COMMUNITY ASSISTANCE
PLANNING REPORT NO. 343

# FOX (ILLINOIS) RIVER WATERSHED MITIGATION PLAN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Special acknowledgement is due to Julia C. Orlowski, PE, CFM, Senior Engineer; Zijia Li, PE, Senior Engineer; Laura K. Herrick, PE, CFM, Chief Environmental Engineer; Dr. Thomas M. Slawski, Chief Biologist; Megan A. Shedivy, Planner; James M. Mahoney, PE, Engineer; Dr. Justin P. Poinsatte, Senior Specialist Biologist; Megan I. Deau, Senior Graphic Designer; and Patricia L. Bouchard, GIS Applications Specialist; for their contributions to the preparation of this report.

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# FOX (ILLINOIS) RIVER WATERSHED MITIGATION PLAN

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# INTRODUCTION AND BACKGROUND 1

## 1.1 INTRODUCTION

In July 2021, the Southeastern Wisconsin Regional Planning Commission (SEWRPC) agreed to prepare a Pre-Disaster Fox (Illinois) River Watershed Mitigation Plan on behalf of the Waukesha County Department of Emergency Management. The plan was designed to be consistent with the guidelines of the Wisconsin Department of Military Affairs (DMA), Division of Emergency Management (DEM), and the Federal Emergency Management Agency (FEMA). For this plan, consideration was given to several hazard conditions, including flooding, dam failures, and drought. The analysis includes three components: 1) profile and analysis of past hazard events, 2) inventory and vulnerability assessment of community assets, and 3) development of hazard mitigation strategies to reduce vulnerabilities and protect communities from future hazard events.

A major impetus for the development of this regional watershed hazard mitigation plan was the extreme flood conditions experienced by the City of Burlington in July 2017. Over two days, the Burlington area experienced three to eight inches of rain, causing the Fox River[1] to rise more than five feet over flood stage. The City experienced extensive flooding to homes, businesses, and roads, and was without power for multiple days after an electrical substation was incapacitated by floodwaters. Other areas in the Fox River watershed also experienced varying degrees of flooding impacts following this storm event. As such, this plan recommends hazard mitigation strategies that would help lessen the severity of flooding impacts in the occurrence of another storm event like the one experienced in July 2017.

## 1.2 OVERVIEW OF STUDY AREA

The Fox River flows 202 miles from its headwaters in southern Washington County and northern Waukesha County to its confluence with the Illinois River in Ottawa, Illinois, as shown in Map 1.1. The Fox River watershed covers 2,648 square miles, with approximately 925 square miles of the watershed in Wisconsin. Kenosha, Racine, Walworth, and Waukesha Counties contain 98 percent of the Fox River watershed area in Wisconsin and for this reason this plan focuses on those four Wisconsin counties. Small portions of the watershed are contained in Jefferson, Milwaukee, and Washington Counties. The Fox River has several major tributaries, including the Mukwonago River, Sugar Creek, Honey Creek, and the White River. The watershed also contains several sizeable lakes, including Pewaukee, Big Muskego, and Geneva Lakes.

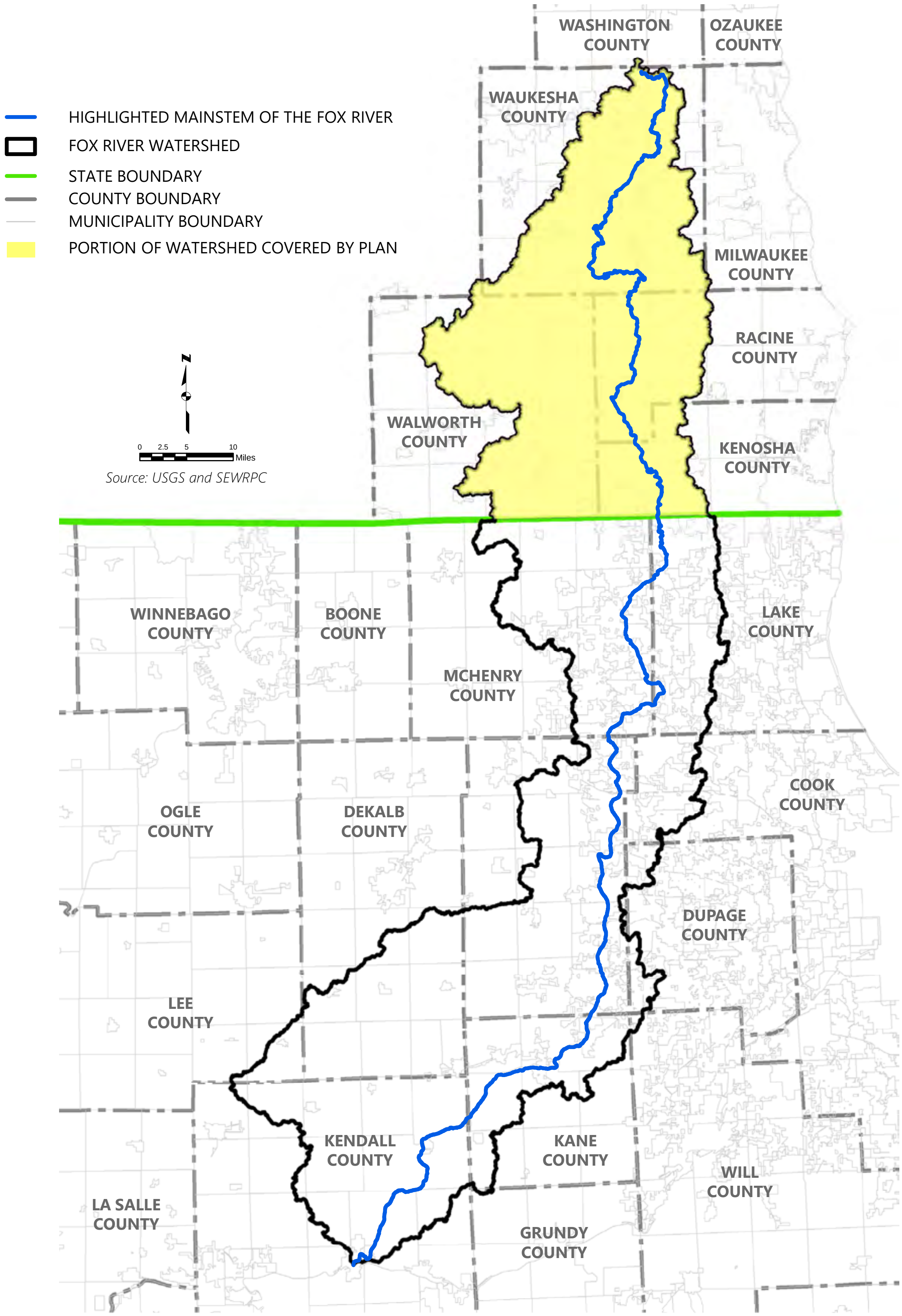
The Wisconsin portion of the Fox River watershed covered by this plan includes 63 municipalities, of which there are nine cities, as shown on Map 1.2. Agricultural and open lands make up much of the watershed. Urban growth is more concentrated in the northern part of the watershed than in the southern portion, although the southern portion of the watershed includes several cities such as Burlington and Lake Geneva.

For the purposes of this study, the Fox River watershed was subdivided into five major subwatersheds and these are also included in Map 1.2. The major subwatersheds are defined by major Fox River tributaries and will be used in subsequent chapters. From upstream to downstream the five major subwatersheds include:

1. Upper Fox River
2. Mukwonago River
3. Middle Fox River
4. White River
5. Lower Fox River

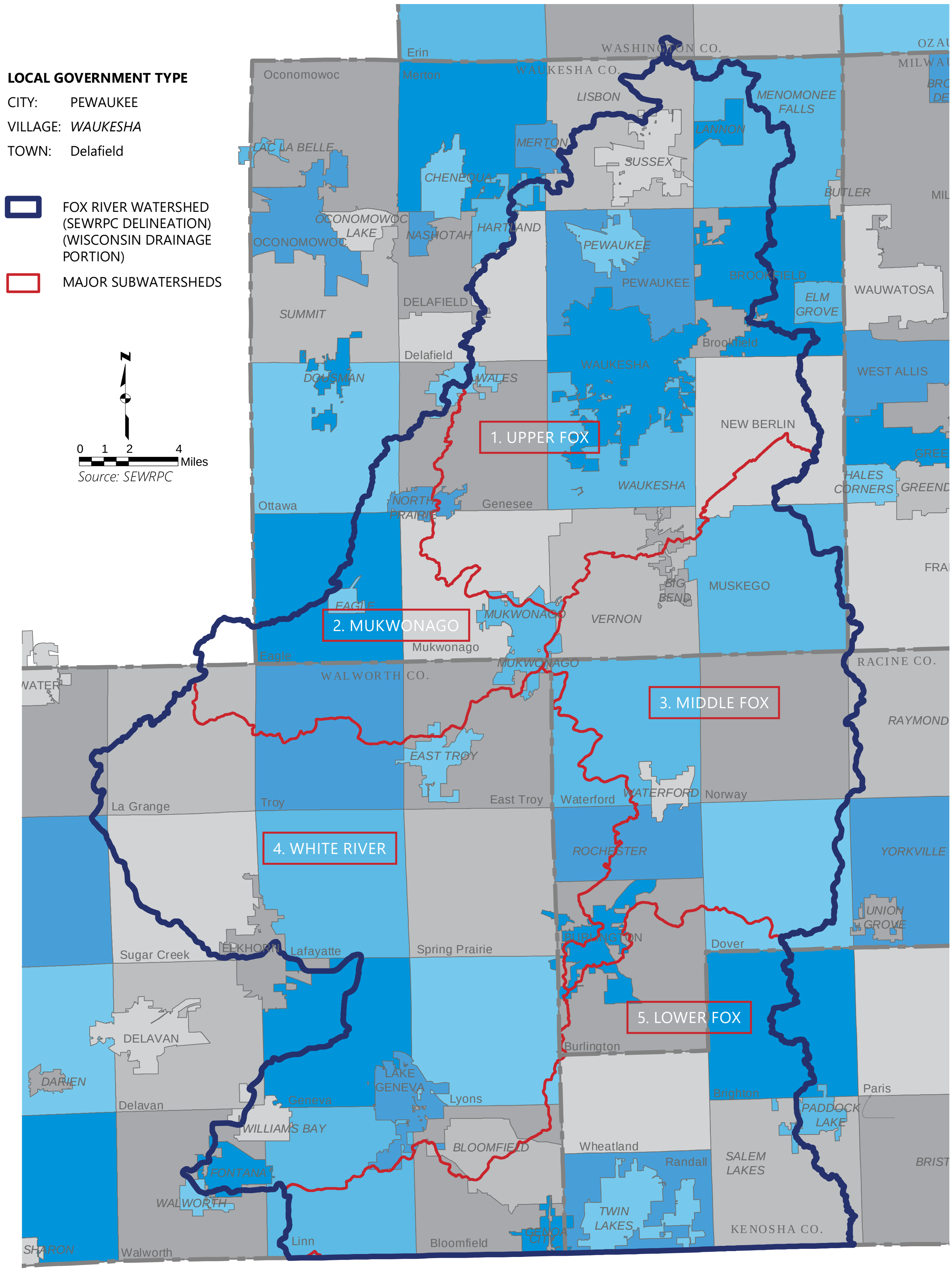
[1] *In this plan, the Fox (Illinois) River will henceforth be referred to as the Fox River for brevity.*

**Map 1.1**
**Fox River Watershed**



Source: USGS and SEWRPC

## Map 1.2
## Fox River Watershed Mitigation Plan - Municipality Map



## 1.3 RELATIONSHIP OF HAZARD MITIGATION PLANNING TO EMERGENCY OPERATIONS PLANNING

The focus of this planning effort is on hazard mitigation measures at the watershed and subwatershed scales. Such measures generally involve lasting, often permanent, strategies designed to reduce the exposure to, probability of, or potential loss from hazardous events, and are intended to be in place well in advance of any events. Such measures tend to focus on actions related to where and how to build structures, education to reduce losses or injury, and programs to improve the safety of identified hazard areas. A hazard mitigation plan outlines multiple strategies for mitigating the hazards potentially impacting an area or community.

This mitigation plan should be distinguished from, but compatible with, an emergency operations plan. An emergency operations plan is defined as a plan which describes how people and property will be protected in and during disaster and disaster threat situations; details who is responsible for conducting specific actions; identifies the personnel, equipment, facilities, supplies, and other resources available for use in the disaster; and outlines how all actions will be coordinated. Numerous such plans have been developed at the jurisdictional level, and often involve mutual assistance and cooperation agreements between local units of government in adjoining municipalities, both within and outside of the Fox River watershed.

Nonetheless, it was discovered as part of this planning effort that many watershed entities were not well versed in how the Fox River stream system works, nor how to find tools to monitor for rainfall events and water levels, nor who is responsible for dams or dam management and coordination among communities. Knowledge in these topics can improve emergency operations and can contribute to long-term mitigation strategies to reduce the long-term risk to human life and property.

## 1.4 RELATIONSHIP OF WATERSHED MITIGATION PLAN TO COUNTYWIDE HAZARD MITIGATION PLANS

This plan is meant to supplement and work in conjunction with the hazard mitigation recommendations made in the latest countywide hazard mitigation plans for Kenosha, Racine, Walworth, and Waukesha Counties. The plan aims to analyze the Fox River watershed on a level not covered by the countywide plans, because watershed geography is not confined based on county boundaries. A watershed-level hazard mitigation plan allows for a full analysis of the Fox River and its tributaries, unimpeded by political borders.

## 1.5 SCOPE AND PURPOSE OF PLAN

This plan focused on water-based hazards including flooding, dam failures, and drought on a watershed level. Vulnerability assessments were done for all the focus issues, and recommendations were made for potential strategies to mitigate the hazards of interest. Through these tasks, the plan aimed to fulfill these primary objectives:

- Coordinate flood hazard mitigation for the watershed
- Improve flood risk assessment and flood forecast warning
- Promote a regional effort to protect communities and infrastructure from flooding and drought
- Develop a prioritized plan for long term resilience
- Identify potential funding sources

To accomplish this, the plan focused on the following scope of work, as identified in the grant proposal:

- Identify insurable structures mapped in the regulatory floodplain, including critical facilities
- Identify major flooded stream crossings for stability, vulnerable utilities, and emergency routes

- Inventory major dams, including their structure and operation
- Review lake, stream, and rain gages for forecasting potential and additional needs
- Identify groundwater recharge areas to preserve
- Identify large floodplain storage areas to preserve

## 1.6 REVIEW OF PLAN DEVELOPMENT EFFORTS, PROCESS AND ADOPTION

Pursuant to a request from the Waukesha County Emergency Management on January 30, 2019, in collaboration with the Wisconsin Emergency Management and the Eagle Spring Lake Management District, SEWRPC prepared a scope of work for the Fox (Illinois) River Watershed - Pre-Disaster Mitigation Plan, transmitted on February 8, 2019. The County submitted a proposal to the FEMA Federal Insurance and Mitigation Administration's Fiscal Year 2019 Pre-Disaster Mitigation (PDM) Grant Program and the grant was approved by FEMA on June 7, 2021.

**Participation of Agencies, Stakeholders, and Public**

The plan was developed as a multi-jurisdictional plan, including the municipalities located within the Wisconsin portion of the Fox River watershed. A Local Planning Team (LPT) was created, with invitations to elected and appointed officials, agency and business representatives, dam operators, and citizens from throughout the watershed knowledgeable in hazard mitigation matters. The LPT was formed so that representatives throughout the Fox River watershed could participate in plan development. Examples of participation include, but are not limited to, attending planning meetings; contributing research, data, or other information; and commenting on drafts of the plan. This group explored the feasibility of potential mitigation measures for each hazard (flooding, dam failures, and drought), identify and prioritize mitigation projects and strategies, and potential funding sources. The planning and data contributions of participating jurisdictions and organizations, including those in the LPT, are listed in Table 1.1.

**Process and Adoption**

A kick-off meeting was held on September 16, 2021, to provide the LPT an opportunity to discuss the plan's purpose, goals, and scope, as well as inventory data available for analysis and discuss next steps for developing the plan. After all attendee comments had been noted and considered, Commission staff began collecting data as part of the vulnerability assessments for flooding, dam failures, and drought. Another planning meeting was held on May 23, 2022, in which the LPT discussed the results of the vulnerability assessment data, as well as reviewed a draft outline for the plan. The LPT also brainstormed potential additional mitigation projects that could be employed within the watershed.

As draft chapters of the plan were completed, copies were placed in downloadable form on the SEWRPC website and a webpage was available on which members of the public could ask questions and submit comments. A planning meeting for published Chapters 1 through 3 was held on March 13, 2023, in which the LPT discussed edits and additional information for the draft text as well as mitigation strategies to include in later chapters. A meeting to discuss draft text for Chapters 4 and 5 was held on June 26, 2023. Following completion of a draft plan and review of the draft by the LPT, a public informational meeting was held to review these sections of the plan with local officials, business and industry, and citizens to solicit their input. Copies of the draft plan were made available at the Waukesha County Division of Emergency Management and on the SEWRPC website.

Wisconsin Emergency Management and FEMA reviewed the plan based on the original scope of work. Following a finding by FEMA that the plan met the scope, the plan was brought to the county boards for adoption (a copy of the draft resolution is included in Appendix E). Copies of the plan were also sent to each of the local units of government highlighting the benefits of adopting the plan, including enhanced priority for relevant projects submitted to grant programs. County and Commission staffs were available to meet with communities on an individual basis to review the plan and consider adoption and implementation steps.

**Table 1.1**
**Participation in the Fox River Watershed Mitigation Plan**

| Entity | Forms of Involvement |
|---|---|
| Cities | |
| Burlington | Provision of data (dams)[a] |
| Lake Geneva | Attendance at LPT meetings |
| Muskego | Provision of data (dams)[a] |
| Waukesha | Attendance at LPT meetings |
| Villages | |
| Mukwonago | Attendance at LPT meetings, Provision of data (dams)[a] |
| Pewaukee | Provision of data (dams)[a] |
| Counties | |
| Kenosha County | Attendance at LPT meetings |
| Racine County | Attendance at LPT meetings, Provision of data (dams)[a] |
| Walworth County | Attendance at LPT meetings, Provision of data (dams)[a] |
| Waukesha County | Attendance at LPT meetings |
| Dam Operation | |
| Eagle Spring Lake Management District | Attendance at LPT meetings, Provision of data (dams)[a] |
| Geneva Lake Level Corporation | Provision of data (dams)[a] |
| Lauderdale Lakes Lake Management District | Provision of data (dams)[a] |
| Other | |
| US Army Corps of Engineers | Attendance at LPT meetings |
| Federal Emergency Management Agency | Provision of data[a] |
| Foth | Attendance at LPT meetings |
| Fox River Flood Coalition (Illinois) | Provision of data[a] |
| Fox River Waterway Agency (Illinois) | Provision of data[a] |
| National Weather Service | Attendance at LPT meetings, Provision of data[a] |
| Resource Environmental Solutions | Attendance at LPT meetings |
| Southeast Wisconsin Fox River Commission | Provision of data[a] |
| Wisconsin Department of Emergency Management | Attendance at LPT meetings, Provision of data[a] |
| Wisconsin Department of Natural Resources | Attendance at LPT meetings, Provision of data[a] |
| Wisconsin Department of Transportation | Attendance at LPT meetings, Provision of data[a] |
| SEWRPC | Attendance at LPT meetings |

[a] *Provision of data includes providing information on hazards experienced, projects undertaken, and outreach efforts as well as sharing of relevant plans, reports, and concerns.*

*Source: SEWRPC*

# WATERSHED INVENTORY 2

## 2.1 INTRODUCTION

Information on pertinent natural and built features within the Fox River watershed is an important consideration in sound hazard mitigation planning. Accordingly, the collection and collation of definitive information in the Fox River watershed regarding basic geographic characteristics, existing and planned land use, surface water system characteristics, critical community facilities, and major infrastructure constitute important steps in the planning process. The following in-depth information regarding the relevant conditions in the study area is useful in formulating and evaluating sound mitigation approaches.

## 2.2 CIVIL DIVISIONS

The Fox River watershed covers 2,648 square miles, with approximately 925 square miles in Wisconsin and the remaining 1,723 square miles in Illinois. Within Wisconsin, the watershed drains portions of six counties (Jefferson, Kenosha, Milwaukee, Racine, Walworth, Washington, and Waukesha) and 65 municipalities. For planning purposes, this study will only include Kenosha, Racine, Walworth, and Waukesha Counties, which comprise more than 98 percent of the total area of the watershed in Wisconsin.

Superimposed over natural boundaries, such as watershed and major subwatershed boundaries, is a pattern of local and political boundaries, as shown in Map 1.2. As indicated on the map, the political boundaries (or civil divisions) are only shown on the Wisconsin portion of the overall watershed. It should be noted that human- and natural-made induced impacts and associated impact reduction strategies in this plan can affect the entire watershed (e.g., communities downstream in Illinois). As previously mentioned in Chapter 1, this plan is focused on the Wisconsin portion of the basin, but neighboring communities at the Wisconsin-Illinois boundary were made aware of this planning effort and contributed to the plan. Political boundaries within the watershed are an important factor because they form the foundation of the public decision-making framework within which intergovernmental, environmental, and development issues may be addressed. For example, actions by communities in upstream areas of the river network can greatly impact communities downstream. Issues include strategies on how to best mitigate future hazard events, such as flooding, dam failure, severe thunderstorms, and drought. Within the watershed, there are ten cities, 24 villages, and 31 towns (shown on Map 1.2). The municipalities with the largest total acreages within the Fox River watershed are the Cities of Muskego, New Berlin, Pewaukee, and Waukesha, and the Villages of Bloomfield, Menomonee Falls, and Salem Lakes, all of which are entirely or nearly entirely located within the watershed (see Table 2.1).

## 2.3 LAND USE

Land use is an important determinant of the potential impact hazards may have, and of the actions which may or should be taken to mitigate the impacts caused by certain hazards. Accordingly, an understanding of the amount, type, and spatial distribution of urban and rural land uses within the watershed is an important consideration in the development of a sound mitigation plan. The existing land use pattern can best be understood within the context of its historical development. This section presents information on past land use, existing land use, and planned land use within the Fox River watershed.

### Historical Urban Growth

Historical records of urban growth and development can help inform the history of land use within a watershed. Urban growth within the Fox River watershed is summarized on Map 2.1 and Table 2.2. In 1850, urban growth only constituted 229 acres of the watershed, which is less than 0.2 percent of the cumulative total urban growth area compared to year 2010 conditions. Between 1850 and 1900, urban growth was largely limited to the Cities of Waukesha and Lake Geneva. The greatest periods of historic urban growth within the watershed occurred between 1950 to 1963, 1970 to 1980, and 2000 to 2010. Most of the current

## Table 2.1
## Fox River Watershed Municipalities: 2015

| Municipality | Land Area (square miles) | Percent of Watershed |
|---|---|---|
| Cities | | |
| Brookfield | 14.3 | 1.5 |
| Burlington | 7.9 | 0.9 |
| Delafield | 0.1 | 0.0 |
| Elkhorn | 3.9 | 0.4 |
| Franklin | 0.4 | 0.0 |
| Lake Geneva | 7.6 | 0.8 |
| Muskego | 31.8 | 3.4 |
| New Berlin | 27.0 | 2.9 |
| Pewaukee | 21.3 | 2.3 |
| Waukesha | 25.7 | 2.8 |
| Towns | | |
| Bloomfield | 19.9 | 2.1 |
| Brighton | 20.5 | 2.2 |
| Brookfield | 5.0 | 0.5 |
| Burlington | 34.2 | 3.7 |
| Delafield | 14.2 | 1.5 |
| Delavan | 0.5 | 0.1 |
| Dover | 31.0 | 3.4 |
| Eagle | 19.5 | 2.1 |
| East Troy | 29.6 | 3.2 |
| Genesee | 26.8 | 2.9 |
| Geneva | 20.2 | 2.2 |
| Lafayette | 34.1 | 3.7 |
| LaGrange | 23.0 | 2.5 |
| Linn | 30.5 | 3.3 |
| Lyons | 34.4 | 3.7 |
| Merton | 0.5 | 0.1 |
| Mukwonago | 30.9 | 3.3 |
| Norway | 35.6 | 3.8 |
| Ottawa | 2.2 | 0.2 |
| Randall | 13.8 | 1.5 |
| Richmond | 0.3 | 0.1 |
| Spring Prairie | 35.8 | 3.9 |
| Sugar Creek | 23.9 | 2.6 |
| Troy | 35.5 | 3.8 |
| Walworth | 2.2 | 0.2 |
| Waterford | 33.7 | 3.6 |
| Wheatland | 24.1 | 2.6 |
| Whitewater | 0.6 | 0.1 |
| Villages | | |
| Big Bend | 3.3 | 0.4 |
| Bloomfield | 13.0 | 1.4 |
| Eagle | 1.4 | 0.1 |
| East Troy | 4.6 | 0.5 |
| Fontana-On-Geneva-Lake | 3.8 | 0.4 |
| Genoa City | 2.6 | 0.3 |
| Hartland | 1.2 | 0.1 |
| Lannon | 2.5 | 0.3 |
| Lisbon | 15.2 | 1.6 |
| Menomonee Falls | 14.8 | 1.6 |
| Merton | 0.0 | 0.0 |
| Mukwonago | 8.2 | 0.9 |
| North Prairie | 2.8 | 0.3 |

**Table continued on next page.**

**Table 2.1 (Continued)**

| Municipality | Land Area (square miles) | Percent of Watershed |
|---|---|---|
| Villages (continued) | | |
| Paddock Lake | 0.5 | 0.1 |
| Pewaukee | 4.5 | 0.5 |
| Raymond | 1.7 | 0.2 |
| Richfield | 0.3 | 0.1 |
| Rochester | 17.7 | 1.9 |
| Salem Lakes | 26.9 | 2.9 |
| Sussex | 7.7 | 0.8 |
| Twin Lakes | 10.0 | 1.1 |
| Vernon | 31.0 | 3.4 |
| Wales | 1.8 | 0.2 |
| Walworth | 0.2 | 0.1 |
| Waterford | 2.5 | 0.3 |
| Waukesha | 20.8 | 2.3 |
| Williams Bay | 3.0 | 0.3 |
| Total | 924.5 | 100.0 |

*Source: SEWRPC*

urban growth is concentrated in the northern half of the watershed, but the southern half of the watershed includes urban centers at the Cities of Burlington, Lake Geneva, and Waterford as well as the Village of Mukwonago.

**Existing Land Use: 2015**

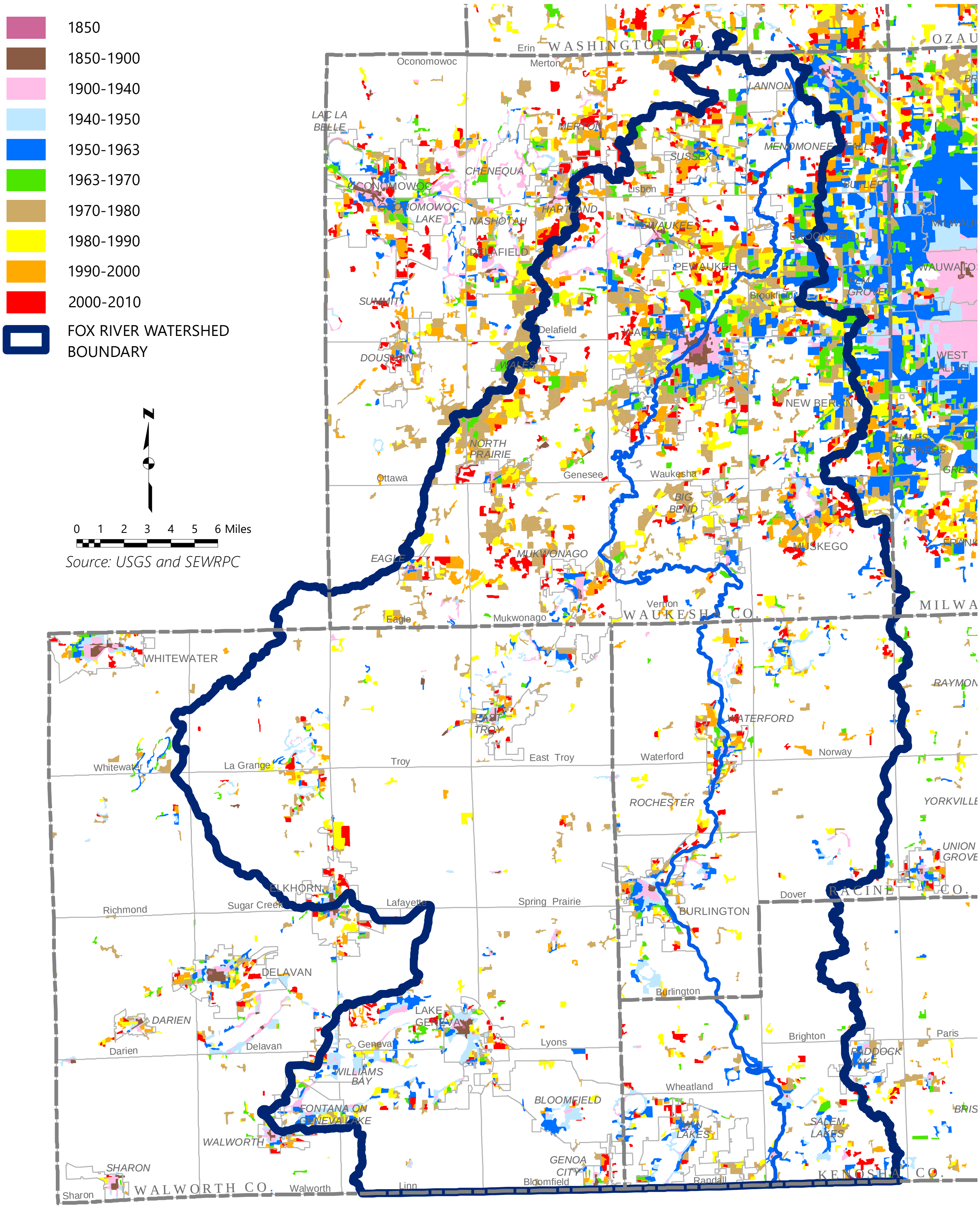
Land uses within the Fox River watershed are based on the SEWRPC land use inventory conducted in 2015, as shown on Map 2.2 and summarized in Table 2.3. Agricultural and open lands were the most dominant land use occupying 47 percent of the Fox River watershed. Residential, wetland, and woodlands land uses were the next most dominant land uses occupying 14, 13, and 9 percent of the watershed, respectively. While the watershed has historically been and remains predominantly rural, urban land use has been expanding within the watershed.

**Planned Land Use**

Planned land use must seek to accommodate the impending demand for land within the Region, which primarily depends on future population, households, and employment levels. SEWRPC recently completed projections of land use, population, households, and employment from the period of 2010 to 2050 to provide a basis for preparation of VISION 2050 (the regional land use and transportation plan). Map 2.3 presents the recommended development pattern from the VISION 2050 land use component plan as it pertains to the Fox River watershed.

Planned urban-density areas depicted on Map 2.3 include the Commission's growth projections for seven land use categories that represent a variety of development densities and mixes of uses. These land use categories, as listed on Map 2.3, include mixed-use city center and traditional neighborhoods; small, medium, and large lot traditional neighborhoods; large lot exurban; rural estate; agricultural and other open lands; and primary environmental corridors. As indicated on Map 2.3, future urban-density areas are associated with the Cities of Brookfield, Burlington, Lake Geneva, Muskego, Pewaukee, and Waukesha. Villages with such anticipated urban-density areas include East Troy, Fontana-on-Geneva Lake, Mukwonago, Salem Lakes, Sussex, Twin Lakes, Waterford, and Williams Bay. There are also several scattered unincorporated communities included as planned urban areas, the largest of which are the Wind Lake area in the Town of Norway, and the Tichigan and Buena Lake areas in the Town of Waterford. Anticipating the needs of future populations, rather than responding to problems as they occur, is a main goal of mitigation planning.

## Map 2.1
## Historic Urban Growth in the Fox River Watershed: 1850 - 2010



## 2.4 SURFACE WATER AND GROUNDWATER RESOURCES

As shown in Map 2.4, the surface water resources within the Fox River watershed include streams, ponds, lakes, and wetlands. They form one of the most important elements of the natural resource base of the watershed. Their contribution to the wildlife habitat, economic development, recreational activity, and aesthetic quality of the watershed are immeasurable. The Fox River and its tributaries receive water from surface-water runoff, springs, seeps, direct precipitation, and human-derived sources such as discharge from wastewater treatment plants. The groundwater resources of the Fox River watershed are hydraulically connected to the surface water resources and provide baseflow to the streams. It is important to understand the watershed's major water resources and their interconnection to properly protect and enhance these water features for watershed planning.

**Table 2.2**
**Fox River Historic Urban Growth: 1850-2010**

| Year | Urban Area (Square Miles) | Cumulative Urban Area (Square Miles) |
|---|---|---|
| 1850 | 0.4 | 0.4 |
| 1880 | 1.5 | 1.9 |
| 1900 | 0.6 | 2.5 |
| 1920 | 3.8 | 6.3 |
| 1940 | 3.7 | 10.1 |
| 1950 | 11.0 | 21.1 |
| 1963 | 26.2 | 47.3 |
| 1970 | 14.3 | 61.7 |
| 1975 | 16.3 | 78.0 |
| 1980 | 23.9 | 101.9 |
| 1985 | 11.3 | 113.2 |
| 1990 | 12.5 | 125.8 |
| 1995 | 11.4 | 137.2 |
| 2000 | 13.2 | 150.4 |
| 2010 | 18.4 | 168.8 |

*Source: SEWRPC*

### Stream Network

In Wisconsin, the Fox River watershed includes 750 miles of perennial streams and 600 miles of intermittent streams.[2] The Fox River becomes a sixth order stream when it merges with the Wind Lake Canal near Rochester in Racine County and continues to be a sixth order stream to the Illinois state line.[3] It is the only sixth order stream in southeastern Wisconsin, draining more land area than any other single watercourse.

