructure)*
Plan Development	*Additional equipment*	*Capital programs*
Continued coordination/mutual aid/interagency agreements	*New ordinance development*	
	New programs/task force	

[c] *Costs are covered under day-to-day operations.*

[d] *Jurisdictions include general purpose units of government—Cities and Villages—and special purpose units of government such as School Districts.*

[e] *Costs to be determined. Partially covered under ongoing programs.*

Source: Milwaukee County and the Southeastern Wisconsin Regional Planning Commission

Table 5.14
Cost-Benefit Analysis Summary of Measures Included in the Milwaukee County Hazard Mitigation Plan: Extreme Temperature Hazards

Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Benefits						Community/ Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance	Low	Moderate	High	Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Nonstructural												
Organize and enhance neighborhood outreach groups who look after vulnerable populations and promote the availability of shelters during extreme heat and cold	--[c]	--[c]	X			X			X			Milwaukee County and all local jurisdictions[d]
Provide special arrangements for payment of heating and cooling bills for customers unable to pay due to financial constraints	--[c]	--[c]	X			X		X		X		Milwaukee County and all local jurisdictions[d]
Reschedule public events to avoid large outdoor gatherings during periods of extreme heat or cold	--[e]	--[e]	X			X		X	X	X		Milwaukee County and all local jurisdictions[d]
Extend public swimming pools hours during extreme heat events	--[c]	--[c]		X		X		X		X		Milwaukee County and all local jurisdictions[d]
Establish and promote a donation program of functional window air conditioner units and fans and distribute these items to vulnerable populations	--[c]	--[c]	X			X		X	X	X		Milwaukee County and all local jurisdictions[d]
Promote and expand winter weather clothing drives (coats, hats, mittens) where people can drop off gently used winter clothing for distribution to vulnerable populations	--[c]	--[c]		X		X		X	X	X		Milwaukee County and all local jurisdictions[d]
Structural												
Promote measures to reduce heat island effects in urban areas	--[c]	--[c]	X			X				X	X	Milwaukee County and all local jurisdictions[d]

Table continued on next page.

Table 5.14 (Continued)

Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Benefits						Community/ Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance	Low	Moderate	High	Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Public Information and Educational Programming												
Produce and distribute emergency preparedness information related to the safe operation of generators, space heaters, fireplaces, and wood stoves	--[c]	--[c]	X			X		X		X		Milwaukee County and all local jurisdictions[d]

[a] *All costs expressed in 2022 dollars unless otherwise noted.*

[b] *Cost of implementation is allocated among three categories of low (less than $100,000 dollars), moderate (greater than $100,000 and less than $1,000,000), and high (greater than $1,000,000) costs, which are generally defined as:*

Low	*Moderate*	*High*
Educational and informational programming	*Addition of new staff*	*Major construction*
Ongoing enforcement of ordinances	*Additional staff hours budgeted*	*New buildings (infrastructure)*
Plan Development	*Additional equipment*	*Capital programs*
Continued coordination/mutual aid/ interagency agreements	*New ordinance development*	
	New programs/task force	

[c] *Costs to be determined. Partially covered under ongoing programs.*

[d] *Jurisdictions include general purpose units of government—Cities and Villages—and special purpose units of government such as School Districts.*

Source: Milwaukee County and the Southeastern Wisconsin Regional Planning Commission

Table 5.15
Cost-Benefit Analysis for Priority Measures Included in the Milwaukee County Hazard Mitigation Plan: Drought Hazards

Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Benefits						Community/ Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance	Low	Moderate	High	Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Nonstructural												
Encourage the development and maintenance of drought emergency plans for local utilities and communities	--[c]	--[c]	X			X						Milwaukee County and all local jurisdictions[d]
Promote regional activities to protect groundwater recharge areas inside and outside of the County	--[e]	--[e]	X			X					X	Milwaukee County and all local jurisdictions[d]
Promote and encourage the use of drought-resistant landscaping practices (i.e., native plantings)	--[f]	--[f]	X			X	X				X	Milwaukee County and all local jurisdictions[d]
Support ordinances to prioritize or control water use during drought conditions	--[c]	--[c]	X			X					X	Milwaukee County and all local jurisdictions[d]
Design and plan for water supply infrastructure systems that are effective and reliable during drought events	--[g]	--[g]		X		X	X			X		Milwaukee County and all local jurisdictions[d]
Structural												
Consider implementing the recommendations made in the regional water supply plan for additional water supply facilities and programs to meet forecast water use demands	--[c]	--[c]	X			X				X	X	Milwaukee County and all local jurisdictions[d]
Continue operation of stream gaging stations and groundwater monitoring wells	--[c]	--[c]		X		X	X			X	X	Milwaukee County, MMSD, and all local jurisdictions[d]

Table continued on next page.

Table 5.15 (Continued)

Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Benefits						Community/ Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance	Low	Moderate	High	Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Public Information and Educational Programming												
Increase public education and awareness of the potential severity of drought events	--[c]	--[c]	X			X	X			X	X	Milwaukee County and all local jurisdictions[d]

[a] *All costs expressed in 2022 dollars unless otherwise noted.*

[b] *Cost of implementation is allocated among three categories of low (less than $100,000 dollars), moderate (greater than $100,000 and less than $1,000,000), and high (greater than $1,000,000) costs, which are generally defined as:*

Low	Moderate	High
Educational and informational programming	*Addition of new staff*	*Major construction*
Ongoing enforcement of ordinances	*Additional staff hours budgeted*	*New buildings (infrastructure)*
Plan Development	*Additional equipment*	*Capital programs*
Continued coordination/mutual aid/ interagency agreements	*New ordinance development*	
	New programs/task force	

[c] *Costs covered under ongoing activity.*

[d] *Jurisdictions include general purpose units of government—Cities and Villages—and special purpose units of government such as School Districts.*

[e] *Costs to be determined based on amount of funding allocated for program.*

[f] *Costs to be determined.*

[g] *Costs are site-specific. Partially covered under ongoing programs.*

Source: Milwaukee County and the Southeastern Wisconsin Regional Planning Commission

Table 5.16
Cost-Benefit Analysis for Priority Measures Included in the Milwaukee County All-Hazards Mitigation Plan: Lake Michigan Coastal Hazards

Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Benefits						Community/ Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance	Low	Moderate	High	Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Regulations and Policy Measures												
Continue to participate in FEMA's NFIP and RiskMAP floodplain mapping program for updated Lake Michigan coastal V and VE zones	--[c]	--[c]	X	--		X	X					Milwaukee County coastal communities
Develop and enforce consistent county and municipal shoreland regulations and policies (i.e., ordinances) relating to setbacks along bluffs and ravines	--[d]	--[d]	X	--	--	X	X	X				Milwaukee County coastal communities
Bluff Top Mitigation Measures												
Develop and encourage bluff top best management practices	--[d]	--[d]	X			X	X				X	Milwaukee County coastal communities
Continue to implement engineering studies that assess the variables influencing bluff stability and shoreline recession which determine the stable slope angle setback.	--[e]	--[e]		X		X	X					Milwaukee County coastal communities
Consider relocating buildings within high-risk bluff failure areas.	--[c]	--[c]		X		X	X	X	X			Milwaukee County coastal communities
Continue to promote or enforce local and County coastal ravine and bluff top setback regulations or recommendations	--[d]	--[d]	X			X	X					Milwaukee County coastal communities
Bluff Face and Near Shore/Shoreline Protection Measures												
Conduct an updated assessment of the condition and effectiveness of all shoreline protection structures in the County	--[e]	--[e]	X			X	X	X			X	Milwaukee County coastal communities

Table continued on next page.

Table 5.16 (Continued)

Mitigation Measures	Estimated Cost[a]		Costs of Implementation[b]			Benefits						Community/ Jurisdictions Affected
	Capital	Average Annual Operation and Maintenance	Low	Moderate	High	Enhanced Preparedness/ Protection	Reduced Property Damage	Reduced Injuries	Reduced Mortalities	Enhanced quality of life/social benefits	Increased Environmental and/or Recreational Benefits/Ecosystems	
Bluff Face and Near Shore/Shoreline Protection Measures (continued)												
Ensure breakwater walls and piers within and around the Port of Milwaukee/Harbor District are properly designed and constructed to withstand severe environmental conditions of Lake Michigan	--[e]	--[e]		X		X	X					City of Milwaukee
Construct and maintain shoreline protection structures and bluff stabilization measures where public and critical infrastructure is at risk	--[c]	--[c]		X		X	X	X				Milwaukee County coastal communities
Possible acquisition and demolition of up to 28 structures identified as potentially being located in the low-lying shores of Lake Michigan's 1-percent-annual-probability floodplain[g]	$34.4 million (2022 dollars)	--[f]			X	X	X					Village of Fox Point
Encourage the practice of non-structural or nature-based shoreline protection measures, such as living revetment or seawalls and artificial beach and beach nourishment.	--[d]	--[d]	X			X	X				X	Milwaukee County coastal communities
Public Informational and Educational Programming												
Work with WCMP to conduct public outreach and to provide technical assistance regarding BMPs to prevent shoreline erosion and bluff recession	--[d]	--[d]	X			X						Milwaukee County and all coastal communities
Promote flood insurance to residents along the County's low-lying coast located in Lake Michigan's flood hazard area	--[c]	--[c]	X			X	X					Milwaukee County and Village of Fox Point

Table continued on next page.

Table 5.16 (Continued)

[a] *All cost expressed in 2022 dollars unless otherwise noted.*

[b] *Cost of implementation is allocated among three categories of low (less than $100,000 dollars), moderate (greater than $100,000 and less than $1,000,000), and high (greater than $1,000,000) costs, which are generally defined as:*

Low	Moderate	High
Educational and informational programming	*Addition of new staff*	*Major construction*
Ongoing enforcement of ordinances	*Additional staff hours budgeted*	*New buildings (infrastructure)*
Plan Development	*Additional equipment*	*Capital programs*
Continued coordination/mutual aid/interagency agreements	*New ordinance development*	
	New programs/task force	

[c] *Cost covered under ongoing programs.*

[d] *Costs to be determined. Partially covered under ongoing programs.*

[e] *Costs are determined by individual evaluations and/or engineer studies conducted at the time of the survey.*

[f] *Costs to be determined.*

[g] *Acquisition and demolition costs of these structures are included in the parcel-based-analyses conducted by Commission staff when determining potential damages caused from a 100-year probability flood as described in Chapter 3.*

Source: Milwaukee County Office of Emergency Management and the Southeastern Regional Planning Commission

#275662 – CAPR-345 Table 5.17 Priority Ranking of Hazards Based Upon Death and Injury
500-1151
MAS/LKH/mid
12/18/2024, 1/9/25

Table 5.17
Priority Ranking of Hazards Affecting Milwaukee County Based Upon Mortality and Injury

Order Based on Local Planning Team[a]	Hazards Identified in the Hazard Vulnerability Assessment Tool	Period of Record (23 Years)	Number of Events per Year (Average)	Total Number of Deaths and Injuries	Number of Mortalities per Year (Average)	Number of Injuries per Year (Average)	Sum of Mortality and Injuries per Year
6, 8	Extreme Temperatures (*Extreme Cold and Heat*)	2000-2022	3.6	114	2.0	3.0	5.0
1	Tornado	2000-2022	0.1	16	0.0	0.7	0.7
2, 9, 10, 11	Thunderstorms (*Hail, Lightning, and Strong Winds*)	2000-2022	14.7	5	0.0	0.2	0.2
5, 12, 22, 23	Flooding (*Stormwater, Riverine, and Inland Lake*)	2000-2022	2.0	4	0.2	0.0	0.2
15	Drought	2000-2022	0.6	0	0.0	0.0	0.0
3, 4, 7	Winter Storms (*Heavy Snow, Ice Storm, and Blizzard*)	2000-2022	8.0	0	0.0	0.0	0.0
14, 16, 21	Lake Michigan Coastal Hazards (*Bluff Failure, Coastal Erosion*)[b]	2000-2022	--	--	--	--	--

[a] *These numbers indicate the ranked order of the hazards assigned by the Milwaukee County Hazard Mitigation Local Planning Team (LPT) through responses given in the Hazard and Vulnerability Assessment Tool (HVA). For more details see Table 3.1 and the Hazard Identification section in Chapter 3 of this report.*