As highlighted on Map 2.5, the Fox River watershed in Wisconsin is delineated into 35 subwatersheds. As discussed in Chapter 1, for this study the Fox River watershed was subdivided into five major subwatersheds that include the following from upstream to downstream:

1. Upper Fox River
2. Mukwonago River
3. Middle Fox River
4. White River
5. Lower Fox River

The major subwatersheds include the following subwatersheds from upstream to downstream (Map 2.5):

1. Upper Fox River
   a. Fox River Mainstem – Northern Upper Fox River, Upper Fox River, Upper Middle Fox River
   b. Tributaries – Sussex Creek, Deer Creek, Poplar Creek, Pewaukee Lake, Pewaukee River, Pebble Creek, Genesee Creek, Pebble Brook

2. Mukwonago River
   a. Tributaries – Jericho Creek, Mukwonago River

[2] *WDNR,* Southeast Fox Illinois River Basin*, dnr.wi.gov.*

[3] *Stream order refers to a system used to organize tributaries by their watershed position. First order streams are the smallest perennial headwater tributaries. Where two first order streams converge, a second order stream results, the convergence of two second order streams produces a third order stream, and so on. More information on stream orders may be found on the USGS website.*

## Map 2.2
## Existing Land Uses in the Fox River Watershed: 2015

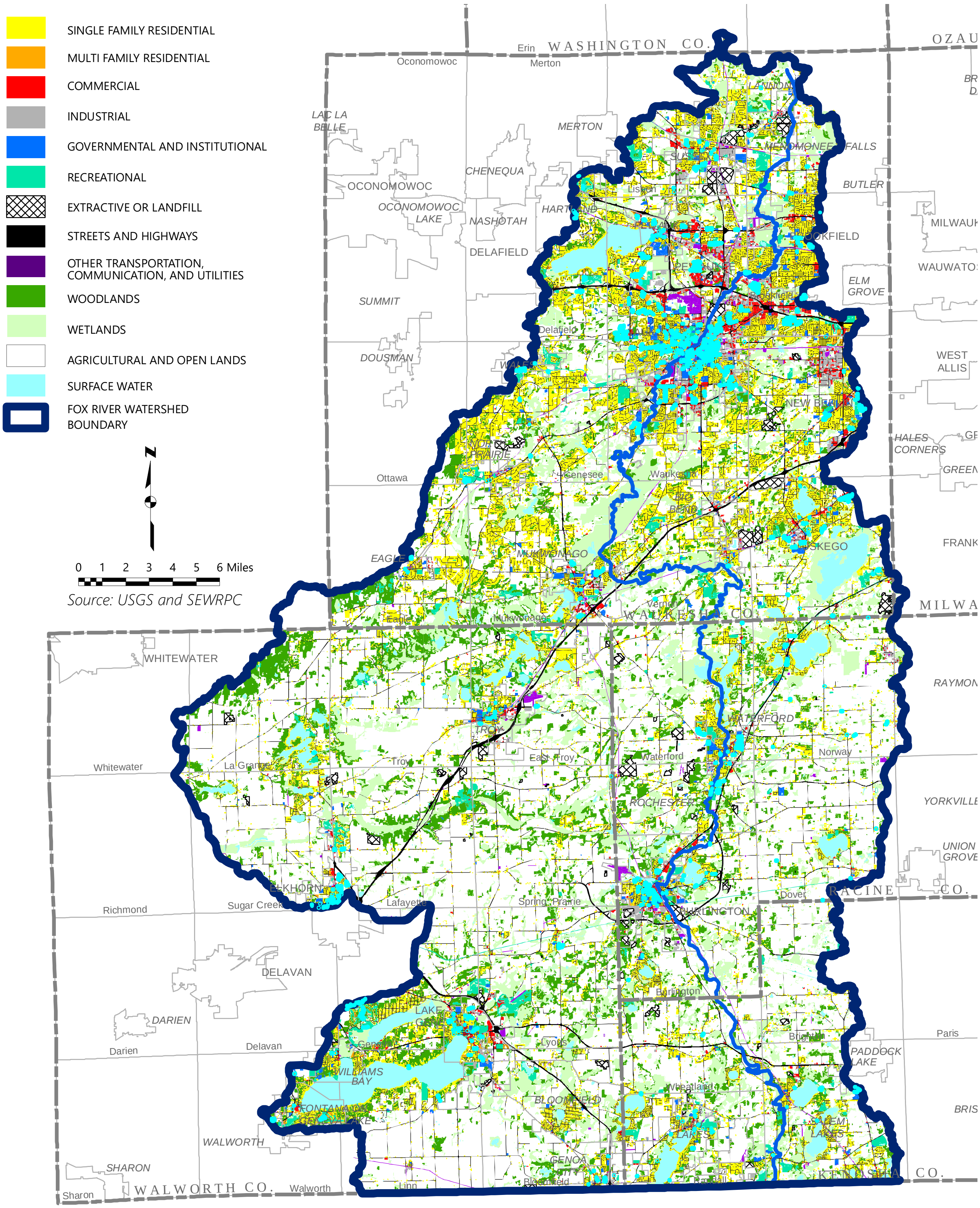


**Table 2.3**
**Fox River Watershed Generalized Land Use: 2015**

| Land Use Category | Square Miles | Percent of Watershed |
|---|---|---|
| Urban | | |
| Residential | 126.0 | 13.6 |
| Commercial | 5.0 | 0.6 |
| Industrial | 6.2 | 0.7 |
| Transportation, Communications, and Utilities | 68.0 | 7.4 |
| Governmental and Institutional | 6.5 | 0.7 |
| Recreational | 17.7 | 1.9 |
| Urban Subtotal | 229.4 | 24.9 |
| Nonurban | | |
| Agricultural and Other Open Lands | 437.8 | 47.3 |
| Extractive | 7.5 | 0.8 |
| Woodlands | 84.0 | 9.0 |
| Wetlands | 122.6 | 13.3 |
| Surface Water | 43.2 | 4.7 |
| Nonurban Subtotal | 695.1 | 75.1 |
| Total | 924.5 | 100.0 |

*Source: SEWRPC*

3. Middle Fox River
   a. Fox River Mainstem – Lower Middle Fox River
   b. Tributaries – Muskego Lake, Wind Lake Drainage Canal, Eagle Creek

4. White River
   a. Tributaries – North Lake Drainage Area, Honey Creek, Sugar Creek, Lake Como, Como Creek, Ore Creek, Lake Geneva, White River, Ivanhoe Creek

5. Lower Fox River
   a. Fox River Mainstem – Lower Fox River
   b. Tributaries – Hoosier Creek, New Munster Creek, Peterson Creek, Bassett Creek, Trevor Creek, Nippersink Creek, East Branch Nippersink Creek, North Branch Nippersink Creek, Twin Lakes

## Floodplains

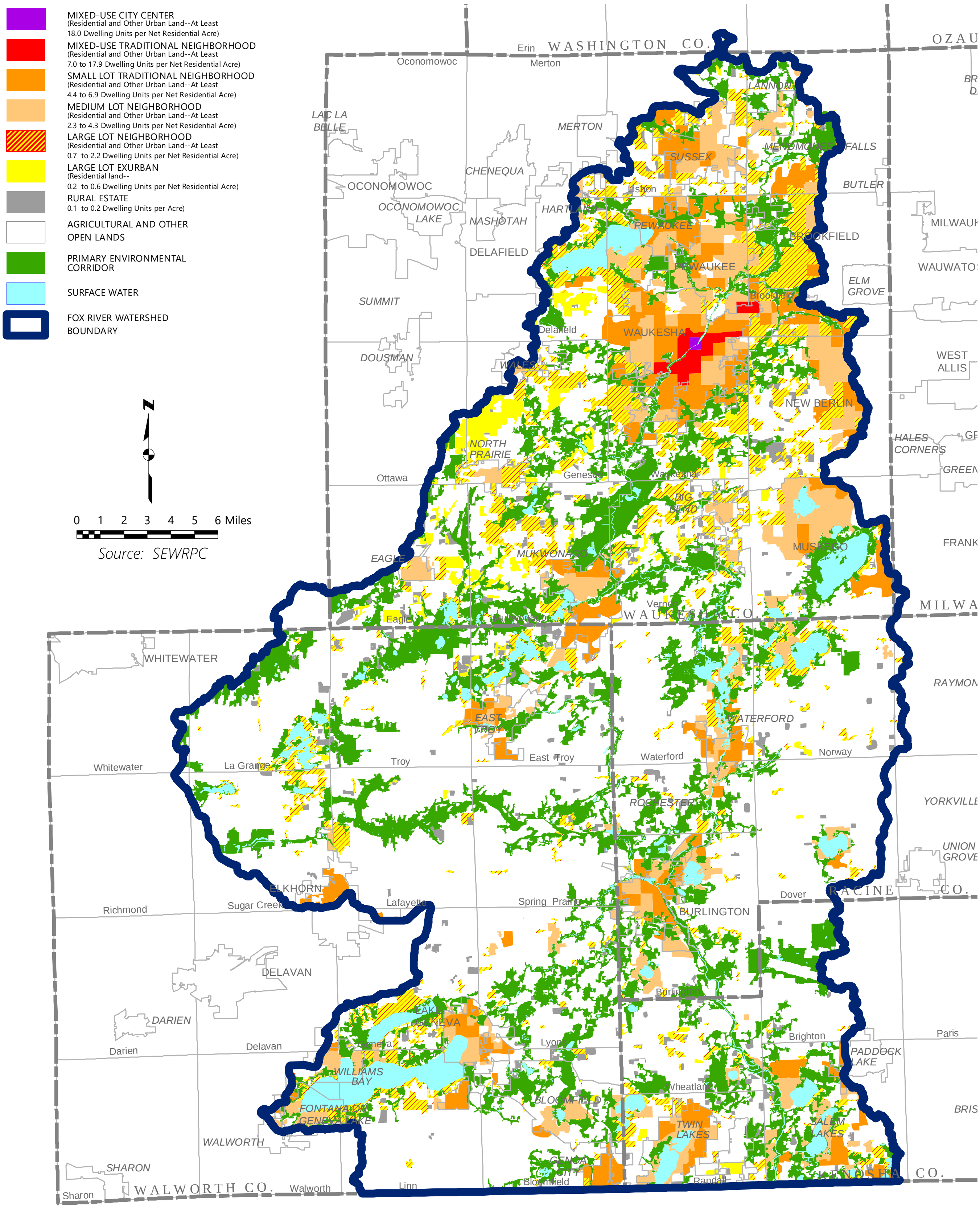
Floodplains are the wide, gently sloping areas contiguous to, and usually lying on both sides of a stream channel. For planning and regulatory purposes, floodplains are normally defined as the areas, excluding the stream channel, subject to inundation by the 1-percent-annual-probability flood event. There is a one percent chance of this flood event being reached or exceeded in any given year. Floodplain areas are generally not well suited to urban development, not only because of the flood hazard, but also because of the presence of high-water tables and, generally, of soils poorly suited to urban uses. Floodplain areas often contain important natural resources, such as high-value woodlands, wetlands, and wildlife natural areas and critical species habitats and, therefore, constitute prime locations for parks and open space areas. Map 2.6 illustrates the 1-percent-annual-probability floodplain in the Fox River watershed.

### *Federal Emergency Management Agency (FEMA) Flood Zones*

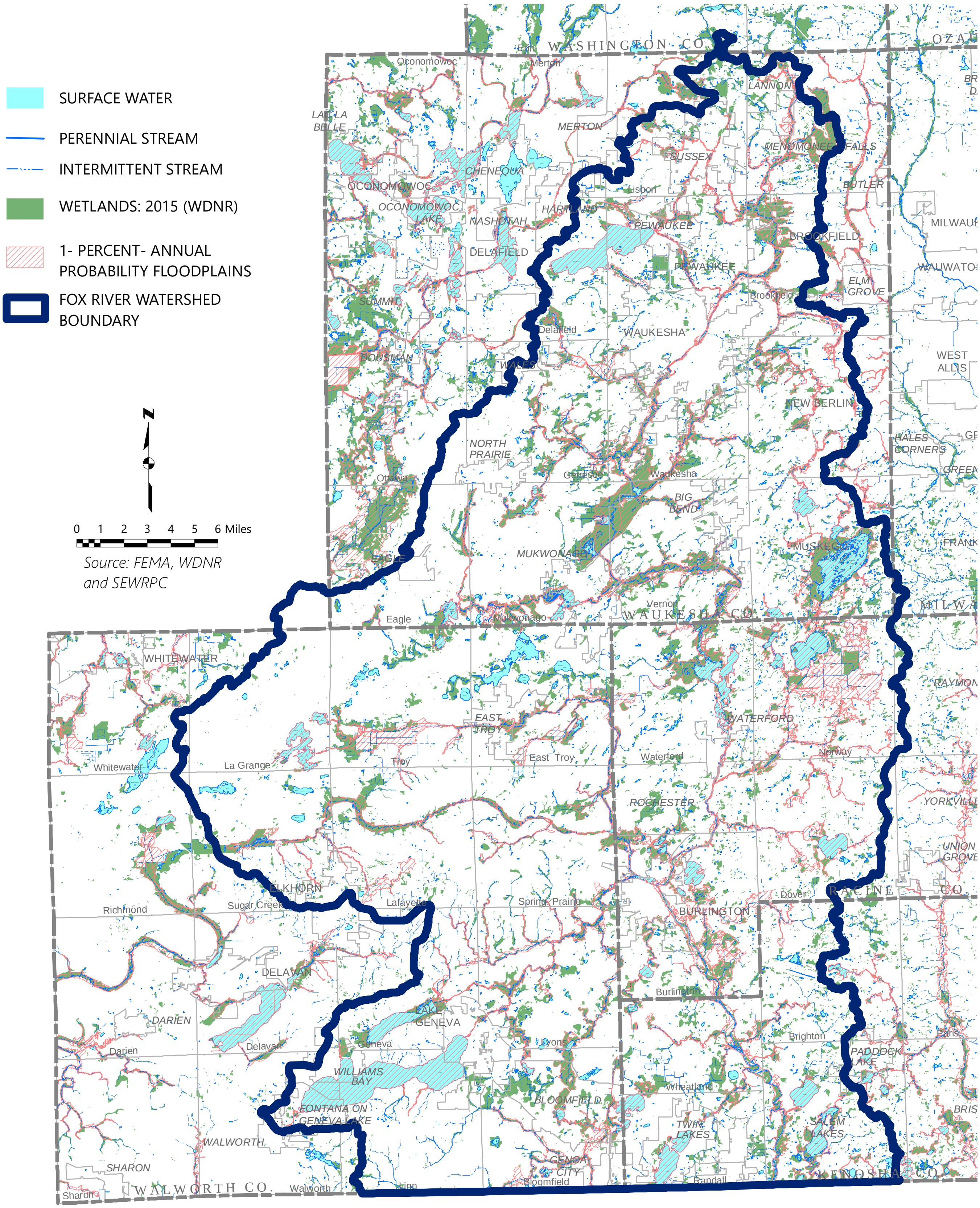
Flood hazard areas identified on FEMA Flood Insurance Rate Maps (FIRMs) are identified as Special Flood Hazard Areas (SFHA). SFHAs are defined as the area that will be inundated by the 1-percent-annual-probability (or chance) flood. The 1-percent-annual-probability flood is also referred to as the "base flood" or "100-year flood."[4] In addition, SFHAs are labeled as zones such as "Zone A" and "Zone AE." Zone A is the *approximate* 1-percent-annual-probability floodplain and was developed using approximate modeling methods. Zone A floodplains do not include water surface elevations. Zone AE is the 1-percent-annual-probabilty (or 100-year) floodplain and was developed using detailed modeling methods, which includes water surface elevations.

[4] *www.fema.gov*

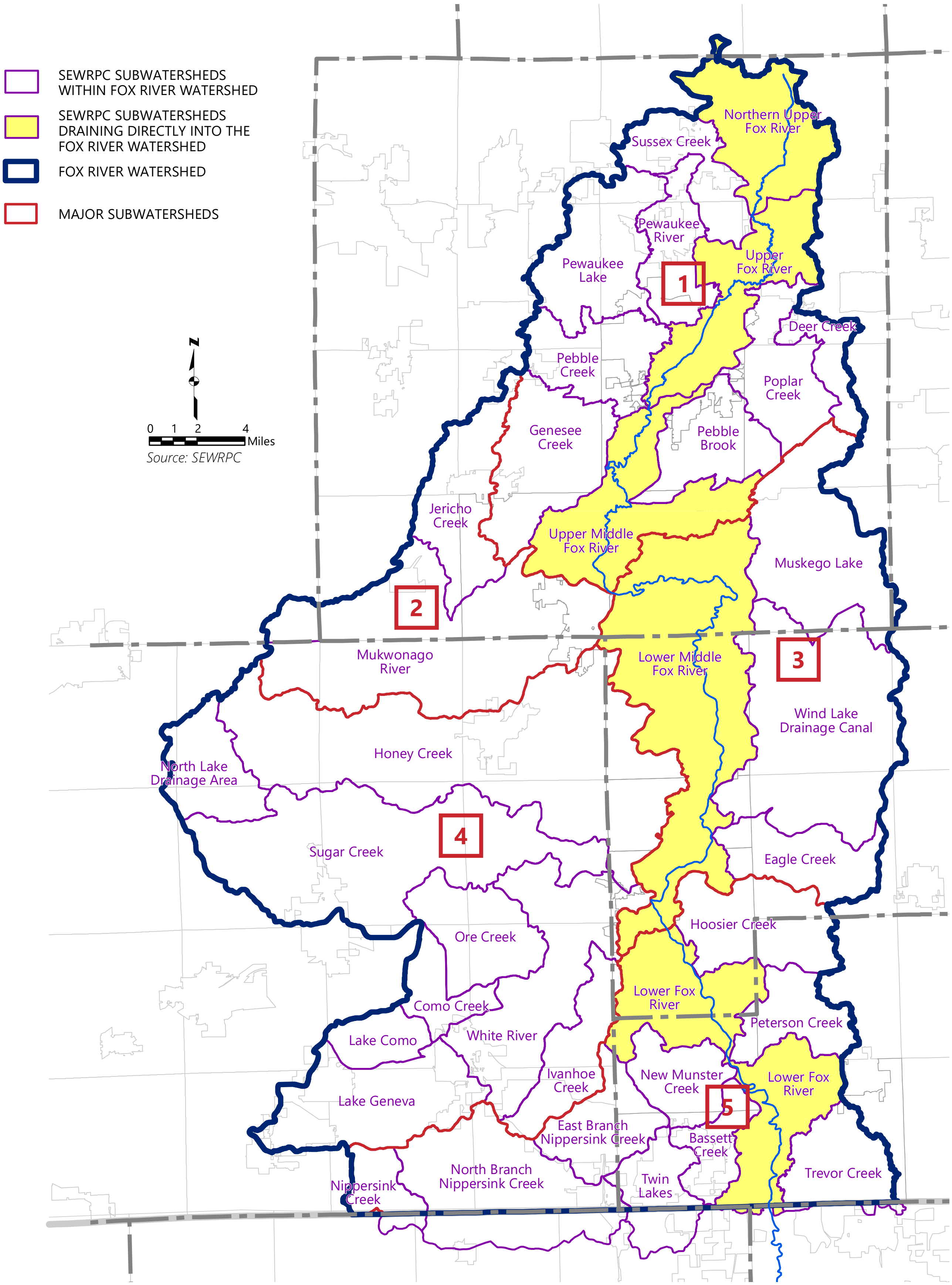
## Map 2.3
## Future Regional Land Use Plan as it Pertains to the Fox River Watershed



**Map 2.4**
**Surface Water, Wetlands and Floodplains in the Fox River Watershed**



**Map 2.5**
**Fox River Subwatershed Index Map**



### *Effective and Preliminary Flood Hazard Areas*

To evaluate flood risks in the Fox River watershed, it is important to utilize the best available floodplain information. Therefore, two sets of FEMA Flood Insurance Rate Maps were used in this study, which included the effective and preliminary mapping. Effective data are flood hazard data that are officially adopted by FEMA and communities participating in the National Flood Insurance Program (NFIP) for regulatory and flood insurance purposes. Preliminary data are new or revised flood hazard data provided to the public for a review prior to becoming the new effective flood hazard data. As of July 2023, effective FIRMs exist for all the counties within the Fox River watershed, while preliminary FIRMs exist for Kenosha, Racine, and Waukesha Counties only. The preliminary FIRMs were developed as part of the latest Risk Mapping, Assessment, and Planning (Risk MAP) effort being completed by WDNR and FEMA. The preliminary FIRMs are not the current regulatory flood mapping; however, they were used to evaluate flood risks in the watershed because they utilized improved data and once finalized will become the new effective flood mapping in the region. The FEMA 1-percent-annual-probablity effective floodplains are found on Map 2.6. Information related to the preliminary FEMA floodplain mapping in the Fox River watershed can be found in Appendix A.

### *Floodplain Zoning*

Section 87.30 of the *Wisconsin Statutes* requires that counties, cities, and villages adopt floodplain zoning ordinances, and all the municipalities in the Fox River watershed have floodplain ordinances in place.[5] These floodplain zoning ordinances are meant to discourage development in the floodplain where practicable, in order to protect life, health, and property, to reduce economic disruption and losses, to reduce the need for rescue operations, and to prevent increases in flood heights. The minimum standards that such ordinances must meet are set forth in Chapter NR 116, "Wisconsin's Floodplain Management Program," of the *Wisconsin Administrative Code*, as well as Title 44 ("Emergency Management and Assistance") of the Code of Federal Regulations. The required regulations govern filling and development within a regulatory floodplain, which is defined as the area that has a 1-percent-annual-probability of being inundated. As required under Chapter NR 116, local floodplain zoning regulations must prohibit nearly all development within the floodway, which is that portion of the floodplain with actively flowing water conveying the 1-percent-annual-probability peak flood flow. Local regulations must also restrict filling and development within the flood fringe, which is that portion of the floodplain located beyond the floodway. Filling within the flood fringe reduces floodwater storage capacity and may increase downstream flood flows and flood depths/elevations.

Ordinances related to floodplain zoning recognize existing uses and structures and regulate them in accordance with sound floodplain management practices. These ordinances are intended to: 1) regulate and diminish proliferation of nonconforming structures[6] and uses in floodplain areas; 2) regulate reconstruction, remodeling, conversion and repair of such nonconforming structures—with the overall intent of lessening public responsibilities generated by continued and expanded development of land and structures inherently incompatible with natural floodplains; and 3) lessen potential danger to life, safety, health, and welfare of persons whose lands are subject to the flood hazard.

## Wetlands

Wetlands form at the transition between surface water, groundwater, and land resources. Wetlands are areas that are inundated or saturated by surface water or groundwater at a frequency, and with a duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally occur in depressions and near the bottom of slopes, particularly along lakeshores and streambanks, and on large land areas that are poorly drained. Wetlands may, however, under certain conditions, occur on slopes and even on hilltops. In addition to being or serving as critical habitat for plants, animals, and other wildlife, wetlands also perform important natural functions in a watershed that include water quality protection by filtering and trapping nutrients and sediment, stabilization of lake levels and streamflow, reduction in stormwater runoff by providing areas for floodwater impoundment and storage, and protection of shorelines from erosion.

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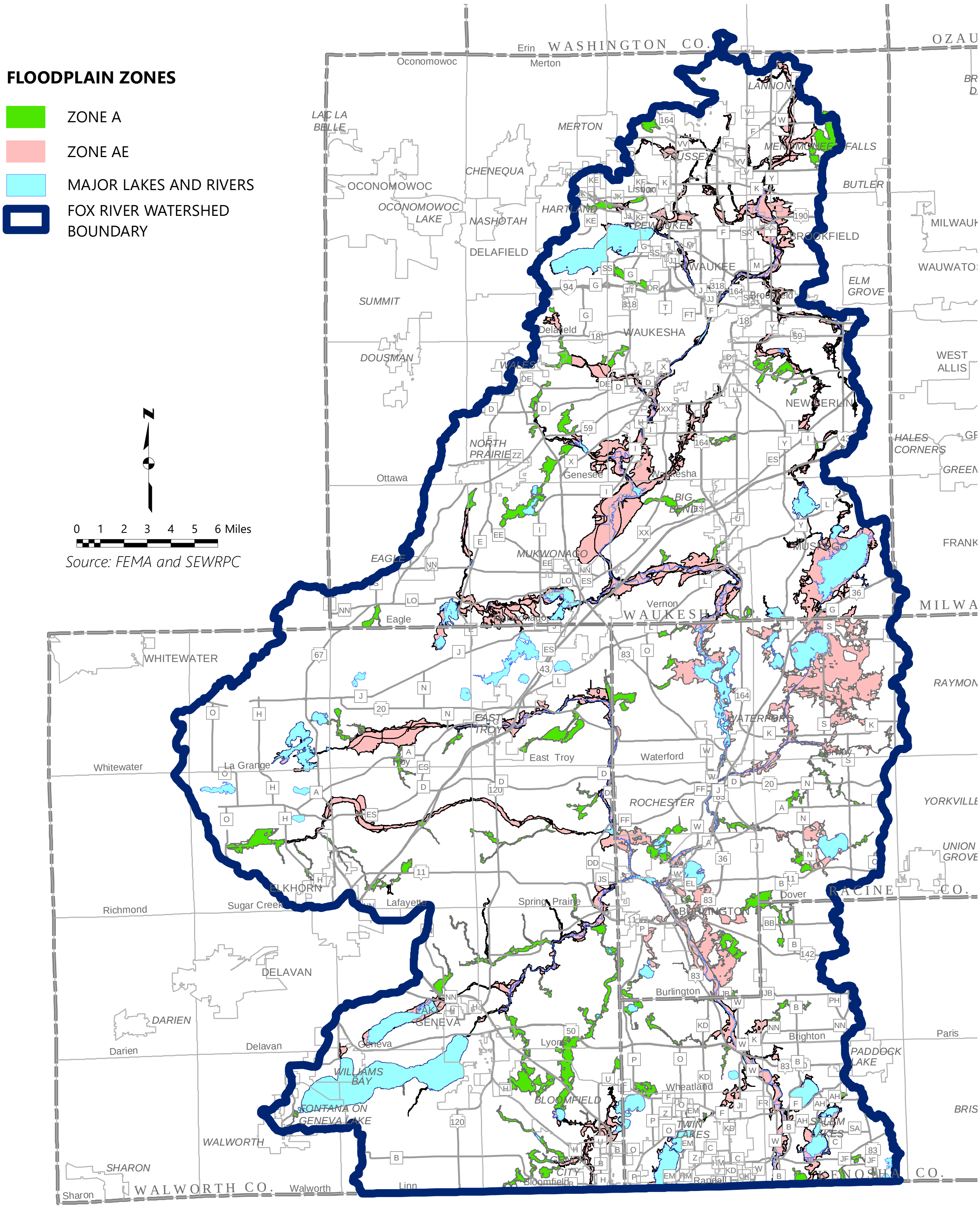
[5] *Towns are covered by the appropriate County floodplain ordinance.*

[6] *Existing lawful buildings in the floodplain not in conformity with the requirements of the floodplain zoning ordinance.*

## Map 2.6
## Effective 100 - Year Floodplains in the Fox River Watershed: 2022




Source: FEMA and SEWRPC

The location and extent of wetlands within the Fox River watershed are shown on Map 2.7. These wetland areas are defined based on the WDNR's Wisconsin Wetland Inventory originally completed for the southeastern Wisconsin region in 1982, and then updated to the year 2015 as part of the regional land use inventory. As presented in Table 2.3, wetlands encompassed about 13 percent of the area of the watershed.

#### *Shoreland and Shoreland-Wetland Zoning*

Under Section 59.692 of the *Wisconsin Statutes*, counties in Wisconsin are required to adopt zoning regulations within statutorily defined shoreland areas, or, those lands that are within 1,000 feet of the ordinary high water mark (OHWM) of a navigable lake, pond, or flowage, or 300 feet of the OHWM of a navigable stream, or, to the landward side of the floodplain, whichever distance is greater, within their unincorporated areas. Standards for county shoreland zoning ordinances are set forth in Chapter NR 115, "Wisconsin's Shoreland Protection Program," of the *Wisconsin Administrative Code*. Chapter NR 115 sets forth requirements regarding lot sizes and building setbacks; restrictions on cutting of trees and shrubbery; and restrictions on filling, grading, lagoons, dredging, ditching, and excavating that must be incorporated into county shoreland zoning regulations. In addition, Chapter NR 115 requires that counties place all wetlands five acres or larger and located within the statutory shoreland zoning jurisdiction area into a wetland conservancy zoning district to ensure their preservation after completion of appropriate wetland inventories by the WDNR. Aside from wetlands within the shoreland zone, selected wetlands generally five acres and larger are also placed into conservancy zoning outside the shoreland zone in the unincorporated areas.

In 1982, the State Legislature extended shoreland-wetland zoning requirements to cities and villages in Wisconsin. Under Sections 62.231 and 61.351, respectively, of the *Wisconsin Statutes* cities and villages in Wisconsin are required to place wetlands five acres or larger and located in statutory shorelands into a shoreland-wetland conservancy zoning district to ensure their preservation. Minimum standards for city and village shoreland-wetland zoning ordinances are set forth in Chapter NR 117, "Wisconsin's City and Village Shoreland-Wetland Protection Program," of the *Wisconsin Administrative Code*. All the municipalities in the Fox River watershed have shoreland and shoreland-wetland zoning protections in place.

### Lakes

There are 83 established lakes of 10 acres of more in the Fox River watershed (see Table 2.4). SEWRPC classifies lakes as either being minor or major, with major being 50 acres or more in lake surface area. There are 49 major lakes identified within the watershed, with the largest being Pewaukee, Big Muskego, and Geneva Lakes. The majority of the lakes are drainage lakes and depths are augmented and controlled by dam structures.

Currently, there are 27 lakes in the watershed that have a lake management district and/or association.[7] These special-purpose units of government are listed in Table 2.5. Lake associations and districts can serve many functions, including the encouragement and enhancement of communication between lake residents and other lake associations or districts; identifying and clarifying the needs of the lake; assist in environmental conservation; promote water education; encourage environmentally sound policy; obtain state funding for projects; assist in aquatic plant removal; maintain lake access; improve fish populations and habitat; and operate and manage dams. For the purpose of this planning effort, several of these functions can play a key role in flood mitigation, such as properly managing a dam and effectively communicating stream flow conditions to other dam operators to help alleviate downstream flooding.

### Groundwater Recharge Areas

Groundwater sustains pond levels and wetlands and provides the perennial baseflow for streams within the watershed including potable water supplies for residences, farming and other businesses. Thus, groundwater resources constitute an important element of the natural resource base within the watershed. The amount, movement, recharge, and discharge of groundwater is controlled by several factors, including precipitation, topography, drainage, land use, soil, and the lithology and water-bearing properties of rock units. The continued growth of population and industry within the Fox River watershed necessitates the wise development and management of groundwater resources.

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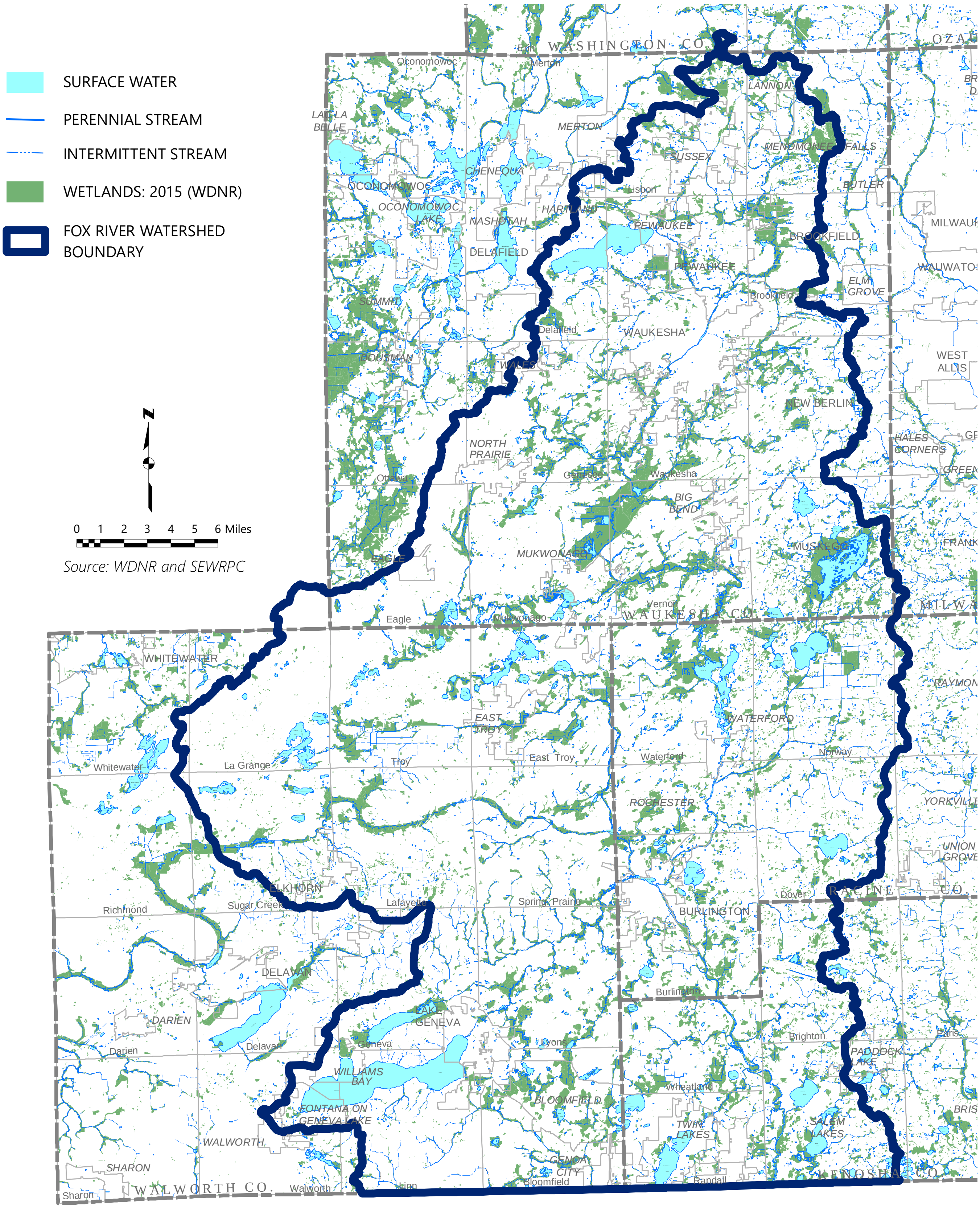
[7] *Wisconsin features two main types of lake organizations, lake associations and lake districts. Lake associations are voluntary groups that have been around since the late 1800s. Lake districts, a more recent creation, are special purpose units of government with taxing authority, similar to a school board or sanitary district. The same lake may have both a voluntary association and a public management district.*

## Map 2.7
## Existing Wetlands in the Fox River Watershed



## Table 2.4
## Lakes Within the Fox River Watershed of 10-Acres or More

| County | Lake Name | Size (acres) |
|---|---|---|
| Kenosha | Benedict Lake | 76 |
| | Camp Lake | 439 |
| | Center Lake | 126 |
| | Cross Lake | 89 |
| | Cull Lake | 13 |
| | Dyer Lake | 61 |
| | Elizabeth Lake | 725 |
| | Flanagan Lake | 11 |
| | Lake Mary | 327 |
| | Lilly Lake | 85 |
| | Peat Lake | 43 |
| | Powers Lake | 451 |
| | Rock Lake | 44 |
| | Silver Lake | 516 |
| | Tombeau Lake | 34 |
| | Voltz Lake | 61 |
| Racine | Bisanabi Lake | 16 |
| | Bohner Lake | 135 |
| | Brock Lake | 11 |
| | Browns Lake | 397 |
| | Buena Lake | 72 |
| | Eagle Lake | 529 |
| | Echo Lake | 70 |
| | Lake Denoon | 167 |
| | Leda Lake | 12 |
| | Long Lake (Burlington) | 84 |
| | Long Lake (Wind Lake) | 105 |
| | Rockland Lake | 45 |
| | Tichigan Lake | 279 |
| | Waubeesee Lake | 139 |
| | Wind Lake | 919 |
| Walworth | Army Lake | 80 |
| | Booth Lake | 118 |
| | Como Lake | 955 |
| | East Troy Pond (Trent) | 29 |
| | Geneva Lake | 5,401 |
| | Goose Pond | 69 |
| | Green Lake | 283 |
| | Hilburn Pond | 13 |
| | Honey Lake (Vienna) | 40 |
| | Lake Beulah | 812 |
| | Lake Ivanhoe | 46 |
| | Lake Wandawega | 120 |
| | Lulu Lake | 95 |
| | Lyons Millpond | 10 |
| | Middle Lake | 197 |
| | Mill Lake | 250 |
| | North Lake | 255 |
| | Pell Lake | 110 |
| | Peterkin Pond | 24 |
| | Peters Lake | 58 |
| | Pickerel Lake | 32 |
| | Pleasant Lake | 145 |
| | Potter Lake | 155 |

**Table continued on next page.**

**Table 2.4 (Continued)**

| County | Lake Name | Size (acres) |
|---|---|---|
| Walworth (continued) | | |
| | Silver Lake | 86 |
| | Swan Lake | 27 |
| | Swift Lake | 20 |
| | Unnamed (744500)[a] | 11 |
| | Unnamed (5577736)[a] | 19 |
| | Unnamed (767200)[a] | 23 |
| | Unnamed (756600)[a] | 27 |
| | Unnamed (758100)[a] | 70 |
| | Unnamed (741900)[a] | 91 |
| Waukesha | Bass Bay Lake | 104 |
| | Big Muskego Lake | 2,194 |
| | Brown Lake | 13 |
| | Etter Lake | 10 |
| | Lannon County Park Pond | 14 |
| | Little Muskego Lake | 470 |
| | Lower Phantom Lake | 373 |
| | Pewaukee Lake | 2,437 |
| | Phantom Lake | 110 |
| | Rainbow Springs Lake | 35 |
| | Roxy Pond | 15 |
| | Saratoga Lake | 28 |
| | Saylesville Millpond | 44 |
| | Spring Lake | 105 |
| | Unnamed (772600) [a] | 14 |
| | Unnamed (764300) [a] | 19 |
| | Unnamed (742275) [a] | 20 |
| | Willow Springs Lake | 41 |
| | Wood Lake | 20 |
| | Eagle Spring Lake | 279 |

[a] *Lakes with an "unknown name" are listed with their state Water Body Identification Code (WBIC)*

*Source: Wisconsin Department of Natural Resources and SEWRPC*

Recharge to groundwater is derived almost entirely from precipitation. The amount of precipitation (and snowmelt) that infiltrates the soil at any location depends mainly on the permeability of the overlying soils and bedrock or other surface materials, including human-made surfaces. As development occurs, stormwater management practices can be instituted that encourage infiltration of runoff. As is the case for surface waters (lakes and streams), the quality of groundwater resources is clearly linked to the health of the biological communities (including humans) inhabiting those waters and their surrounding watersheds.[8]

Ideally, practices that promote infiltration need to be located on soils with permeable subsoils and adequate groundwater separation to allow infiltration but minimize the potential for groundwater contamination. Most of the precipitation that does infiltrate (either naturally or through a stormwater management practice) will generally only migrate within the shallow aquifer system and discharge in a nearby wetland or stream system. This process helps support baseflows, wetland vegetation, and wildlife habitat in these water resources, which is especially important during dry or drought-like conditions.

A groundwater recharge potential map derived from a soil-water balance recharge model was developed under the SEWRPC water supply planning program for the southeastern Wisconsin region. Groundwater recharge potential in the Fox River watershed is shown on Map 2.8. This map can be used for identifying and protecting recharge areas that are the most beneficial to the baseflow of the ponds, streams, springs, and

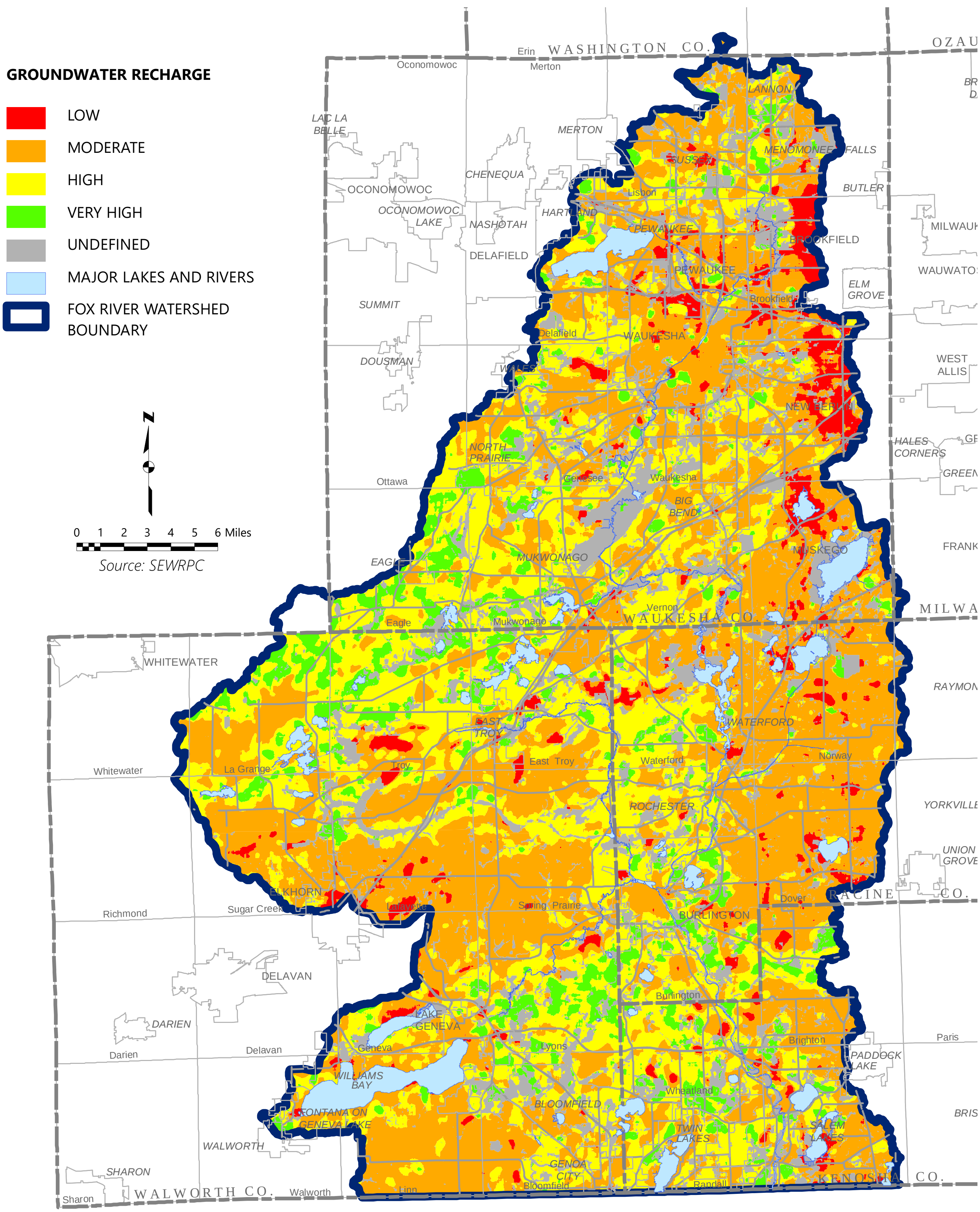
[8] *David Hambright, "Golden Algae & the Health of Oklahoma Lakes," LAKELINE, Volume 32(3), Fall 2012.*

**Table 2.5**
**Lake Associations and Districts Within the Fox River Watershed**

| County | Lake Name | Organization(s) | Type(s) |
|---|---|---|---|
| Kenosha | Benedict and Tombeau | Lake Benedict and Tombeau Management | Lake District |
| | Camp and Center | Camp and Center Lake Rehabilitation District | Lake District |
| | Cross | Cross Lake Improvement Association | Lake Association |
| | Lilly | Lilly Lake Protection and Rehabilitation District | Lake District |
| | Mary (Twin Lakes) | Mary Lake Channel Association | Lake Association |
| | Powers | District of Powers Lake | Lake District |
| | Rock | Rock Lake Highlands Association and Rock Lake Restoration Association, Inc. | Lake Associations |
| | Silver | Silver Lake Management District, and Silver Lake Protection Association | Lake District and Lake Association |
| | Voltz | Voltz Lake Management District | Lake District |
| Racine | Bohners Lake | Bohners Lake Association and Bohners Lake Sanitary District #1 | Lake Association and Sanitation District |
| | Browns Lake | Browns Lake Advisory Committee | Other |
| | Eagle Lake | Eagle Lake Improvement Association and Eagle Management District | Lake Association and Lake District |
| | Long Lake | Long Lake Protection District | Lake District |
| | Wind Lake | Wind Lake Management District | Lake District |
| Walworth | Lake Beulah | Lake Beulah Management District and Lake Beulah Protection and Improvement Association | Lake District and Lake Association |
| | Lake Como | Lake Como Committee | Other |
| | Geneva Lake | Geneva Lake Association, Inc. | Lake Association |
| | Honey Lake | Honey Lake Improvement Association and Honey Lake Protection and Rehabilitation District | Lake Association and Lake District |
| | Pleasant Lake | Pleasant Lake Protection and Rehabilitation District | Lake Association |
| | Potters Lake | Potters Lake Protection and Rehabilitation District | Lake District |
| Waukesha | Big Muskego Lake | Big Muskego and Bass Bay Protection and Rehabilitation District | Lake District |
| | Lake Denoon | Lake Denoon Lake District | Lake Association and Lake District |
| | Eagle Spring Lake | Eagle Spring Lake Management District | Lake District |
| | Little Muskego Lake | Little Muskego Lake Association and Little Muskego Protection and Rehabilitation District | Lake Association and Lake District |
| | Pewaukee Lake | Lake Pewaukee Sanitary District and Pewaukee Lake Improvement Association | Sanitation District and Lake Association |
| | Phantom Lakes | Phantom Lakes Management District | Lake District |
| | Spring Lake | Spring Lake of Waukesha County Property Owners Association, Inc. | Lake Association |

*Source: Wisconsin Department of Natural Resources and SEWRPC*

## Map 2.8
## Groundwater Recharge Areas in the Fox River Watershed: 2015



wetlands in the Fox River watershed.[9] Groundwater recharge potential was divided into four main categories defined as low, moderate, high, and very high. Any areas that were not defined in the modeling were placed into the category "undefined." These undefined areas make up about 17 percent of the Fox River watershed and are most often associated with stream corridors and wetland areas, as shown on Map 2.8. Much of the Fox River watershed can be considered to have either moderate (43.3 percent) or high (28.2 percent) groundwater recharge potential. Groundwater recharge potential is considered to be very high in about 6.8 percent of the watershed and low in about 4.7 percent of the watershed. Preserving groundwater recharge areas, particularly those located on agricultural and other open lands that have not yet been developed, is an important goal for protecting water resources in the Fox River watershed.

## 2.5 CRITICAL COMMUNITY FACILITIES AND INFRASTRUCTURE

FEMA generally defines critical facilities as resources that are vital to the health and welfare of the population and that are especially important following hazard events. Critical facilities include, but are not limited to emergency shelters, police and fire stations, dispatch centers, hospitals, nursing homes, daycares, schools, government administration buildings, financial institutions, and hazardous storage facilities. It should be noted that certain community infrastructure and utilities are considered critical as well, such as major roadways, railways, airports, water and wastewater treatment facilities, telecommunication lines, and electrical power lines or substations. The type and location of these facilities are important considerations in hazard mitigation planning, because of their potential involvement in certain hazard situations. As such, a critical facility should not be located in a floodplain because if flooded, it may result in significant hazards to public health and safety or interrupt essential services and operations for the community during and/or after a flood. If a critical facility must be located in a floodplain it should be provided a higher level of protection so that it can continue to function and provide services during and after a flood event. Critical facilities located within the floodplain of the Fox River watershed are identified and noted in Chapter 3 of this report.

### Major Roadways

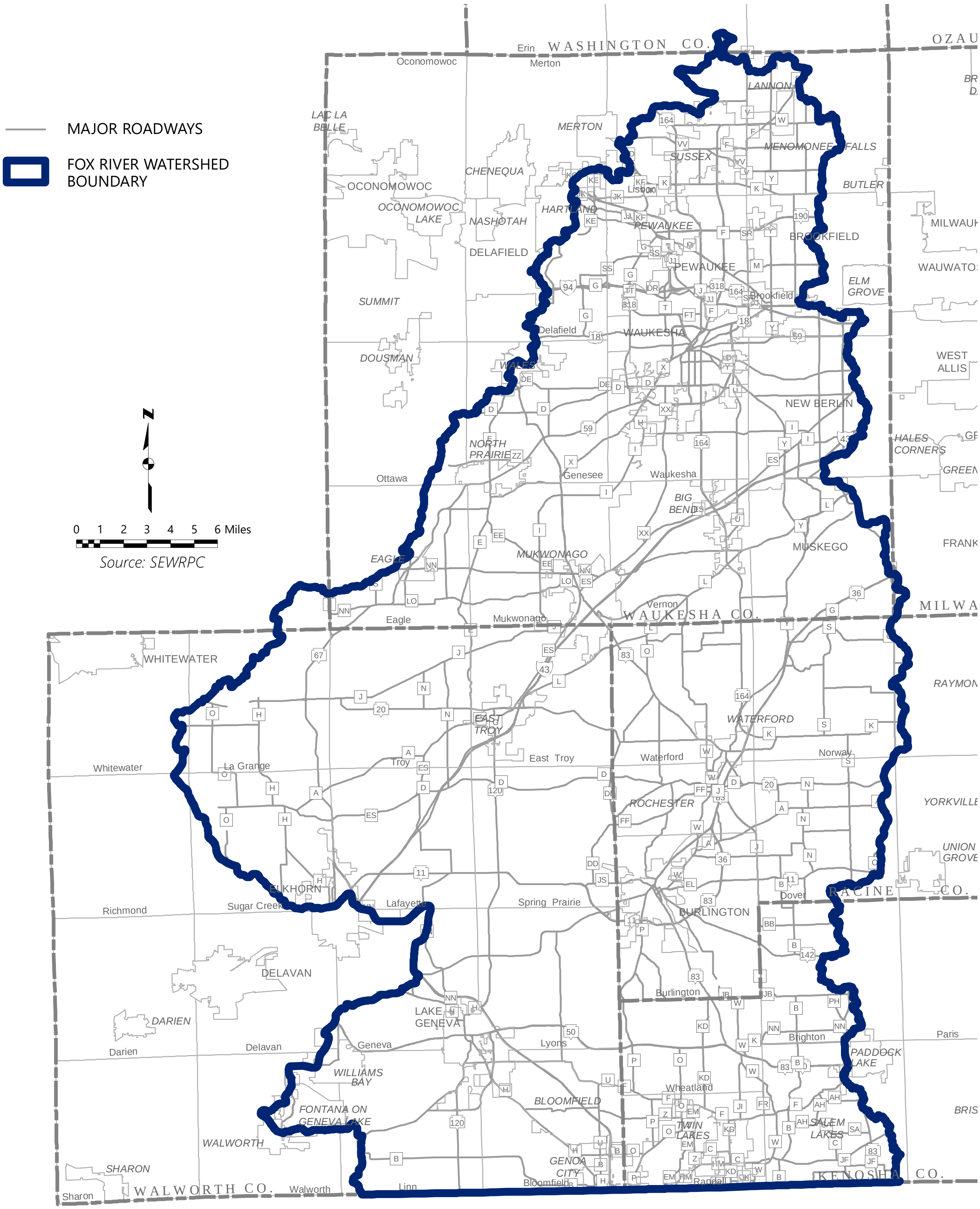
Major streets and highway systems are intended to provide a high degree of travel mobility between and through urban areas throughout the Fox River watershed. Flooded roads can impact transportation routes, prevent people from getting to hospitals or other critical facilities, emergency vehicle response, and shut down businesses. Not only can road flooding be a nuisance, but it can also be a serious safety hazard and even impact the desirability of an area. The major roadway systems (Interstate highways, US Highways, County Road highways, and other arterial and select collector roadways) within the Fox River watershed are shown on Map 2.9. Because of the impact a flood event can have on transportation systems, it is important to have an understanding and consideration of the existing major roadways during the preparation of flood mitigation planning. Chapter 3 of this report details the impact of roadway flooding in the Fox River watershed.

### Dams

A dam is an artificial barrier to a watercourse whose primary purpose is to impound or divert water. WDNR lists 109 dams in the watershed, in which 22 of those dams are considered "abandoned". Map 2.10 shows the 87 existing dams not considered abandoned in the watershed. Of these 87 dams, seven have 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 lifeline facilities during failure or mis-operation. Another six dams have been designated with a significant hazard rating, meaning the potential for economic loss, environmental damage, or disruption of lifeline facilities during failure or mis-operation. The remaining dams have been classified as low hazard, or a hazard rating has not been assigned (see Table 2.6). Chapter 3 of this report describes in detail the general characteristics and functions of dams, dam rating systems, main dams classification within the watershed, historic dam construction and flooding, and how dams within the Fox River watershed were analyzed in response to flood hazard impacts.

[9] *SEWRPC Technical Report No. 47,* Groundwater Recharge in Southeastern Wisconsin Estimated by a GIS-Based Water Balance Model*, July 2008.*

## Map 2.9
## Major Roadway Systems in the Fox River Watershed: 2015



## Map 2.10
## Dams Located in the Fox River Watershed: 2022

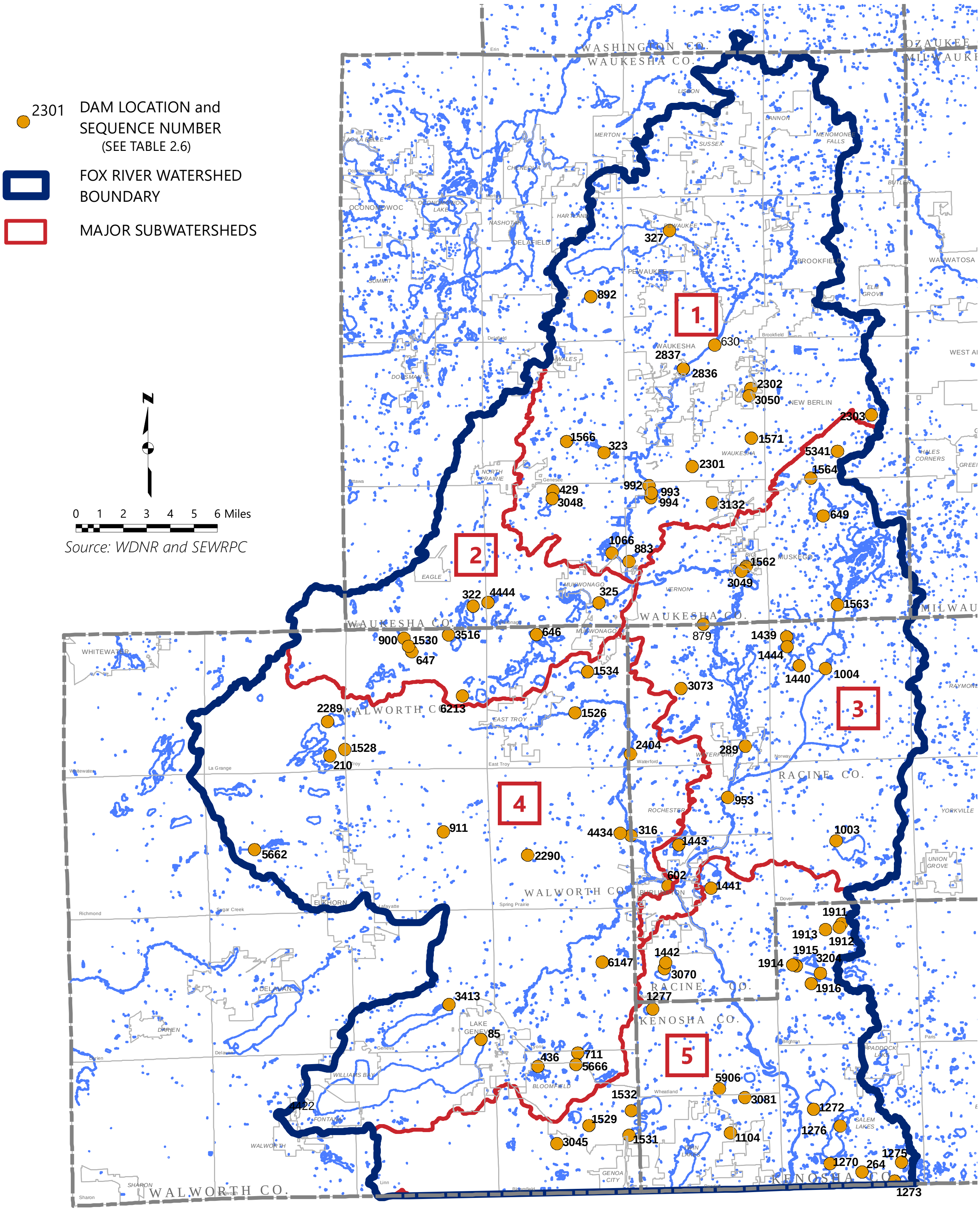


**Table 2.6**
**Dams Located Within the Fox River Watershed: 2022**

| County | WDNR Dam Sequence Number (see Map 2.10) | Official Dam Name | Owner | Size | Local Stream Name | Hazard Rating |
|---|---|---|---|---|---|---|
| Kenosha | 264 | Rock Lake | -- | Large | Rock Lake Outlet | -- |
| | 1104 | Hawke | Sheryl A. Hawke | Small | Bassett Creek | -- |
| | 1270 | Camp Lake | Kenosha County DPW | Large | Camp Lake Outlet | Low |
| | 1272 | Silver Lake | Brian Sullivan | Small | Silver Lake Outlet | -- |
| | 1273 | Cross Lake | Harbhajan Singh Samra | Small | Cross Lake Outlet | -- |
| | 1275 | Voltz Lake | Unknown | Small | Voltz Lake Outlet | -- |
| | 1276 | Center Lake | Center Lake Cons-Sports | Small | Center Lake Outlet | -- |
| | 1277 | Dyer Lake | Kenosha Boy Scouts | Small | Dyer Lake Outlet | -- |
| | 1911 | Bong Recreation Area 2 | WDNR | Small | Unnamed Tributary to Hoosier Creek Canal | -- |
| | 1912 | Bong Recreation Area 3 | WDNR | Small | Unnamed Tributary to Hoosier Creek Canal | -- |
| | 1913 | Bong Recreation Area 4 | WDNR | Small | Unnamed Tributary to Hoosier Creek Canal | -- |
| | 1914 | Bong Recreation Area 5 | WDNR | Small | Unnamed Tributary to Peterson Creek | -- |
| | 1915 | Bong Recreation Area 6 | WDNR | Small | Unnamed Tributary to Peterson Creek | -- |
| | 1916 | Bong Recreation Area 7 | WDNR | Small | Unnamed Tributary to Peterson Creek | -- |
| | 3081 | New Munster Wildlife Area | WDNR | Small | Tributary to Bassett Creek | -- |
| | 3204 | Bong Recreation Area 1 | WDNR | Small | Hoosier Creek Canal | -- |
| | 5906 | Meyer Material KD Pit | Kenosha County | Large | Unnamed Tributary to Palmer Creek | High |
| Racine | 289 | Waterford | Racine County | Large | Fox River | Significant |
| | 602 | Burlington | City Of Burlington | Large | White River | Significant |
| | 953 | Rochester | Racine County | Large | Fox River | Low |
| | 1003 | Eagle Lake | Racine County | Large | Eagle Creek | Low |
| | 1004 | Wind Lake | Racine County | Large | Muskego Creek | Low |
| | 1439 | Lake Denoon | -- | Small | Lake Denoon Outlet | -- |
| | 1440 | Waubeesee | Town of Norway | Large | Lake Waubeesee Outlet | Low |
| | 1441 | Browns Lake | Browns Lake Sanitary District | Small | Browns Lake Outlet | -- |
| | 1442 | Bohner Lake | Racine County | Small | Spring Brook | -- |
| | 1443 | Long Lake | Town of Norway | Small | Long Lake Outlet | -- |
| | 1444 | Lake Kee Nong A Mong | Town of Norway | Small | Lake Kee Nong A Mong Outlet | -- |
| | 2404 | Joseph Shaffer | Kathryn Babcock-Shaffer Declaration of Trust | Small | Honey Creek | -- |
| | 3070 | Bohner Pond | Racine County | Small | Spring Creek | -- |
| | 3073 | Tichigan Wildlife Area | WDNR | Small | Tichigan Creek | -- |

**Table continued on next page.**

### Table 2.6 (Continued)

| County | WDNR Dam Sequence Number (see Map 2.10) | Official Dam Name | Owner | Size | Local Stream Name | Hazard Rating |
|---|---|---|---|---|---|---|
| Walworth | 85 | Lake Geneva | Lake Geneva Lake Level Board | Large | White River | Low |
| | 210 | Lauderdale Lakes | Lauderdale Lakes Lake Management District | Large | Honey Creek | High |
| | 316 | Honey Lake | Honey Lake Protection & Rehabilitation District | Large | Sugar Creek | Low |
| | 436 | Grethe | Series F of LG5, LLC | Large | Bloomfield Creek | Low |
| | 646 | Lake Beulah | Lake Beulah Management District & Walworth County | Large | Lake Beulah Outlet | High |
| | 647 | Pabst | Mary Butler | Large | Bakers Creek | Low |
| | 711 | Val Sauer | Tuscany of Lake Geneva Property Owners Association | Small | Lake Ivanhoe Inlet | -- |
| | 900 | Kettle Moraine Estates Corp | Michael Pautz | Large | Lulu Lake Tributary and Mukwonago River | Low |
| | 911 | Elmer Droster | Sugar Creek Preserve, LLC | Large | Sugar Creek Tributary | Low |
| | 1526 | Hilburn | Scott and Kristen Parks | Small | Honey Creek | -- |
| | 1528 | Cedar Grove | Millpond Farm Company – John Friedberg | Small | Honey Creek | -- |
| | 1529 | Pell Lake | Warren Smadbeck | Small | Pell Lake Outlet | -- |
| | 1530 | Pabst Diversion | Ronald and Mary Stalker | Small | Bakers Creek | -- |
| | 1531 | Lake Tombeau | Lake Benedict Lake Tombeau Management District | Small | Lake Tombeau Outlet | Low |
| | 1532 | Powers Lake | Town of Bloomfield | Small | Powers Lake Outlet | Low |
| | 1534 | Potters Lake | Potters Lake Protection and Rehabilitation District | Small | Potters Lake Outlet | -- |
| | 2289 | Laurance Motl | -- | Small | Pleasant Lake Bog Outlet | -- |
| | 2290 | Charles Roubik | Prochacka Living Trust | Small | Branch Of Sugar Creek | -- |
| | 3045 | Elmer Fries | William Hammerstrom | Small | Nippersink Creek | -- |
| | 3413 | Lake Como | Town of Geneva | Small | Como Creek | -- |
| | 4434 | Vienna[b] | -- | Small | Sugar Creek | -- |
| | 5662 | Turtle Valley Phase III | WDNR | Large | Sugar Creek | Low |
| | 5666 | Bloomfield Wetland Restoration | WDNR | Small | Unnamed Tributary | -- |
| | 6147 | Brown | Markalus Griffin | Large | Unnamed Tributary to White River | -- |
| | 6213 | Willow Pond | Barbara Roeder | Large | Unnamed Tributary to Pickerel Lake | Low |
| Waukesha | 322 | Wambold | Eagle Spring Lake Management District | Large | Mukwonago River | Significant |
| | 323 | Saylesville Roller Mill | John and Wendy Curran | Large | White Creek | Low |
| | 325 | Mukwonago | Village of Mukwonago | Large | Mukwonago River | Low |
| | 327 | Pewaukee | Village of Pewaukee | Large | Pewaukee River | High |
| | 429 | Willow Springs Lake | Spring Brook Lake Management District | Large | Spring Brook | Low |

**Table continued on next page.**

**Table 2.6 (Continued)**

| County | WDNR Dam Sequence Number (see Map 2.10) | Official Dam Name | Owner | Size | Local Stream Name | Hazard Rating |
|---|---|---|---|---|---|---|
| Waukesha (continued) | 630 | Saratoga Mill | City of Waukesha | Large | Fox River | Low |
| | 649 | Little Muskego | City of Muskego | Large | Muskego Creek | High |
| | 879 | Reischl | Norris Inc. | Large | Tributary to Fox River | Low |
| | 883 | Hidden Lakes | Hidden Lakes Homeowners Association | Large | Tributary to Fox River | Low |
| | 892 | Salow Lake | Dover Bay Homeowners Association | Large | Zion Creek | High |
| | 992 | Vernon Marsh-Ref. Flowage | WDNR | Small | Drainage Ditch-Tributary to Fox River | -- |
| | 993 | Vernon Marsh-Mid. Flowage | WDNR | Large | Mill Brook | Low |
| | 994 | Vernon Marsh-N. Flowage | WDNR | Large | Pebble Brook | Low |
| | 1066 | Southwest Flowage | WDNR | Small | Non-Navigable Ditch to Fox River | -- |
| | 1562 | Fraser | -- | -- | Tributary to Fox | -- |
| | 1563 | Muskego | City of Muskego | Small | Muskego Creek | Low |
| | 1564 | Blott | Linnie Lac Management District | Large | Muskego Creek | High |
| | 1566 | Morey | H. Sydow | -- | White Creek | -- |
| | 1571 | Jensen | -- | -- | Mill Creek | -- |
| | 2301 | Girl Scouts Camp Chinook | Girl Scouts Camp Chinook | -- | Not On a Stream | -- |
| | 2302 | Minooka Park | Waukesha County Parks | Small | Tributary to Pebble Brook | -- |
| | 2303 | Regal Manors III | -- | -- | Not On a Stream | -- |
| | 2836 | Abendroth & Assoc. No. 1 | -- | Small | Tributary to Fox River | -- |
| | 2837 | Abendroth & Assoc. No. 2 | -- | Small | Tributary to Fox River | -- |
| | 3048 | Douglas Dunlop | Douglas Dunlop | -- | Unnamed | -- |
| | 3049 | Robert L. Huberty | -- | Small | Tributary to Fox River | -- |
| | 3050 | Howard Hass | -- | Small | Tributary to Pebble Creek | -- |
| | 3132 | West Allis Kennel Club | West Allis Kennel Club | Small | Mill Brook | -- |
| | 3516 | Donnelly | Nina Herman Donnelly | -- | Non-Navigable Stream | -- |
| | 4444 | Hogan's Dam | Frank Hogan | -- | -- | -- |
| | 5341 | Calhoun Park | City of New Berlin | Small | -- | -- |

Note: This table excludes the 22 dams considered "abandoned" by WDNR; however, information related to those dams and other dams in Wisconsin can be found on the WDNR website.

[a] *Information not available ("--").*

*Source: Wisconsin Department of Natural Resources and SEWRPC*

## 2.6 NATIONAL WEATHER SERVICE EXTREME WEATHER AND HYDROLOGIC WARNING SYSTEM

The National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) provides a weather-related hazard warnings to the public. The NWS extreme weather and hydrologic warning system issues severe weather alerts for any given region based on their weather and hydrologic forecasting models. Their forecasting models use available weather data from weather balloons, weather buoys, satellites, aircraft sensors, radars, and ground station gages, as well as hydrologic data from stream flow gages and lake level gages to accurately capture current weather conditions and predict future weather events. When extreme weather events are detected or predicted, NWS issues alerts in the form of warnings, watches, and advisories. A warning is issued when a hazardous weather condition is occurring or imminent that threatens life or property. It is intended for emergency action to be taken immediately. A watch is issued when a hazardous weather condition is possible, but the occurrence, location, or timing is uncertain, to provide time for emergency actions to be taken. An advisory is issued when a hazardous weather condition is occurring or imminent but for a less serious condition than a warning. An advisory is intended for caution to be exercised. Alerts are issued for weather conditions such as tornadoes, thunderstorms, winds, or winter storms. They are also issued for flooding events. The alerts can be obtained from the NWS Storm Prediction Center website, the NOAA Weather Radio, and through the Wireless Emergency Alerts (WEA) on mobile phones and through most weather mobile apps. These alerts can be used by the communities for storm-related emergency preparations.

## 2.7 MONITORING GAGES

Monitoring gages, including stream, lake, and rain gages, are used throughout the Fox River watershed to measure current hydrologic and hydraulic conditions. Historical gage data can provide an understanding of the range of values seen in the past, to place current conditions in context. Gages can also act as an early warning for upcoming flooding events by showing where large rain events have occurred and rising water levels which can provide information to emergency responders about which areas may experience the worst flood conditions. Drought conditions can also be monitored using stream, lake, and rain gages.

### Stream Gages

The United States Geological Survey (USGS) manages a network of stream gages across the United States. Most stream gages are equipped with a water-stage recorder and a crest stage gage to record the current water level and the peak water level, respectively. The water surface elevation data is then compared to a gage-specific rating curve to estimate streamflow. USGS provides raw data as well as statistical analysis based on the collected data.

#### *Observational*

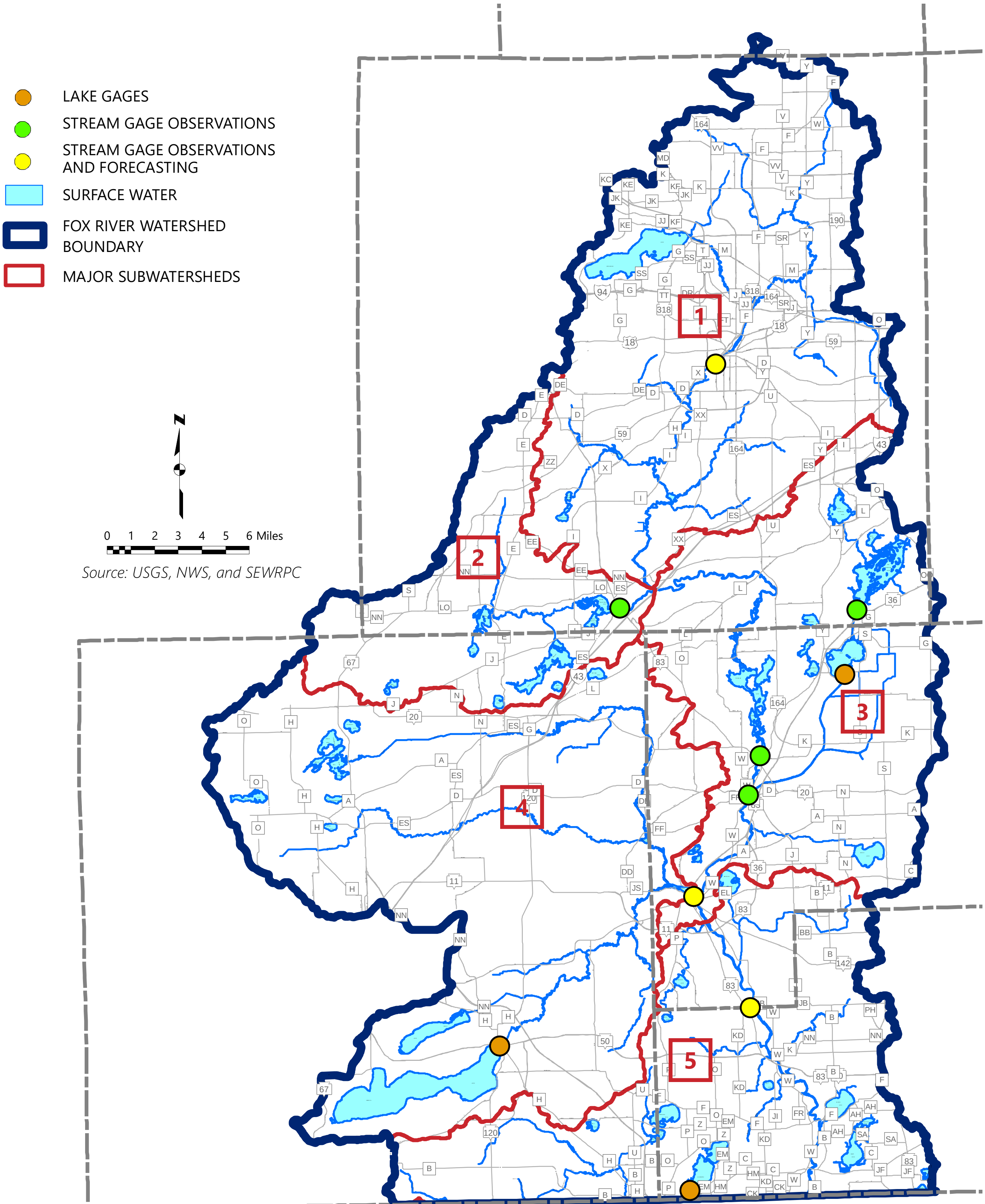
There are seven stream gages within the Fox River watershed, as shown in Map 2.11. Their locations and capabilities are described in Table 2.7. These stream gages have observational data reporting capabilities, which means their online reporting pages provide data on current and historical conditions for water stage height and flow rate, and data is usually available within one hour of measurement. USGS also provides statistics for daily discharge, based on historical flow rate records for a specific gage. Several USGS stream gages in the Fox River watershed have been discontinued, as summarized in Table 2.8. Although these gages no longer provide current stage height or flow data, their records provide valuable historical data to better understand the hydrology of the watershed.

#### *Forecasting*

The National Weather Service (NWS) also provides river level forecasting tools for the stream gages along the Fox River at Waukesha, New Munster, and Burlington. These features can be found online[10] and are described below.

[10] *For more information, see www.water.weather.gov/ahps.*

**Map 2.11**
**Stream and Lake Gage Locations in the Fox River Watershed**



## Table 2.7
## Active Stream Gages in the Fox River Watershed

| Location | Waterway | USGS Stream Gage Site Number | Major Subwatershed | Years of Operation | Observational Data Available | Future Forecasting Available |
|---|---|---|---|---|---|---|
| City of Waukesha, 40 feet downstream of Prairie Street bridge | Fox River | 05543830 | 1. Upper Fox | 1967 - Present | Yes | Yes |
| Village of Mukwonago, 800 feet downstream of Mukwonago Dam | Mukwonago River | 05544200 | 2. Mukwonago | 1973 - Present | Yes | No |
| City of Muskego, at the dam outlet of Muskego Lake | Muskego Canal | 05544385 | 3. Middle Fox | 1987 - 1989, 1995 - 2006, 2010 - Present | Yes | No |
| Village of Waterford, 175 feet upstream of Waterford dam | Fox River | 05544348 | 3. Middle Fox | 2015 - Present | Yes | No |
| Village of Rochester at E. Main Street bridge, 0.4 miles upstream of Rochester Dam | Fox River | 05544475 | 3. Middle Fox | 2011 - Present | Yes | No |
| City of Burlington, just downstream of E. Jefferson Street | Fox River | 05545334 | 3. Middle Fox | 1973 - Present | Yes | Yes |
| Town of New Munster, 40 feet downstream of bridge on CTH JB | Fox River | 05545750 | 5. Lower Fox | 1939 - 1993[a], 1993 - Present | Yes | Yes |

[a] *Prior to October 1993, this gage was published as "at Wilmot" under USGS stream gage site number 05546500.*

*Source: USGS, National Weather Service*

## Table 2.8
## Discontinued Stream Gages in the Fox River Watershed

| Location | Waterway | USGS Stream Gage Site Number | Major Subwatershed | Years of Operation |
|---|---|---|---|---|
| City of Waukesha, just downstream of Watertown Road crossing | Fox River | 05543800 | 1. Upper Fox | 1993 - 2000 |
| City of Muskego, 0.3 miles upstream of Little Muskego Lake | Jewel Creek | 05544371 | 3. Middle Fox | 1999 - 2004 |
| Town of La Grange, at the outlet of Lauderdale Lakes into Honey Creek | Honey Creek | 05544800 | 4. White River | 1993 - 1994 |
| Village of Williams Bay, at outlet to Geneva Lake | Southwick Creek | 05545131 | 4. White River | 1998 - 2000 |
| Town of Linn, at Lackey Lane crossing near Geneva Lake | Birches Creek | 05545133 | 4. White River | 1998 - 2001 |
| Town of Lyons, just upstream of State Road 36 crossing | White River | 05545300 | 4. White River | 1958 - 1964, 1967 - 1982 |
| Village of Genoa City, just downstream of Main Street crossing | North Branch Nippersink Creek | 05548170 | 5. Lower Fox | 2011 - 2013 |

*Source: USGS*

Hydrograph River Forecast

When the river stage rises above its assigned action flood stage, which is the stage at which flood mitigation action is taken, NWS provides a river stage forecast for the next seven days. The NWS forecast considers the current river stage, reservoir conditions, the past precipitation, and future forecasted precipitation for the next 24 hours to develop the river stage forecast.

Chance of Exceeding River Stage

NWS provides two different 3-month outlooks describing the chance of exceeding various river stage thresholds, as a weekly chance of exceeding various river stages and as a seasonal outlook. As an example, the bar graph shown in Figure 2.1 indicates that on August 22, 2022, NWS predicted that there was about a 25 percent chance of river stage exceeding 3.5 feet at the Fox River gage in Waukesha in the week between September 19 and September 26, 2022. The bar graph predicts the probabilities of exceeding given river stages based on current river conditions. The lower line graph in Figure 2.1 shows the conditional simulation, which is the current outlook, predicted that there is a 10 percent chance that the river stage will exceed 5.2 feet in the three months between August 29 and November 27, 2022, while historically there is a 10 percent chance that the river stage will exceed 4.9 feet in the same time period. The historical simulation graph represents the probabilities of exceeding given river stages based on past events. When the conditional simulation line is graphed higher than or to the left of the historical simulation line, the chances are greater for higher water levels.

Short Term Probabilistic Guidance

The short-term probabilistic guidance is currently an experimental tool produced by NWS's Hydrologic Ensemble Forecast Service to provide a range of possible river levels for the upcoming forecasted ten-day period. This guidance includes ten days of precipitation forecasts. These results are presented graphically, as seen in the example in Figure 2.2. The curves represent the probability that a river level forecast is within a certain range, suggesting the likelihood that a given forecast will match the observed river level. The goal of the tool is to better quantify the uncertainty in river level forecasts to aid in planning efforts. The uncertainty in forecasting comes from both the unpredictability of weather forecasts as well as the uncertainties inherent to modeling. Because this forecasting process is automated, the stage forecasts are always available, not only during flood events.

Inundation Mapping

NWS also provides a web-based tool to show the extent of flooding in a localized area around the Fox River gages in Waukesha, New Munster, and Burlington. A map of the inundated areas is shown when the water level exceeds the riverbank, which is considered minor flood stage. The flood mapping tool can show flood extents for theoretical scenarios and specific river stages, and it can also show current flooding conditions (posted within one hour of observation) and flood forecasting when flood stage conditions are present. This mapping is provided as a tool to help communities plan emergency escape routes and understand which areas are at greatest risk.