[b] *No available data for Milwaukee County.*

Source: National Oceanic and Atmospheric Administration, and National Environmental Satellite, Data and Information Service, and the U.S. Department of Agriculture Risk Management Agency

#275663 – CAPR-345 Table 5.18 Priority Ranking of Hazards Based Upon Property and Crop Damages
500-1151
MAS/LKH/mid
12/12/2024, 1/9/25

Table 5.18
Priority Ranking of Hazards Affecting Milwaukee County Based Upon Average Annual Damages

Order Based on Local Planning Team[a]	Hazards Identified in the Hazard Vulnerability Assessment Tool[b]	Period of Record (23 Years)	Number of Incidents Per Year (Average)	Total Property Damage Per Year (Dollars)[c]	Total Crop Damage Per Year (dollars)	Sum of Property and Crop Damages Per Year (dollars)	Priority Ranking Based on Analysis
5, 12, 22, 23	Flooding (*Stormwater and Riverine*)	2000-2022	2.0	7,427,391	6,766	7,434,157	1
2, 9, 10, 11	Thunderstorms (*Heavy Rain, Hail, Lightning, and Strong Winds*)	2000-2022	14.7	1,052,088	33,717	1,085,805	2
1	Tornado	2000-2022	0.1	458,720	901	459,621	3
15	Drought	2000-2022	0.6	0	14,016	14,016	4
3, 4, 7	Winter Storms (*Heavy Snow, Ice Storm, and Blizzard*)	2000-2022	8.1	6,279	980	7,259	5
6, 8	Extreme Temperatures (*Extreme Cold and Heat*)	2000-2022	3.6	1,268	89	1,357	6
14, 16, 21	Lake Michigan Coastal Hazards (*Bluff Failure, Coastal Erosion*)[d]	2000-2022	--	--	--	--	7

[a] *These numbers indicate the ranked order of the hazards assigned by the Milwaukee County Hazard Mitigation Local Planning Team (LPT) through responses given in the Hazard and Vulnerability Assessment Tool (HVA). For more details see Table 3.1 and the Hazard Identification section in Chapter 3 of this report.*

[b] *Similar hazardous events listed in the HVA tool (see Table 3.1)—as shown in parentheses—were combined into one category of similar nature for this hazard mitigation Plan. For example, "heavy snow," "ice storm," and "blizzard" in the HVA tool was combined into the "Winter Storms" for this hazard mitigation plan.*

[c] *Dollar values were adjusted to year 2022 by using the average annual Consumer Price Index (CPI) values from the U.S. Department of Labor, Bureau of Labor Statistics.*

[d] *No data available so not included in the Damage Ranking Assessment of this Report.*

Source: National Oceanic and Atmospheric Administration, National Environmental Satellite, Data and Information Service, and the U.S. Department of Agriculture Risk Management Agency

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Chapter 5

HAZARD MITIGATION STRATEGIES

FIGURES

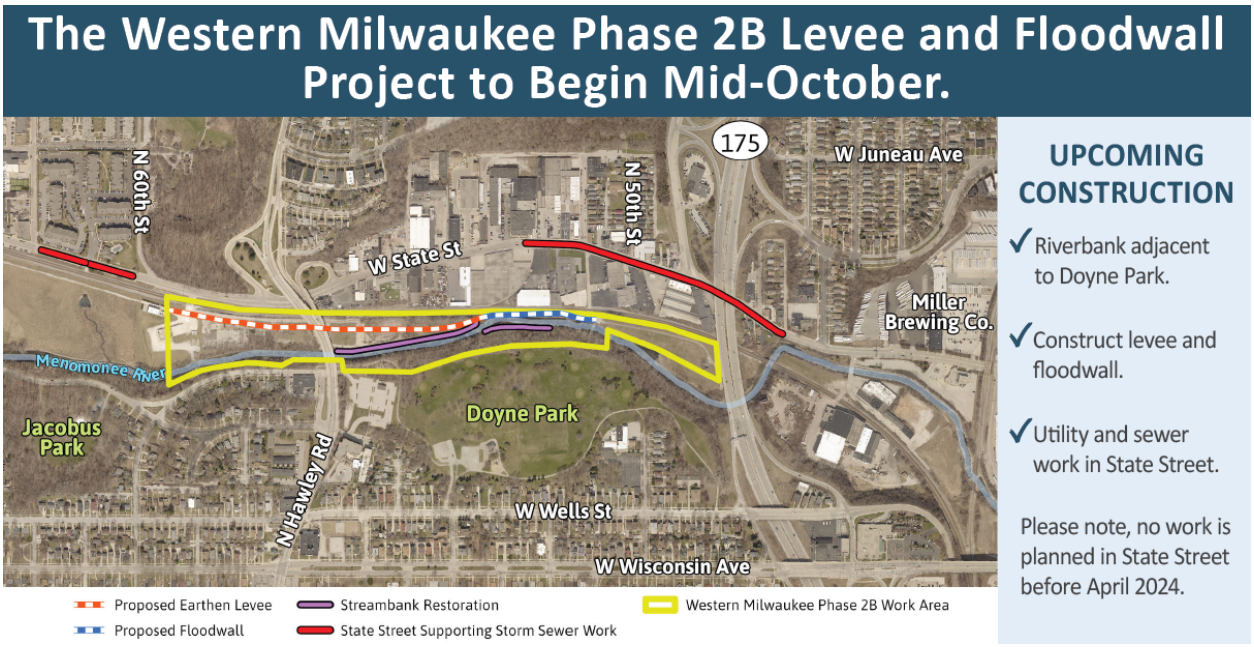
#275989 – CAPR-345 Figure 5.1 City of Milwaukee #MKEALERT
500-1151
MAS/mid
1/15/2024

Figure 5.1
City of Milwaukee Alerting and Notification App.

Source: City of Milwaukee

#274648 – CAPR-345 Figure 5.2 Western Milwaukee River Phase 2B Project
500-1151
MAS/mid
11.13.2024

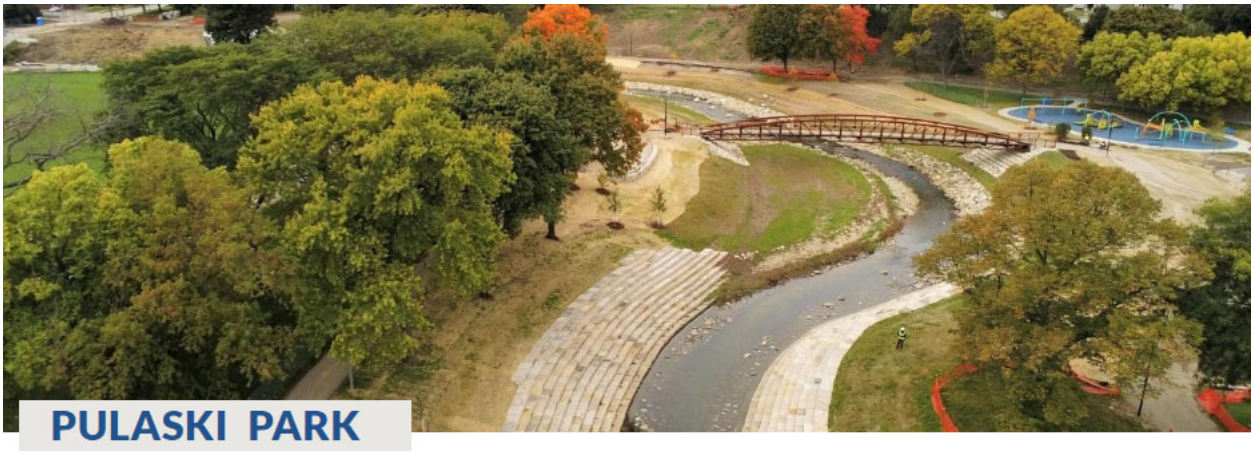
Figure 5.2
Menomonee River of Western Milwaukee Watercourse Project



Source: Milwaukee Metropolitan Sewerage District

#274653 – CAPR-345 Figure 5.3 Pulaski Park
500-1151
MAS/mid
11.13.2024

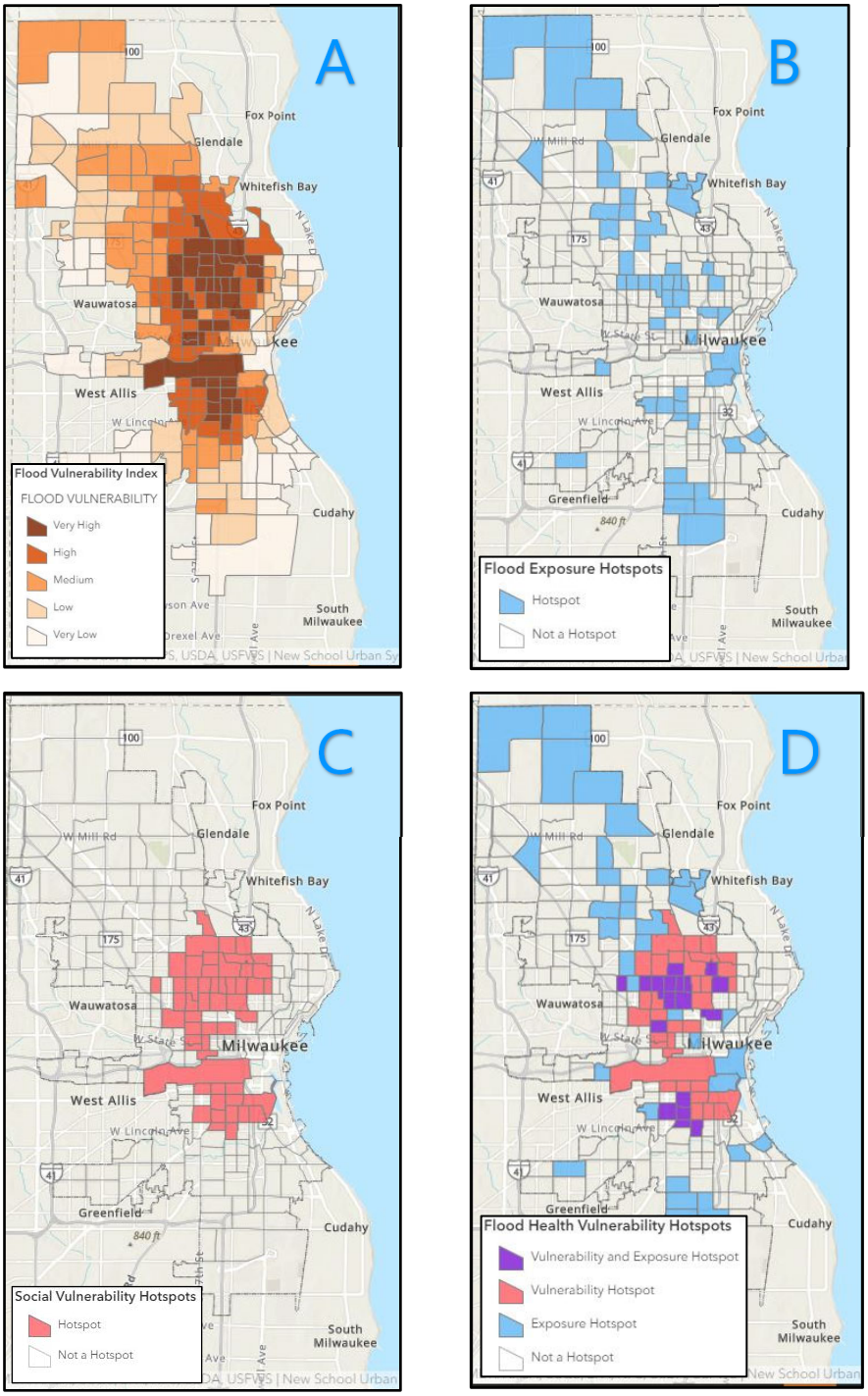
Figure 5.3
Milwaukee Metropolitan Sewerage District, Milwaukee County, City of Milwaukee and Partners: Pulaski Park Kinnickinnic River Watercourse Project



Source: Milwaukee Metropolitan Sewerage District Project Page Website

#274657 – CAPR-345 Figure 5.4 Milwaukee FVI (A-D)
500-1151
MAS/mid
11.12.2024

Figure 5.4
City of Milwaukee Flood and Health Vulnerability Assessment: Flood Vulnerability Locations