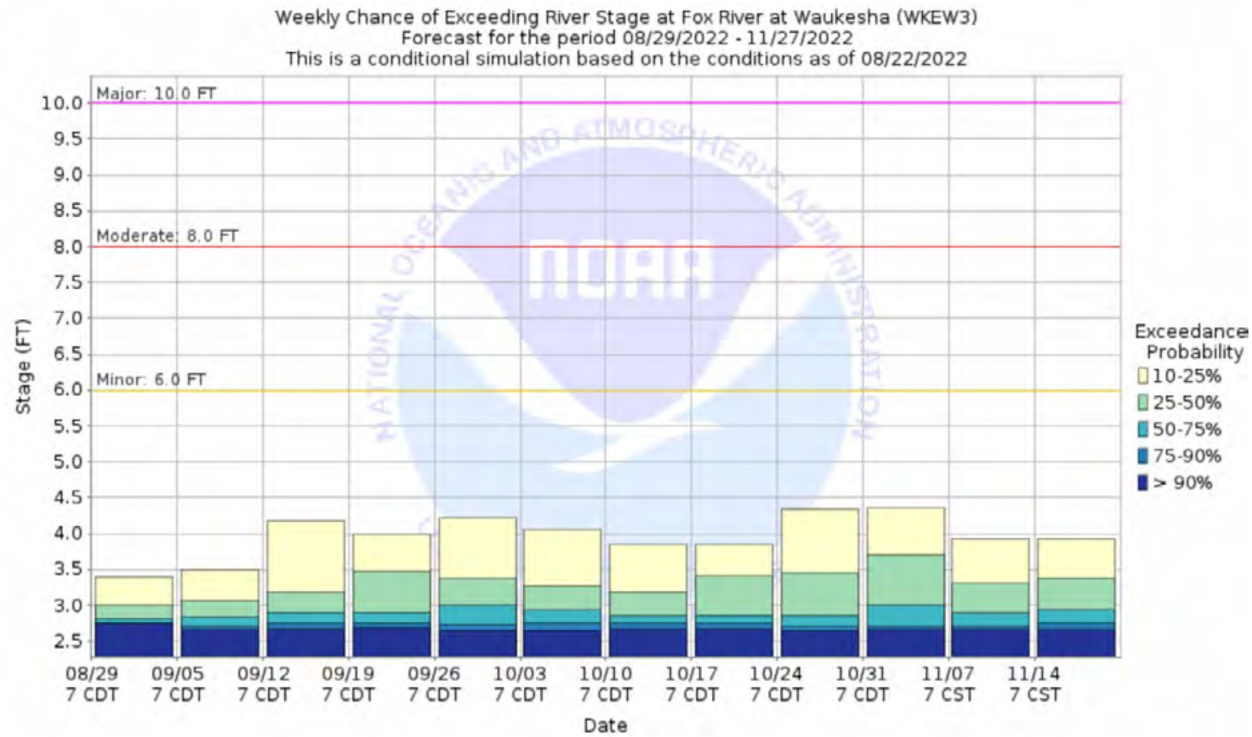
**Lake Level Gages**

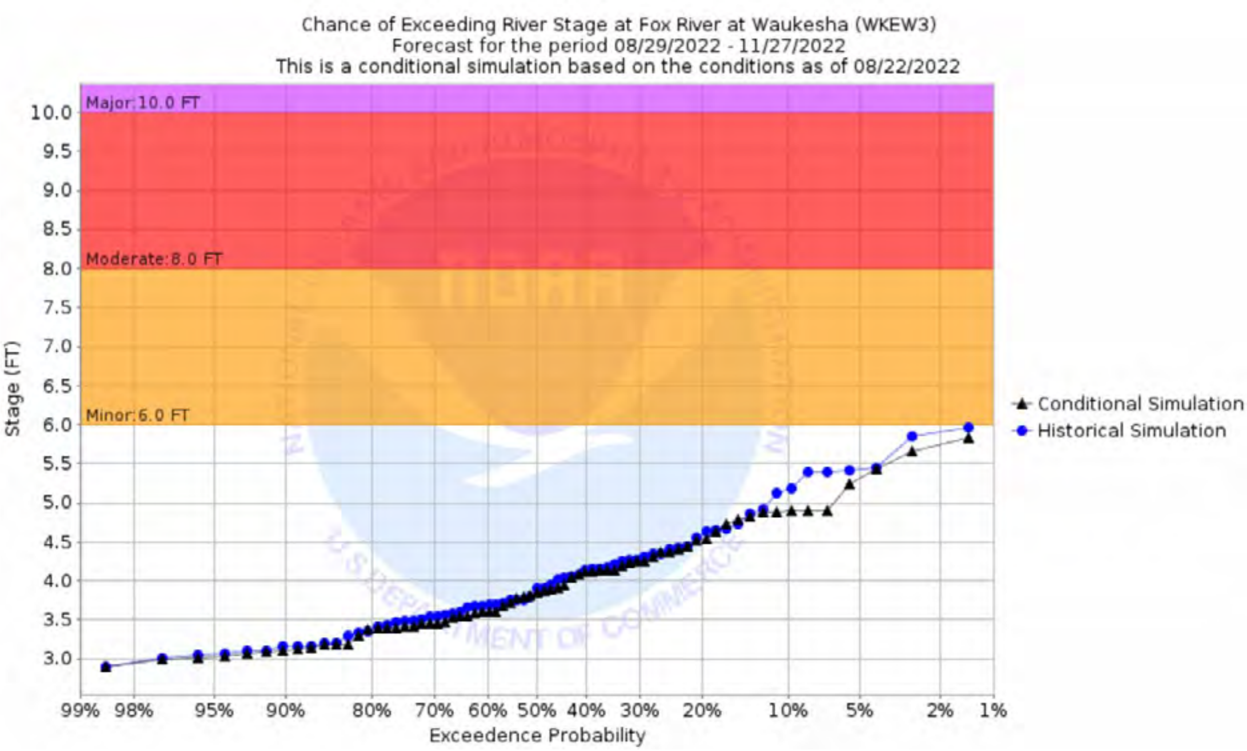
Lake level gages are another useful tool for anticipating flood events in the Fox River watershed. The gages can be used in conjunction with other available datasets to inform proper flood warning and response. Currently, three lake level gages are available in the watershed (Map 2.11). They are located near the outlets of Wind Lake, Geneva Lake, and Elizabeth Lake. All three gages are operated by USGS and report level data every fifteen minutes, and their data are published on the USGS website. The data is viewable in the USGS National Water Dashboard.

**Rain Gages**

Available land-based rain gages in the region can also be utilized to provide flood warning. Only gages with hourly or sub-hourly recording intervals were considered feasible for this purpose. Daily rain gages operated by wastewater treatment plants and some volunteer networks would not be able to provide the adequate data frequency needed to anticipate potential floods quickly. Five sources of hourly and sub-hourly rain gages exist in the region: Airports, WDNR, USGS, Milwaukee Metropolitan Sewerage District (MMSD), and volunteer networks published by Weather Underground. A limited number of government-managed rain gages operate within the Fox River watershed; however, a greater number of rain gages can be found in the

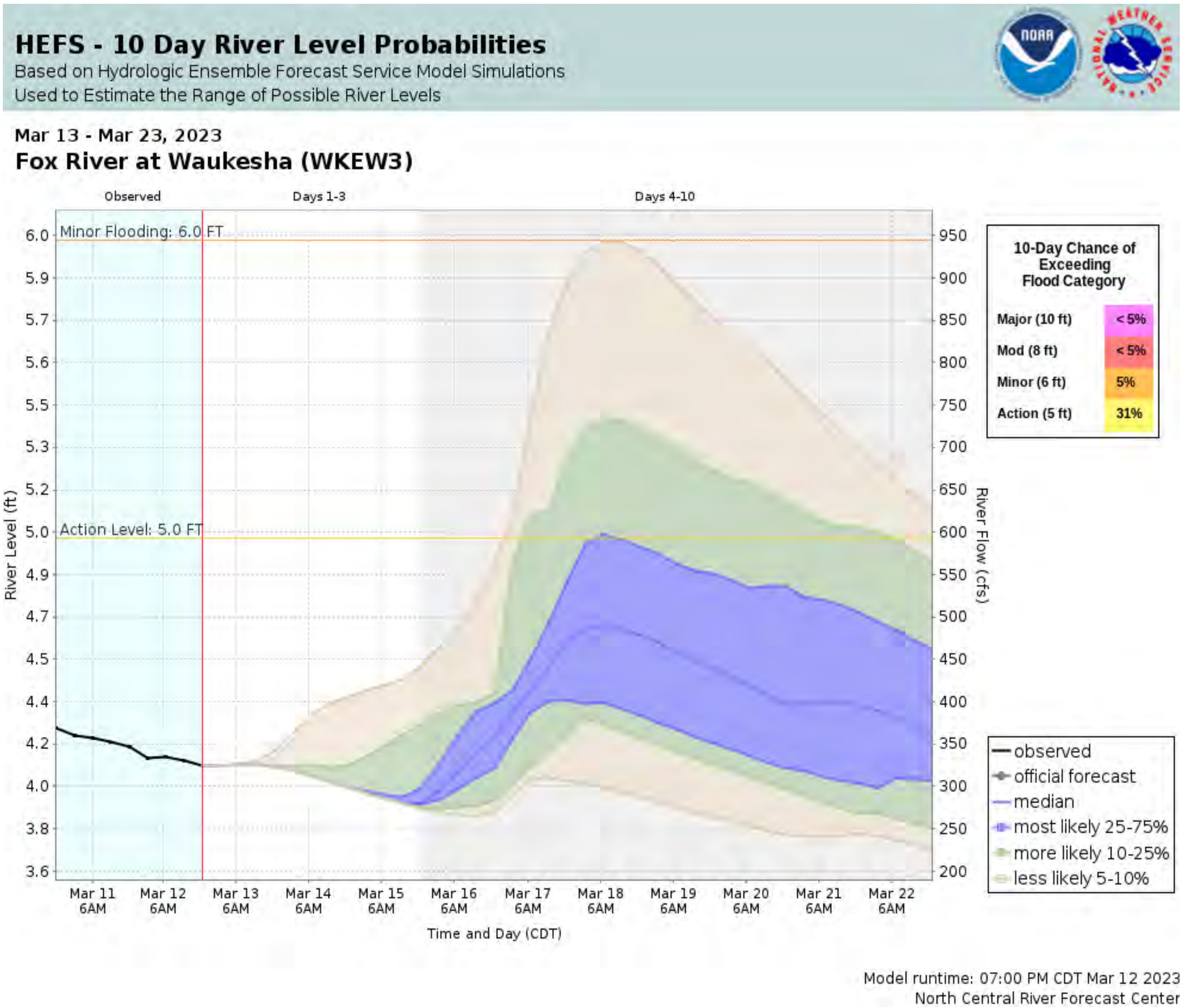
**Figure 2.1**
**Examples of Forecasts for Weekly and Cumulative Chance for Exceeding River Stage**




*Source: National Weather Service*

**Figure 2.2**
**Example of Short-Term Probabilistic Guidance for River Stage Forecasting**



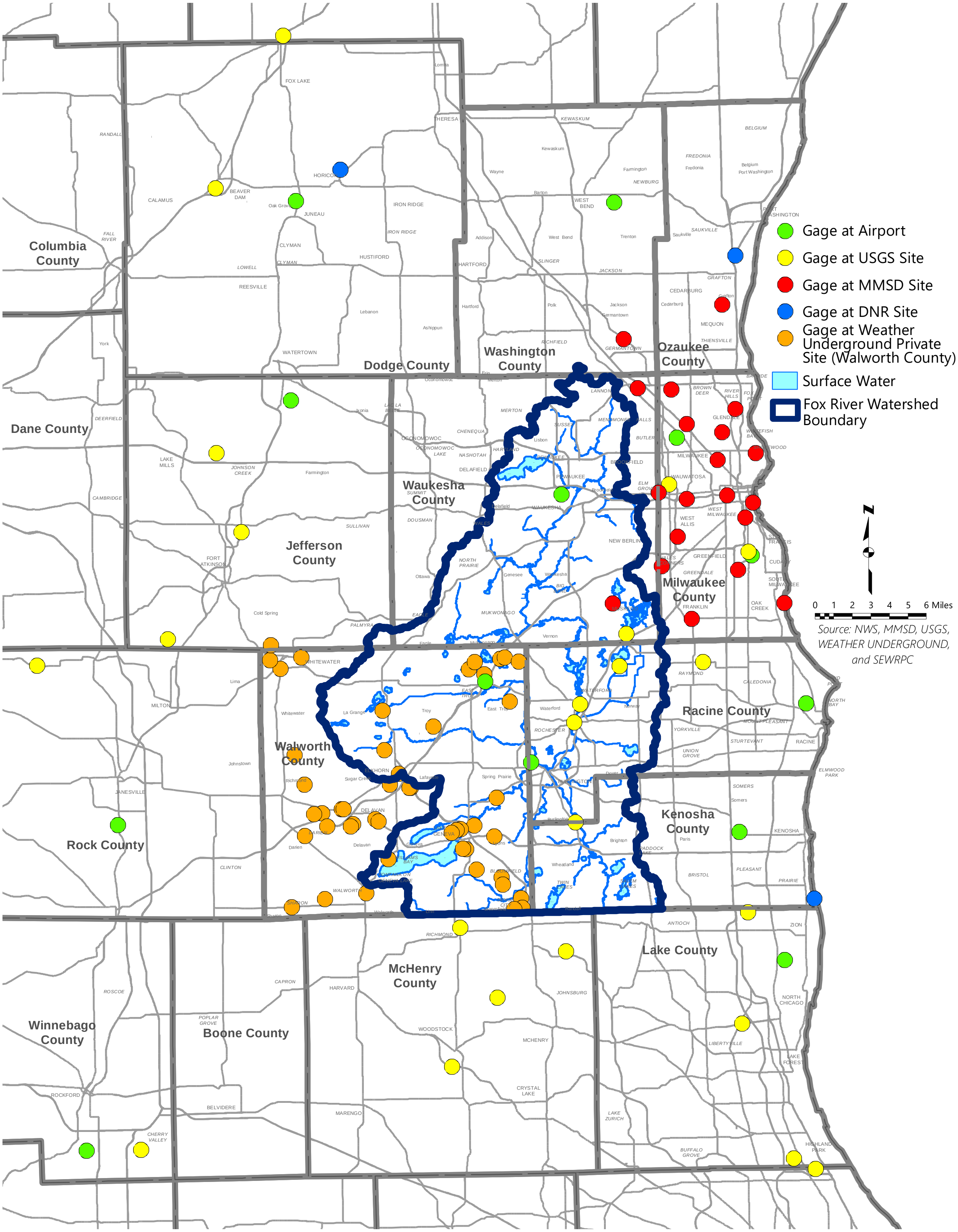

*Source: National Weather Service*

surrounding region. The regional rain gages outside of the watershed can be used to anticipate flood events within the watershed based on the directionality of severe storm events. Map 2.12 depicts the hourly and sub-hourly rain gages in the Fox River region.

Airports in the region operate rain gages under the ownership of various entities including NOAA NWS, Federal Aviation Administration (FAA), Municipality, County, and private ownership. Only three such gages are in operation within the Fox River watershed, while 10 additional airport gages exist in the surrounding region. The gage data is publicly available on the NOAA National Centers for Environmental Information (NCEI) website.[11] The airport gages have rainfall recording frequencies of between 20 minutes and one hour; however, it takes several days for the data to be published online. The lengthy data publication delay makes these gages unusable for timely flood anticipation unless some coordination can be established with the airport weather gage operators to obtain the data more quickly. A detailed list, description, and data publication location of rain gages at airports can be found in Appendix B.

[11] *Rainfall data for all airport gages can be downloaded from the NCEI website except the gage at the West Bend Municipal Airport. That gage is privately owned and operated and would require coordination with the operator to obtain rainfall information.*

## Map 2.12
## Sub-Daily Rain Gages in and near the Fox River Watershed



Several gages are also available on USGS, MMSD, and WDNR sites in the region. Five rain gages operate on USGS monitoring sites within the Fox River watershed and 18 gages outside of the watershed in the region. The owners and operators of these gages vary between NWS and USGS. The gages on USGS sites have rainfall recording frequencies of between five and 15 minutes, and the data are published online within a few hours. MMSD operates only one gage inside the Fox River watershed and 19 gages outside of the watershed in the District's service area. The MMSD gages have five-minute rainfall recording frequencies and their data are published online in real-time. Three NWS rain gages exist on WDNR sites outside of the watershed in the region. The gages on WDNR sites record rainfall every hour and the data are published online within a few hours. Gages on USGS, MMSD, and WDNR sites can be useful for flood anticipation in the Fox River watershed. It is worth noting that USGS often adds or removes gages to and from their gage network, therefore rain gage availability should be monitored regularly.[12] A detailed list, description, and data publication location of these rain gages can be found in Appendix B.

Lastly, because the rain gages operated by governmental agencies are still quite limited in the Fox River watershed and the surrounding region, volunteer networks can be utilized to supplement the gaps in the available rainfall data. Weather Underground (WU) publishes an expansive network of community volunteer weather gages. The weather gage locations can be viewed and selected on the "WunderMap" within the WU website. More gages are displayed on the "WunderMap" as the map is zoomed in. The gage data is published online in real-time and are in sub-hourly intervals. However, the data may be less reliable compared to those operated by governmental agencies. It is suggested that rainfall observations not be reliant on any individual volunteer weather gage but rather be based on multiple gages in the same vicinity to assess their reliability. Additionally, two precipitation datasets are published by WU[13]. They are precipitation rate and precipitation accumulation. The precipitation rate is the rate of rainfall in inches per hour. The precipitation accumulation is the cumulative measured rainfall for a daily 24-hour period. Both datasets are published online every five minutes. It is recommended that the precipitation accumulation data is used for rainfall observations to predict flooding. Map 2.12 shows the locations of the currently available (May 2022) sub-hourly rain gages in Walworth County only as an example of available gages in southeastern Wisconsin. It has been observed that the WU gages are more densely distributed in areas of higher population such as in the City of Waukesha.

[12] *Currently available rainfall information at USGS sites can be viewed on the USGS National Water Dashboard at dashboard.waterdata.usgs.gov.*

[13] *For more information, see www.wunderground.com.*

# HAZARD IDENTIFICATION 3

## 3.1 INTRODUCTION

To evaluate various hazard mitigation alternatives for the Fox River watershed and select the most effective and feasible hazard mitigation strategies, the hazards within the scope of this report must first be analyzed and vulnerability to each hazard documented. This report focuses on hazards caused by flooding, dams, and drought. Accordingly, this chapter provides profiles of the extent and severity of hazard events that occurred in the Fox River watershed, as well as assessment of the vulnerability and risk associated with each type of hazard.

## 3.2 VULNERABILITY ASSESSMENT FOR FLOODING

Floods are natural events that provide many environmental benefits, such as enriching soils and recharging aquifers. However, floodwaters can also create danger for people and cause damage to structures, roads, and dams due to high water levels and quick-flowing velocities. Nationwide, hundreds of flood hazard events occur each year, making it one of the most common hazards in all 50 states and U.S. territories.[14]

Floodplains are the wide, gently sloping areas contiguous to, and usually lying on both sides of, a stream, channel or lake. For planning and regulatory purposes, floodplains are normally defined as the areas subject to inundation by the 1-percent-annual-probability (100-year recurrence interval) flood event. The 1-percent-annual-probability flood has a one-percent chance of occurring in any given year. The area that is inundated during this flood event is also called the Special Flood Hazard Area (SFHA) by the Federal Emergency Management Agency (FEMA). The 1-percent-annual-probability floodplains shown on Map 2.6 in Chapter 2 of this report have been identified by the Counties, Southeastern Wisconsin Regional Planning Commission (SEWRPC), Wisconsin Department of Natural Resources (WDNR), and FEMA and represent the FEMA effective floodplains in the Fox River watershed. A map of where floodplains were updated for the latest preliminary work is available in Appendix A.

**Historical Flooding Problems**

A comprehensive watershed plan was completed for the Fox River watershed in 1969[15] under the direction of the SEWRPC Fox River Watershed Committee. That plan was subsequently amended in 1975.[16] The watershed plan and the subsequent 1975 amendment described three major flood events which occurred within the watershed in July 1938, April 1960, and April 1973. The April 1960 flood was caused by a combination of rainfall and snowmelt. Measurements of the snow cover at the U.S. Weather Bureau Station in Milwaukee indicate that the depth of snow on the ground immediately prior to the flood was 24 inches, which is equivalent to 2.8 inches of water. Studies by the U.S. Weather Bureau indicate that a snow cover with this water equivalent has a 4 percent chance of occurring in March.[17] Temperatures, after having been below normal for most of the month, began to rise on March 27 and reached a high of 62°F on the 29th. Starting in the evening of March 29, rain fell intermittently for a period of about 24 hours. It was determined that the average depth of rainfall on the watershed during this 24-hour period was 1.5 inches. Seasonal precipitation studies conducted in 1960 by the U.S. Weather Bureau indicated that a storm of this magnitude has a 5 percent chance of occurring in March. The probability of such rain and snow cover occurring together

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

[15] *SEWRPC Planning Report No. 12,* A Comprehensive Plan for the Fox River Watershed*, April 1969.*

[16] *SEWRPC Community Assistance Planning Report No. 5,* Drainage and Water Level Control Plan for the Waterford-Rochester-Wind Lake Area of the Lower Fox River Watershed*, May 1975.*

[17] *U.S. Department of Commerce, Weather Bureau, Technical Paper No. 50, Frequency of Maximum Water Equivalent of March Snow Cover in North Central United States, 1964.*

is the product of their individual probabilities. Therefore, the probability of these two events occurring in combination in late March of any year is 0.2 percent. These two unusual events combined to produce a peak flood flow of 7,520 cubic feet per second (cfs) at the U.S. Geological Survey (USGS) Fox River gaging station at Wilmot. A discharge of 2,300 cfs was measured at the Fox River at the Waukesha gage; however, it is believed that this measurement was taken after the peak flow had passed.

The 1960 Fox River mainstem flood was the highest recorded in the 53 years that the USGS had operated the gaging station at Wilmot.[18] However, it was not an event of such rare magnitude or severity in other parts of the watershed. Generally, floods generated by snowmelt are most severe on large rivers. Smaller tributaries are more sensitive to high-intensity rainfalls and normally do not produce record flood peaks as a result of snowmelt. The flood that occurred in July 1938 is an example of how portions of the watershed may respond to high-intensity rainfalls. The storm that produced the 1938 flood appears to have been centered over the Village of Williams Bay in Walworth County where 6.76 inches of rain were recorded in less than 24 hours. The storm began on June 30 and continued into July 1. Review of the isohyetal map shows that part of the storm covered an area upstream from the Echo Lake Dam in the City of Burlington, Racine County. A discharge of 4,140 cfs was measured by the USGS at the outlet of Echo Lake following this storm. The discharge that occurred on the White River at the outlet of Echo Lake during the 1960 flood is not known; however, residents of the area upstream from the dam indicated that the 1938 flood was much more severe.

The April 1973 flood event was the largest flood in the memory of local farmers questioned in 1975. The farmers lived in the vicinity of the Fox River mainstem between the Village of Big Bend and Rochester and in the area tributary to the Wind Lake Drainage Canal. Agricultural damage due to flooding in those areas was estimated to be $129,000 (1975 dollars) on an average annual basis over the five-year period 1970 to 1975.

Between June 7 and June 13, 2008, a series of storm events caused major flash flooding around southeastern Wisconsin. The Mukwonago River crested on June 13 at 4.95 ft, and on June 15 the Fox River crested at 13.54 ft in Burlington and at 15.18 ft in New Munster, all of which broke records at the time. Communities experienced standing water up to four feet deep, causing some impassable roads and damage to vehicles, as well as damage to structures in Kenosha, Racine, Walworth, and Waukesha Counties. The National Centers for Environmental Information (NCEI), formerly the National Climatic Data Center, estimated that these storms caused $67.8 million (2008 dollars) in damages to structures in the four counties, about $63 million of which happened to structures in Waukesha County.[19] Additionally, some farm fields experienced flooding through early July, with an estimated $9.8 million (2008 dollars) in agricultural losses over the four counties.

### *July 2017 Flooding Event*

#### Rainfall

One of the most substantial flooding events in the Fox River watershed in recent history was caused by torrential rainfall that started in the evening on July 11, 2017, and continued through the morning of July 12. Approximately three to eight inches of rain fell on the Fox River watershed during this time. At the Burlington Municipal Airport rain gage, 7.33 inches of rain was recorded within a 12-hour period, which equated to approximately a 0.2-percent-annual-probability (500-year) storm event. Appendix B summarizes the rainfall frequencies for the July 2017 event throughout the Fox River watershed.

#### Flooding Impacts in Burlington

The City of Burlington experienced major flooding due to the July 2017 storm event. The Fox River in Burlington crested at 16.15 ft on July 13, more than five feet over the flood stage.[20] The Fox River flooding blocked many roads and bridges in the City of Burlington and limited passage between the east and west parts of the City. Homes were impacted by flooding just east of the confluence of the White River and Fox River, from North Spring Street to Capital Street. Veterans Park and Riverside Park also experienced

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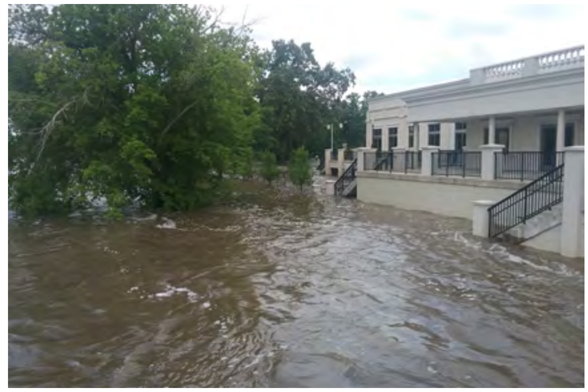
[18] *After removal of the Fox River dam at Wilmot the U.S. Geological Survey relocated the gaging station about 11 miles upstream to CTH JB in October 1993.*

[19] *National Climatic Data Center,* Storm Data and Unusual Weather Phenomena with Late Reports and Corrections, *Volume 5, Number 6, June 2008.*

[20] *National Climatic Data Center,* Storm Data and Unusual Weather Phenomena with Late Reports and Corrections, *Volume 59, Number 7, July 2017.*

extensive flooding, as shown in Figure 3.1. The WE Energies substation adjacent to Riverside Park was also submerged, contributing to the loss of power for up to three days for approximately 25,000 customers.[21] The Fox River State Bank also experienced flooding, resulting in the destruction of all the cash inside their vault.[22] This flooding event caused a level of destruction and disruption to daily life that was unprecedented in the City of Burlington.

**Figure 3.1**
**Photograph of Veterans Terrace in the City of Burlington on July 13, 2017**



*Source: Wisconsin Department of Natural Resources*

Flooding Impacts in Other Communities

Other communities within the Fox River watershed also experienced varying levels of flooding during the July 2017 storm event, creating a range of consequences across the watershed. In the City of Waukesha, floodwaters displaced storm drains and manhole covers, and the Waukesha City Hall experienced flooding in its basement.[23] Floodwaters also created secondary problems throughout the watershed. For example, sanitary sewer overflows were reported in 15 communities throughout Kenosha, Racine, and Walworth Counties, and more than 16.7 million gallons of sewage was released into the Fox River between July 12 and 16 to prevent backups into local basements.[24] In response to flooding issues throughout the watershed, the Governor declared a state of emergency in twenty counties (including Kenosha, Racine, and Walworth Counties) and called on the Wisconsin National Guard to deploy roughly one hundred soldiers to help with activities like traffic control, health and welfare checks, and sandbagging. The NCEI's Storm Events Database reported that this storm event caused approximately $37.9 million in damages to property over the four counties of interest, as well as approximately $82,000 in damages to crops (2017 dollars).[7]

### Vulnerability and Community Impacts Assessment

To assess the vulnerability of the Fox River watershed to flooding hazards and related stormwater drainage problems, the applicable basic inventory asset data described in Chapter 2 was refined and analyzed. For this purpose, consideration was given to potential structure flooding, including critical facilities, and potential roadway flooding.

The analyses estimating the flooding impacts to structures and road crossings that would result from a 1-percent-annual-probability flood were based on the FEMA effective floodplains that were available at the time the analyses were conducted. Where available, FEMA preliminary floodplain mapping was also used for a separate analysis in Kenosha County (published March 28, 2022), Racine County (published December 23, 2021), and Waukesha County (published September 15, 2021). The preliminary floodplain analysis results can be found in Appendix A.

#### *Flooded Structures Count*

Commission staff conducted a parcel-based analysis to estimate the number of structures that would experience flooding as the result of a 1-percent-annual-probability flood event. GIS was used to identify those structures that are wholly or partially located in the mapped 1-percent-annual-probability floodplain. This was done as a visual check only and riverine flood elevations were not compared to topography. The structures were then examined using both 2015 orthophotography and tax parcel information to classify each building as residential, commercial, agricultural, manufactured homes, governmental, community utility, or other. Critical facilities within the floodplains were also specially identified in this analysis. Structures were not counted if they were removed from the FEMA floodplain by a Letter of Map Revision (LOMR) or Letter of Map Amendment (LOMA). Affected structures were counted for both the effective floodplain mapping and the new preliminary floodplain mapping (Appendix A).

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[21] *Elkhorn Independent,* Neighboring community devastated by water, *July 20, 2017.*

[22] *Wisconsin Department of Natural Resources,* Floodplain & Shoreland Management Notes*, Summer Newsletter, 2017.*

[23] *Waukesha Freeman,* RAIN on the RAMPAGE*, July 13, 2017.*

[24] *Milwaukee Journal Sentinel,* Flood damage costs rising; sanitary sewers overflow*, July 21, 2017.*

Impact of Flooded Structures

In total, 1,255 structures were counted within the effective 1-percent-annual-probability floodplain in the Fox River watershed (Table 3.1). The locations of these structures are shown on Map 3.1. This map also highlights the top ten municipalities with the highest estimated number of affected structures. Communities with the highest expected flooding impacts in order are the Town of Norway, the Village of Salem Lakes, the Town of Burlington, the City of Burlington, and the City of Waukesha.

A similar structure count was completed using a combination of effective floodplain maps and the most recent preliminary floodplain mapping that was available at the time of assessment. Although preliminary floodplain mapping is not final and cannot be used for regulatory purposes, these floodplain maps often provide more detail than prior floodplain maps and represent more up-to-date conditions. When preliminary maps were taken into consideration, 1,290 structures were counted within 1-percent-annual-probability floodplains in the Fox River watershed. A summary of the number of structures affected by the most recent floodplain mapping, including preliminary floodplain maps, is provided in Appendix A.

As of October 2022, there were 48 structures that are considered by the National Flood Insurance Program to be repetitive- or severe repetitive-loss properties within the Fox River watershed. A summary of these structures by county is provided in Table 3.2. Repetitive-loss structures are those that have two or more flood insurance claims of at least $1,000 each. Severe repetitive-loss properties are:

- Those that either have four or more flood insurance claims for damages to buildings or contents of at least $5,000 each
- Two or more flood insurance claims for building damages that total more than the existing value of the building

The Wisconsin Division Emergency Management (WEM) has made the acquisition and demolition of repetitive loss and severe repetitive-loss properties a priority. Acquisition and demolition of such properties are eligible for funding through the FEMA Hazard Mitigation Grant Program (HMGP) and Pre-Disaster Mitigation Program (PDM).

Critical Facilities

The flooded structure count also identified critical facilities, which are structures that provide services that are considered imperative for the health and welfare of the population, as defined in Chapter 2. It is important to pay close attention to which critical facilities are threatened by the 1-percent-annual-probability floodplain because of the problems that can arise when these facilities are out of service. The critical facility structures potentially at risk from the 1-percent-annual-probability flood in the Fox River watershed are itemized below.

- Electric Power Substation, located at 532 Calumet Street, City of Burlington
- Dover Township Wastewater Treatment Plant, located at 25306 Kickapoo Drive, Town of Dover
- Williams Bay Water Department, located at 153 Elkhorn Road, Village of Williams Bay
- City of Waukesha Water Utility, located at 1032 Baxter Street, City of Waukesha
- Wisconsin Electric Power Co., located at 121 Union Street, City of Waukesha
- Lake Pewaukee Sanitary District Building, located at N22W28024 Edgewater Drive, City of Pewaukee
- Salem Lakes Lift Station (formerly Silver Lake Wastewater Treatment Facility), located at 9344 296th Avenue, Village of Salem Lakes

It should be noted that the structures listed above were assessed for flood risk based on a comparison of FEMA floodplain maps and orthophotography of the region. A comparison of FEMA effective 1-percent-annual-probability water surface elevation values and a review of land elevations surrounding the critical facility would provide a more accurate assessment of the level of flood risk.