Source: Groundwork Milwaukee, Wisconsin Health Professionals for Climate Action, Medical College of Wisconsin, and the City of Milwaukee, Milwaukee Flood and Health Vulnerability Assessment, *July 2023.*

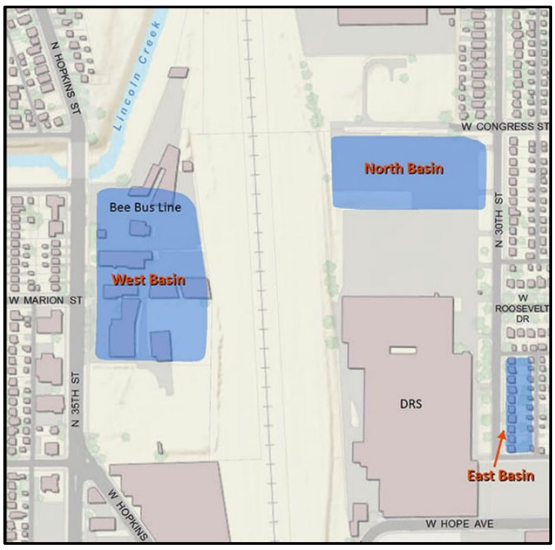
#274660 – CAPR-345 Figure 5.5 Time Lapse photos USGS stream site
500-1151
MAS/mid
12.2.24

Figure 5.5
Milwaukee Metropolitan Sewerage District Watercourse Corridor Study: Real-Time Imaging Data Collection on Kinnickinnic River Mainstem at S.11th Street: 2022

Source: United States Geological Survey and Milwaukee Metropolitan Sewerage District

#274694 – CAPR-345 Figure 5.6 North 30th St. corridor project
500-1151
MAS/mid
12.12.2024

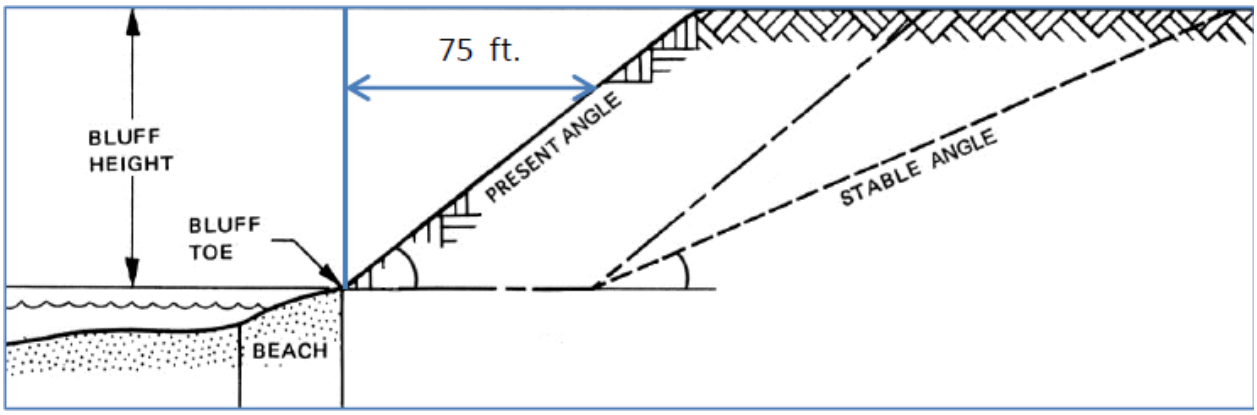
Figure 5.6
Milwaukee Metropolitan Sewerage District North 30th Street Corridor Project



Source: Milwaukee Metropolitan Sewerage District (Left) and Reflo (Right)

#2275346 – CAPR-345 Figure 5.7 Wisconsin's Shoreland Setback of 75FT from Bluff Toe
500-1151
MAS/mid
12/23/2025

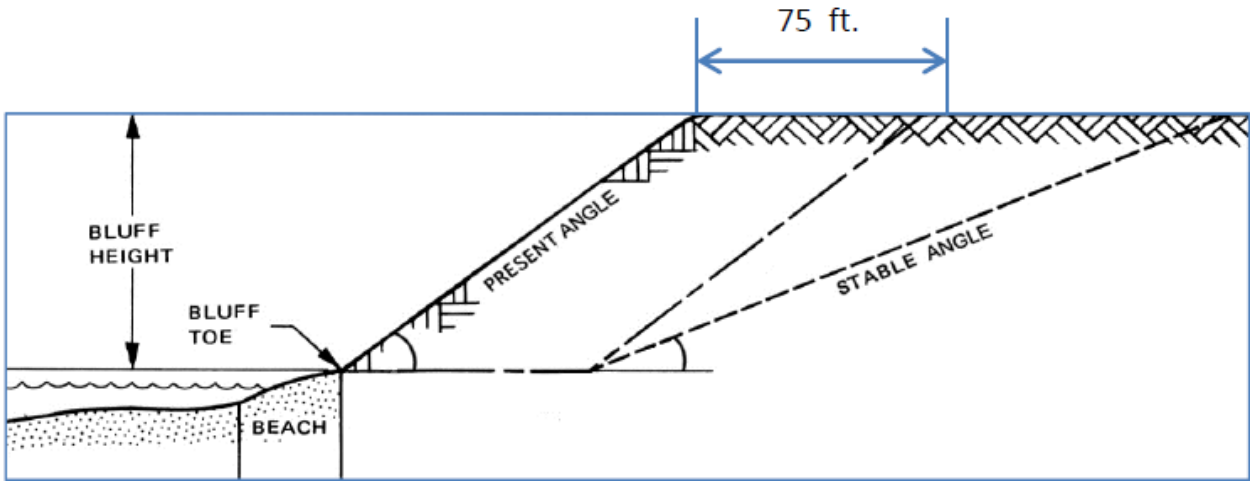
Figure 5.7
Wisconsin Shoreland Setback Requirement of 75 Feet from Bluff Toe



Source: Wisconsin Coastal Management Program

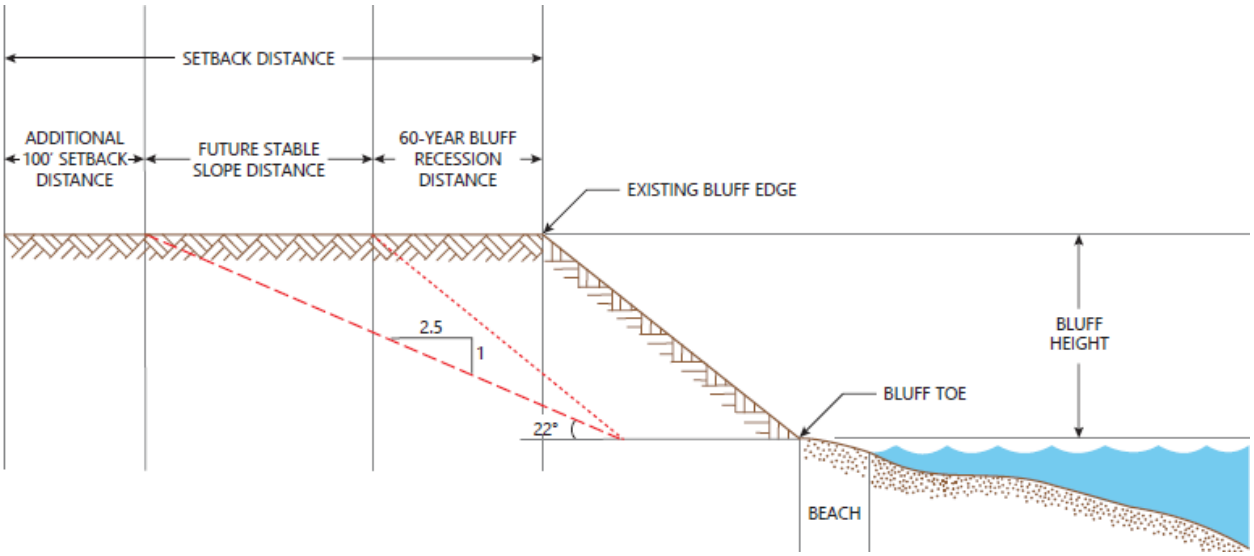
#275347 – CAPR-345 Figure 5.7 Modified Shoreland Setback
500-1151
MAS/mid
11/2024

Figure 5.8
Modified Shoreland Setback



Source: Wisconsin Coastal Management Program

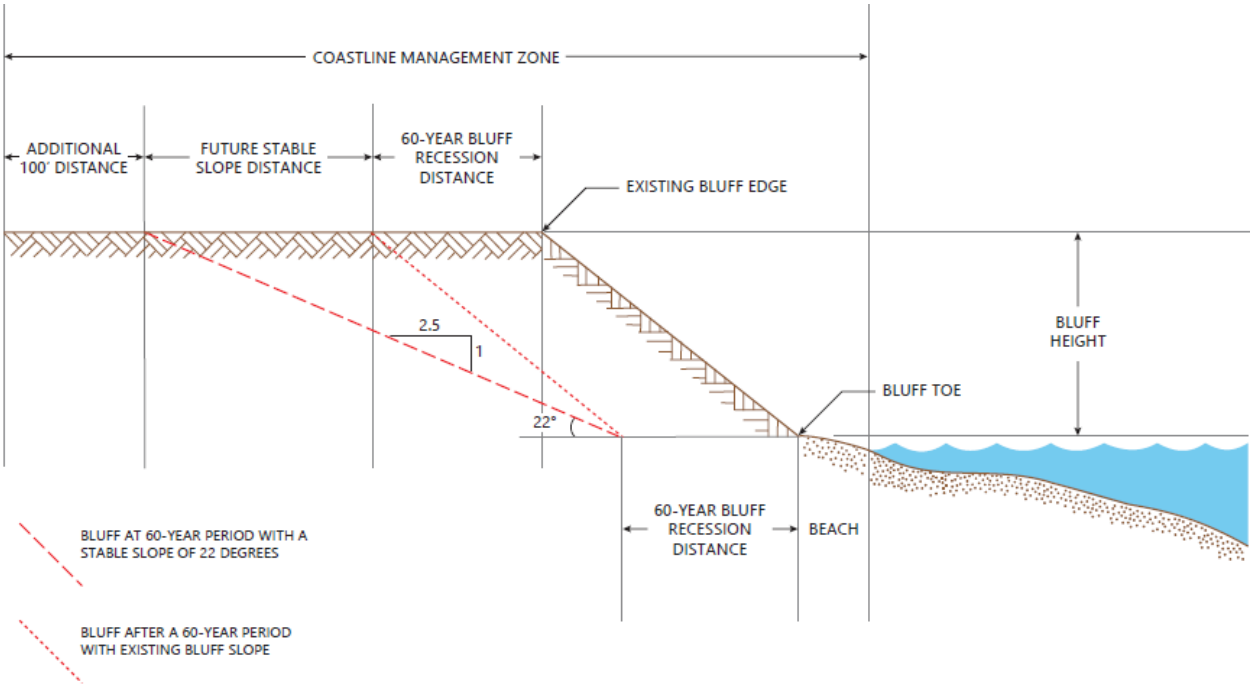
Figure 5.9
Recommended Erosion Hazard Setback from Lake Michigan Bluffs and Ravines



Source: University of Wisconsin Sea Grant and Southeastern Wisconsin Regional Planning Commission

#275355 – CAPR-345 Figure 5.10 CMZ Bluff Setback
500-1151
MAS/mid
11/2024

Figure 5.10
Coastal Management Zone Setback



Source: University of Wisconsin Sea Grant Program and the Southeastern Wisconsin Regional Planning Commission

#275473 – CAPR-345 Figure 5.11 2024 Aerials of Structures on the Milwaukee County Coastline
500-1151
MAS/mid
12/3/2024

Figure 5.11
Examples of Potential Structural Coastal Hazard Concern: 2024

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 the Southeastern Wisconsin Regional Planning Commission

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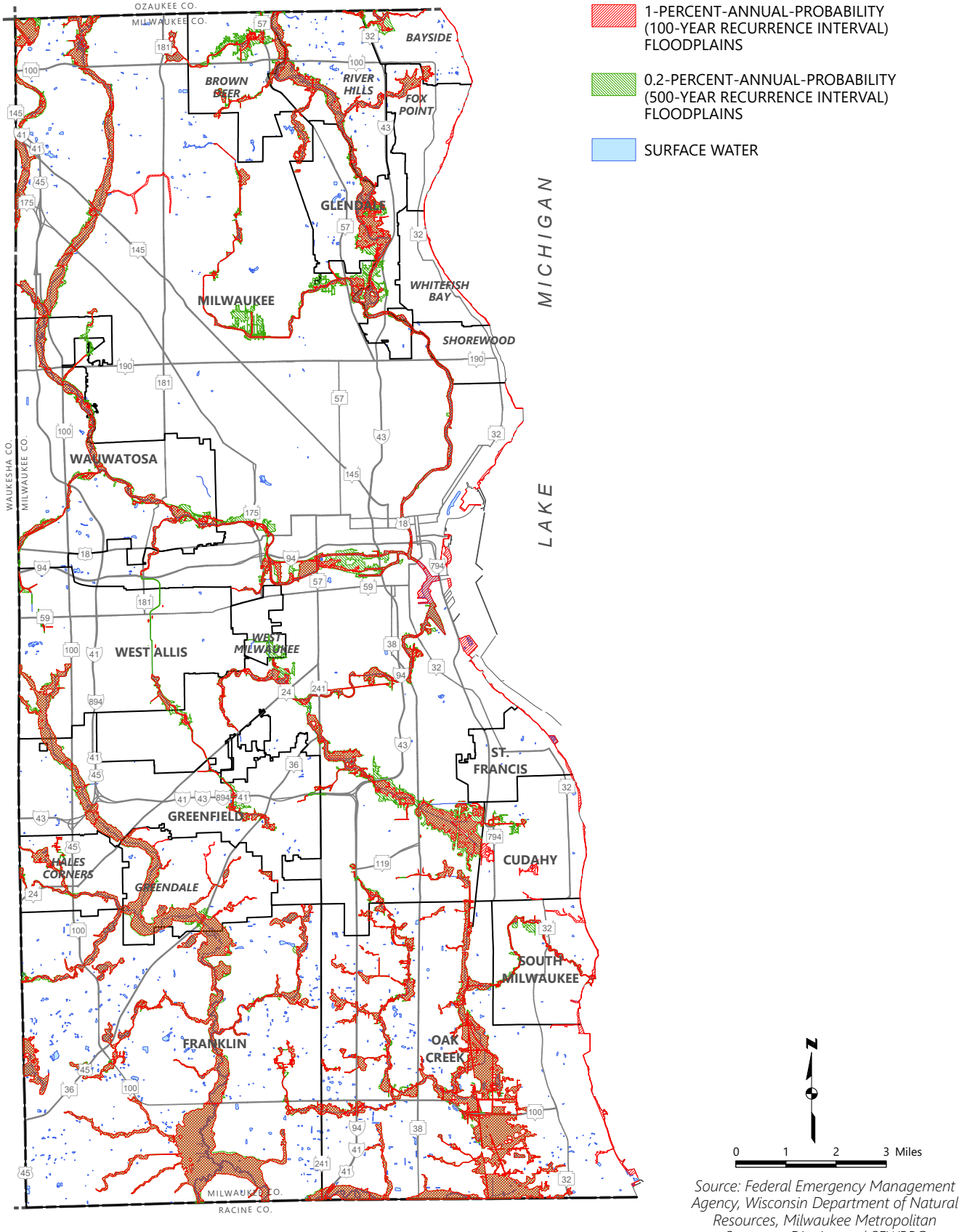
MILWAUKEE COUNTY HAZARD MITIGATION PLAN UPDATE: 2024-2029

Chapter 5

HAZARD MITIGATION STRATEGIES

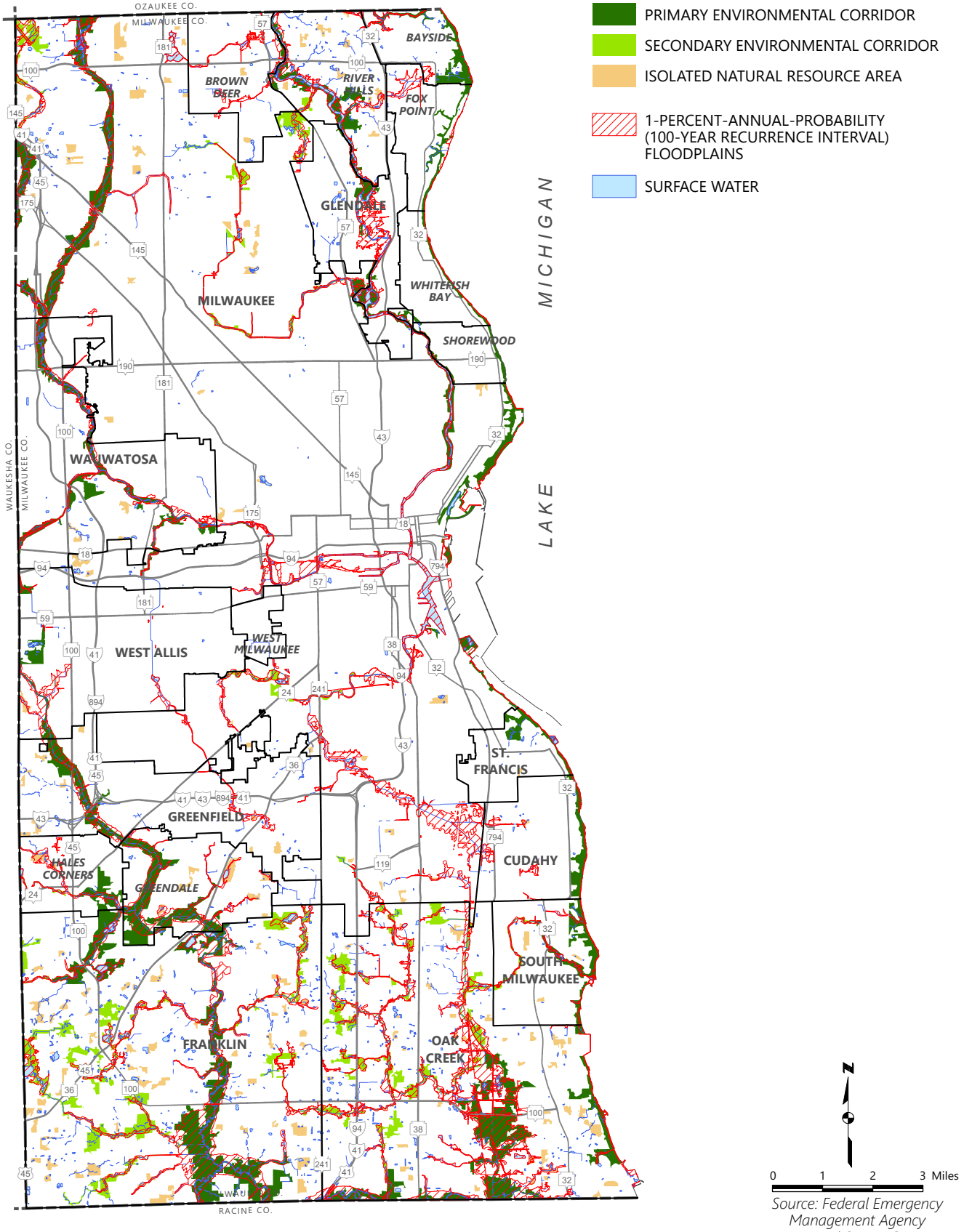
MAPS

Map 5.1
100- and 500-Year Floodplains in Milwaukee County



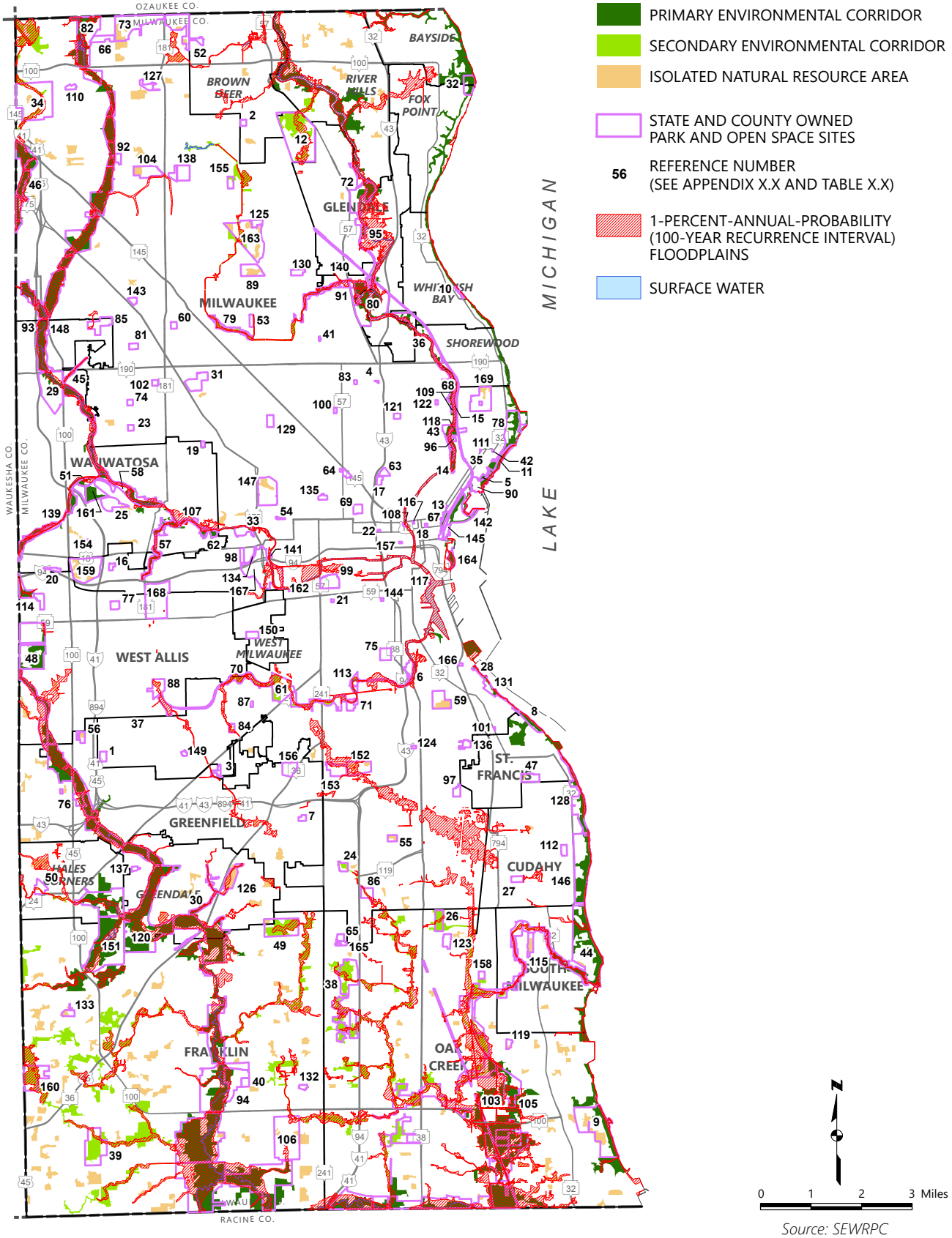
Source: Federal Emergency Management Agency, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC

Map 5.2
Environmental Corridors, Isolated Natural Resource Areas, and 100-Year Floodplains in Milwaukee County