**Table 3.1**
**Flooded Structure Count in Effective Floodplain by Municipality and Structure Type**

| Municipality | Residential | Commercial | Agricultural | Manufactured Homes | Community Utility | Government | Other | Total Structures |
|---|---|---|---|---|---|---|---|---|
| Kenosha County | | | | | | | | |
| Town of Brighton | -- | -- | -- | -- | -- | -- | -- | 0 |
| Town of Randall | 9 | -- | -- | -- | -- | -- | -- | 9 |
| Town of Wheatland | 27 | 4 | -- | -- | -- | -- | -- | 31 |
| Village of Salem Lakes | 142 | 2 | -- | 17 | 1 | -- | -- | 162 |
| Village of Twin Lakes | 4 | -- | -- | -- | -- | -- | -- | 4 |
| Kenosha County Total | 182 | 6 | -- | 17 | 1 | -- | -- | 206 |
| Racine County | | | | | | | | |
| City of Burlington | 44 | 8 | -- | -- | 1 | -- | 1 | 54 |
| Town of Burlington | 28 | -- | 2 | 69 | -- | -- | -- | 99 |
| Town of Dover | 23 | 1 | -- | -- | 3 | -- | -- | 27 |
| Town of Norway | 274 | 3 | 11 | -- | 1 | -- | -- | 289 |
| Town of Waterford | 42 | -- | -- | -- | -- | -- | -- | 42 |
| Village of Rochester | 6 | -- | -- | -- | -- | -- | 1 | 7 |
| Village of Waterford | 4 | -- | -- | -- | -- | -- | 1 | 5 |
| Racine County Total | 421 | 12 | 13 | 69 | 5 | -- | 3 | 523 |
| Walworth County | | | | | | | | |
| City of Lake Geneva | -- | 1 | -- | -- | -- | -- | -- | 1 |
| Town of Bloomfield | 3 | 2 | -- | -- | -- | -- | -- | 5 |
| Town of East Troy | 1 | 1 | 1 | -- | -- | -- | -- | 3 |
| Town of Geneva | 26 | 4 | -- | -- | -- | -- | -- | 30 |
| Town of La Grange | 6 | -- | -- | -- | -- | -- | -- | 6 |
| Town of LaFayette | 4 | 2 | 1 | -- | -- | -- | -- | 7 |
| Town of Linn | 5 | -- | -- | -- | -- | -- | -- | 5 |
| Town of Lyons | 11 | 2 | 2 | 4 | -- | -- | -- | 19 |
| Town of Spring Prairie | 3 | -- | 1 | -- | -- | -- | -- | 4 |
| Town of Sugar Creek | 1 | -- | 1 | -- | -- | -- | -- | 2 |
| Town of Troy | 1 | -- | -- | -- | -- | -- | -- | 1 |
| Village of Bloomfield | 9 | 1 | 1 | -- | -- | -- | -- | 11 |
| Village of East Troy | 1 | 2 | -- | -- | -- | -- | -- | 3 |
| Village of Fontana | 3 | 1 | -- | -- | -- | -- | -- | 4 |
| Village of Genoa City | 3 | -- | -- | -- | -- | -- | -- | 3 |
| Village of Williams Bay | -- | -- | -- | -- | 2 | -- | -- | 2 |
| Walworth County Total | 77 | 16 | 7 | 4 | 2 | -- | -- | 106 |

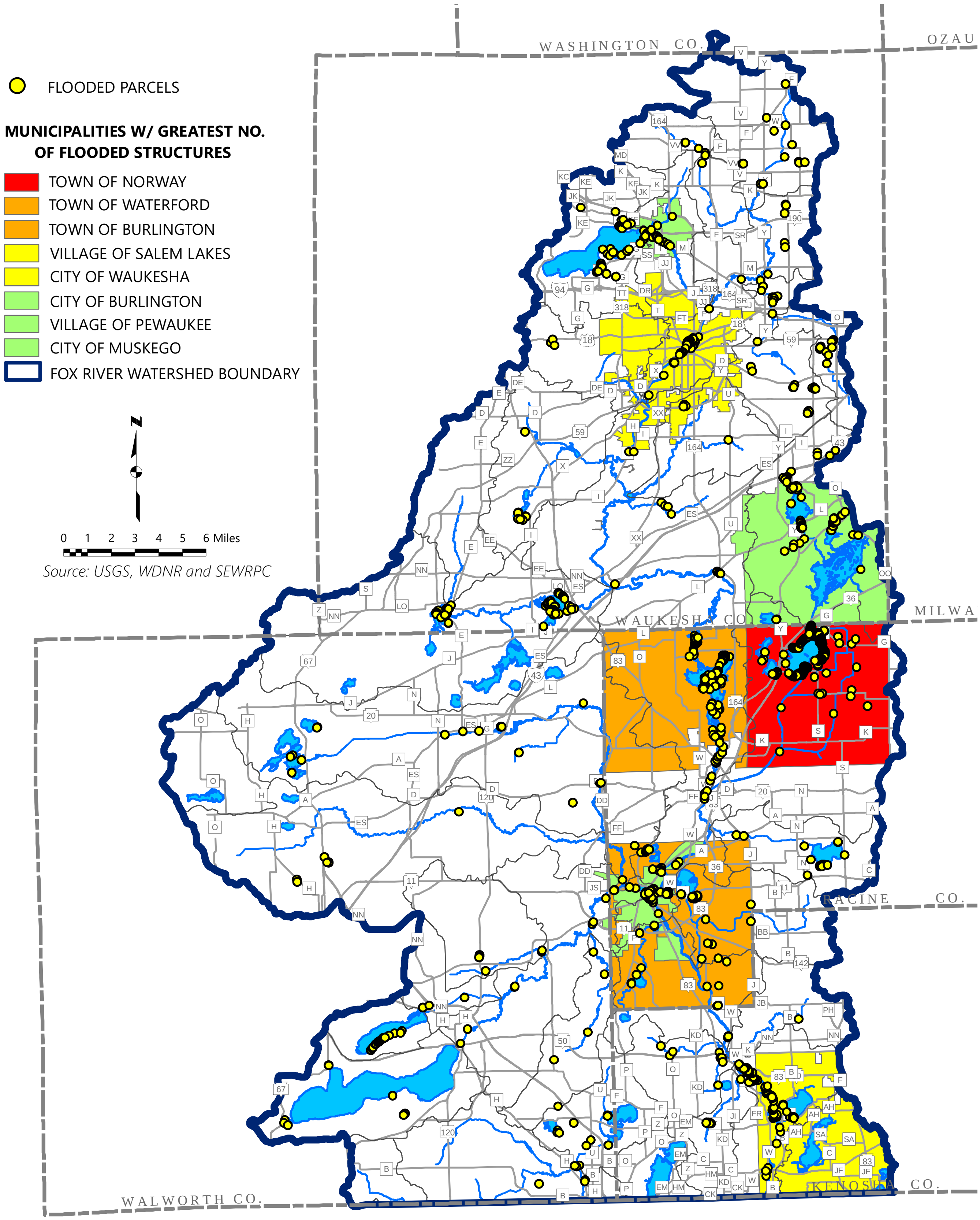
**Table continued on next page.**

**Table 3.1 (Continued)**

| Municipality | Residential | Commercial | Agricultural | Manufactured Homes | Community Utility | Government | Other | Total Structures |
|---|---|---|---|---|---|---|---|---|
| Waukesha County | | | | | | | | |
| City of Brookfield | 8 | 1 | -- | -- | -- | 1 | -- | 10 |
| City of Muskego | 52 | 4 | -- | -- | -- | -- | -- | 56 |
| City of New Berlin | 21 | 9 | -- | -- | -- | -- | 7 | 37 |
| City of Pewaukee | 38 | 5 | -- | -- | -- | -- | -- | 43 |
| City of Waukesha | 58 | 9 | -- | -- | 3 | 1 | 6 | 77 |
| Town of Brookfield | 7 | 1 | -- | -- | -- | -- | -- | 8 |
| Town of Delafield | 4 | 1 | -- | -- | -- | 1 | -- | 6 |
| Town of Eagle | 28 | -- | -- | -- | -- | -- | -- | 28 |
| Town of Genesee | 1 | 1 | -- | -- | -- | -- | -- | 2 |
| Town of Mukwonago | 47 | -- | -- | -- | -- | -- | -- | 47 |
| Village of Big Bend | 4 | -- | -- | -- | -- | -- | 1 | 5 |
| Village of Lannon | 1 | -- | -- | -- | -- | -- | 1 | 2 |
| Village of Menomonee Falls | 8 | 1 | -- | -- | -- | -- | -- | 9 |
| Village of Mukwonago | 11 | 1 | -- | -- | -- | -- | -- | 12 |
| Village of Pewaukee | 20 | 21 | -- | -- | -- | 4 | 10 | 55 |
| Village of Sussex | 3 | 2 | -- | -- | -- | 3 | -- | 8 |
| Village of Vernon | 8 | 4 | -- | -- | -- | -- | -- | 12 |
| Village of Waukesha | 2 | 1 | -- | -- | -- | -- | -- | 3 |
| Waukesha County Total | 321 | 61 | -- | -- | 3 | 10 | 25 | 420 |
| Total | 1,001 | 95 | 20 | 90 | 11 | 10 | 28 | 1,255 |

*Source: SEWRPC*

## Map 3.1
## Flooded Structures in the Effective Floodplains in the Fox River Watershed




Source: USGS, WDNR and SEWRPC

**Table 3.2**
**Repetitive and Severe Loss Structures in the Fox River Watershed**

| County | Repetitive Loss Structures | Severe Loss Structures | Total Structures |
|---|---|---|---|
| Kenosha | 21 | 6 | 27 |
| Racine | 4 | 0 | 4 |
| Walworth | 4 | 0 | 4 |
| Waukesha | 13 | 0 | 13 |
| Total | 42 | 6 | 48 |

*Source: Wisconsin Department of Emergency Management*

### *Roadway Flooding Analysis*

Within the Fox River watershed, major roadways were evaluated for potential flooding due to riverine flooding sources. The major roadways evaluated include interstate highways, state highways, county highways, plus other arterial and select major collector roadways. No minor collector and local roadways were evaluated as part of this study. Map 2.9 in Chapter 2 shows all the major roadways evaluated for potential flooding. GIS and FEMA FIS reports were used to identify major roadways overtopped by the 1-percent-annual-probability event. Two sets of FEMA Flood Insurance Rate Maps (FIRMs) were used to identify roadway flooding locations, that being the current effective and preliminary mapping.

Potential major roadway flooding was first identified in GIS at locations where the major roads appeared to be inundated by the effective and preliminary 1-percent-annual-probability floodplain. The roadway locations with potential flooding were then identified in the corresponding flood profile exhibits in the effective and preliminary FIS reports. The 1-percent-annual-probability flood elevations and the top of road elevations from the FIS reports were recorded, and the roadway flood depths were calculated. For several potentially flooded roads, no top of road information was available in the FIS reports. This was the case when the flooded roadway was parallel to the stream or when the floodplain was designated as Zone A, an approximated floodplain with no associated flood elevation. In such cases, the top of road elevations were estimated using GIS terrain data derived from LiDAR. The terrain data for Racine and Kenosha Counties were completed in 2017. The terrain data for Walworth and Waukesha Counties represent year 2015. Map 3.2 shows the roadway flooding locations based on the effective floodplains. The roadway flooding locations are color coded based on flood depth. The preliminary floodplain map for the road overtopping can be found in Appendix A.

Table 3.3 summarizes the number of roadway flooding locations in each county within the Fox River watershed. In the Fox River watershed, according to the effective FIRMs, there were 70 major roadways identified to flood during the 1-percent-annual-probablity flood event. When the preliminary FIRMs were used where available, there were a total of 78 major roadways identified to flood during the 1-percent-annual-probability flood event. A roadway is often considered impassable when flood depths reach one foot. Utilizing the effective FIRMs, flooding depths of one foot or greater were identified for 32 major roadways. Utilizing the preliminary FIRMs, 42 major roadways would be flooded one foot or greater. Maximum flood depths of up to five feet were tabulated for major roadways in the Fox River watershed. A detailed list of all the identified roadway flooding locations during the 1-percent-annual-probability flood event with their computed flood depths can be found in Appendix C.

<u>Bridge and Culvert Structure Condition Ratings</u>

In addition to assessing the risks of roadway flooding, bridge and culvert structure conditions were also evaluated within the Fox River watershed. Roadway flooding compounded with poor bridge/culvert structure conditions would increase the risks of flood hazards in the watershed. The Federal Highway Administration (FHWA) National Bridge Inventory (NBI) bridge condition ratings were obtained from the latest (May 2022) inspection reports for publicly maintained bridge and culvert structures. Twenty roadways identified to flood during the 1-percent-annual-probability event, according to either the effective or the preliminary FIRMs, have available NBI structure condition ratings. Currently only two culvert structures identified to have roadway flooding are rated poor or worse (NBI rating of 4 or lower). One structure is located under CTH JJ along Pewaukee Lake Tributary in Waukesha County, and the other structure is located under CTH XX along Pebble Brook also in Waukesha County. Appendix C provides a full list of the 20 roadway bridges/culvert and their NBI bridge condition ratings.

## Map 3.2
## Major Roadway Flooding Locations: Effective 1-Percent-Annual-Probablity Floodplain in the Fox River Watershed

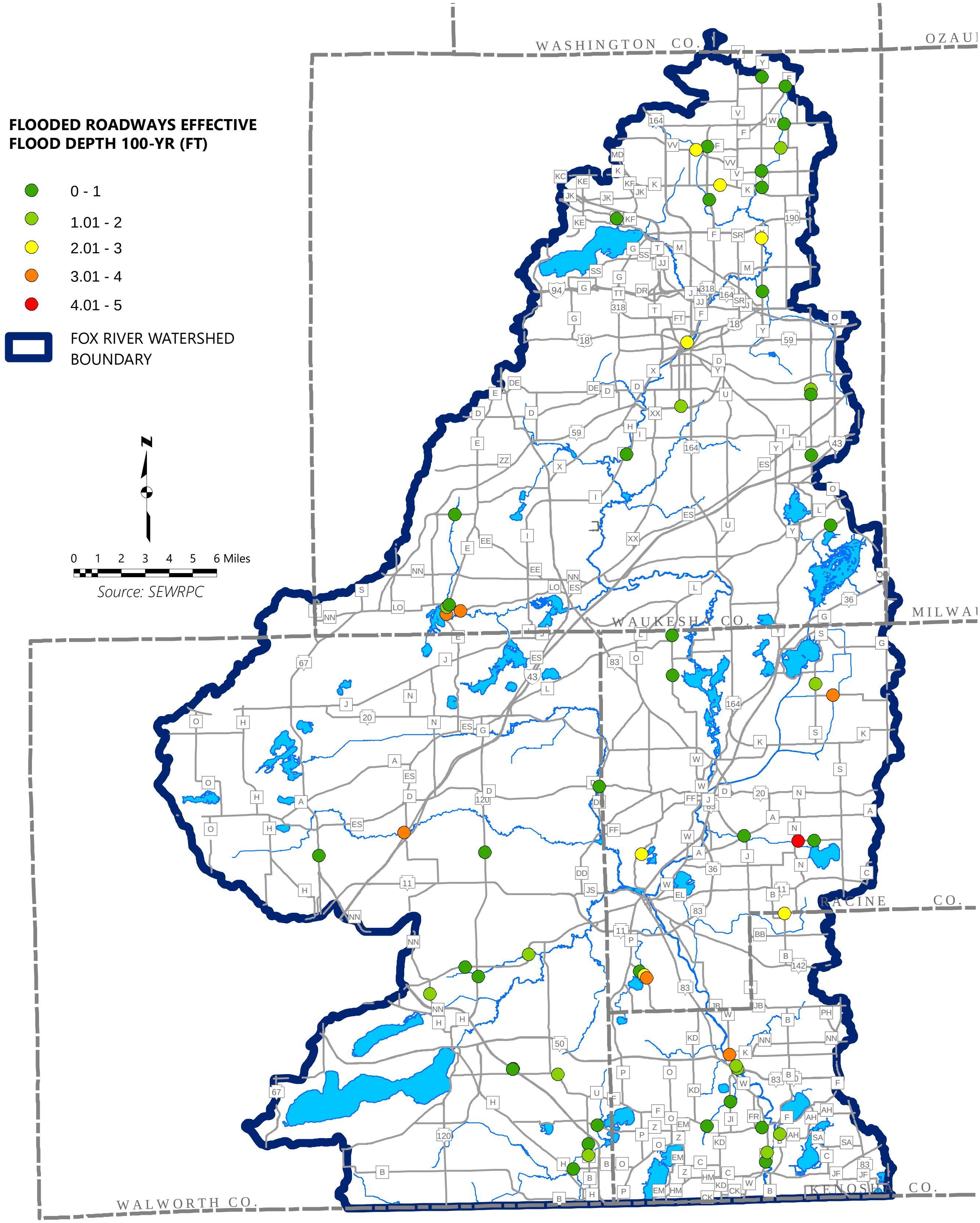


**Table 3.3**
**Summary of Roadway Flooding in the Fox River Watershed**

| County | Number of Major Roadways Identified to be Flooded During the 1-Percent-Annual-Probability Flood Event | |
|---|---|---|
| | FEMA Effective Floodplain | FEMA Preliminary Floodplain[a] |
| Kenosha | 10 | 12 |
| Racine | 12 | 16 |
| Walworth | 15 | -- |
| Waukesha | 33 | 35 |
| Total | 70 | 78[b] |

[a] *As of July 2023, FEMA preliminary floodplain mapping exists for Kenosha, Racine, and Waukesha Counties only.*

[b] *Total includes the Walworth County total based on the FEMA effective floodplain.*

*Source: Federal Emergency Management Agency and SEWRPC*

The complete 2021 NBI dataset were also obtained from WEM. The 2021 dataset contained bridge conditions data through the end of 2020. The 2021 NBI dataset contains all publicly maintained highway bridges and culverts greater than a 20-foot span. All the bridges and culverts within the NBI dataset over watercourses in the Fox River watershed were assessed for their structural conditions. Table 3.4 summarizes their condition ratings. A total of 241 bridge and culvert structures were identified in the Fox River watershed. A detailed list of each structure can be found in Appendix C. Out of the 241 structures, 23 were identified to have some components of the structure being rated poor or worse (NBI rating of 4 or lower).

It should be noted that most local bridges and culverts in the watershed are not listed within the NBI dataset, and therefore their structural conditions could not be obtained. Communities should utilize any locally available bridge or culvert structural conditions data to further assess hazard risks.

### *Vulnerable Infrastructure Assessment for Fox River Bank and Bed Erosion*

In 2017, the Commission inspected the riverbank and riverbed stability along the lower 27 miles of Fox River mainstem from the Waterford Dam to the Wisconsin-Illinois border. The inspection was completed in a kayak using GPS and camera equipment. The field review identified 14 riverbank locations with excessive erosion and/or unstable banks that have the potential to compromise adjacent infrastructure. Infrastructure types impacted by the erosion sites included roads, railroads, bridges, and buildings. To quantify the erosion severity, measurements were taken for bank height, length, slope, and bathymetry. Soil composition and river morphology were also considered, and historical aerial photography was compared to recent aerial photos to note visible changes. Table 3.5 summarizes the 14 erosion sites on the Fox River mainstem with information on their location, length, severity, ownership, impacted infrastructure type, and whether the impacted infrastructure is currently within the FEMA 1-percent-annual-probability floodplain.

### *Vulnerable Population Assessment for Floods*

An evaluation was made for flooding impacts to vulnerable populations in the Fox River watershed. Vulnerable populations that were considered included disabled populations, those in economic distress,[25] and those living in poverty.[26] For the Fox River watershed in Wisconsin these vulnerable populations are predominantly clustered in the Cities of Burlington and Waukesha, the Villages of East Troy and Twin Lakes, and the Towns of Bloomfield, East Troy, Linn, and Salem.[13] Based on the effective floodplain mapping (Map 2.6) vulnerable populations in the Cities of Burlington and Waukesha are at a higher risk of flooding from the Fox River mainstem. Populations in the cities and villages are also more susceptible to stormwater flooding due to the compact nature of development.

[25] *The United States Department of Commerce, Economic Development Administration (EDA) considers an area economically distressed if its residents have an average 24-month unemployment rate that is higher than average by at least one percentage point, or if its residents have an average annual per capita income level at or below 80 percent of the U.S. average.*

[26] *Southeastern Wisconsin Regional Planning Commission and Milwaukee 7 Regional Economic Development Partnership,* Comprehensive Economic Development Strategy for Southeastern Wisconsin: 2021-2025, *September 2021.*

## Table 3.4
## Summary of 2021 WisDOT Bridge and Culvert Conditions in the Fox River Watershed

| County | Number of WisDOT Bridges and Culverts Over Watercourses in the Fox River Watershed for Each NBI Condition Rating | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Excellent Condition (9) | Very Good Condition (8) | Good Condition (7) | Satisfactory Condition (6) | Fair Condition (5) | Poor Condition (4) | Serious Condition (3) | Critical Condition (2) | Imminent Failure Condition (1) | Failed Condition (0) |
| Kenosha | 0 | 2 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 |
| Racine | 0 | 2 | 17 | 10 | 7 | 4 | 1 | 0 | 0 | 0 |
| Walworth | 0 | 6 | 27 | 17 | 12 | 4 | 2 | 0 | 0 | 0 |
| Waukesha | 4 | 11 | 50 | 28 | 18 | 9 | 3 | 0 | 0 | 0 |
| Total | 4 | 210 | 96 | 57 | 40 | 17 | 6 | 0 | 0 | 0 |

Note: Latest Bridge Inspection Reports as of May 2022 were reviewed for bridges rated Serious Condition (3) or worse. One bridge was discovered to have been replaced after the 2021 NBI dataset was compiled (Appendix C). The 2022 condition of that bridge is reflected in this table.

*Source: United States Department of Transportation Federal Highway Administration and SEWRPC*

## Table 3.5
## Fox River Erosion Impacts to Infrastructure (Downstream of Waterford Dam): 2017

| Location | Erosion Length (ft) | Infrastructure Type | County | Erosion Severity[a] | Public Ownership | FEMA 1-Percent-Annual-Probability Road Flooding | FEMA 1-Percent-Annual-Probability Building Flooding |
|---|---|---|---|---|---|---|---|
| Adjacent to CTH W and 1.5 miles downstream of CTH F | 1,960 | Road | Kenosha | Slight | Yes | Yes | N/A |
| Immediately downstream of CTH F[b] | 620 | Road and Bridge | Kenosha | Moderate | No | No | N/A |
| Adjacent to CTH W and S. Riverside Drive[b] | 720 | Road and Building | Kenosha | Moderate | No | No | No |
| Adjacent to W. Lake Street[b] | 1,030 | Road and Building | Kenosha | Moderate | Partial | Yes | Yes |
| Adjacent to CTH W and 3.3 miles downstream of STH 50/83[b] | 340 | Road and Building | Kenosha | Severe | Yes | No | No |
| Adjacent to CTH W and 1.6 miles downstream of STH 50/83[b] | 1,170 | Road | Kenosha | Moderate | Yes | No | N/A |
| Adjacent to CTH W and 0.2 miles upstream of STH 50/83 | 480 | Road | Kenosha | Very Severe | Yes | Yes | N/A |
| Adjacent to 330th Avenue | 770 | Building | Kenosha | Moderate | No | N/A | No |
| Immediately downstream of CTH JB[c] | 700 | Road and Bridge | Kenosha | Moderate | No | No | N/A |
| Adjacent to Canadian National Railroad and 0.7 mi upstream of CTH JB | 790 | Railroad | Racine | Moderate | No | No | N/A |
| 0.1 mi upstream of STH 11/36/83 | 520 | Railroad | Racine | Moderate | No | No | N/A |
| Immediately downstream of E. State Street | 340 | Road, Bridge, and Building | Racine | Severe | No | No | Yes |
| Adjacent to Milwaukee Ave and 1.1 mi downstream of CTH W | 900 | Road | Racine | Very Severe | No | Effective: No<br>Preliminary: Yes | N/A |
| Adjacent to N. River Road and River Ridge Circle | 460 | Building | Racine | Moderate | No | N/A | No |

[a] *Erosion severity was rated by SEWRPC staff based on observable features of the bank and changes in historical aerial photography.*

[b] *Deep scour holes were observed at these erosion locations based on field inspection conducted in 2017.*

[c] *The CTH JB bridge over Fox River has a 2021 NBI Bridge Condition Rating of 5 (Fair Condition).*

*Source: SEWRPC*

***Potential Future Changes in Flood Conditions***

Changes in land use can have a direct impact on flood flows and stages and, accordingly, can impact flooding problems. The changes in urban land use over the 35-year period from 2015 through 2050 are expected to result in an increase in the amounts of impervious surface in these watersheds. In the absence of mitigative measures, this could lead to increases in future flood flows and stages, especially in downstream areas. As is discussed previously in this report, there are a number of regulatory programs in place that are intended to mitigate the flood impact from development. These include implementing current floodplain and related ordinances and existing and ongoing stormwater management plans and regulations.

Changes in climate are likely to affect the potential for flooding in the Fox River watershed during the 21st century. Model projections show Wisconsin receiving more precipitation and more frequent intense precipitation events. These models suggest that by 2050 annual average temperatures in Wisconsin will increase by about 4° to 6°F and the frequency and magnitude of extreme rainfall events (2-5 inches) will be enhanced. By the mid-21st century, Southeastern Wisconsin may receive three more precipitation events of two or more inches in 24 hours per decade, roughly a 25 percent increase in the frequency of heavy precipitation events.[27] This is likely to increase the frequency of high flows and high water levels and potentially increase the frequency and severity of flooding. In particular, the expected increases in the magnitude and frequency of large rainfall events will likely increase flood magnitudes in streams and rivers in Wisconsin, although the amount of increase will vary from place to place. The amount of precipitation that falls as rain during winter and early spring months is expected to significantly increase.

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

The projected increase in the magnitude and frequency of heavy storms could also affect the performance of existing and planned stormwater management and flood mitigation systems. This increase could also expand flood hazard areas, such as the 1-percent-annual-probability flood hazard area, beyond their existing boundaries, potentially encompassing more existing development. This could lead to an increase in the risk of flood damages and a future need for greater floodplain storage capacity, larger stormwater management facilities, and updated programs.

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

## 3.3 VULNERABILITY ASSESSMENT FOR DAMS

Dams are any artificial barriers in or across a watercourse which have the primary purpose of impounding or diverting water.[28] Dams are built for the purposes of flood management, power generation, industry, and to create recreational opportunities. Designs and configurations of dams can vary greatly, from a simple fixed-crest spillway with no operable components to more complex configurations that contain various types of operable gates, overflow weirs, and stop log systems that allow an operator to control flow and water levels.

[27] *Wisconsin Initiative on Climate Change Impacts,* Wisconsin's Changing Climate: Impacts and Adaptation*, Nelson Institute for Environmental Studies, University of Wisconsin-Madison and Wisconsin Department of Natural Resources, 2011.*

[28] *Wisconsin Administrative Code, NR 333.03.*

A properly functioning dam can control water levels in the upstream impoundment by impeding streamflow below the weir elevation. Dams with controlled spillways, such as operable gates or stop logs, can release impounded water to modify water levels and alter stream flow over time in a managed fashion. However, if a dam fails or experiences overtopping, large amounts of water can be rapidly discharged downstream with the potential to cause significant damage. Assessing the potential for loss in the event of a dam failure is an important part of flood hazard mitigation.

In Wisconsin, the WDNR inspects dams and assigns hazard ratings for all large dams. A dam classified as a *large dam* either has a structural height of over six feet and impounds at least 50 acre-feet of water or has a structural height of at least 25 feet and impounds more than 15 acre-feet of water. A dam that does not meet these criteria is classified by the WDNR as a *small dam*. All large dams have regulatory design standards and are required to be inspected due to their potential to impact downstream areas in the event of a dam failure. Hazard ratings assigned to large dams are based on the degree and type of development downstream of the dam and the potential for loss of life or damage to property in the event of a dam failure. Hazard ratings are not related to the condition of the dam nor the likelihood of failure.

Dams with a hazard rating of *low hazard* have no development immediately downstream of the dam with future development in the hydraulic shadow prohibited. Failure of a low hazard dam would result in no probable loss of human life, low economic losses, low environmental damage, and no significant disruption to critical facilities. A rating of *significant hazard* is assigned to dams with no development in the hydraulic shadow that would be inundated to a depth of greater than two feet, have a prohibition on future development in the hydraulic shadow, and a failure of which would result in no probable loss of human life but may cause economic loss, environmental damage, or disruption of critical facilities. Dams with a hazard rating of *high hazard* have development in the dam failure shadow that would be inundated to a depth of greater than two feet or do not have land use controls in their local zoning ordinance that prohibit future development in the hydraulic shadow, and loss of human life is probable in the event of a dam failure. All assessments of dam failure inundation are based on a dam failure during the 1-percent-annual-probability (100-year recurrence interval) flooding event.

An Emergency Action Plan (EAP) is a document that characterizes emergency events that a dam could experience and outlines responses to mitigate the emergency and to protect life and property. *Wisconsin Administrative Code* requires an EAP for all large dams. All EAPs require a dam failure analysis, which is a study that assesses the impact of a dam breach to downstream areas. The extents of inundation from a failure are mapped to produce a dam failure shadow, or hydraulic shadow, which is the area downstream of a dam that would experience flooding in the event of a failure during a 1-percent-annual-probability event. Also included in an EAP are protocols for determining the level of emergency, a flowchart describing the chain of communication and contacts during an emergency, and reentry and recovery requirements. These processes are outlined to provide responders with a plan to respond to a dam emergency in an efficient manner to reduce the chance of loss of life or damage to property.

Chapter NR 333 of the *Wisconsin Administrative Code* also requires that all large dams have an Inspection, Operation, and Maintenance Plan (IOM), which identifies the parties that are responsible for operating, inspecting, and maintaining a dam and outlines operational procedures. An IOM is an important tool in avoiding an emergency by setting forth procedures for routinely inspecting the dam as well as identifying and mitigating problems before they develop into emergencies. Similarly, the IOM provides guidelines for operators to effectively operate the dam and control flows to maintain compliance with any water level or discharge requirements for the specific dam. While there are no codified requirements for information to be included in an IOM, general guidelines are to include a description of the physical dam; operational guidelines for low, normal, and high flow conditions; the frequency and process for inspections; and procedures for maintenance.

**Historical Dam Construction and Incidents**

The first dam in Wisconsin was built in 1809, with many dams being constructed across the state and Region in the ensuing decades of the nineteenth and twentieth centuries.[29] Many of the early dams were built to power mills and to create flowages to aid in the transport of goods. Enacted in 1840, the Milldam

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[29] *WDNR Dam Safety Program,* "History of Dams in Wisconsin," accessed September 19, 2022. dnr.wisconsin.gov/topic/dams/history.html.

Act was the first dam regulation in the Territory of Wisconsin. This act encouraged the construction of mill-powering dams to facilitate settlement in the state and allowed dam impoundments to flood private lands without obtaining easements. Due to the strife this created with private landowners whose land could be flooded without compensation, the Milldam Act was repealed, reinstated, and recreated several times before being declared constitutional in 1860. The following decades saw legislation continue to be expanded to address permitting, the rights of upstream and downstream landowners, safety concerns, and standards for design, construction, reconstruction, and inspections. Upon its creation in 1967, the WDNR was granted jurisdiction over dams within Wisconsin, and it currently oversees all dam design and construction standards, maintenance, repair, and other regulatory issues. WDNR also enforces operational orders that dictate water levels and base flows downstream.

In the early years before modern engineering and geotechnical design principles, dams were created in a more haphazard way. Some early dams were built using twigs, while earthen embankments were constructed by mounding whatever material was on site. Lacking modern structural understanding, these early dams pose a safety concern and require substantial inspection efforts to assure current regulations are met. Over the years, many of these early dams have failed and were subsequently reconstructed at the same location. The following cases are historical events of dam problems in the Fox River watershed.

***Eagleville Mill Dam Failures***

In September 1875, the Eagleville Mill Dam (now known as the Kroll Outlet portion of Wambold Dam on Eagle Spring Lake) experienced a dam failure due to high winds during a repair, resulting in breakage of 160 feet of dam, completely draining the lake.[30] Then in approximately 1895,[31] the dam experienced a dam failure after the installation of a McCormack Holyoke Turbine. During a storm the soil of the dam was disturbed and a large wave overtopped the dam, washing it out. This resulted in two workers losing their lives after being swept away while trying to stem the flow of the breach.

***1992 Wilmot Dam Failure***

The Wilmot Dam was located on the Fox River in the Village of Wilmot. The dam was originally constructed in 1836 and functioned as part of a flour and feed mill.[32] The dam generated hydroelectric power from the 1890s to 1928, at which time power generation ceased and the dam was no longer being maintained. In 1929, the Wisconsin Railroad Commission, the oversight body for dams in the state at that time, granted ownership of the dam to Racine County. The County maintained the dam and completed a reconstruction of the dam in the 1940s. However, the dam failed in February 1992, and what remained of the dam was removed later that year.

***1997 Little Muskego Lake***

Heavy rainfall on June 20 and 21, 1997, delivered three to four inches of rain over a 26-hour storm event in the Muskego area in Waukesha County. Flash flooding from the rainfall caused property damages but no casualties. On Jewel Creek, a tributary of Little Muskego Lake, high water levels and flows stressed a small earthen dam to the point of near failure. A small portion of the dam was breached on June 21, however efforts from the WDNR on June 21 and 22 to gradually lower the lake water levels in a controlled manner avoided any serious flooding.[33]

***2008 Mukwonago Dam***

Nearly eight inches of rainfall were recorded between June 1 and 12, 2008, in Mukwonago, with particularly large events on June 7-8 and June 12. This intense rainfall resulted in elevated flood flows that stressed the Mukwonago Dam, which is located on the Mukwonago River and impounds Upper Phantom Lake and Lower Phantom Lake. The dam showed signs of potential failure on June 10, with water cascading around

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[30] *Date and details taken from a newspaper article dated September 13, 1975, describing the event that occurred one hundred years prior, provided by Peter Jensen.*

[31] *Year estimated based on church meeting notes from the Unitarian Universalist Church of Mukwonago, WI, on September 18, 1920, that memorialize the two workers that lost their lives 25 years prior. Source: Wisconsin Historical Society CompuServe document, provided by Peter Jensen.*

[32] *Kenosha Historical Center, June 4, 2020.*

[33] *City of New Berlin,* "Linnie Lac Dam Site," accessed on September 19th, 2022. www.newberlin.org/543/Linnie-Lac-Dam.

the dam and saturating surrounding soils. Officials notified communities downstream of the dam in Racine who were already experiencing high flood water elevations on the Fox River. A dam failure could also have jeopardized the railroad bridge and Highway 83 bridge directly downstream of the dam. The dam did hold, and after the 2008 flood abated the rock riprap along the south side of the dam was replaced and an auxiliary spillway was constructed in 2012 to add further protections during future floods. An EAP for the Mukwonago dam was created in 2010.

**Vulnerability and Community Impacts Assessment**

An inventory of main dams was completed to assess the vulnerability and impacts of flooding to communities associated with dams across the Fox River watershed. There is no legal definition of a *main dam*, however dams that were larger in size, had operable gates, or impounded large lakes were designated main dams for the purposes of this plan, as these dams were determined to have a greater impact on water levels and flows along the Fox River. Of the 87 total dams within the watershed (Map 2.10), 19 dams were identified as main dams and were included in this detailed assessment (Map 3.3). The WDNR dam inventory provided physical specifications, administrative information, regulatory classifications, and historical data. Commission staff obtained additional information, such as dam EAPs, IOMs, high-water protocols, and other documents through requests to WDNR staff and dam owners. Upon reviewing the available records, Commission staff summarized the following information for each dam: age, regulatory compliance, size, hazard rating, spillway characteristics, water level operating ranges, known impairments and condition, availability of failure shadow, potential impact of dam failure, and operation notes.

Building an inventory of data pertaining to the physical dams is only one important aspect to consider; understanding the dam operations across the watershed is similarly important, especially the interconnectedness of dams and how the actions at one dam can impact flow conditions at downstream dams. Part of this inventory investigated the level of communication among the operators. While it was found that they exchange some communication, it was apparent that this was an underutilized tool with yet untapped potential. Dam operations and operator communication are discussed in detail in Chapter 4.

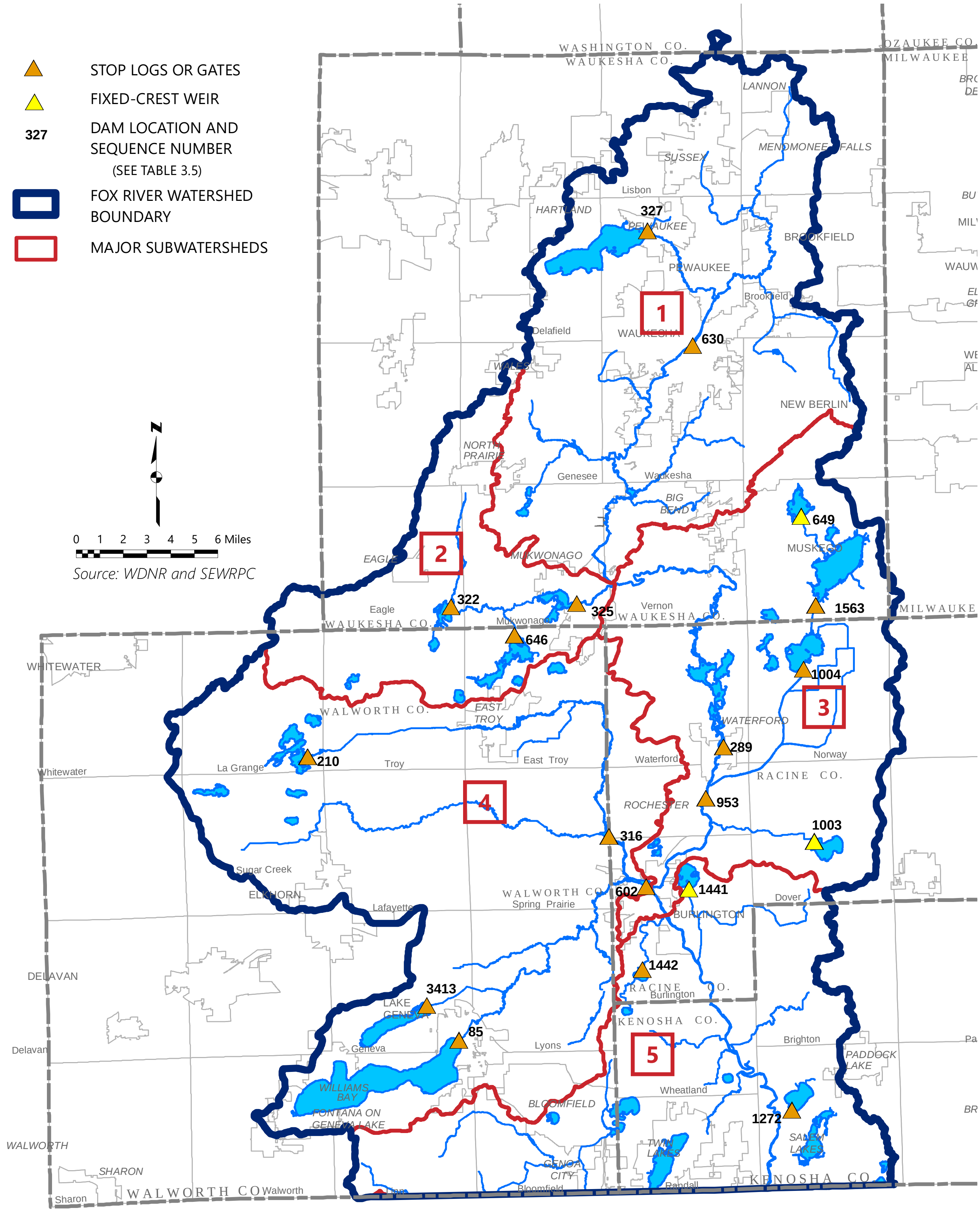
***Age of Dam Structures***

Many dams across the state and Region and within the Fox River watershed were originally constructed in the 1800s. Originally built in 1835 using brush, the Burlington (Echo Lake) Dam was the first to be constructed and was followed by the Mukwonago Dam in 1848, the Pewaukee Dam in the 1840s, and the Geneva Dam in the late 1800s. Most dams originally built in this era have experienced reconstructions and improvements, many of which have significantly modified the original structure, such as replacing a wooden dam with structural concrete. Appendix D presents the documented date of the most recent major improvement to each main dam in the Fox River watershed.

It can be difficult to identify a single age for a dam because improvements are often completed for different components of a dam at different times. As such, dam age is best presented as a series of ages for each major component of the dam, such as the gates, dam structure, and embankments. This data is currently not recorded and made available for all the Fox River watershed dams. For the main dams in the Fox River watershed, ages range from four to 88 years, based on documented most recent work (Appendix D). Knowing the age of the respective dam components can help owners inspect in greater detail older structures and take necessary corrective action as needed.

*Wisconsin State Statute* requires dam inspections and maintenance to preserve dam structural integrity and safety as they age. Older dams that are in weakened condition can pose a higher risk of failing, especially under the added stress of a flooding event. Additionally, older dams constructed in the nineteenth and early twentieth centuries predate modern understanding of geotechnical engineering and dam safety. Modern earthen embankments contain a clay core constructed by compacting each lift of material layer by layer, which maximizes stability and impermeability of the clay core. Internal drainage systems are added to earthen embankments to siphon away water that may be within the embankment and prevent it from undermining the structure. Modern construction includes embankment slopes constructed with shallower grades to increase stability and are often reinforced with rock armoring. Soil types are stringently tested to make sure the material used in and around the dam matches or exceeds that which was used in the design. Older dams may not meet some of these modern-day design standards, which can increase the vulnerability of the structure. It is worth noting the presence of these concerns so that adequate attention can be paid during inspections for older dams.

**Map 3.3**
**Main Dams in the Fox River Watershed**



***Dam Ownership and Operations***

Each dam owner is responsible for operation and maintenance of their dam. Table 3.6 summarizes the owners of each main dam in the Fox River watershed. The owner facilitates dam inspections and is responsible for improvements required to keep the dam in statutory compliance. However, the network of parties involved with a dam goes beyond the owner to emergency managers, regulators, elected officials, and first responders. Everyone must work with the owner to ensure the dam is properly maintained and operated, as well as be prepared for an emergency response so that any downstream risk to life and property is minimized. With assistance from WDNR, dam owners develop EAPs and IOMs to coordinate the responsibilities of the various parties involved with the dam and identify pathways of communication.