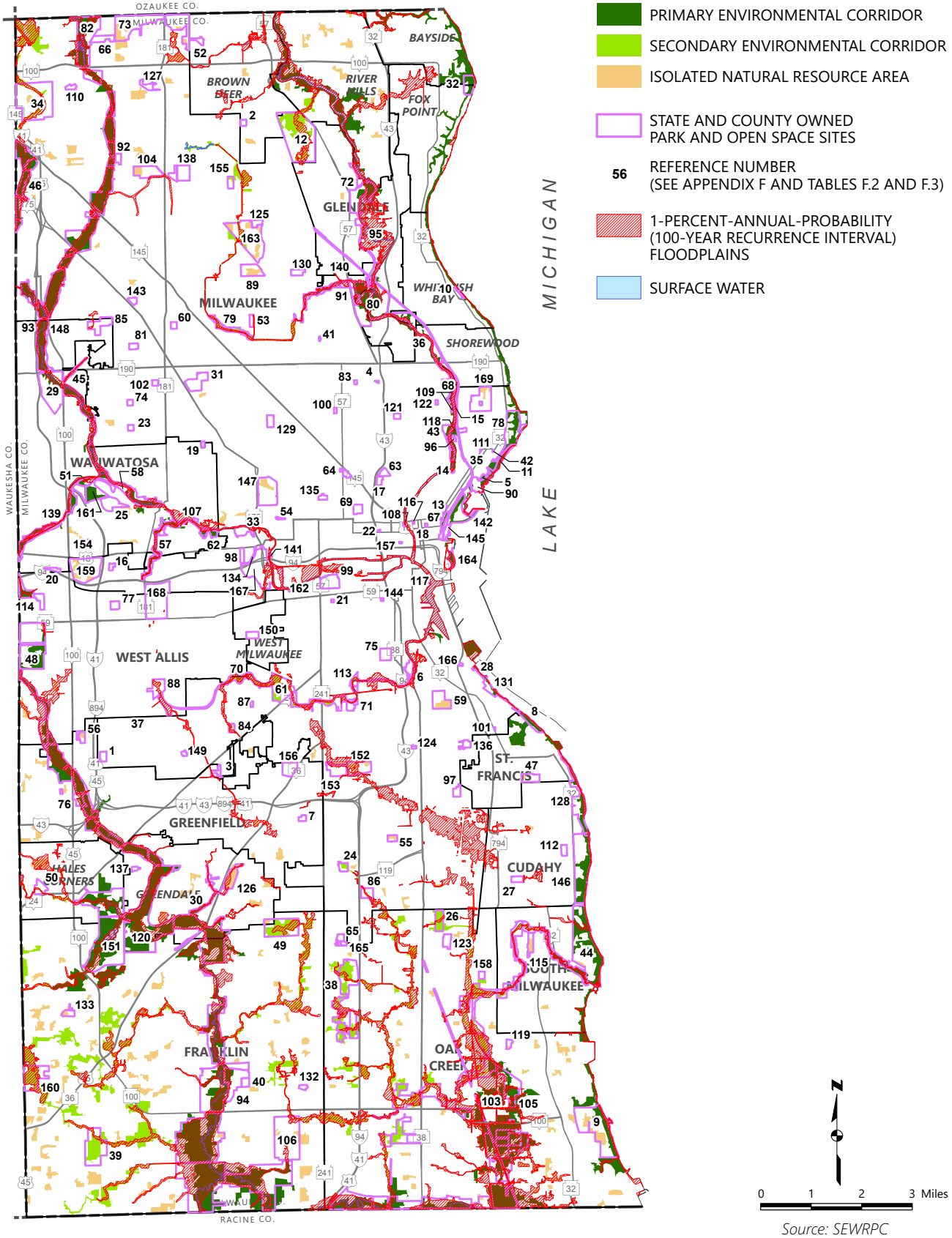
Source: Federal Emergency Management Agency and SEWRPC

Map 5.3
Environmental Corridors, Isolated Natural Resource Areas, and Park and Open Space Sites in Milwaukee County



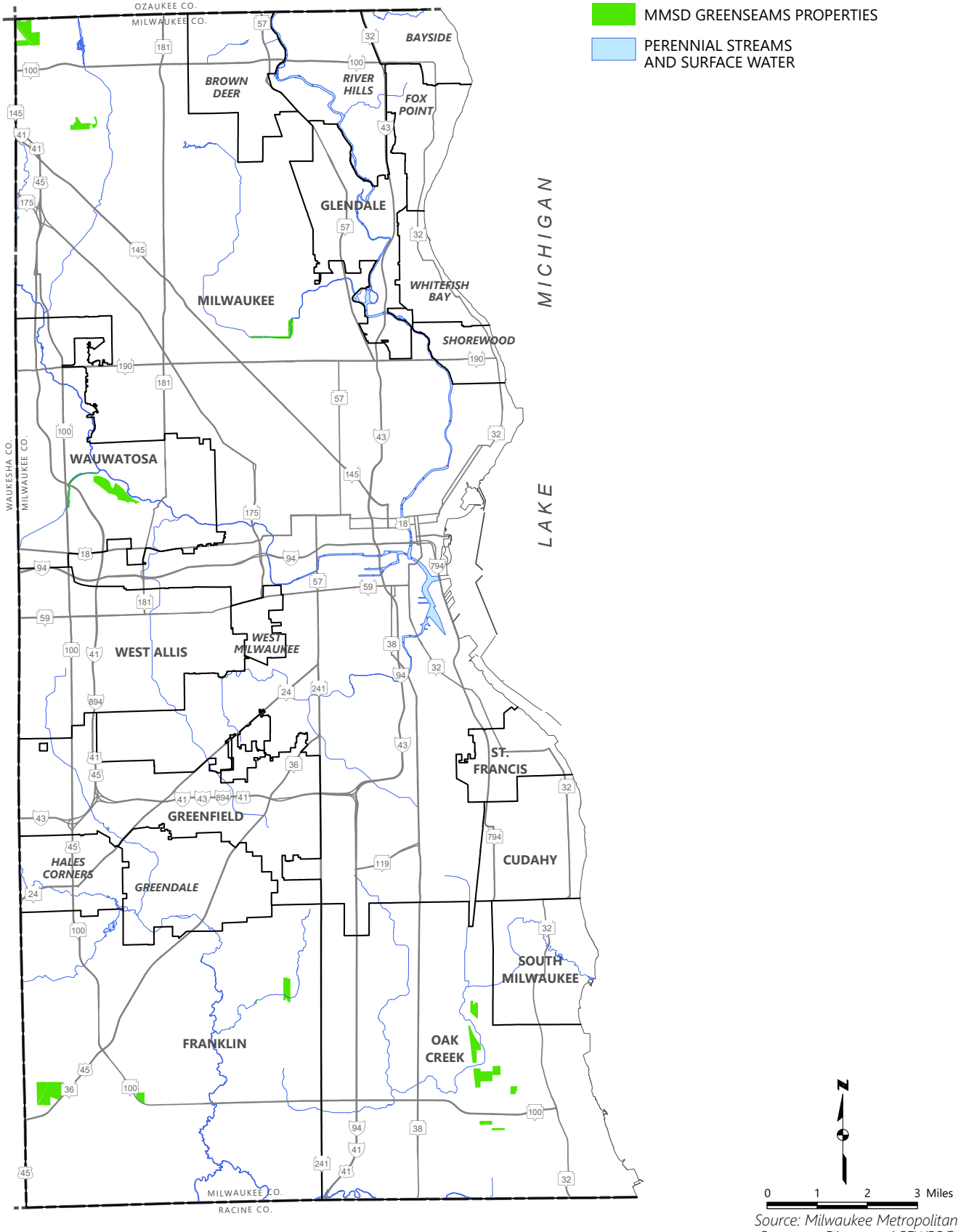
Source: SEWRPC

Map 5.3
Environmental Corridors, Isolated Natural Resource Areas, and Park and Open Space Sites in Milwaukee County



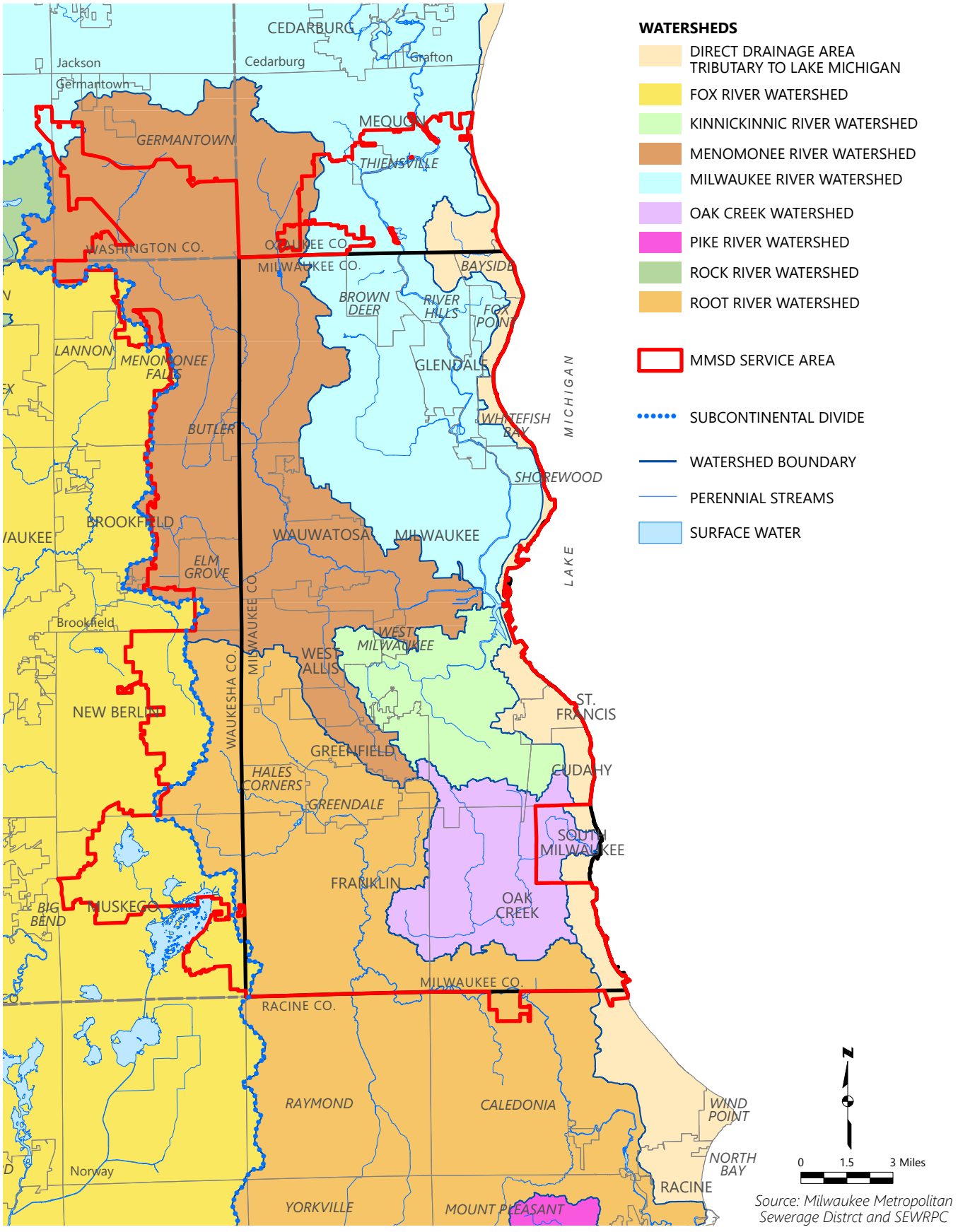
Source: SEWRPC

Map 5.4
Milwaukee Metropolitan Sewerage Distrct (MMSD) Greenseams Locations within Milwaukee County: 2024