Within the Fox River watershed, most dams are operated in accordance with local operation and water level policies, but without appreciable coordination with nearby dam operators. Operation and response frameworks outlined in IOMs and EAPs predominately cover plans for a single, isolated dam and do not assess coordination between or among dam owners and operators. Considering the hydraulic connectivity of adjacent dams can help with flood or emergency preparedness. An upstream operator can notify a downstream operator of changing flow conditions at the upstream dam that may impact the flow conditions at a downstream dam in a matter of hours, especially during flood or emergency dam breach events. The prospect of a watershed-wide operator communication program is an opportunity to reduce the hazard associated with dams with particular emphasis of communication among the five main subwatersheds. Chapter 4 of this report discusses the prospect of an inter-dam communication network among dam owners and operators.

***Inspection of Dams***

*Wisconsin State Statute* mandates inspections of large dams as an essential component of dam management and safety.[34] Inspections are designed to identify deficiencies before they manifest into larger, more threatening issues that could pose an imminent threat to life and property downstream of the dam. Identifying a problem in its early stages during a routine inspection helps to provide adequate time to develop and implement a solution. Large dams that are classified as high hazard or significant hazard are to be inspected at least once every ten years by the WDNR. Additionally, the owner of a high hazard dam shall have the dam inspected by a licensed engineer at least four times between WNDR inspections and the owner of a significant hazard dam least two times between WDNR inspections. Owners of low hazard dams are required to have the dam inspected once every ten years by a licensed engineer, not specifically by the WDNR. In addition to the regular WDNR and professional consultant inspections, an owner must inspect their dam after each high water event.

Following each inspection, the owner of a dam shall submit a report of the inspection results to the WDNR within 90 days of its completion. The report must include any deficiencies of the dam observed during the inspection, recommendations for addressing the deficiencies, and recommendations for improving the structural integrity and safety of the dam.

***Water Level Operating Ranges***

Most of the main dams in the Fox River watershed have impoundment water levels set by WDNR operating orders. These orders can either be for a single normal water level for operation or joint minimum and maximum water levels. The ordered water levels can also vary seasonally, typically with lower winter levels than summer levels. The dam operator must maintain water levels within the ordered range to the best of their ability. Having a narrow, defined range of water levels helps to moderate stream flows and minimize lake damages. Additionally, many of the dams create an impoundment that is managed for recreation. Maintaining water levels within the assigned operation range assures that there will be sufficient water in the impoundment for the intended recreational activities. Table 3.7 summarizes the known operating water levels for the main dams in the Fox River watershed.

***Potential Impacts of Dam Failure***

When a dam fails, a large amount of water can be discharged downstream in an uncontrolled manner in a relatively short period of time. Dams are most likely to fail during a flood event due to the added forces on the dam structures from the flood flows and potential debris. The additional volume of water released downstream from a dam breach can raise the flood water elevations, potentially inundating structures that

[34] *For more information, see* Wisconsin State Statute *31.19(2): docs.legis.wisconsin.gov/statutes/statutes/31/19*.

**Table 3.6**
**Ownership of Main Dams in the Fox River Watershed**

| Dam Name | WDNR Dam Sequence Number | Owner and Operator of Dam | County |
|---|---|---|---|
| Barstow (Waukesha, Saratoga Mill) | 630 | City of Waukesha | Waukesha |
| Beulah | 646 | Lake Beulah Management District | Walworth |
| Bohner | 1442 | Racine County | Racine |
| Browns Lake | 1441 | Browns Lake Sanitary District | Racine |
| Burlington (Echo Lake) | 602 | City of Burlington | Racine |
| Como | 3413 | Town of Geneva | Walworth |
| Eagle Lake | 1003 | Racine County | Racine |
| Eagle Springs Lake (Wambold) | 322 | Eagle Spring Lake Management District | Waukesha |
| Geneva | 85 | Lake Geneva Lake Level Board | Walworth |
| Honey Lake | 316 | Honey Lake Protection & Rehabilitation District | Walworth |
| Lauderdale Lakes | 210 | Lauderdale Lakes Lake Management District | Walworth |
| Little Muskego | 649 | City of Muskego | Waukesha |
| Mukwonago | 325 | Village of Mukwonago | Waukesha |
| Muskego | 1563 | City of Muskego | Waukesha |
| Pewaukee | 327 | Village of Pewaukee | Waukesha |
| Rochester | 953 | Racine County | Racine |
| Silver Lake | 1272 | Brian Sullivan | Kenosha |
| Waterford (Buena Lake) | 289 | Racine County | Racine |
| Wind Lake | 1004 | Racine County | Racine |

*Source: Wisconsin Department of Natural Resources and SEWRPC*

are outside the mapped floodplain, posing a risk to life and property. Dam failure analyses are completed to determine the full area of inundation, called a hydraulic shadow or failure shadow.

Dam failure analyses are required for all large dams in the state of Wisconsin and are used to establish the hazard rating of the dam, the spillway capacity requirements, land use controls needed downstream of the dam, and to inform the emergency action plan for the dam. The modeling completed during a dam failure analysis includes hydrological studies to define the hydraulic shadow from the worst case dam failure during the 1-percent-annual-probability (100-year recurrence interval) event. The hydraulic analyses for the 1-percent-annual-probability event are completed under three scenarios: dam in place, dam non-existent, and dam in place with failure. The analysis also maps the flow over the spillways for the flood recurrence interval required for the spillway design as summarized in Table 3.8.

Part of mitigating the risk from a dam failure or mis-operation is establishing land use controls[35] downstream of the dam within the impacted area, as determined in the dam failure analysis. These controls limit future development in the hydraulic shadow such that loss of life is improbable in the event of a dam failure. Lacking these land use controls is one of the criterion that causes a dam to be classified as high hazard. A dam can be reduced to a significant or low hazard rating with the implementation of such land use controls, provided the other criteria for a significant hazard rating discussed in this chapter are met.

Table 3.9 presents the hazard rating for each main dam in the Fox River watershed. The dams listed in the table are organized by major subwatershed and listed upstream to downstream. There are four dams with a high hazard rating, three with a significant hazard rating, ten with a low hazard rating, and two with no hazard rating. Only the Lower Fox River subwatershed does not have a high or significant hazard dam. A high hazard dam is located in each of the other four major subwatersheds. The Mukwonago, Middle Fox, and White River subwatersheds each contain one significant hazard dam as well. All four of the high hazard dams and two of the significant hazard dams have expected impacts downstream from a potential dam failure. These impacts are described as follows.

[35] *Per NR 333.03(9), "'Land use controls in place' means future development within the hydraulic shadow is required to conform to the criteria specified in a zoning ordinance adopted and approved pursuant to s. 87.30, Stats., and also consistent with land use plans developed under s. 66.1001, Stats., or through restrictive covenants, easements, or other appropriate legal arrangements between the owner of the dam and the owners of all property within the hydraulic shadow."*

**Table 3.7**
**Water Level Operating Ranges of Main Dams in the Fox River Watershed**

| Dam Name | Water Level Operating Range[a] | | Spillway Type[f] | County |
|---|---|---|---|---|
| | Summer[b] | Winter | | |
| Barstow (Waukesha, Saratoga Mill) | Unknown | Unknown | Stop Logs or Gates | Waukesha |
| Beulah | 807.24 ft – 807.83 ft | 807.24 ft – 807.83 ft | Fixed-Crested Weir | Walworth |
| Bohner | Unknown | Unknown | Stop Logs or Gates | Racine |
| Browns Lake | Unknown | Unknown | Fixed-Crested Weir | Racine |
| Burlington (Echo Lake) | 762.26 ft | 762.26 ft | Stop Logs or Gates | Racine |
| Como | 849.15 ft – 849.35 ft | 849.15 ft – 849.35 ft | Stop Logs or Gates | Walworth |
| Eagle Lake | Unknown | Unknown | Fixed-Crested Weir | Racine |
| Eagle Spring Lake (Wambold) | 819.95 ft – 820.25 ft[c] | 819.95 ft – 820.25 ft | Stop Logs or Gates | Waukesha |
| Geneva | 854.34 ft – 854.92 ft[d] | 854.34 ft – 854.92 ft | Stop Logs or Gates | Walworth |
| Honey Lake | 769.5 ft | 767.8 ft | Stop Logs or Gates | Walworth |
| Lauderdale Lakes | 884.41 ft | 884.41 ft | Stop Logs or Gates | Walworth |
| Little Muskego | 792.0 ft | 790.0 ft | Stop Logs or Gates | Waukesha |
| Mukwonago | 787.83 ft | 787.83 ft | Stop Logs or Gates | Waukesha |
| Muskego | 771.46 ft- 771.66 ft | 771.46 ft- 771.66 ft | Stop Logs or Gates | Waukesha |
| Pewaukee | 852.8 ft | 852.2 ft | Stop Logs or Gates | Waukesha |
| Rochester | Minimum: 765.0 ft<br>Normal: 765.5 ft<br>Maximum: 766.5 ft | Minimum: 765.0 ft<br>Normal: 765.5 ft<br>Maximum: 766.5 ft | Stop Logs or Gates | Racine |
| Silver Lake | Minimum: 97.64 ft[e]<br>Normal: 99.14 ft<br>Maximum: 99.64 ft | Normal: 97.64 ft | Stop Logs or Gates | Kenosha |
| Waterford (Buena Lake) | Minimum: 772.63 ft | Minimum: 772.63 ft | Stop Logs or Gates | Racine |
| Wind Lake | 768.44 ft | 767.94 ft | Stop Logs or Gates | Racine |

[a] *Elevations are in the vertical datum NGVD 29.*

[b] *Summer is non-winter, and the specific dates defining summer/non-winter and winter can vary among dams.*

[c] *The Lake Management District informal policy is to maintain the lake level at 820.15 ft NGVD 29. Four cubic feet per second are to be released at all times between the two dams.*

[d] *Geneva Lake does not have a DNR water level order, however the operating range listed is derived from the fixed spillway crest elevation and a water level of seven inches above the spillway crest, which is when the High Water Dam Facility Management process commences as described in the EAP.*

[e] *The operating elevations for Silver Lake are in a local datum.*

[f] *A spillway that has an operable gate or stop logs has a crest elevation that can be changed. A spillway with a fixed crest weir has a crest elevation that cannot be changed.*

*Source: Eagle Spring Lake Management District, Geneva Lake Level Corporation, Wisconsin Department of Natural Resources, and SEWRPC*

### Beulah Dam

The Lake Beulah Dam is a high hazard dam located on the northeast side of the lake. There is dense housing development downstream with several homes along the stream banks. A dam failure analysis was completed in July 2004 and showed that the houses located directly downstream of the dam would be inundated if the dam failed during a 1-percent-annual-probability (100-year recurrence interval) event. Additionally, County Highway J would be closed. There are no critical facilities within the hydraulic shadow.

### Burlington (Echo Lake) Dam

Impounding the White River to form Echo Lake, the Burlington Dam located in downtown Burlington is a significant hazard dam. The Milwaukee Avenue bridge is approximately 370 feet downstream of the dam and the concrete-lined channel under Bridge Street is approximately 700 feet downstream. The confluence of the White River and the Fox River is approximately 1,500 feet downstream of the dam. The dam failure analysis referenced in the 2015 EAP determined 280 parcels would be impacted in a dam failure during a 1-percent-annual-probability flooding event. These parcels include residential, commercial, and industrial development but none of these structures are critical facilities.

**Table 3.8**
**Required Spillway Design Capacities[a]**

| Dam Hazard Rating | Minimum Principal Spillway Capacity | Minimum Total Spillway Capacity |
|---|---|---|
| Low | 10-percent-annual-probability (10-year recurrence interval) event | 1-percent-annual-probability (100-year recurrence interval) event |
| Significant | 2-percent-annual-probability (50-year recurrence interval) event | 0.2-percent-annual-probability (500-year recurrence interval) event |
| High | 1-percent-annual-probability (100-year recurrence interval) event | 0.1-percent-annual-probability (1000-year recurrence interval) event |

[a] *Reproduced from NR 333.07(1).*

*Source: Wisconsin Department of Natural Resources*

Eagle Spring Lake (Wambold) Dam

The Eagle Spring Lake (Wambold) Dam is a significant hazard dam. The dam is comprised of a central mechanical lift gate accompanied by stop boards on the side spillways, which discharge into the Mukwonago River. Residential structures are in the immediate vicinity of the dam, including downstream along the Mukwonago River. The land use further downstream is primarily agricultural, natural lands, and recreational. The dam failure analysis in the 2018 Emergency Response Plan produced by the Lake District determined that a failure of the dam would result in property damage to the adjacent residential structures as well as environmental damage, but no loss of life nor impacts to critical infrastructure would be expected. Inundation of the structures due to dam failure would be less than two feet. Strict floodplain zoning restrictions are in place downstream of the dam that prevent future development in impacted areas.

Lauderdale Lakes Dam

The Lauderdale Lake Dam is a high hazard dam and impounds a small half-acre lagoon connected to the main body of the lake by a dual-cell box culvert under Sterlingworth Drive. The main dam contains a concrete spillway with stoplogs and an earthen embankment on either side of the dam structure. A second part of the dam complex is the Sterlingworth Bay embankment, which is a 300-foot-long earthen embankment north of the main dam, along the southern shore of Sterlingworth Bay. The Sterlingworth Bay embankment was constructed in conjunction with the deepening of the bay. Interstate Highway 12 (I-12) is located approximately 500 feet downstream of the dam.

A dam failure analysis for only the main dam was completed in 2009. A failure of the main dam was shown to not inundate any structures or campgrounds, however the effect on the Sterlingworth Bay embankment from a dam breach is likely to cause consequent unstable and unsafe conditions for the embankment. A subsequent dam failure analysis was completed in 2016 that assessed the failure of the Sterlingworth Bay embankment. A complete failure was determined to have the potential to cause downstream property damage, damage to I-12, vehicle damage, the possible loss of life of motorists and pedestrians, and the possible loss of life of residents in the three condominiums located on the Sterlingworth Bay embankment. The EAP outlines procedures to reroute traffic around the I-12 bridge, as it is assumed a degree of bridge instability may occur from the flood flows and debris.

Little Muskego Lake Dam

The Little Muskego Lake Dam is a high hazard dam positioned along the southern shore of Little Muskego Lake. The dam consists of a concrete control structure with three operable gates that discharge into Muskego Creek. The dam failure analysis included in the EAP determined that there are twenty properties downstream of the dam along Muskego Creek with potentially impacted structures. The inundated structures include residential and commercial properties, with no critical facilities impacted.

Pewaukee Lake Dam

The Pewaukee Lake Dam is a high hazard dam located along the far eastern bay of the lake and has a bottom-draw gate to control lake water levels and spillway discharge. The WDNR has determined that any potential dam failure would be more likely to come from a gate failure rather than an embankment failure due to the substantial width of the embankment. The dam failure analysis completed in 2004 showed that a gate failure during the 1-percent-annual-probability flood event would increase downstream flood

**Table 3.9**
**Size and Hazard Rating of Main Dams in the Fox River Watershed**

| Dam Name[a] | County | Major Subwatershed | WDNR Dam Sequence Number | Size | Hazard Rating | Spillway Type[b] | Failure Shadow Available[c] (Y/N) |
|---|---|---|---|---|---|---|---|
| Pewaukee | Waukesha | 1. Upper Fox | 327 | Large | High | Stop Logs or ates | N |
| Barstow (Waukesha, Saratoga Mill) | Waukesha | 1. Upper Fox | 630 | Large | Low | Stop Logs or Gates | N |
| Eagle Springs Lake (Wambold) | Waukesha | 2. Mukwonago | 322 | Large | Significant | Stop Logs or Gates | Y |
| Beulah | Walworth | 2. Mukwonago | 646 | Large | High | Stop Logs or Gates | Y |
| Mukwonago | Waukesha | 2. Mukwonago | 325 | Large | Low | Stop Logs or Gates | Y |
| Little Muskego | Waukesha | 3. Middle Fox | 649 | Large | High | Fixed-Crested Weir | Y |
| Muskego | Waukesha | 3. Middle Fox | 1563 | Small | Low | Stop Logs or Gates | N/A[d] |
| Wind Lake | Racine | 3. Middle Fox | 1004 | Large | Low | Stop Logs or Gates | N |
| Waterford (Buena Lake) | Racine | 3. Middle Fox | 289 | Large | Significant | Stop Logs or Gates | Y |
| Rochester | Racine | 3. Middle Fox | 953 | Large | Low | Stop Logs or Gates | N[e] |
| Eagle Lake | Racine | 3. Middle Fox | 1003 | Large | Low | Fixed-Crested Weir | N[e] |
| Lauderdale Lakes | Walworth | 4. White River | 210 | Large | High | Stop Logs or Gates | Y |
| Honey Lake | Walworth | 4. White River | 316 | Large | Low | Stop Logs or Gates | N[e] |
| Como | Walworth | 4. White River | 3413 | Small | None | Stop Logs or Gates | N/A |
| Geneva | Walworth | 4. White River | 85 | Large | Low | Stop Logs or Gates | N[e] |
| Burlington (Echo Lake) | Racine | 4. White River | 602 | Large | Significant | Stop Logs or Gates | Y |
| Bohner | Racine | 5. Lower Fox | 1442 | Small | Low | Stop Logs or Gates | N/A |
| Browns Lake | Racine | 5. Lower Fox | 1441 | Small | None (Est. Low) | Fixed-Crested Weir | N/A |
| Silver Lake | Kenosha | 5. Lower Fox | 1272 | Small | Low | Stop Logs or Gates | N/A |

[a] *Dams are listed from upstream to downstream, by major subwatershed.*

[b] *A spillway that has an operable gate or stop logs has a crest elevation that can be changed. A spillway with a fixed crest weir has a crest elevation that cannot be changed.*

[c] *The determination of whether a failure shadow is available was based on Commission staff's ability to locate documentation.*

[d] *Dam failure analyses are only required for large dams per NR 333. N/A means not applicable for small dams.*

[e] *The Eagle Lake Dam, Geneva Lake Dam, Rochester Dam, and Honey Lake Dam failure shadows match the effective floodplains. As such, the respective dam failure analyses did not need to be adopted.*

*Source: Wisconsin Department of Natural Resources and SEWRPC*

elevations on the Pewaukee River approximately 0.2 feet above the effective 100-year flood elevations. A total of 25 properties were determined to be inundated by a dam failure, including residential, commercial, and municipal parcels.

Waterford Dam

The Waterford Dam is located on the Fox River mainstem and is used to control the water levels in the upstream impoundment commonly called Tichigan Lake, Buena Lake, and Conservancy Bay. The Waterford Dam is a significant hazard dam and consists of two portions: the west spillway and the east spillway. The west spillway contains two radial gates, two fixed-crest spillways on either side of the respective gates, and an approximately 120-foot earthen embankment. The eastern spillway consists of a 126-foot fixed-crest spillway and an approximately 250-foot earthen embankment. The dam failure analysis in the 2013 EAP determined that 45 properties downstream of the dam have structures that would be potentially inundated from a dam failure during a 1-percent-annual-probability event. These parcels are a mix of commercial and residential development.

***Vulnerable Population Assessment for Dam Failure***

An evaluation was made for flooding impacts to vulnerable populations in the Fox River watershed. Vulnerable populations that were considered included disabled populations, those in economic distress, and those living in poverty.[36] For the Fox River watershed in Wisconsin these vulnerable populations are predominantly clustered in the Cities of Burlington and Waukesha, the Villages of East Troy and Twin Lakes, and the Towns of Bloomfield, East Troy, Linn, and Salem. Properties and infrastructure directly downstream of high hazard and significant hazard dams are at greatest risk, as described previously. Based on the communities listed above, a dam failure at the Echo Lake Dam in the City of Burlington could potentially impact vulnerable populations.

***Potential Future Changes for Dam Impacts***

The future impacts to dams are closely linked to the potential climate change impacts on flooding discussed earlier in the chapter. Increases in developed land use can increase peak flows during storm events by decreasing the permeable surface in a watershed. Predicted increases in precipitation and storm frequency can also contribute to high flow conditions becoming more common in the future. Higher lake water levels can cause additional stress on dam structural features. Extreme rain events may cause flows that exceed the dam's spillway capacity, which could cause erosion around the primary or auxiliary spillway, or high flows could overtop the crest of the dam. Additionally, aging dams may have been constructed based on design storms calculated from data that may not adequately reflect future conditions. It should also be noted that current dam operational orders may limit the ability of dam operators to discharge flows in excess of the operational order.

## 3.4 VULNERABILITY ASSESSMENT FOR DROUGHT

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

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

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

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

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

[36] *SEWRPC 2021, 2022 op. cit.*

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

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

- D0: Abnormally Dry
  - Short-term dryness slowing planting and growth of crops or pastures
  - Some lingering water deficits (coming out of drought conditions)
  - Pastures or crops not fully recovered (coming out of drought conditions)

- D1: Moderate Drought
  - Some damage to crops and pastures
  - Streams, reservoirs, or wells low, some water shortages developing or imminent
  - Voluntary water-use restrictions requested

- D2: Severe Drought
  - Crop or pasture losses likely
  - Water shortages common
  - Water restrictions imposed

- D3: Extreme Drought
  - Major crop and pasture losses
  - Widespread water shortages or restrictions

- D4: Exceptional Drought
  - Exceptional and widespread crop and pasture losses
  - Shortages of water in reservoirs, streams, and wells creating water emergencies

**Historical Drought Problems**

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

To look at the impact of droughts on streamflows, the dataset for the USGS stream gage on the Fox River at New Munster was used. This gage has been active since 1939[37], which is the longer period of record for flows on the Fox River mainstem. This dataset was used to investigate the impacts of drought on stream flows. Commission staff tabulated annual or monthly averages using the gage dataset of average daily flows for the drought periods discussed in Table 3.10. Based on the values in Table 3.10, flows during drought times at the Fox River at New Munster gage were noticeably lower than what was seen over the full 83 year period of record. It should be noted that lower flows for a month would potentially have a smaller impact than lower flows over the course of a year.

[37] *The Fox River at New Munster gage (USGS stream gage site number 05545750) was known as the Fox River "at Wilmot" (USGS stream gage site number 05546500) from 1939 to 1993.*

**Table 3.10**
**Flows on the Fox River at New Munster[a] During Periods of Drought**

| Year | Monthly Mean Flows (cfs)[b] | | | | | | | | | | | | Annual[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | January | February | March | April | May | June | July | August | September | October | November | December | Mean (cfs) |
| 1976 | 223 | 626 | 1,968 | 1,063 | 966 | 503 | 154 | 173 | **144** | 177 | 178 | 154 | 559 |
| 1977 | **134** | 163 | 533 | 549 | 172 | 136 | 164 | 165 | 219 | 291 | 419 | 449 | 229 |
| 1987 | 424 | 408 | 774 | 1,312 | 920 | **300** | 359 | 732 | 561 | 349 | 449 | 1,093 | 748 |
| 1988 | 801 | 958 | 796 | 1,096 | 405 | 124 | **106** | 114 | 192 | 204 | 501 | 302 | 539 |
| 2002 | 452 | 581 | 772 | 1,055 | 590 | 863 | **218** | 365 | 275 | 355 | 291 | 256 | 504 |
| 2003 | 193 | 156 | 329 | 365 | 781 | 319 | 288 | 144 | **106** | 127 | 406 | 462 | 308 |
| 2005 | 470 | 951 | 768 | 687 | 391 | 202 | 164 | **128** | 169 | 156 | 293 | 248 | 382 |
| 2007 | 675 | 428 | 1,639 | 1,631 | 625 | 544 | **311** | 1,818 | 814 | 599 | 416 | 808 | 863 |
| 2012 | 628 | 504 | 1,140 | 550 | 616 | 207 | 138 | **129** | 150 | 239 | 229 | 329 | 406 |
| Full Record Mean[c] | 489 | 594 | 1,139 | 1,115 | 809 | 656 | 460 | 368 | 372 | 440 | 499 | 513 | 623 |

[a] *The Fox River at New Munster USGS stream gage (site number 05545750) was known as the Fox River "at Wilmot" (site number 05546500) from 1939 to 1993.*

[b] *Monthly and annual mean flows are the average of mean daily flows as appropriate. Bolded flow values are the lowest monthly mean for the year.*

[c] *The full record mean represents the full period of record for the flow gage from 1939 to 2021.*

*Source: United States Geological Survey*

The 1929-1934 drought may be the most significant in Wisconsin history considering its duration as well as its severity. This drought affected a large majority of the United States and contributed to the Dust Bowl period that greatly damaged agriculture throughout Wisconsin (see Figure 3.2). The drought continued until the early 1940s in some parts of the state.

The drought of 1976-1977 was most severe in a wide band stretching from north to south across the state. Sixty-five counties were declared federal disaster areas and deemed eligible for assistance under the Disaster Relief Act. Additionally, numerous private and municipal wells went dry due to lowered groundwater tables. It was estimated that the Fox River watershed counties of interest sustained more than $690,000 (2021 dollars) in drought related crop damages, as shown in Table 3.11.

In 1987 and 1988 Wisconsin experienced one of the most severe droughts in recent history. It was characterized not only by below normal precipitation, but also by persistent dry air and above normal temperatures. The drought occurred early in the growing season and resulted in a 30 to 60 percent crop loss, with agricultural losses set at $1.3 billion in Wisconsin. Fifty-two percent of the State's farms were estimated to have crop losses of 50 percent or more, with 14 percent estimated having losses of 70 percent or more. It is estimated that the Fox River watershed counties of interest sustained about $4.6 million (2021 dollars) in drought related crop damages (Table 3.11).

**Description of Recent Drought Events**

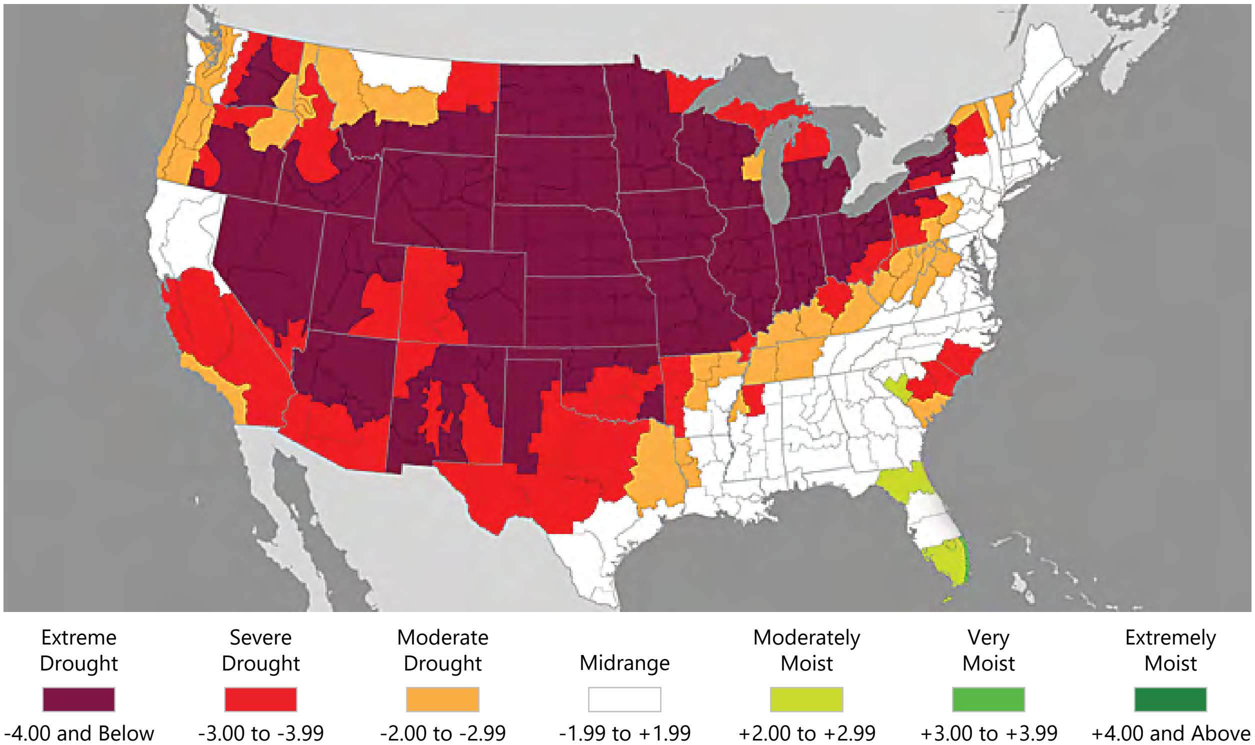
The summer of 2002 was a drought period in south-central and southeastern Wisconsin. Most locations received less than one inch of rain for the first 11 days of August, with Milwaukee Mitchell International Airport (MMIA) reporting only 0.24 inches during this period. This drought affected much of the country, with about 45 percent under severe or extreme drought conditions. The NCEI crop loss estimate database and USDA Risk Management Agency reported a total of about $4.85 million (2021 dollars) in drought related crop losses in the four counties of interest (see Table 3.11).

Drought conditions returned to south-central and southeast Wisconsin in August 2003. For much of the year, the jet stream and associated low pressure systems stayed north of Wisconsin resulting in few cold front passages. As a result, precipitation was far below normal for the year. For example, at MMIA 22.3 inches of precipitation were recorded for the year, about 12.5 inches below normal, making 2003 the driest year since 1963. This drought continued into September 2003 and was determined to be severe (D2) by the U.S. Drought Monitor. The drought resulted in estimated losses of 25 to 50 percent of the corn crop and about 50 percent of the soybean crop. On July 28, 2003, a statewide drought emergency was declared. As result, the WDNR was able to approve temporary permits for agricultural producers to irrigate dry crops by diverting water from streams or lakes. About $4.58 million (2021 dollars) in indemnities were paid to farmers in the four counties of interest from federal crop insurance programs.

Drought conditions developed in southeastern and south-central Wisconsin during the summer and fall of 2005. By mid-July, the drought worsened from abnormally dry to a D2 or "severe" drought. During this time, only 12.5 inches of precipitation had been recorded for the year at MMIA, which is about 9.5 inches below normal. On July 15, 2005, a statewide drought emergency was declared which allowed the WDNR to grant temporary permits to irrigate dry crops by diverting water from streams or lakes. The U.S. Department of Agriculture (USDA) issued a Secretarial Disaster Declaration for drought for portions of Wisconsin. In addition, the Small Business Administration (SBA) made federal disaster loans available to nonfarm agriculture-dependent business for drought-related losses. The drought resulted in estimated losses of 35 to 40 percent of the corn crop and 50 percent of the soybean crop in the state. In the Fox River watershed counties of interest, about $3.39 million (2021 dollars) in indemnities were paid to farmers from federal crop insurance programs.

A short-lived drought affected the Fox River watershed during summer 2007. Abnormally dry conditions began in late June as the jet stream steered storm systems away from southeastern Wisconsin. By late July, these dry conditions had intensified to moderate drought. Drought conditions persisted until late August when thunderstorms provided some relief. Crop insurance indemnities of about $361,000 (2021 dollars) were paid out to farmers in the counties of interest from federal crop insurance programs in 2007.

**Figure 3.2**
**Palmer Drought Severity Index for July 1934**




*Source: National Climatic Data Center and SEWRPC*

In June 2012, due to the lack of rain, a drought slowly developed over south-central and southeastern Wisconsin. By August, conditions were extremely dry with above normal temperatures, increasing the effects on the already stressed crops and water supply. For many farmers across the region the drought conditions reduced crop yields. In the counties of interest, agricultural producers received over $25.4 million (2021 dollars) in crop insurance indemnities (Table 3.11). This drought resulted in an emergency declaration, which authorized the WDNR to expedite temporary permit applications for water withdrawals from lakes and streams for the purpose of watering crops.

A graphical summary of historical drought severity for southeastern Wisconsin from 1895 to 2018 is provided in Figure 3.3.

**Vulnerability and Community Impact Assessment**

Droughts can cause a myriad of concerns for the community, agriculture, and natural systems within the Fox River watershed. Severe droughts may result in reduced yields or the loss of agricultural crops and forest products, undernourished wildlife and livestock, and lower land values. They can also reduce water levels and flows in surface waterbodies and groundwater. Water quality may also decline, and the number and severity of wildfires may increase during a drought. Additionally, the loss of vegetation in the absence of sufficient water to maintain it can result increased flooding, even from an average rainfall.

***Agricultural Concerns***

The Fox River watershed is vulnerable to agricultural drought. According to the 2017 Census of Agriculture, the four counties of interest (Kenosha, Racine, Walworth, and Waukesha Counties) contain a total of approximately 495,000 acres of farmland, which covers about 28 percent of their total land area. Even small droughts of limited duration can significantly reduce crop growth and yields, adversely affecting farm income. More substantial events can decimate croplands and result in total loss, hurting the local economy. Due to the importance of agriculture to the economy in the Fox River watershed and the potential for large crop losses, drought is a major natural hazard threat. In addition, groundwater levels can be affected by

## Table 3.11
## Estimates of Crop Losses Due to Drought in Counties of Interest: 1976-2021

| | NCEI Loss Estimate (2021 dollars) | | | | | Crop Insurance Indemnity Paid (2021 dollars) | | | | | Loss Estimate Used in Risk Assessment (2021 dollars)[a] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | Kenosha | Racine | Walworth | Waukesha | Total | Kenosha | Racine | Walworth | Waukesha | Total | |
| 1976 | -- | -- | -- | -- | -- | 96,873 | -- | 452,403 | 134,291 | 683,567 | 683,567 |
| 1977 | -- | -- | -- | -- | -- | -- | 1,495 | 2,762 | 2,261 | 6,519 | 6,519 |
| 1978 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1979 | -- | -- | -- | -- | -- | 46,998 | 20,388 | 49,045 | -- | 116,431 | 116,431 |
| 1980 | -- | -- | -- | -- | -- | -- | -- | 7,527 | 1,693 | 9,220 | 9,220 |
| 1981 | -- | -- | -- | -- | -- | -- | 21,761 | 3,558 | -- | 25,319 | 25,319 |
| 1982 | -- | -- | -- | -- | -- | -- | -- | -- | 6,012 | 6,012 | 6,012 |
| 1983 | -- | -- | -- | -- | -- | -- | -- | 11,905 | 337,201 | 349,106 | 349,106 |
| 1984 | -- | -- | -- | -- | -- | -- | -- | 9,323 | 652,854 | 662,177 | 662,177 |
| 1985 | -- | -- | -- | -- | -- | 12,459 | 28,054 | 391,917 | 2,035,739 | 2,468,169 | 2,468,169 |
| 1986 | -- | -- | -- | -- | -- | -- | -- | -- | 1,299 | 1,299 | 1,299 |
| 1987 | -- | -- | -- | -- | -- | -- | -- | 331,564 | 64,449 | 396,013 | 396,013 |
| 1988 | -- | -- | -- | -- | -- | 308,498 | 311,364 | 1,351,809 | 2,229,567 | 4,201,237 | 4,201,237 |
| 1989 | -- | -- | -- | -- | -- | 2,869 | 19,442 | 76,783 | 187,867 | 286,962 | 286,962 |
| 1990 | -- | -- | -- | -- | -- | -- | 2,370 | -- | 2,762 | 5,132 | 5,132 |
| 1991 | -- | -- | -- | -- | -- | 226,145 | 150,593 | 799,855 | 143,164 | 1,319,757 | 1,319,757 |
| 1992 | -- | -- | -- | -- | -- | 64,830 | 80,755 | 196,096 | 205,450 | 547,132 | 547,132 |
| 1993 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1994 | -- | -- | -- | -- | -- | 34,329 | 36,377 | 9,731 | 16,951 | 97,388 | 97,388 |
| 1995 | -- | -- | -- | -- | -- | 66,895 | 45,455 | 102,656 | 130,078 | 345,084 | 345,084 |
| 1996 | -- | -- | -- | -- | -- | 17,106 | 95,270 | 67,154 | 67,919 | 247,449 | 247,449 |
| 1997 | -- | -- | -- | -- | -- | -- | 1,829 | -- | 2,353 | 4,182 | 4,182 |
| 1998 | -- | -- | -- | -- | -- | 757 | 14,112 | 14,886 | 6,923 | 36,677 | 36,677 |
| 1999 | -- | -- | -- | -- | -- | 106,627 | 208,621 | 206,170 | 38,908 | 560,326 | 560,326 |
| 2000 | -- | -- | -- | -- | -- | 12,858 | 6,574 | 276,357 | 33,569 | 329,358 | 329,358 |
| 2001 | -- | -- | -- | -- | -- | 121,810 | 216,112 | 367,587 | 540,475 | 1,245,985 | 1,245,985 |
| 2002 | 721,103 | 721,103 | 721,103 | 288,441 | 1,802,750 | 368,090 | 348,821 | 3,652,383 | 482,578 | 4,851,873 | 4,851,873 |
| 2003 | -- | -- | -- | -- | -- | 317,183 | 456,388 | 2,390,411 | 1,411,429 | 4,575,411 | 4,575,411 |
| 2004 | -- | -- | -- | -- | -- | 44,497 | 13,799 | 102,510 | 206,624 | 367,431 | 367,431 |
| 2005 | -- | -- | -- | -- | -- | 758,374 | 550,431 | 1,766,745 | 311,829 | 3,387,380 | 3,387,380 |

**Table continued on next page.**

**Table 3.11 (Continued)**

| | NCEI Loss Estimate (2021 dollars) | | | | | Crop Insurance Indemnity Paid (2021 dollars) | | | | | Loss Estimate |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | Kenosha | Racine | Walworth | Waukesha | Total | Kenosha | Racine | Walworth | Waukesha | Total | **Used in Risk Assessment (2021 dollars)[a]** |
| 2006 | -- | -- | -- | -- | -- | 9,469 | 2,819 | 284,784 | 99,287 | 396,358 | 396,358 |
| 2007 | -- | 31,829 | 63,658 | 63,658 | 159,145 | 3,501 | 12,756 | 33,278 | 311,839 | 361,373 | 361,373 |
| 2008 | -- | -- | -- | -- | -- | 371,619 | 688,470 | 1,432,843 | 1,626,035 | 4,118,967 | 4,118,967 |
| 2009 | -- | -- | -- | -- | -- | 25,302 | 9,344 | 29,040 | 363,992 | 427,677 | 427,677 |
| 2010 | -- | -- | -- | -- | -- | -- | 1,718 | 883 | -- | 2,601 | 2,601 |
| 2011 | -- | -- | -- | -- | -- | 444 | 65,741 | 101,682 | 179,813 | 347,680 | 347,680 |
| 2012 | -- | -- | -- | -- | -- | 841,000 | 1,353,212 | 19,052,798 | 4,165,742 | 25,412,752 | 25,412,752 |
| 2013 | -- | -- | -- | -- | -- | 86,933 | 68,093 | 412,740 | 58,230 | 625,996 | 625,996 |
| 2014 | -- | -- | -- | -- | -- | -- | 6,217 | 144 | 20,447 | 26,809 | 26,809 |
| 2015 | -- | -- | -- | -- | -- | 946 | 27,871 | 34,836 | 157,792 | 221,445 | 221,445 |
| 2016 | -- | -- | -- | -- | -- | 19,576 | 206,806 | 307,395 | 210,003 | 743,780 | 743,780 |
| 2017 | -- | -- | -- | -- | -- | 1,266 | 1,347 | 16,321 | -- | 18,935 | 18,935 |
| 2018 | -- | -- | -- | -- | -- | -- | 2,529 | -- | -- | 2,529 | 2,529 |
| 2019 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 2020 | -- | -- | -- | -- | -- | 85,661 | -- | 4,215 | 164,011 | 253,887 | 253,887 |
| 2021 | -- | -- | -- | -- | -- | 92,596 | 316,421 | 798,209 | 248,077 | 1,455,303 | 1,455,303 |
| Total | 721,103 | 752,932 | 784,761 | 352,099 | 2,610,895 | 4,145,512 | 5,393,352 | 35,150,307 | 16,859,516 | 61,548,687 | 61,548,687 |

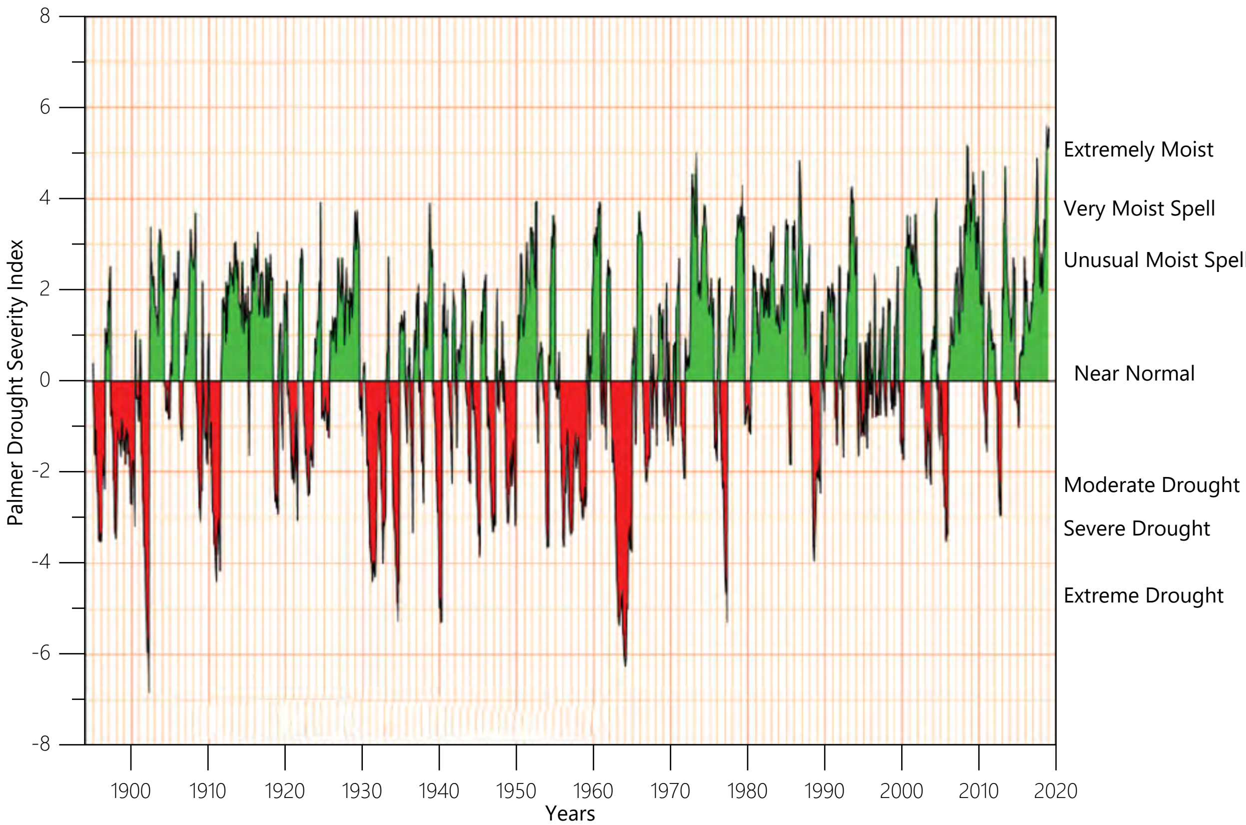
Note: Dollar Values were adjusted to year 2021 by the average annual Consumer Price Index (CPI) values from the U.S. Department of Labor, Bureau of Labor Statistics.

In many instances damages from hazard events go unreported. This table represents estimated losses and should not be considered as exact documentation of damages and losses incurred from a particular event or time period.

[a] *For those years in which loss estimates were available from both the NCEI and crop insurance indemnities, the larger value was used.*

*Source: National Centers for Environmental Information (NCEI), the U.S. Department of Agriculture Risk Management Agency, and SEWRPC*

**Figure 3.3**
**Palmer Drought Severity Index for Southeastern Wisconsin: 1895-2022**




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

drought conditions. This is especially important considering everyone in the Fox River watershed depends on groundwater for their water supply. The most severe droughts may only happen on average every 25 or 50 years, but the 2012 drought proves that, while severe droughts are rare, they can be devastating to agriculture, damaging to the local economy, and negatively impact the natural surface water system and groundwater supply system.

Drought generally impacts agricultural output by reducing crop yields and the health and product output of livestock such as milk. As a result, a drought will seriously impact the economy of the entire watershed. The concern for agricultural losses due to drought is difficult to estimate because each incident will impact the watershed differently based on the length of the drought, when it occurs in the planting season, which crops were planted, and where they were planted.

Estimates of agricultural losses experienced in Kenosha, Racine, Walworth, and Waukesha Counties due to drought over the period 1976 through 2021 are shown in Table 3.11. These estimates come from two sources: event descriptions in the National Centers for Environment Information (NCEI) storm events database and records of indemnities paid to agricultural operators by federal crop insurance programs.[38] For those years in which loss estimates were available from both the NCEI and crop insurance indemnities, the larger value was used to estimate losses due to drought for that year. The loss estimates reflect several factors. First, crop losses often go unreported. Second, federal crop insurance policies offer coverage to only certain types of crops in any particular year. Third, agricultural operators generally insure only a portion of their crops when purchasing federal crop insurance. Thus, loss estimates derived from these two sources are likely to be underestimates of actual losses. It should be noted that indemnities for drought related losses were paid out in most years. This probably reflects variability in rainfall (or lack thereof) causing localized crop losses. Based on these sources, it is estimated that the counties of interest experienced crop damages

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

of nearly $61.5 million (2021 dollars) between 1976 and 2021. It is important to note that not all these crop damages occurred within the Fox River watershed.

In 2017, the most recent year for which agriculture census data is available, the market value of agricultural products sold by farms in the four counties of interest was about $365 million (in 2017 dollars). This was comprised of about $220 million in crops and $145 million in livestock, poultry, and their products.[39] Based on the crop insurance indemnities paid from 1976 to 2021 (Table 3.9), an average of $1.3 million (in 2021 dollars) of crop insurance indemnities is paid per year, which is approximately 0.73 percent of the market value of all crops, or about 0.44 percent of the market value of all agricultural products sold by farms in the counties of interest will be lost to drought each year. It is also expected that there will be considerable variation among years in the amount of losses experienced. Again, it is important to note that agricultural losses due to drought are assumed to be underreported, thus the loss numbers cited above are likely to be substantially underestimated.

***Baseflow Concerns***

Flows in rivers and streams are replenished by surface water runoff during precipitation events and by shallow groundwater aquifers. However, long periods without precipitation could cause a decrease in riverine flows, as noted previously for various historical drought events (Table 3.9). Dry conditions can also reduce riverine water depth. For example, during the summer 2012 drought, some river stages reached record lows. National Weather Service data indicates that on July 11, 2012, the river stage at the Fox River stream gage in Waukesha dropped to 2.63 feet, which was among the lowest river stages ever recorded at this gage. Similarly, several days later record low river stages were recorded at the Fox River stream gages in Burlington (5.44 feet on July 15) and New Munster (4.72 feet on July 16). Abnormally low river stages can cause several consequences, including lower water quality due to reduced dilution of pollutants, impaired ability for fish to travel upstream and downstream in very shallow areas, and changes to riparian habitat. Additionally, droughts can reduce groundwater aquifer volumes, so that during a severe drought some wells, mainly private wells, may go dry. Currently a project is underway to divert Lake Michigan water to the City of Waukesha to replace groundwater for drinking water supply. Thus the City will shut off their groundwater wells. This change may affect baseflows in the Fox River watershed and a more detailed evaluation of the potential impacts of this project can be found in Chapter 4.

***Vulnerable Population Assessment for Drought***

An evaluation was made for flooding impacts to vulnerable populations in the Fox River watershed. Vulnerable populations that were considered included disabled populations, those in economic distress, and those living in poverty.[40] For the Fox River watershed in Wisconsin these vulnerable populations are predominantly clustered in the Cities of Burlington and Waukesha, the Villages of East Troy and Twin Lakes, and the Towns of Bloomfield, East Troy, Linn, and Salem. Drought has the greatest impact on the agricultural community within the Fox River watershed. Agricultural and open land use is highlighted on Map 2.2. Based on this information, drought could have particularly negative economic effects on vulnerable populations in the Towns of Bloomfield and East Troy.

***Potential Future Changes in Drought Conditions***

Based upon NCEI data, from 2002 through 2021, the Fox River watershed had about a 10 percent probability of drought conditions occurring during a portion of any given year. Some of these episodes are likely to be of short duration. The statewide historical record indicates that severe droughts can be expected to occur at roughly 10-year intervals. As can be seen in Figure 3.3, southeastern Wisconsin regularly experienced drought to at least a moderate level two to three times every ten years from 1895 through 2018.[41] Changes in climate, including changes to precipitation frequency and intensity, should be monitored for their potential to create drought conditions in the Fox River watershed.

[39] *U.S. Department of Agriculture National Agricultural Statistics Service, 2017 Census of Agriculture: Wisconsin State and County Data, Volume 1, Geographic Area Series, April 2019.*

[40] *SEWRPC 2021, 2022 op. cit.*

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

# HAZARD MITIGATION STRATEGIES 4

Hazard mitigation planning may be defined as the systematic evaluation of the nature and vulnerability of hazards present, along with the development and implementation of sustained actions to reduce or eliminate long-term risks from hazards and their effect. Specific purposes of hazard mitigation include eliminating loss of life, reducing danger to human health and safety, minimizing monetary damage to private and public property, reducing the cost of utilities and services, and minimizing disruption in community affairs. Hazard mitigation also involves both avoiding intensifying existing hazards and creating new hazards. The recommended strategies in this plan to mitigate hazards from flooding, dams, and drought are discussed in the following sections.

## 4.1 HAZARD MITIGATION COMPONENT FOR FLOODING

As discussed in Section 3.2, historically flooding has caused major hazards within the Fox River watershed. This section recommends a variety of strategies to mitigate the effects of flooding, including land preservation and enhancement, improvements to infrastructure, and additional monitoring of watershed hydrologic conditions.

### Flood Storage Areas Preservation and Enhancement

Natural watershed features such as floodplains, wetlands, and natural closed depressions are vital for storing water during flood events. During large storm events, these features function as flood storage. They attenuate peak flows by storing flood water and gradually discharging it, which decreases peak flow downstream. This process naturally mitigates damaging flood events. Therefore, large existing flood storage areas in the watershed, including wetlands and potentially restorable wetlands, should be preserved, protected from development, and enhanced when possible. The following sections detail recommended management actions for flood storage areas.

#### *Existing Floodplain Preservation*

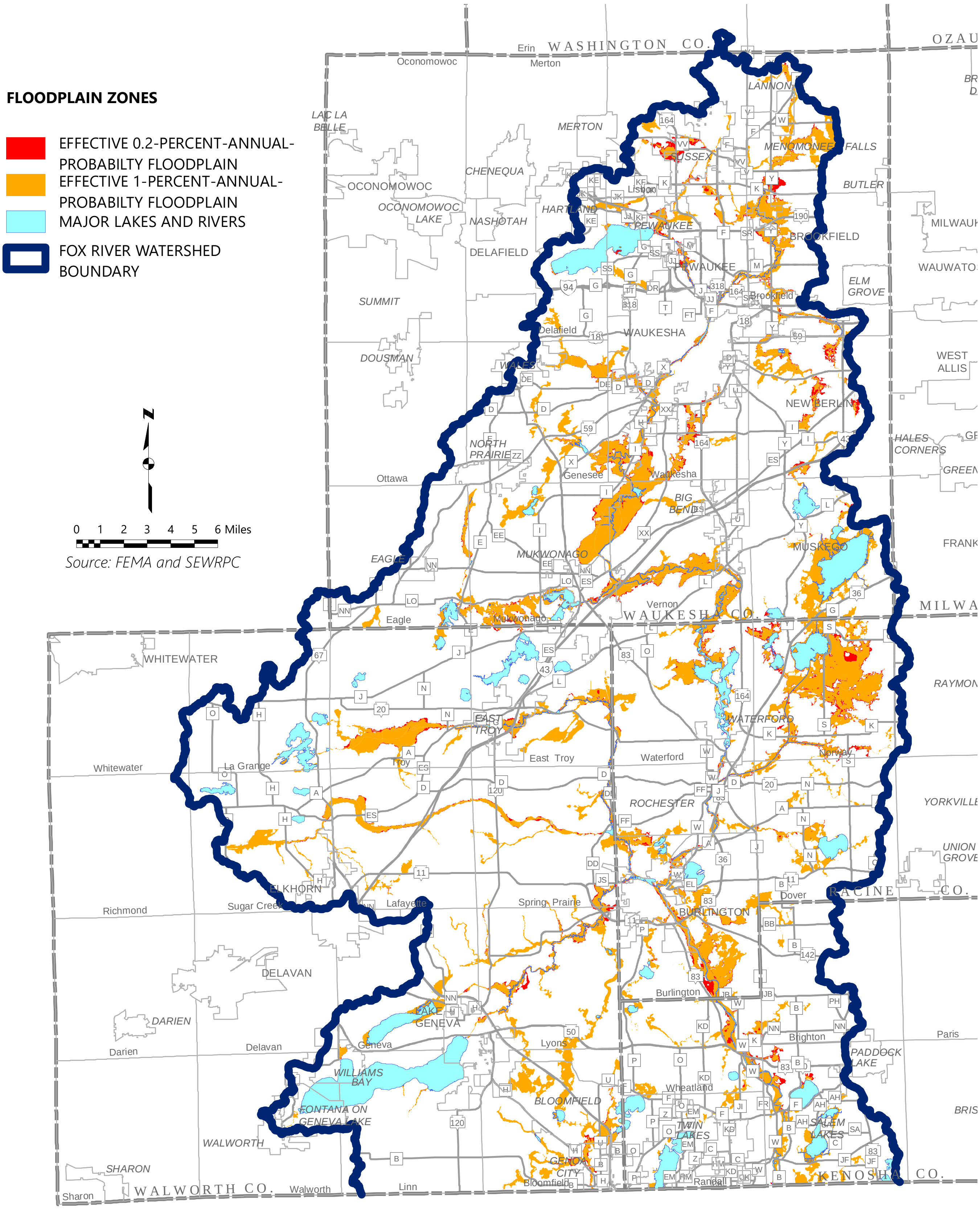
As detailed in Chapter 2, the four major counties in the Fox River watershed have several pertinent floodplain management regulations in place, most notably in the form of zoning regulations and ordinances. The floodplain zoning ordinances are intended to preserve the floodwater conveyance and storage capacity of floodplain areas and to prevent new development in flood-prone areas. Implementing and enforcing these regulations on an ongoing basis is an integral part of the watershed flood mitigation strategy.

In addition to implementing and enforcing existing floodplain zoning regulations, more restrictive floodplain zoning ordinances can be considered to enhance flood storage preservation in the watershed. Currently, floodplain zoning ordinances only apply to the Federal Emergency Management Agency's (FEMA) special flood hazard area (SFHA) 1-percent-annual-probability floodplain. The FEMA 0.2-percent-annual-probablity floodplain can be considered for adoption to protect additional flood storage areas in the watershed. The effective FEMA 0.2-percent-annual-probability floodplains are shown in red on Map 4.1, which provides a slightly larger floodplain footprint compared to the FEMA SFHA.

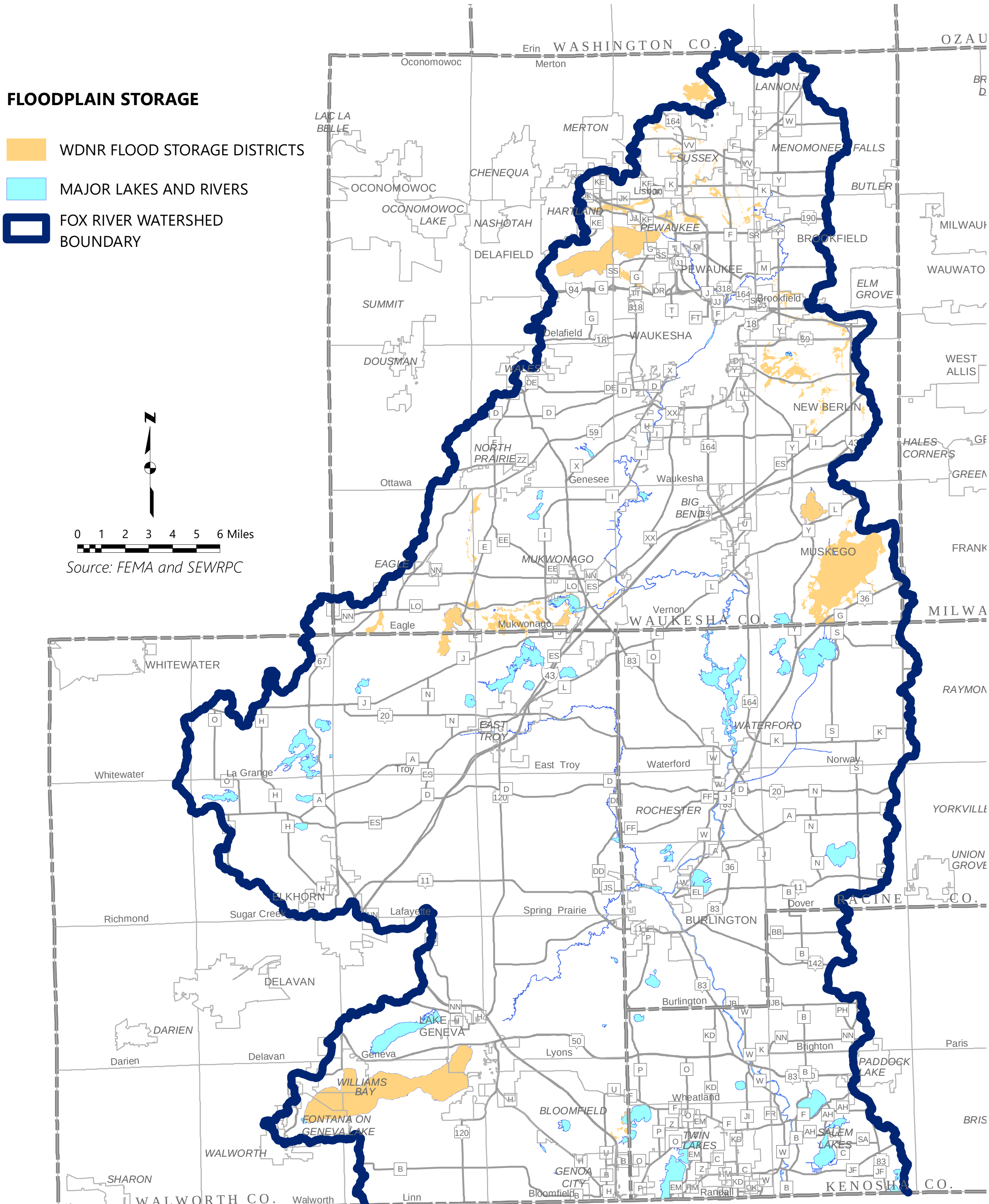
Ordinances related to Flood Storage Districts can also be considered. Currently, Waukesha and Walworth Counties include Flood Storage Districts (FSDs) in their zoning ordinance, and the FSDs in the Fox River watershed are shown on Map 4.2.[42] FSDs are areas of floodplain where storage capacities for floodwaters were used in riverine modeling to reduce the regional flood discharge. Development in the FSD is restricted by requiring new development or redevelopment to meet a condition of equal cut and fill to not reduce the regional flood storage capacity. This can be accomplished by either providing an equal amount of new flood storage on site or an equal amount of flood storage in the immediate area of the proposed development. This requirement ensures that the flood storage capacity of the watershed is maintained

[42] *Map 4.2 shows flood storage district areas based on information obtained from WDNR Surface Water Data Viewer as of 2022.*

## Map 4.1
## FEMA Effective 0.2-Percent-Annual-Probability Floodplains in the Fox River Watershed



## Map 4.2
## Flood Storage Districts in the Fox River Watershed




Source: FEMA and SEWRPC

where development occurs. During new floodplain modeling efforts, counties in the Fox River watershed can consider representing large storage areas to incorporate as FSDs in their zoning ordinances.

Map 4.3 identifies select FEMA SFHA 1-percent-annual-probability floodplain areas that are especially important for the purpose of flood storage and flood mitigation in the Fox River watershed. Both the FEMA effective and preliminary flood mapping were evaluated for this selection. These floodplain areas were selected for their larger flood storage size and for their strategic locations to effectively attenuate flood flows. Strategic locations include large floodplain areas close to urban developments and along streams with large drainage areas. More attention should be placed on these floodplain areas to ensure their preservation.

Existing floodplains can also be better utilized by implementing projects that increase connectivity of the stream to its floodplain, particularly around incised streams and areas where the main channel was intentionally separated from the floodplain with manmade berms. An existing floodplain may also be widened in open natural areas where there is no existing development. Both practices can help mitigate flood risks by providing additional flood storage capacity. These projects may also create additional habitat and improve ecological function of the waterway.

***Existing Wetland Preservation***

As detailed in Chapter 2, the four major counties in the Fox River watershed have several pertinent wetland management regulations in place, most notably in the form of zoning regulations and ordinances. The wetland zoning ordinance, specifically shoreland-wetland or conservation districts, seeks to maintain the stormwater and floodwater storage capacity of wetlands in the counties and prohibits certain land uses detrimental to wetlands. Implementing and enforcing these regulations on an ongoing basis is an integral part of the watershed flood mitigation strategy.

In the past, cities and villages were also allowed to adopt shoreland zoning standards more restrictive than those contained in NR 115. Currently, requirements in the 2015 Wisconsin Act 55 do not allow jurisdictions to have shoreland zoning ordinances that are more restrictive than State shoreland zoning standards. Specifically, this requirement impacts regulation of shoreland wetlands. The State standard requires the placement of all wetlands five acres or larger that are located within the statutory shoreland zoning jurisdiction areas into a wetland conservancy zoning district to ensure their preservation. Wisconsin Act 55 does not allow local jurisdictions to place wetlands less than five acres into the protective wetland conservancy zoning district, however it does not prohibit cities and villages from protecting wetlands outside the shoreland zoning district. It is recommended that cities and villages consider implementing protection measures for wetlands less than five acres where feasible.

The location and extent of wetlands within the Fox River watershed are shown on Map 2.7 in Chapter 2. These wetland areas are defined based on the Wisconsin Wetland Inventory originally completed for the Southeastern Wisconsin region in 1982, and then updated in 2015 as part of the regional land use inventory. Map 4.4 identifies select wetland areas in the watershed that are especially important for the purpose of flood storage and flood mitigation. These wetland areas were selected for their larger flood storage size, their locations in riparian zones, and their strategic locations in the watershed to effectively attenuate flood flows. The select wetland areas are meant to supplement the floodplain flood storage areas identified on Map 4.3. More attention should be focused on these wetland areas to ensure their preservation.

***Potentially Restorable Wetlands***

Wetland restoration can help mitigate flooding downstream by retaining surface water in its hydric soils and depressions and slowly releasing the water after peak flow times have passed. According to the US Environmental Protection Agency (USEPA), a typical one-acre wetland can store about one million gallons of water, assuming an average three feet of water depth.[43] A comparison of the area of mapped wetlands between current conditions and historical conditions indicate significant loss of wetlands in the Region.[44] Restoring wetlands, particularly riparian buffers, can provide water storage to mitigate flooding.

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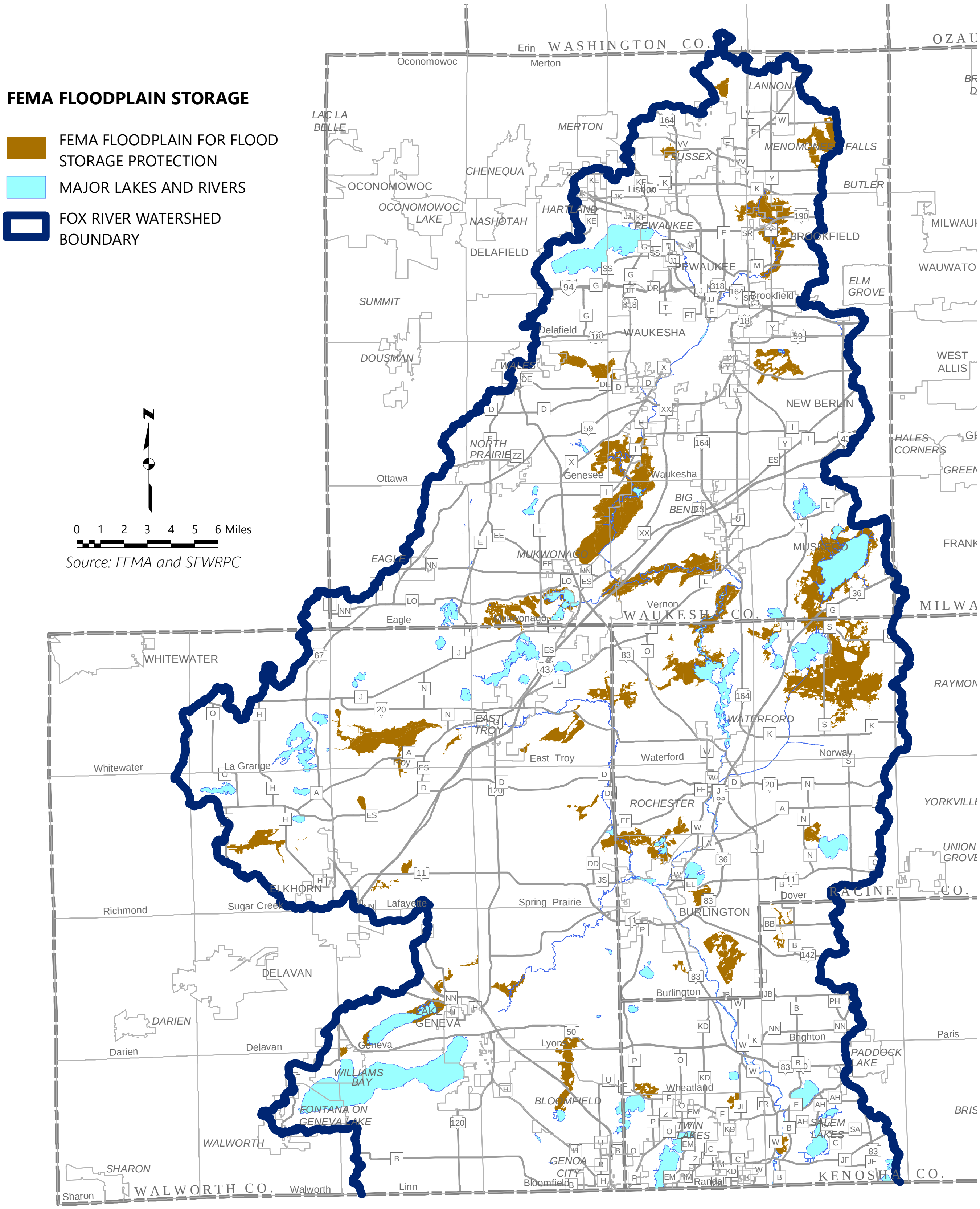
[43] *U.S. Environmental Protection Agency (USEPA)*, Wetlands: Protecting Life and Property from Flooding, *May 2006, USEPA843-F-06-001*.

[44] *SEWRPC Community Assistance Planning Report No. 330*, A Restoration Plan for the Oak Creek Watershed, *December 2021*.

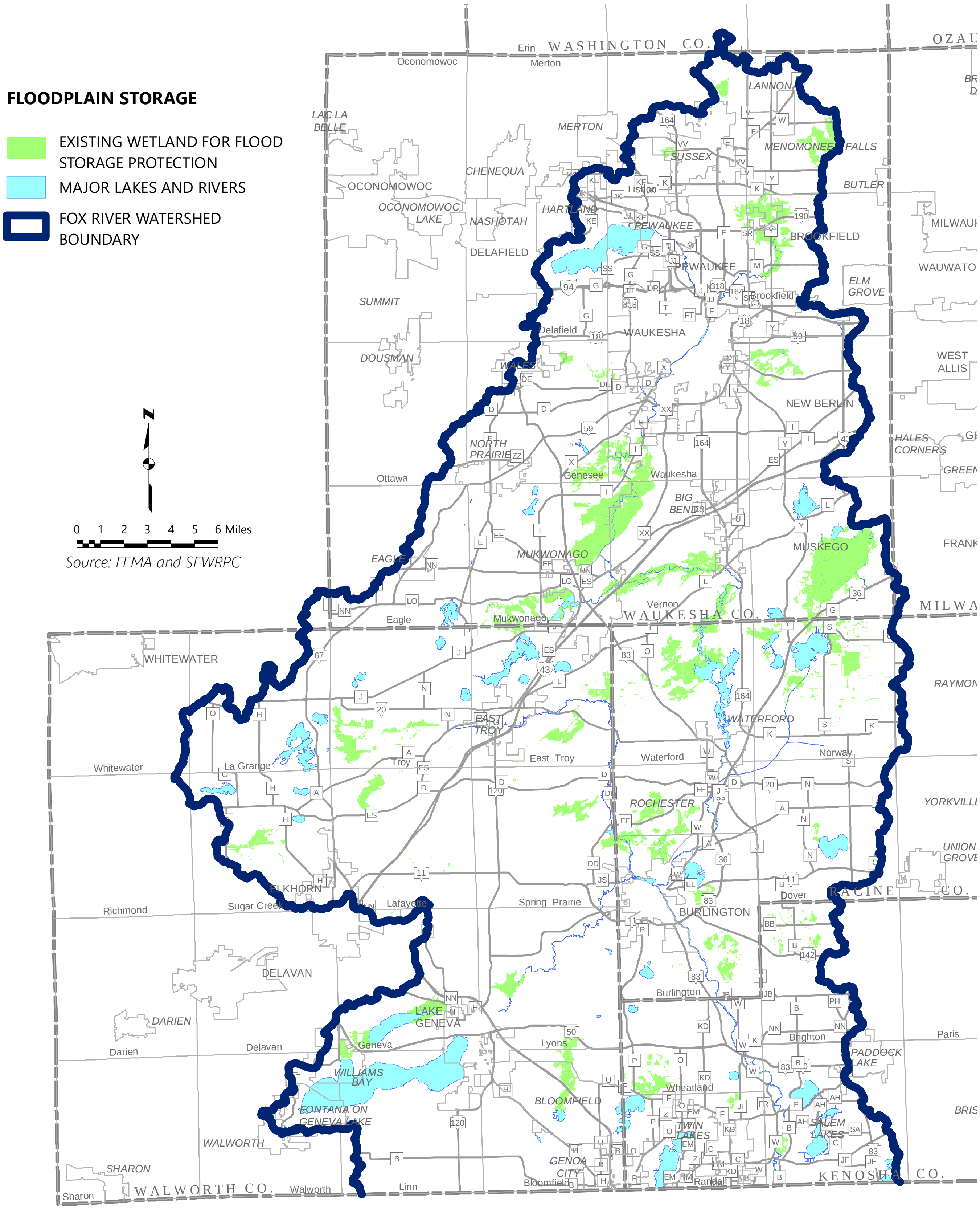
**Map 4.3**

**Select FEMA Special Flood Hazard Areas for Flood Storage Protection in the Fox River Watershed**




Source: FEMA and SEWRPC

## Map 4.4
## Select Existing Wetland Areas for Flood Storage Protection in the Fox River Watershed



Potentially restorable wetlands (PRWs) were identified by the Wisconsin Department of Natural Resources (WDNR) based on soil attributes (particularly the hydric soil class), current land use, topography, and compatibility with restoration techniques. In 2017, the WDNR and The Nature Conservancy completed a watershed-based wetland analysis with an associated web tool, Wetlands by Design, to guide wetland conservation and restoration throughout Wisconsin. Map 4.5 presents the watershed PRWs from the 2017 WDNR PRW dataset as obtained from the Wetlands by Design web tool.

Wetlands by Design ranks watersheds (down to the scale of USGS 12-digit Hydrologic Units) based on conservation opportunities. In each watershed, Wetlands by Design ranks the level of wetland loss of ecosystem services (most, moderate, and least), which includes flood abatement, fish and aquatic habitat, sediment retention, nutrient transformation, and surface water supply. For each ecosystem service, Wetlands by Design further ranks the quality of ecosystem service (very high, high, and moderate) provided by existing wetlands and PRWs once their function is restored. For this plan, the flood abatement ranking by Wetlands by Design is the most pertinent. The web tool ranks the Fox River watershed as "Most Loss" for flood abatement and details many site-specific opportunities for wetland restoration to mitigate flooding. It is recommended that the Wetlands by Design tool should be used in selecting, prioritizing, and planning wetland restoration efforts in the watershed.

Map 4.6 identifies select PRW areas that are especially important to prioritize wetland restoration for the purpose of flood storage and flood mitigation in the Fox River watershed. These wetland areas were selected for their larger flood storage size, their locations in riparian zones, and their strategic locations in the watershed to effectively attenuate flood flows.

Some methods for restoring wetland areas include constructing shallow earthen depressions in the landscape for pooling and planting native wetland vegetation. If the PRW being restored was formerly used for agriculture, is it recommended to consider disrupting existing drain tile networks and plugging drainage ditches to increase water retention on the landscape. Restoring wetlands may also provide additional benefits besides flood attenuation, such as improved water quality, increased habitat for migratory birds, and potential for human recreation.

#### *Combined Flood Storage Areas for Preservation and Enhancement*

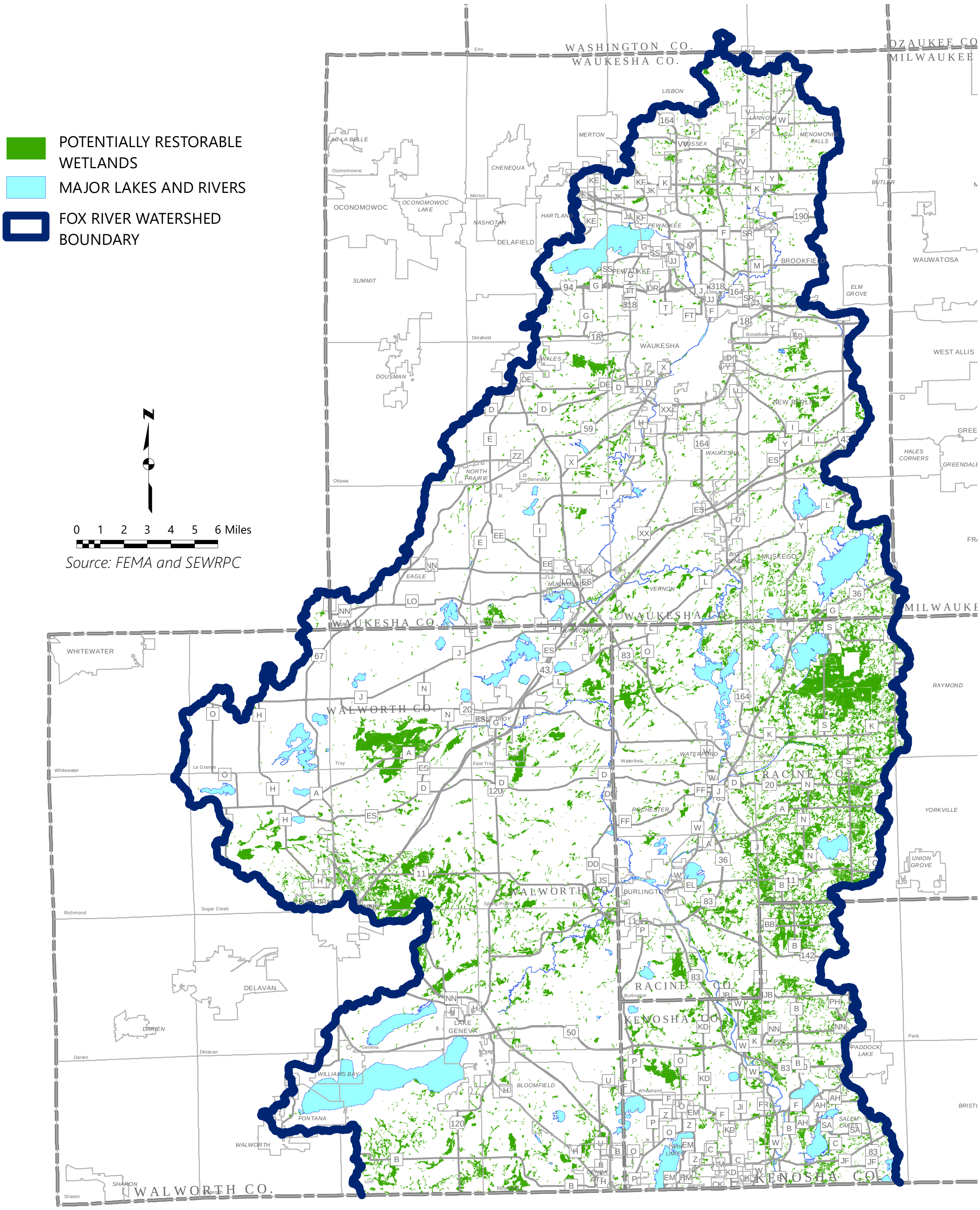
Map 4.7 shows the flood storage areas in the Fox River watershed identified to be the most important for preservation and enhancement. The map combines the select floodplain, wetland, and PRW areas discussed in the previous sections. It is recommended that these areas be protected from development by upholding existing zoning ordinances and implementing new, more restrictive regulations. Wetland restoration projects should also be pursued in strategic locations to improve flood storage.