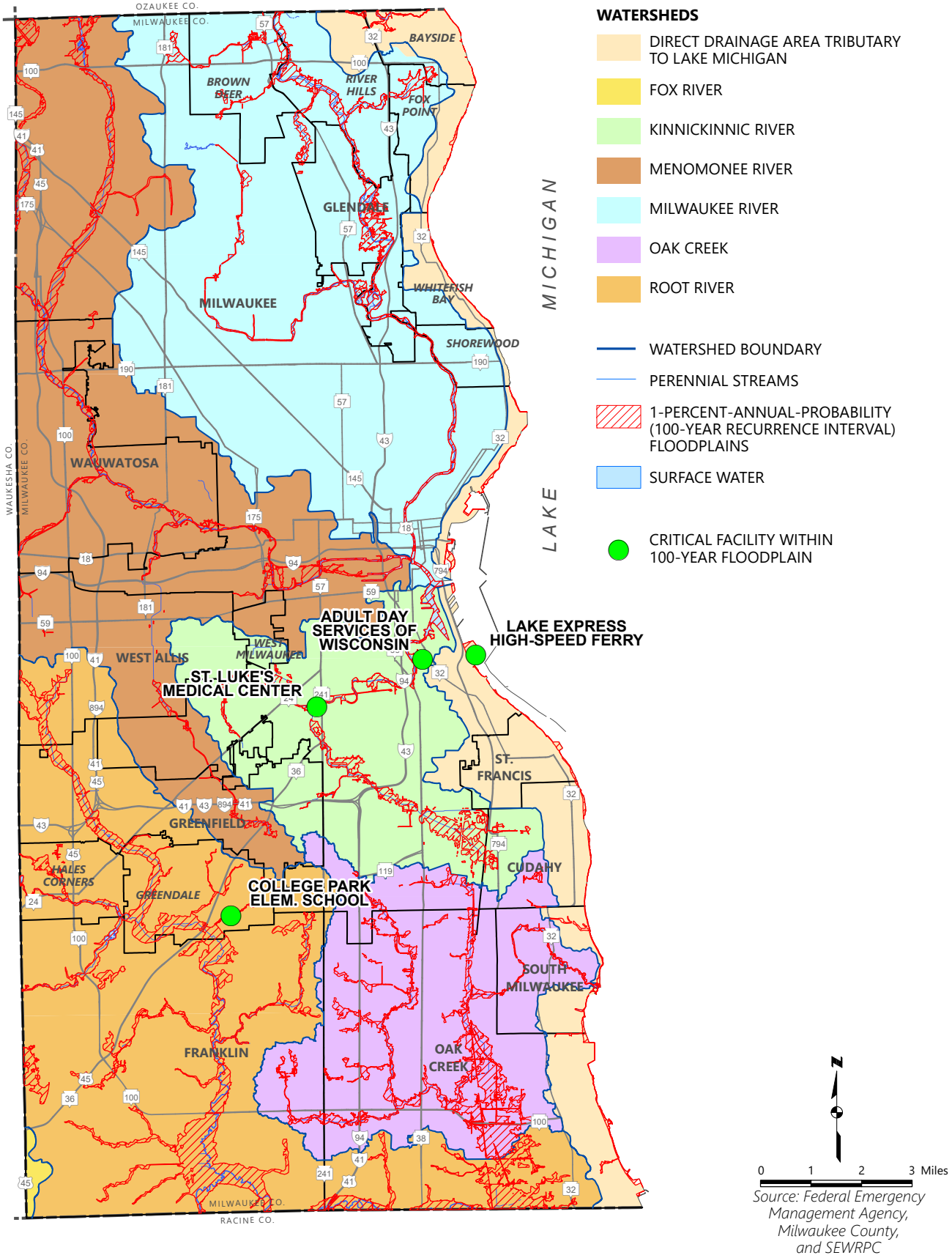
Source: Milwaukee Metropolitan Sewerage Distrct and SEWRPC

Map 5.5
Milwaukee Metropolitan Sewerage Distrct (MMSD) Service Area and Major Watersheds in Milwaukee County



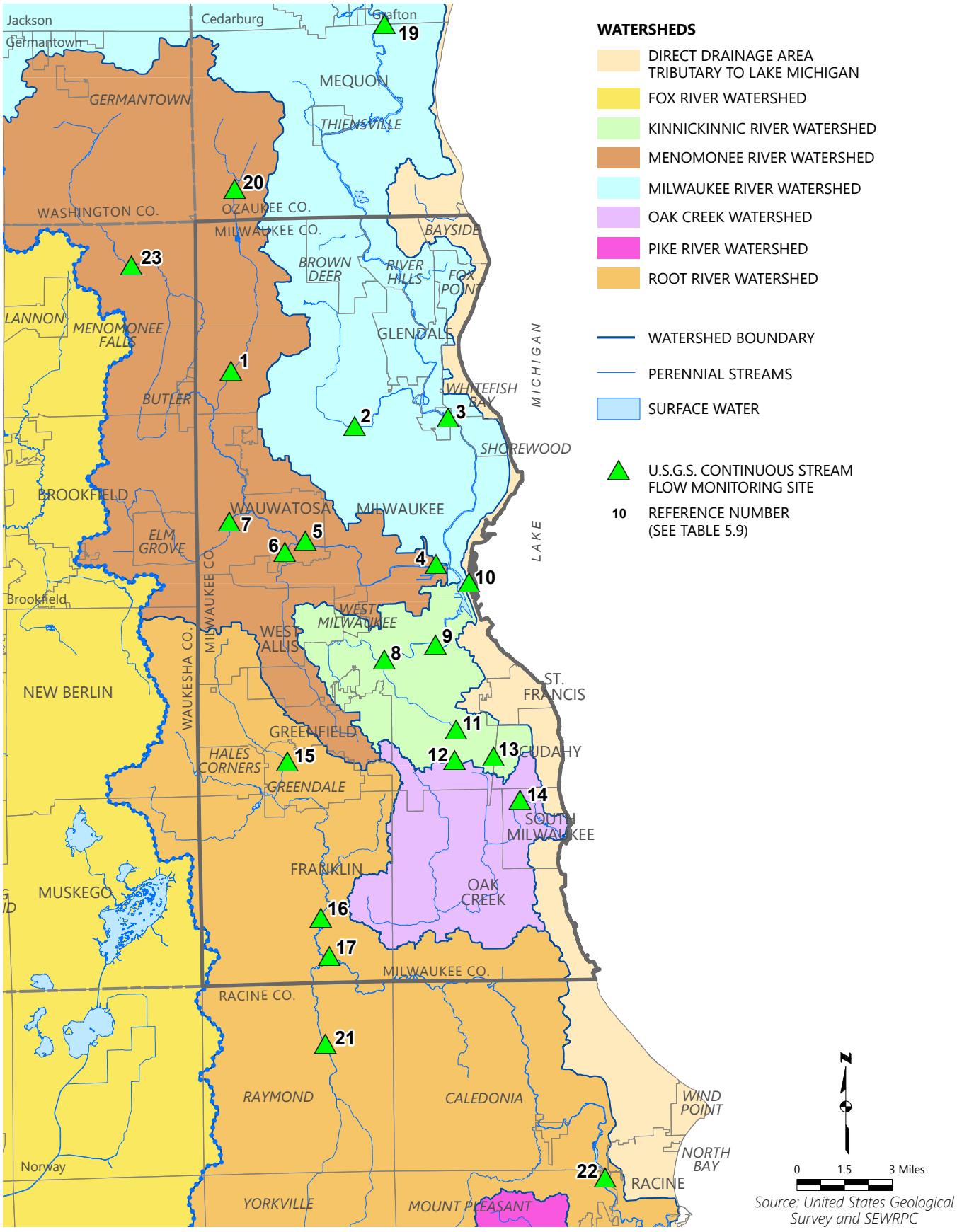
Source: Milwaukee Metropolitan Sewerage Distrct and SEWRPC

Map 5.6
Critical Community Facilities Located within the 100-Year Floodplain of Milwaukee County Via Parcel-Based Analysis



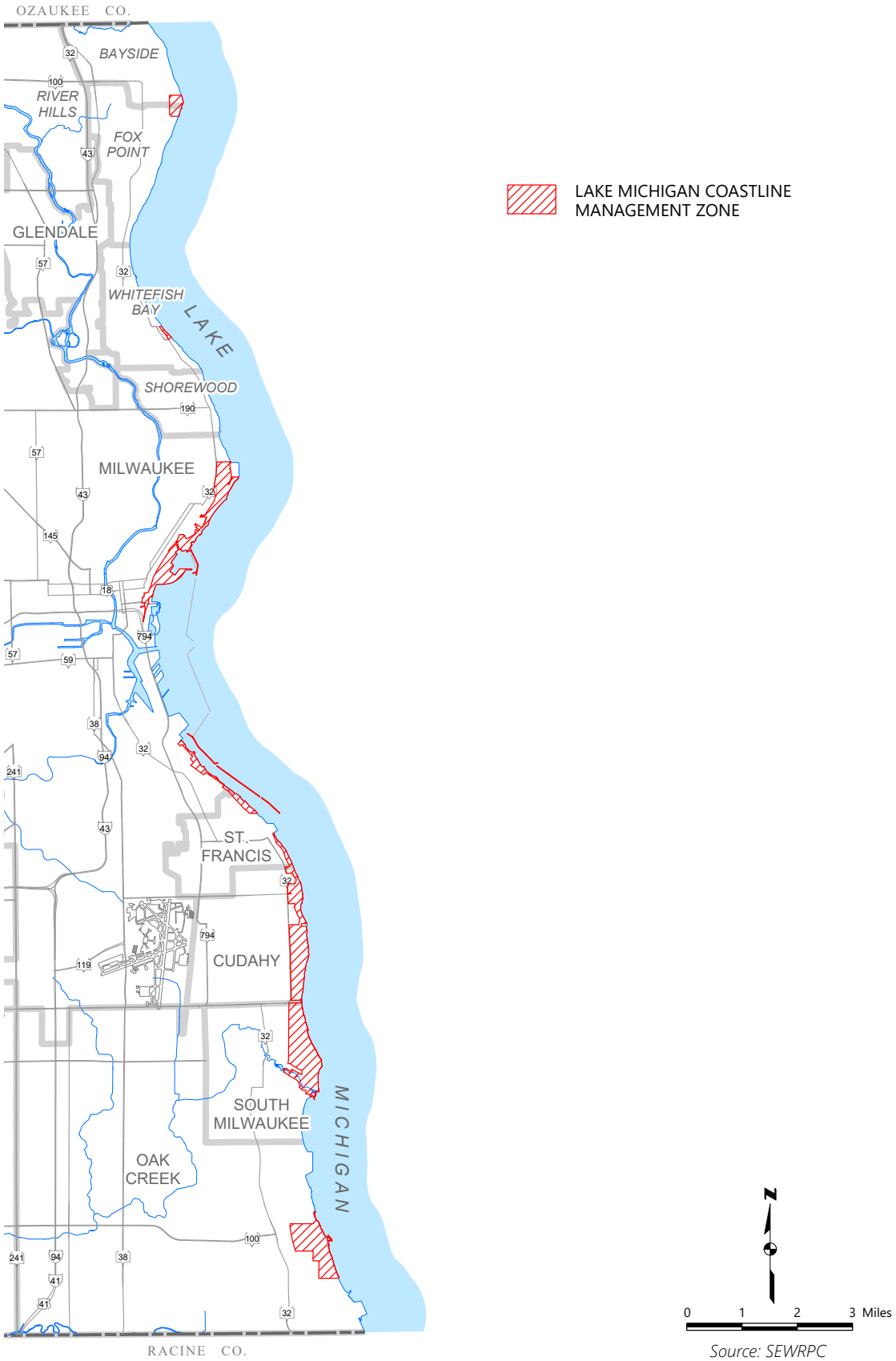
Source: Federal Emergency Management Agency, Milwaukee County, and SEWRPC

Map 5.7
USGS Stream Flow Gage Locations in Milwaukee County



Source: United States Geological Survey and SEWRPC

Map 5.8
Lake Michigan Coastline Management Zone: 2019



Source: SEWRPC

Map 5.9 (South Half)
Environmental Corridors and Isolated Natural Resource Areas along the Milwaukee County Lake Michigan Coastline: 2015

PRIMARY ENVIRONMENTAL CORRIDOR
SECONDARY ENVIRONMENTAL CORRIDOR
ISOLATED NATURAL RESOURCE AREA
SURFACE WATER

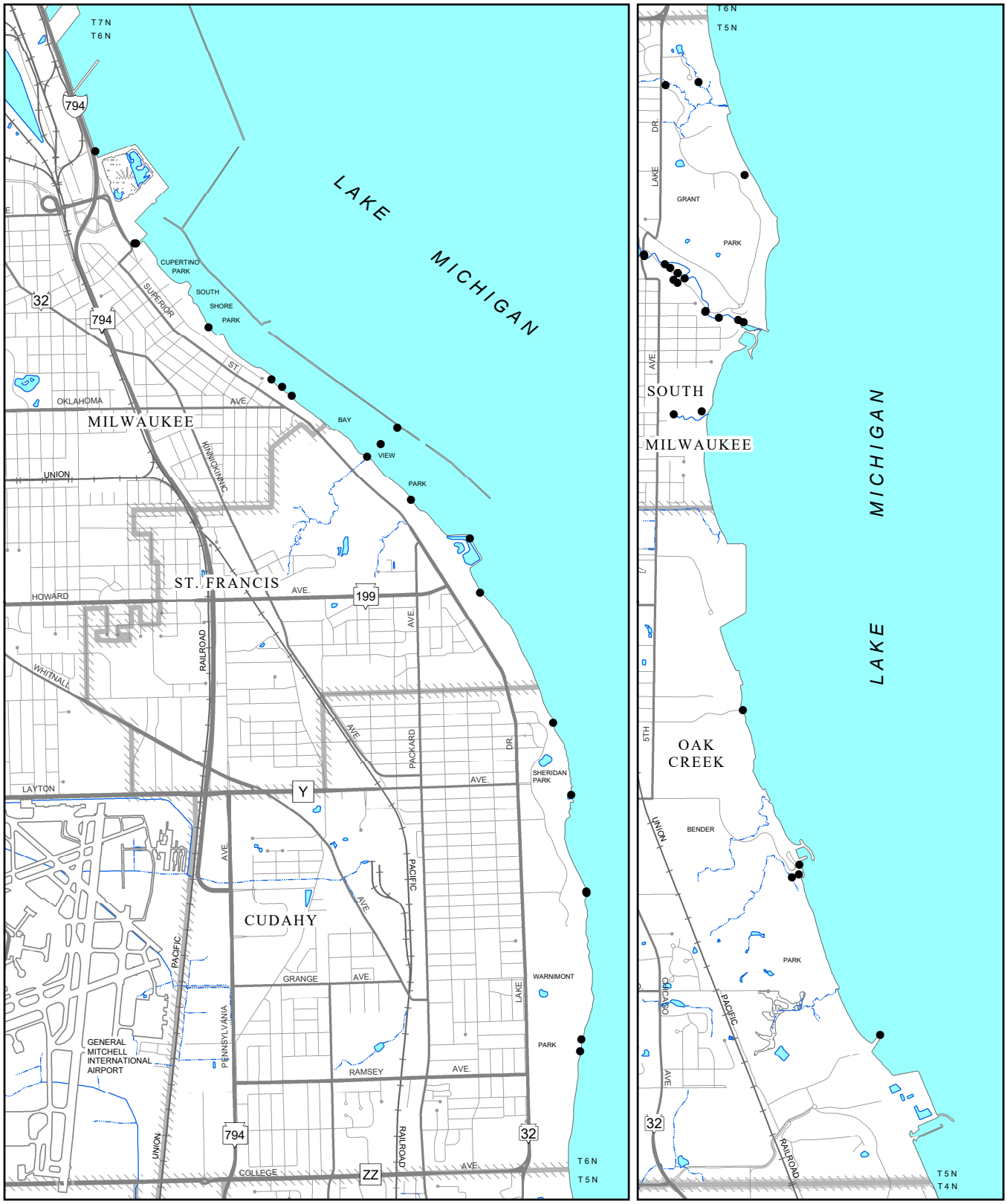
0 0.25 0.5 0.75 1 Miles

Source: SEWRPC

Map 5.9 (North Half)
Environmental Corridors and Isolated Natural Resource Areas along the Milwaukee County Lake Michigan Coastline: 2015

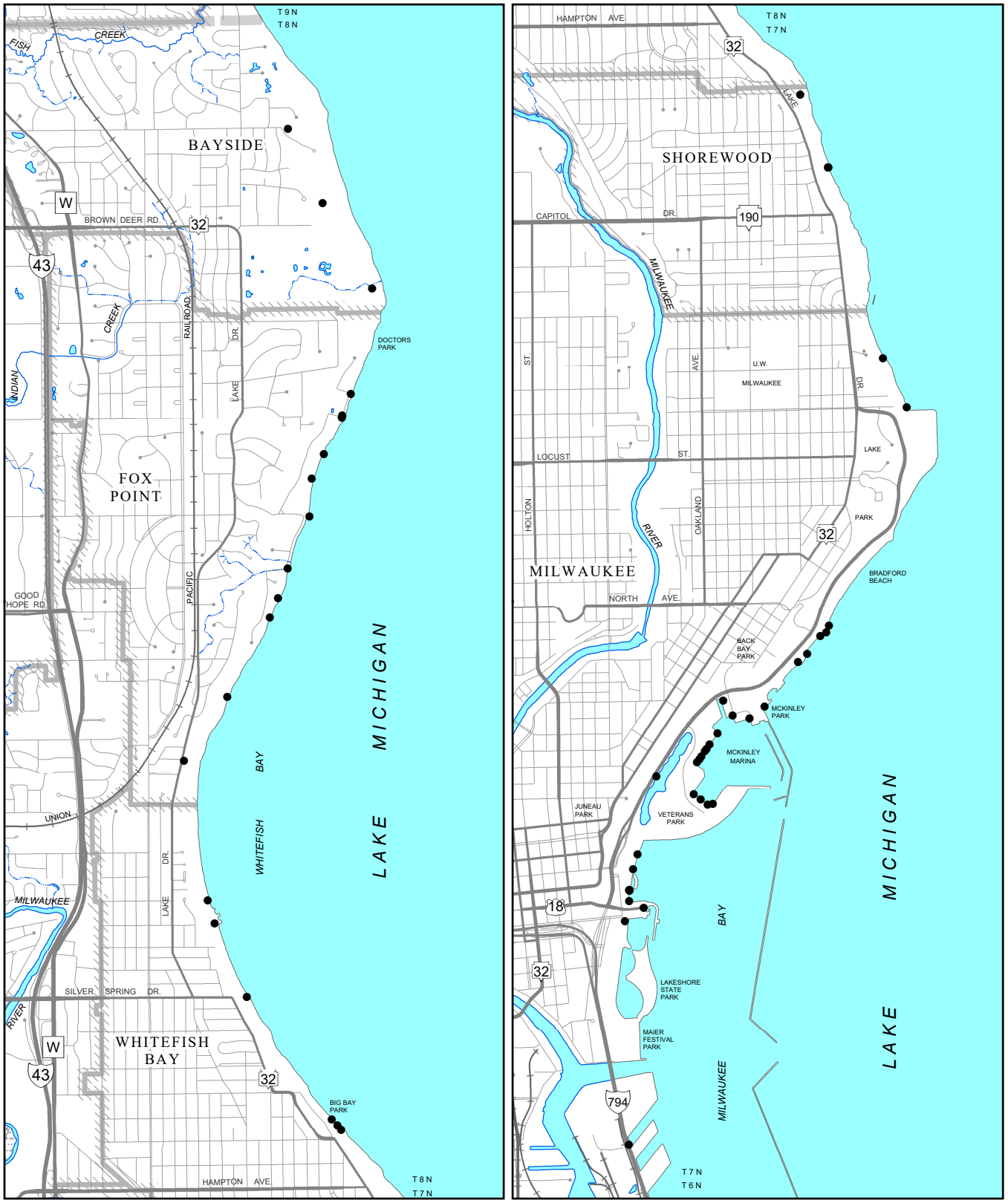
Source: SEWRPC

Map 5.10 (South Half)
Stormwater Outfalls along the Milwaukee County Lake Michigan Coastline



Source: Milwaukee County Municipalities, Milwaukee County, Wisconsin Coastal Management Program, and SEWRPC

Map 5.10 (North Half)
Stormwater Outfalls along the Milwaukee County Lake Michigan Coastline

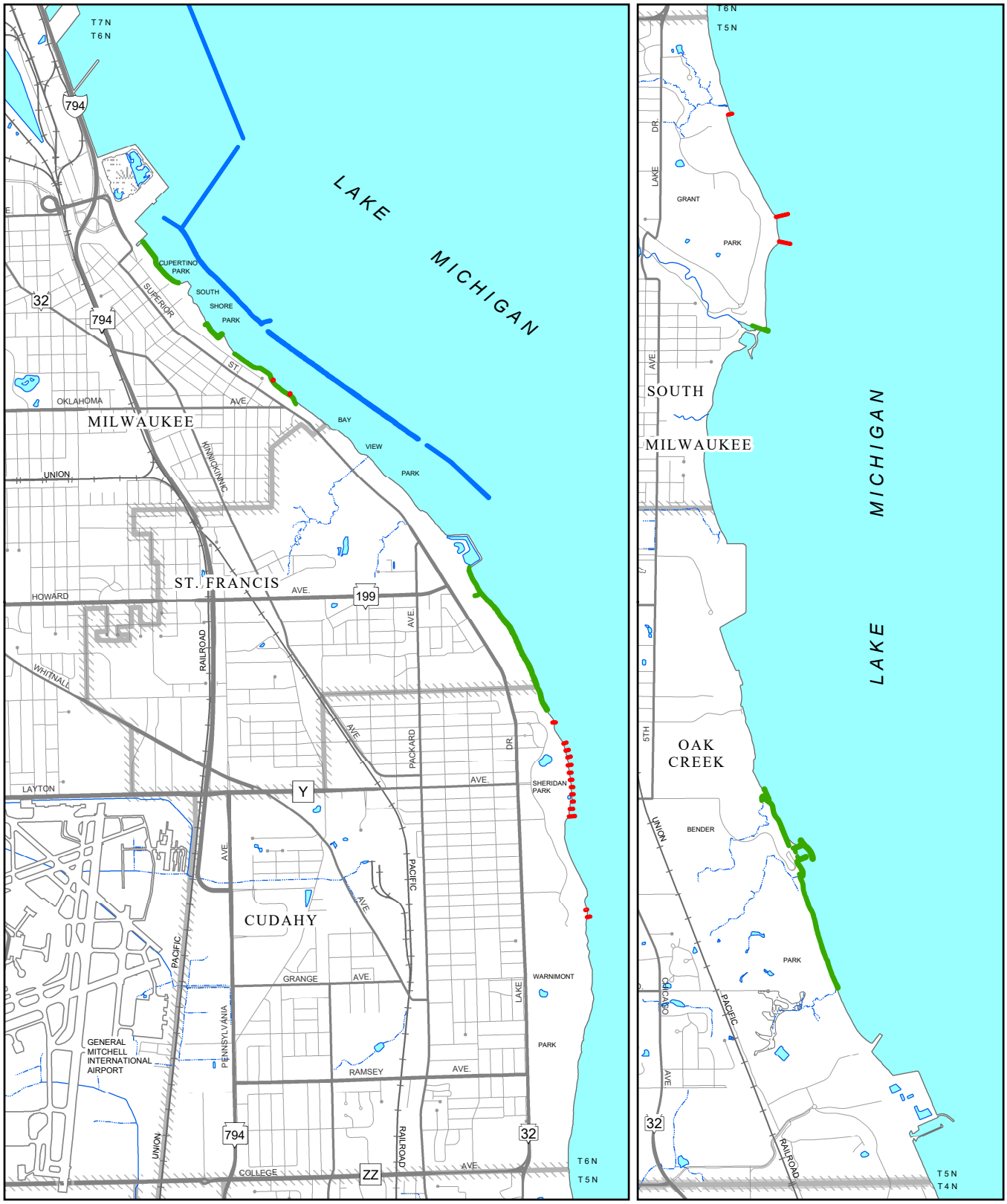


● STORMWATER OUTFALL

0 0.25 0.5 0.75 1 Miles

Source: Milwaukee County Municipalities, Milwaukee County, Wisconsin Coastal Management Program, and SEWRPC

Map 5.11 (South Half)
Shoreline Protection Structures along the Milwaukee County Coastline: 2019

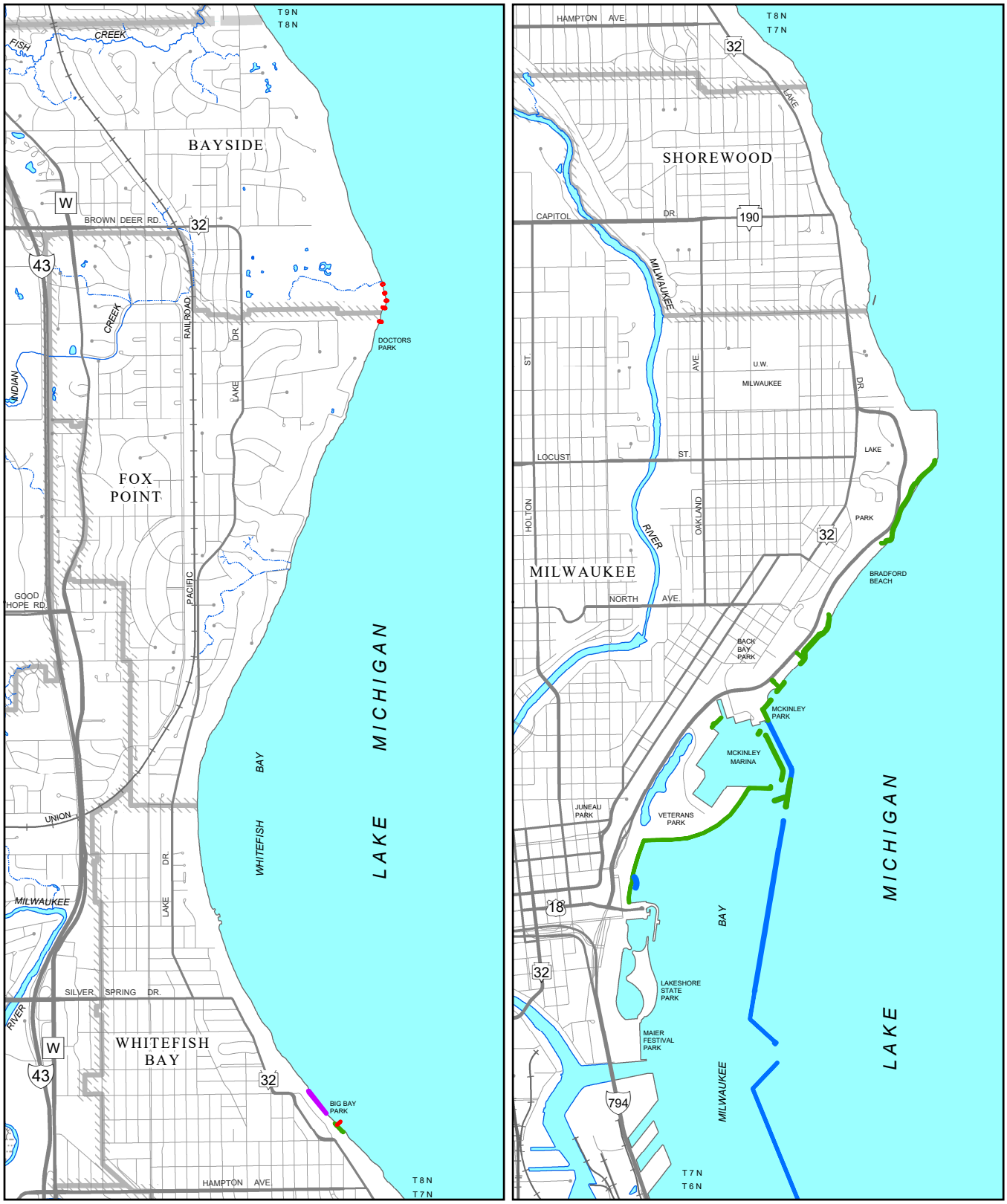


BREAKWATER
BULKHEAD
GROIN
REVETMENT (INCLUDING RIP RAP)

0 0.25 0.5 0.75 1 Miles

Source: Milwaukee County and SEWRPC

Map 5.11 (North Half)
Shoreline Protection Structures along the Milwaukee County Coastline: 2019

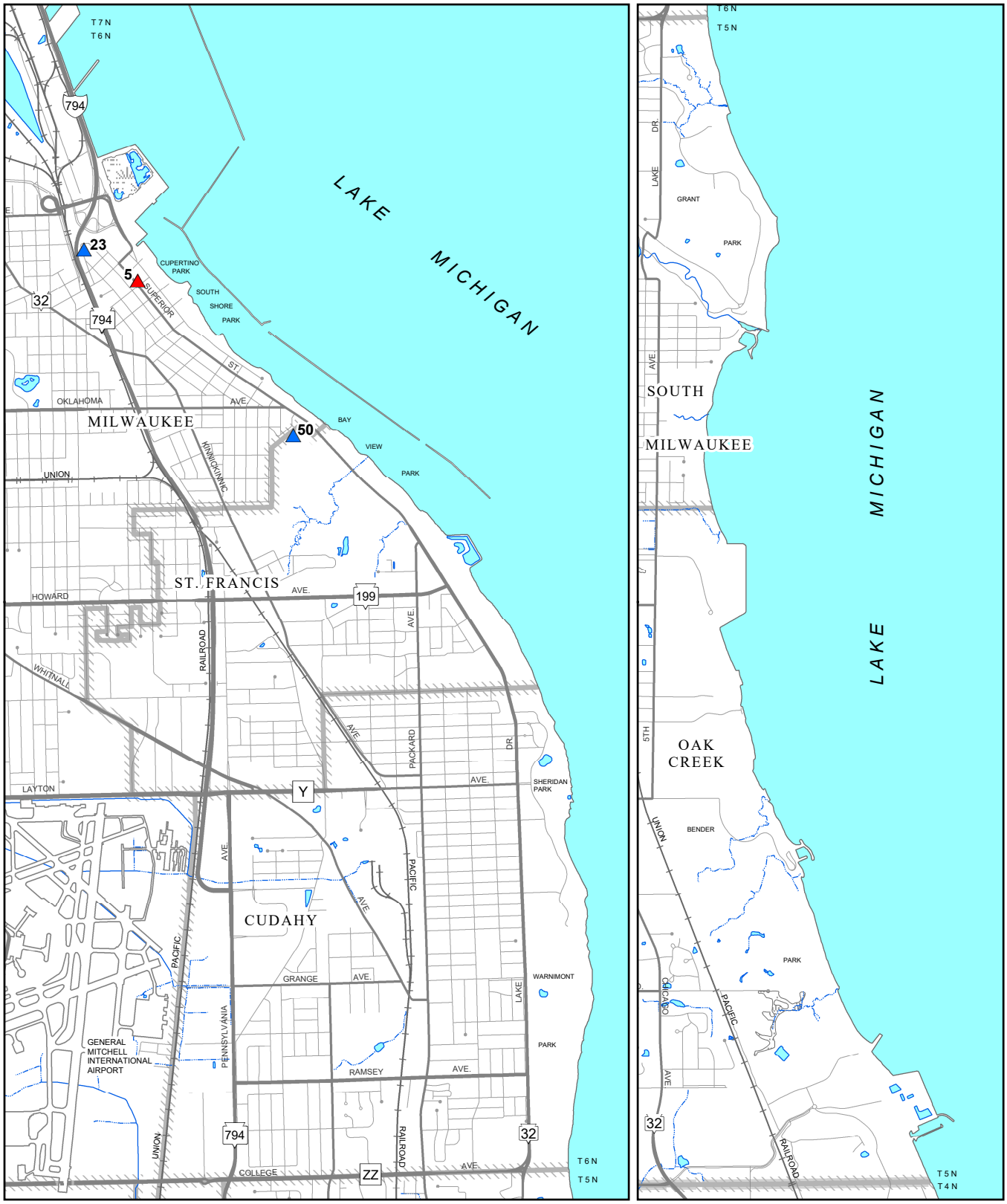


BREAKWATER
BULKHEAD
GROIN
REVETMENT (INCLUDING RIP RAP)

0 0.25 0.5 0.75 1 Miles

Source: Milwaukee County and SEWRPC

Map 5.12 (South Half)
Historic Sites and Districts along the Milwaukee County Lake Michigan Coastline



HISTORIC SITE

HISTORIC DISTRICT

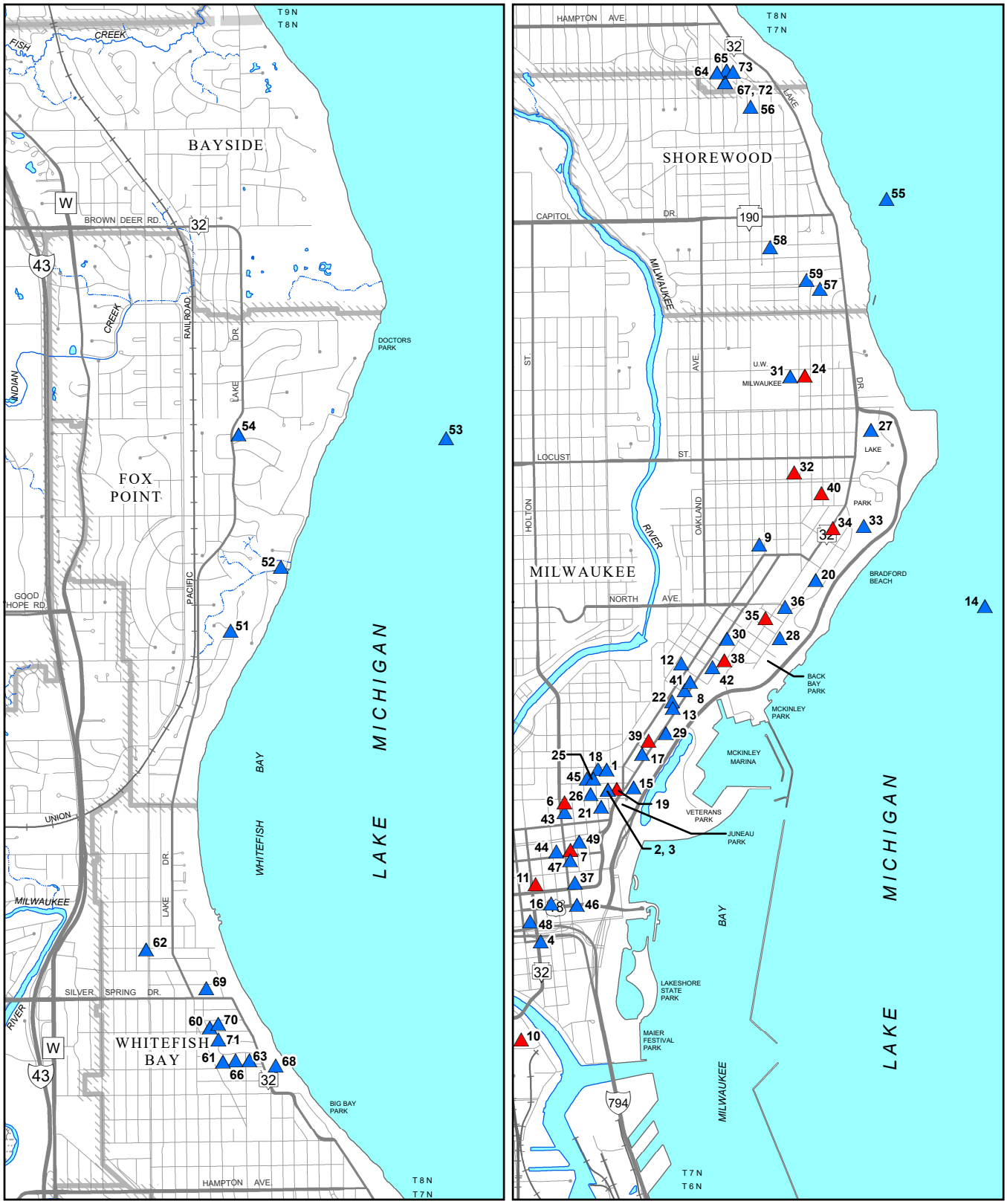
33 REFERENCE NUMBER (SEE APPENDIX F AND TABLE F.4)

Note: Historic sites and districts are only being shown within one-half mile from the Lake Michigan shoreline.

0 0.25 0.5 0.75 1 Miles

Source: SEWRPC

Map 5.12 (North Half)
Historic Sites and Districts along the Milwaukee County Lake Michigan Coastline



HISTORIC SITE

HISTORIC DISTRICT

33 REFERENCE NUMBER (SEE APPENDIX F AND TABLE F.4)

Note: Historic sites and districts are only being shown within one-half mile from the Lake Michigan shoreline.

0 0.25 0.5 0.75 1 Miles

Source: SEWRPC