Additionally, Map 4.7 also shows flood storage areas under public interest ownership. Currently 27 percent of the flood storage areas in Map 4.7 are protected through public interest ownership, with the State, counties, municipalities, and several nature conservation organizations each holding ownership to multiple parcels in the shown flood storage areas. It is recommended that, as opportunities arise, sites not in existing public or public-interest ownership should be voluntarily acquired and placed in protective ownership.

#### *Green Infrastructure as a Supplemental Tool*

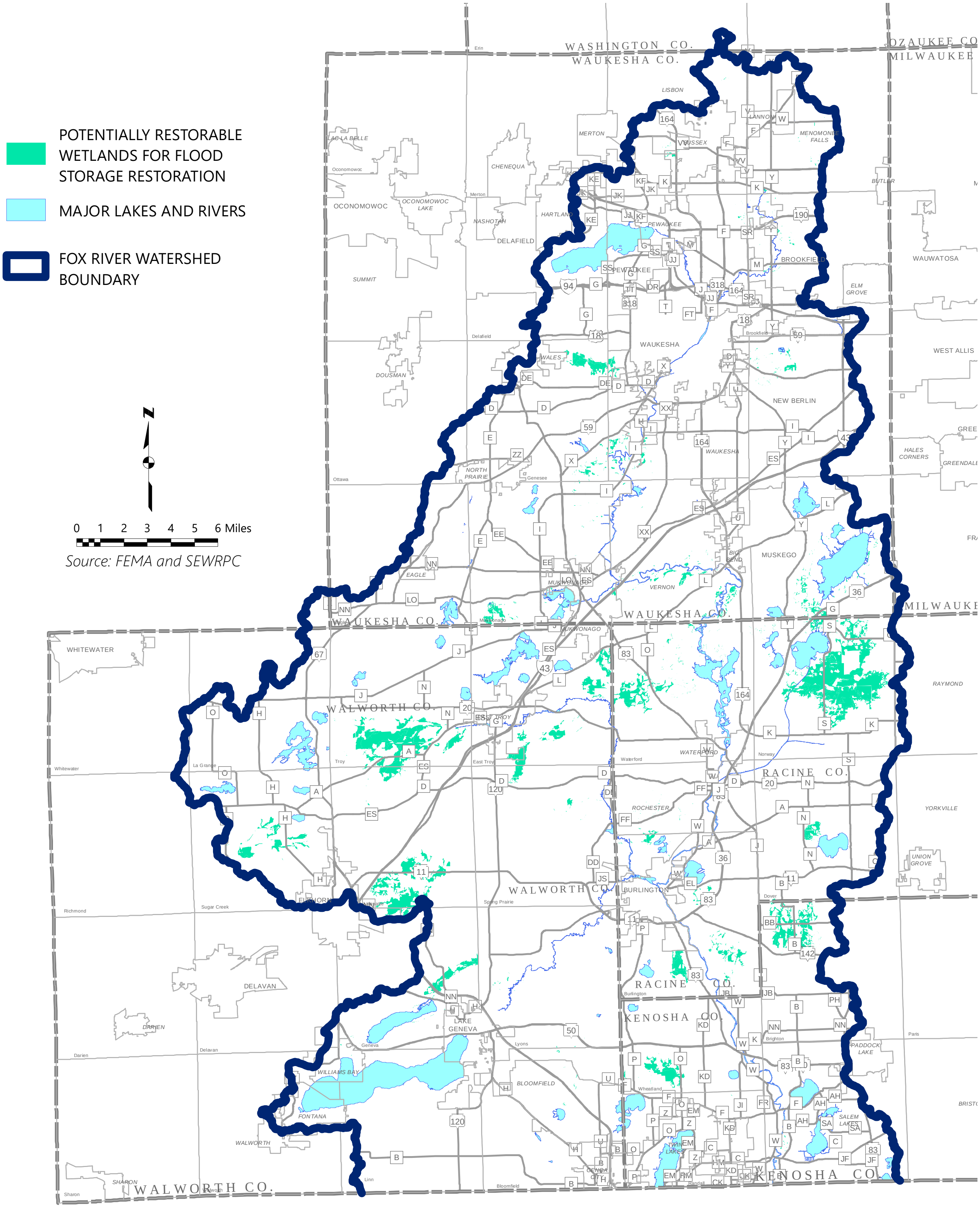
Certain green infrastructure practices can also help manage stormwater to help reduce peak flows downstream. Retention ponds can reduce flows into nearby streams by providing some stormwater storage and gradually releasing the water into the groundwater through infiltration through the soil media underneath. Similarly, detention ponds and 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 rains by diverting some stormwater to be used in gardening. These practices can also provide additional benefits of improving water quality and increasing aesthetics when they are properly maintained. It should be noted that green infrastructure practices can provide some flow reduction, but they should be considered supplemental to flood storage efforts at a floodplain and wetland scale due to their smaller storage capacities.

**Map 4.5**
**2017 WDNR Potentially Restorable Wetland Areas in the Fox River Watershed**

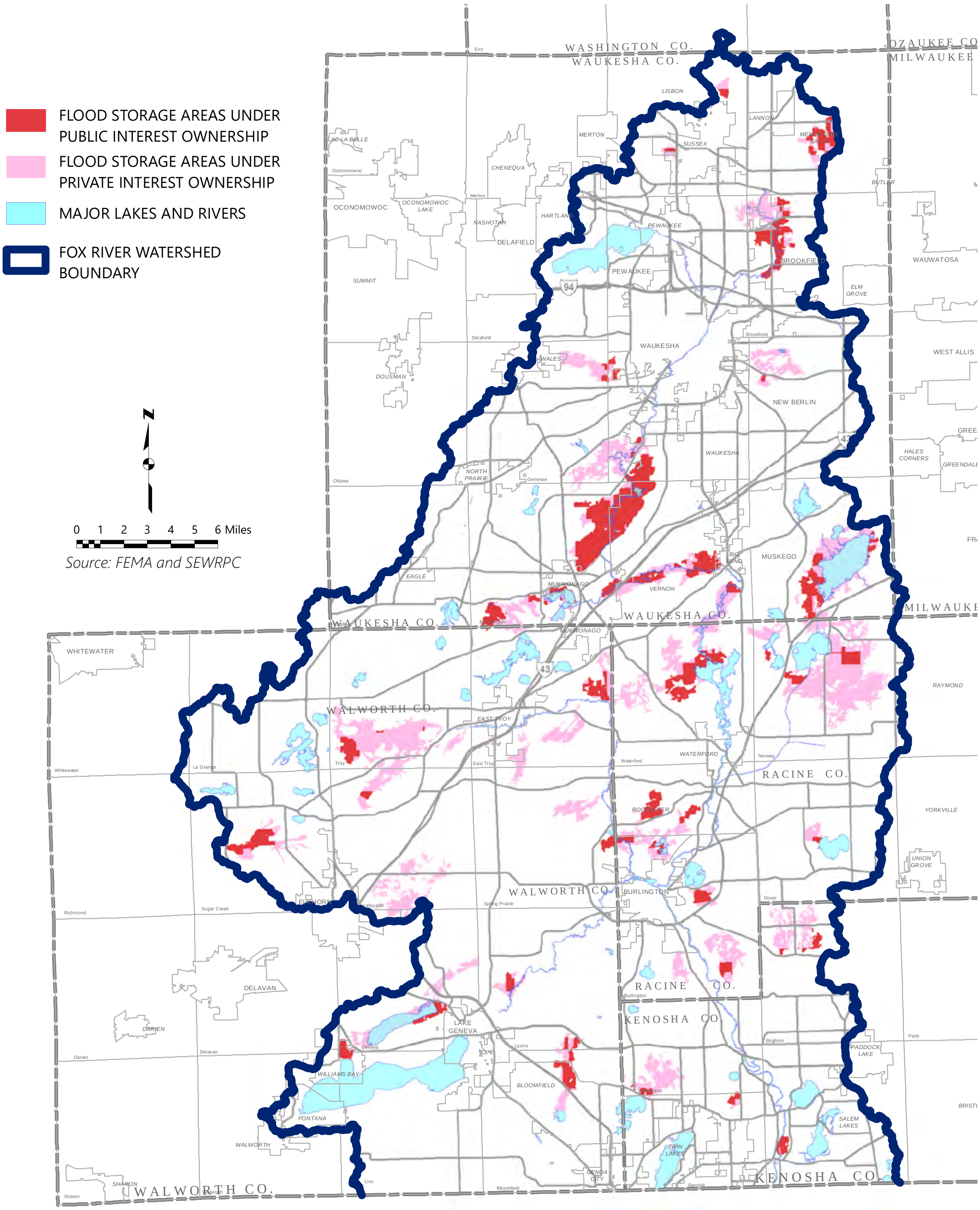



Source: FEMA and SEWRPC

## Map 4.6
## Priority Potentially Restorable Wetland Areas for Restoration to Provide Flood Storage in the Fox River Watershed



## Map 4.7
## Overall Flood Storage Areas for Preservation and Enhancement in the Fox River Watershed




*Source: FEMA and SEWRPC*

***Special Project Area Recommendations for Flood Attenuation Through Restoration***

In addition to preserving and enhancing floodplains and wetlands throughout the watershed, certain areas have been identified through this planning process as having potential to attenuate floodwaters through natural restoration and reconnection to the floodplain. These areas are identified below.

<u>Wind Lake Canal</u>

It is recommended to evaluate the feasibility of naturalizing the Wind Lake Canal and adjacent floodplains to improve ecological function and reduce impacts to the Fox River through increased flood attenuation and decreased sedimentation. Potential projects could consider improving the Wind Lake Canal to provide good conveyance and to better connect the canal to its floodplain. The effectiveness of wetland restoration adjacent to the Wind Lake Canal should also be considered to reduce the impacts of flooding in a watershed where the hydrology is highly manipulated to promote drainage.

<u>Fox River from Silver Lake to Wilmot</u>

It is recommended to evaluate the feasibility of reducing the impact of flooding along the Fox River and improving river and floodplain resilience from Silver Lake to Wilmot in Kenosha County by increasing the hydraulic connectivity between the river and its floodplain and backwaters. It is recommended to utilize publicly owned land within the Fox River floodplain in this reach to improve ecosystem functions including flood attenuation, reduced sedimentation, and protection of aquatic habitat.

**Additional Floodplain Mapping**

Rivers and streams within the Fox River watershed vary in their current level of floodplain mapping detail. In Zone AE floodplains, detailed engineering analyses were used to determine base flood elevations for the FEMA SFHA 1-percent-annual-probability event. These floodplains usually show both floodway and floodfringe areas, and base flood elevations are available. Some streams have been modeled with more approximate studies, resulting in Zone A floodplains. These areas do not differentiate between the floodway and floodfringe, and base flood elevations are not available. Finally, some streams in the watershed have no floodplain mapping of any form.

In Map 4.8, Commission staff identified several example stream reaches that could benefit from new or more detailed floodplain study. Priority was given to reaches with a higher density of development in the surrounding area. Table 4.1 lists these reaches along with their approximate locations. This should not be considered an exhaustive list, and it is recommended that communities look at their local FEMA FIRM maps for opportunities to improve floodplain mapping in their jurisdiction.

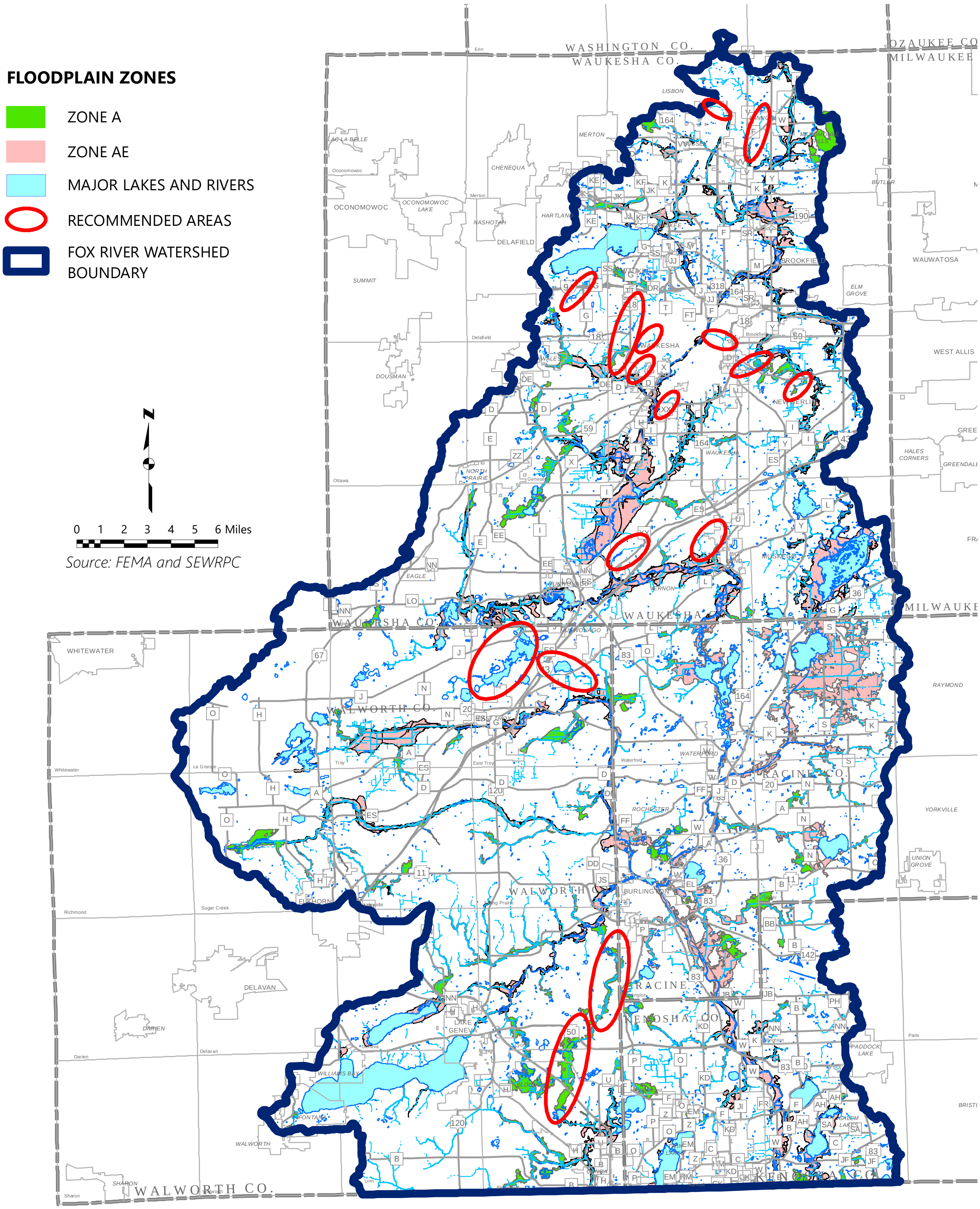
Improving floodplain mapping within the Fox River watershed can provide significant advantages for the watershed by highlighting the areas of highest flooding risk along a river or stream. Refining studies to replace A zones with AE zones can provide a greater level of accuracy for understanding the impact of the 1-percent-annual-probability flood event. A designated floodway helps the community identify the highest danger from quick-moving water where regulations on development should be most restrictive.

Similarly, conducting engineering studies to produce new floodplain mapping in previously unmapped areas will accurately inform flood risks and guide future urban development, specifically preventing development from occurring in flood-prone areas. For a previously unmapped stream reach, a community should assess whether a detailed engineering analysis to produce AE zone flood maps would be beneficial, or whether a simpler engineering analysis to produce A zone mapping would be sufficient. This decision can be made based on current and planned development in the area, as well as available funding and staff time.

**Additional Gaging Locations**

Monitoring gages are located across the Fox River watershed to measure current hydraulic and hydrologic conditions in streams and lakes as well as to measure rainfall. Chapter 2 discusses the currently available monitoring gages within the watershed. Access to reliable data is important for understanding the conditions on the landscape. Gages can offer early warning of flooding events by detecting rising water levels, which can give emergency responders information on where the most severe flooding may occur and improve response times as well as help communities prepare. An effective gage network has sufficient coverage across the watershed that provides a complete picture of the area without having significant data gaps.

## Map 4.8
## Recommended Areas of Additional Floodplain Mapping in the Fox River Watershed




Source: FEMA and SEWRPC

**Table 4.1**
**Recommended Reaches for Additional Floodplain Mapping in the Fox River Watershed**

| County | Municipality | Public Land Survey System | Reach | WDNR Waterbody ID Code (WBIC) | Current Mapping Status[a] |
|---|---|---|---|---|---|
| Walworth | Town of East Troy | T4NR18E | Lake Beulah | 766600 | Unmapped |
| | Town of East Troy | T4NR18E | Potter Lake | 753800 | Unmapped |
| | Town of Lyons and Town of Bloomfield | T2NR18E, T1NR18E | Spring Valley Creek (Pell Lake Tributary 2) | 756200 | Zone A |
| Waukesha | City of New Berlin | T6NR20E | Unnamed (tributary to Poplar Creek, 1,700 ft upstream of Greenfield Avenue) | 773000 | Zone A |
| | City of New Berlin | T6NR20E | Unnamed (tributary to Poplar Creek, 4,100 ft upstream of W. Cleveland Avenue) | 3000218 | Unmapped section of partially mapped reach |
| | City of Waukesha | T6NR19E | Unnamed (tributary to Pebble Creek, 1,800 ft downstream of Madison Street) | 3000119 | Unmapped |
| | City of Waukesha | T6NR19E | Unnamed (tributary to Pebble Creek, 2,200 ft downstream of Merrill Hills Road) | 3000120 | Unmapped |
| | City of Waukesha | T6NR19E and T7NR19E | Unnamed (tributary to the Fox River at Saratoga Lake) | 771650 | Unmapped |
| | City of Waukesha and Village of Waukesha | T6NR18E, T6NR19E, T7NR19E | Pebble Creek | 771300 | Partially Zone A, partially unmapped |
| | Town of Delafield | T7NR18E | Zion Creek | 772400 | Unmapped section of partially mapped reach |
| | Village of Menomonee Falls | T8NR20E | Unnamed (tributary to Unnamed Tributary WBIC 773500, listed below) | 5034587 | Unmapped |
| | Village of Sussex | T8NR19E | Unnamed (tributary to Fox River near corner of Silver Spring Drive and Lannon Road) | 773500 | Unmapped section of partially mapped reach |
| | Village of Vernon | T5NR19E | Artesian Brook | 765200 | Zone A |
| | Village of Vernon | T5NR19E | Unnamed (tributary to pond with outlet near corner of Hartwig Avenue and Lakeside Drive) | 5037762 | Unmapped |

[a] *Current mapping status is based on the most current floodplain map drafts available at the time of analysis. Preliminary draft floodplains were used for Kenosha County (published March 28, 2022), Racine County (published December 23rd, 2022), and Waukesha County (published September 15, 2022). Effective floodplain mapping was used for Walworth County (effective April 6, 2022).*

*Source: Federal Emergency Management Agency, Wisconsin Department of Natural Resources, and SEWRPC*

The current network of monitoring gages in the Fox River watershed could be further improved with the installation of additional gage locations to provide more complete coverage of the watershed.

***Stream Gages***

There are currently seven stream observation gages in the Fox River watershed, including three with forecasting capability, as shown in Map 2.11 in Chapter 2. Five of the gages are located on the main stem of the Fox River, one is located at the outlet of Lower Phantom Lake on the Mukwonago River approximately 2.3 miles upstream of the confluence with the Fox River, and one gage is located near the outlet of Muskego Lake on the Muskego Canal approximately ten miles upstream of the confluence with the Fox River. To develop a network of stream gages that provides wider coverage of the watershed, four additional streamflow gage locations are recommended as shown in Map 4.9. This includes a gage on Honey Creek, a gage on Sugar Creek, and a gage on the White River, as well as a gage on the Fox River mainstem approximately two miles downstream of the confluence with the Mukwonago River.

Currently there are no stream gages on Honey Creek, Sugar Creek, or the White River, and new stream gages on these reaches would deliver useful monitoring of river stage and flows for residents of the White River subwatershed. These new gages would also provide context to understand those reaches' relative contributions to the Fox River. The confluence of these reaches with the Fox River is located just upstream of Burlington, and for this reason monitoring in these locations would be particularly advantageous to predicting flood conditions in Burlington. This can provide valuable lead time to implement emergency response measures for flooding.

The recommended location of the stream gage on the Fox River mainstem near Mukwonago would bisect the long stretch of river between the current gage near Waukesha to the north and the gage near the outlet of Tichigan (Buena) Lake to the south. This recommended gage location is downstream of multiple tributary confluences with the Fox River that are not captured by the Waukesha stream gage. Adding a monitoring gage at the recommended location would provide useful hydraulic data for the downstream communities near Tichigan Lake. Availability of reliable upstream flow data can help these communities better respond to developing flooding events.

Based on communication with the United States Geological Survey (USGS),[45] the estimated cost to install a new USGS flow gage is approximately $15,000 (2023 dollars). The total annual cost of operation is approximately $13,000. The USGS would share the cost of annual operation, with the USGS paying 25 percent and local partners paying 75 percent of the annual cost.

***Rain Gages***

Section 2.6 discusses the current rain gage network in the Fox River watershed. As shown in Map 2.12 there are three airports with rain gages and one Milwaukee Metropolitan Sewerage District (MMSD) rain gage in the watershed. The five current rain gages at the United States Geological Survey (USGS) sites in the watershed are limited to Racine County and the southern edge of Waukesha County. There is a notable lack of publicly supported rain gages in portions of Walworth County, Kenosha County, and the rest of Waukesha County in the watershed. Additional rain gages in these three areas would provide a more complete coverage of rainfall data across the watershed. The quick recording frequencies and data publishing times of rain gages at USGS sites makes them a useful tool to communities for flood mitigation. Additional USGS rain gages would provide reliable near-real-time rainfall observations throughout the watershed, which would aid in predicting locations of severe flooding and implement preemptive mitigation efforts. It is recommended that rain gages be added at the recommended USGS stream gage locations shown on Map 4.9. Care should be taken to choose rain gage locations where precipitation would not be blocked by tree cover, ideally with at least twenty feet of clearance from nearby trees.

According to USGS,[46] the cost to purchase and install a rain gage at an existing stream gage site is $2,500. The annual cost to operate a published rain gage is $2,700 in instances where USGS officially approves the data, which involves quality assurance practices that make the data citable and archived long term.

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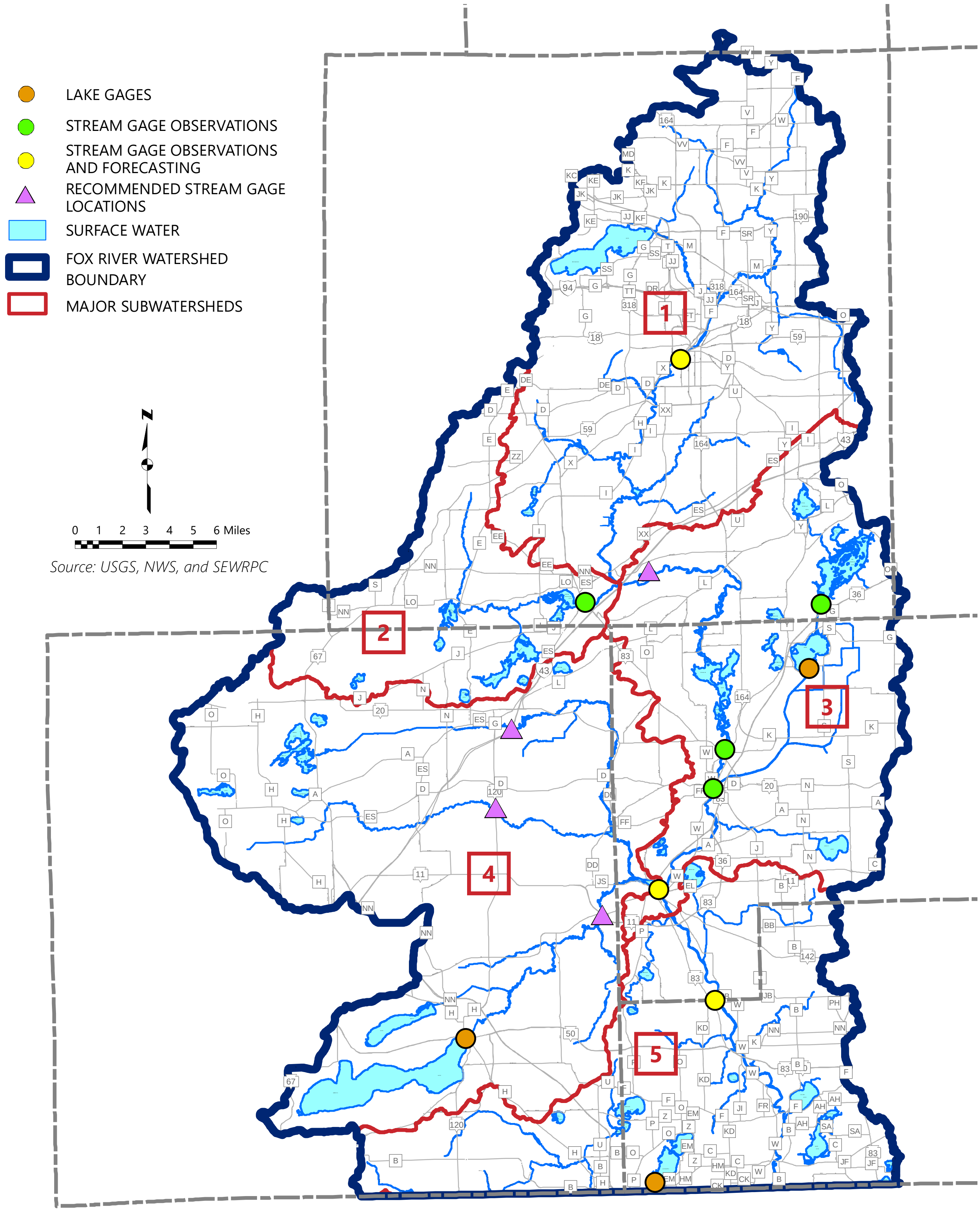
[45] *Electronic mail communication from Robert Waschbusch on July 28, 2022.*

[46] *Waschbusch, Robert Email to Laura Herrick, March 22, 2023.*

## Map 4.9
## Recommended Additional Stream Gage Locations in the Fox River Watershed




*Source: USGS, NWS, and SEWRPC*

Optionally, rain gage data can be uploaded online without official approval practices for $1,350 annually. It is strongly recommended that existing and new rain gages at USGS sites be operated as published gages with the annual cost of $2,700. The continual quality assurance practices for published gages would ensure their proper maintenance, thereby preventing the gages from reporting unreliable and unusable data.

Although the Fox River watershed contains three airport gages, it should be noted that the Waukesha County Airport gage only operates and reports rainfall online at night, and the East Troy Municipal Airport does not publicly report its data online at all. It is recommended that the Waukesha County Airport rain gage be operated both day and night and that rainfall data from both airport gages be reported in near real-time online to provide accurate information to surrounding watershed stakeholders.

Weather Underground (WU) publishes data in real-time for an expansive network of volunteer-run rain gages across the watershed and surrounding region. The distribution of WU gages provides good coverage of the Fox River watershed. However, as discussed in Chapter 2, data from volunteer-run rain gages may be less reliable than data from those operated by governmental agencies. As such, the WU gages should be used to supplement data from governmental agency gages where there are spatial data gaps in those networks.

**Removal of Structures in Floodplain**

As summarized in Table 3.1, there were 1,255 structures identified as having a footprint in the effective 1-percent-annual-probability floodplain within the Fox River watershed. That total included 48 structures that are repetitive- or severe repetitive-loss properties as identified by the National Flood Insurance Program. It is recommended that communities review the structures mapped in the regulatory floodplain within their jurisdiction using the latest topographic contour data to identify which structures have the highest risk of flooding. It is also recommended that the counties calculate the potential structural damage costs that could be incurred from flooding, based on anticipated depth of flooding and tax assessment data.

It is recommended that communities develop a plan to voluntarily acquire and demolish structures in the floodplain as opportunities arise and funding becomes available, with particular emphasis on removing repetitive- and severe repetitive-loss properties from the floodplain. The Kenosha County Fox River Flood Mitigation Program provides a good program example for how to buy out structures in the floodplain. Since 1995, Kenosha County's Fox River Flood Mitigation Program has reduced potential flood damages by voluntarily acquiring and demolishing residential structures located in the 1-percent-annual-probability floodplain of the Fox River in a project area between State Trunk Highway (STH) 50 and County Trunk Highway (CTH) F within the Village of Silver Lake and the Towns of Salem and Wheatland. In total, the owners of 128 homes have participated in this program since its inception, and an additional 31 homes are eligible for participation. The County helps residents participate by encouraging interested parties to fill out a Notice of Voluntary Interest and helping residents get pre-approved for acquisition with Wisconsin Emergency Management (WEM). Preapproval will allow all parties to be ready when funding becomes available, such as a disaster allocation after a major flooding event. Funding is provided by several sources, including FEMA, WEM, WDNR, Federal Community Development Block Grants, and Kenosha County. Normally the buyout program offers homeowners a higher price than market value to incentivize the purchase when the homeowner would not otherwise be interested in selling. However, in recent years Kenosha County started setting aside additional funds to have available to purchase a home closer to market value when a residence goes up for sale; this allows for a more efficient use of funds and prevents a new homeowner from buying a house in the floodplain.

After parcels in the floodplain are acquired and structures are removed, it is recommended that the land remain an open space and be used for additional public recreational, ecological, or environmental purposes when possible. The Army Corps of Engineers is currently investigating the feasibility of conducting stream restoration work along the riparian corridor in the area of the Kenosha County buyouts under Section 519 of the Water Resources Development Act of 2000. This project would aim to reconnect the floodplain, wetland, and backwater areas with the main Fox River channel, as well as implement bank stabilization practices to reduce soil erosion and increase habitat for wildlife. Projects like these can increase flooding resilience while also providing supplemental benefits such as improving water quality and ecological function.

### Roadway Flooding Protection

In Chapter 3, 70 major roadways in the Fox River watershed were identified to flood during the 1-percent-annual-probability flood event according to the FEMA effective FIRM maps. When the preliminary FIRMs were used instead of the effective FIRMs, a total of 78 major roadways were identified to flood in the Fox River watershed. Map 3.2 shows the roadway flooding locations in the effective floodplain. The roadway flooding locations in the preliminary floodplain and a detailed list of each roadway location and flood depth can be found in Appendix C.

In addition, in Chapter 3 the Federal Highway Administration (FHWA) National Bridge Inventory (NBI) bridge conditions data were analyzed for highway bridges and culverts in the Fox River watershed. A total of 241 riverine bridges and culverts within the 2021 NBI dataset were identified in the watershed. A list of each structure and their NBI structural condition ratings can be found in Appendix C. Out of the 241 structures with NBI ratings, 20 major structures would be overtopped by the 1-percent-annual-probability flood event, based on the FEMA effective and preliminary floodplains. Appendix C provides a list of those 20 structures.

It is recommended that impacted communities evaluate the list of flooded major roadways and mitigate risks when possible. Communities should note flooding depths greater than 1.5 feet, which would be impassable for emergency equipment, and plan alternate routes for these locations. Communities should also prioritize maintenance, repair, or replacement of bridges and culverts with poor structural ratings. In certain cases, sections of roadways, bridges, and culverts can be redesigned and replaced to prevent flood overtopping. A recent project to raise the road along STH 50 from CTH W to the Wisconsin Central Railroad in Kenosha County provides a good example of mitigative action to protect roadways from flooding. Design strategies including raising the roadway elevations or increasing the sizes of culverts or bridge openings can be considered. However, designs should avoid significantly changing flood elevations upstream or downstream or reducing flood storage. Stream crossing replacements should also be designed to allow for fish passage through the crossing during normal flow conditions.

### Streambank Erosion Protection for Infrastructure on the Fox River Mainstem

As summarized in Chapter 3, in 2017 Commission staff identified locations on the Fox River mainstem between Waterford Dam and the Wisconsin-Illinois state line where streambank erosion was threatening infrastructure, including buildings, roads, bridges, and railroads. As part of SEWRPC Memorandum Report No. 257 (in draft), these erosion sites were ranked by priority based on staff professional judgement, as "Watch", "Warning", or "Imminent Threat", as shown in Table 4.2. Because the level of erosion at these sites may have changed in the last six years, municipalities should investigate these sites within their jurisdictions to determine the current level of erosion and potential harm to nearby infrastructure. It is recommended that municipalities develop a schedule to monitor the deterioration of these sites and develop conceptual plans to stabilize the streambank to protect nearby infrastructure where needed.

There are a wide range of streambank erosion mitigation strategies that could be employed at these erosion sites, and these methods should be considered on a site-by-site basis. Hard armoring such as riprap and gabion baskets can provide robust protection for banks receiving heavy hydraulic force, and mats made of geotextile or coconut fiber fabric can help hold existing soils in place. Bioengineering methods such as seeding banks and live stakes can help reinforce streambanks via deep root systems, while also improving riparian habitat.

## 4.2 HAZARD MITIGATION COMPONENT FOR DAMS

As reviewed in Section 3.2, there are 87 active dams within the entire Fox River watershed, 19 of which are considered "main dams" for the purposes of this study. The main dams were identified for their ability to affect the hydrology of the entire watershed in a substantial way, particularly those dams along the Fox River and its largest tributaries. Many of these main dams impound lakes and reservoirs and have the capacity to store and release substantial volumes of water using operable gates. Nearly all these dams are owned by separate entities, including Counties, municipalities, lake districts, and private owners (see Table 3.6). Consequently, most of these dams are operated individually with little coordination of water levels and flows between them. As discussed in greater detail in this section, communication between adjacent dam operators varies considerably across with the watershed, with some operators communicating frequently

## Table 4.2
## Fox River Erosion Impacts to Infrastructure with Prioritization Rank (Downstream of Waterford Dam)

| Location | Erosion Length (ft) | Infrastructure Type | County | Erosion Severity | Public Ownership | FEMA 1-Percent-Annual-Probability Road Flooding | FEMA 1-Percent-Annual-Probability Building Flooding | Prioritization Rank |
|---|---|---|---|---|---|---|---|---|
| Adjacent to CTH W and 1.5 miles downstream of CTH F | 1,960 | Road | Kenosha | Slight | Yes | Yes | N/A | Warning |
| Immediately downstream of CTH F[a] | 620 | Road and Bridge | Kenosha | Moderate | No | No | N/A | Imminent Threat |
| Adjacent to CTH W and S. Riverside Drive[a] | 720 | Road and Building | Kenosha | Moderate | No | No | No | Imminent Threat |
| Adjacent to W Lake Street[a] | 1,030 | Road and Building | Kenosha | Moderate | Partial | Yes | Yes | Warning |
| Adjacent to CTH W and 3.3 miles downstream of STH 50/83[a] | 340 | Road and Building | Kenosha | Severe | Yes | No | No | Imminent Threat |
| Adjacent to CTH W and 1.6 miles downstream of STH 50/83[a] | 1,170 | Road | Kenosha | Moderate | Yes | No | N/A | Imminent Threat |
| Adjacent to CTH W and 0.2 miles upstream of STH 50/83 | 480 | Road | Kenosha | Very Severe | Yes | Yes | N/A | Warning |
| Adjacent to 330th Avenue | 770 | Building | Kenosha | Moderate | No | N/A | No | Watch |
| Immediately downstream of CTH JB[b] | 700 | Road and Bridge | Kenosha | Moderate | No | No | N/A | Warning |
| Adjacent to Canadian National Railroad and 0.7 miles upstream of CTH JB | 790 | Railroad | Racine | Moderate | No | No | N/A | Warning |
| 0.1 miles upstream of STH 11/36/83 | 520 | Railroad | Racine | Moderate | No | No | N/A | Warning |
| Immediately downstream of E. State Street | 340 | Road, Bridge, and Building | Racine | Severe | No | No | Yes | Warning |
| Adjacent to Milwaukee Avenue and 1.1 miles downstream of CTH W | 900 | Road | Racine | Very Severe | No | Effective: No Preliminary: Yes | N/A | Imminent Threat |
| Adjacent to N. River Road and River Ridge Circle | 460 | Building | Racine | Moderate | No | N/A | No | Watch |

[a] *Deep scour holes were observed at these erosion locations based on field inspection conducted in 2017. The scour may further compromise the adjacent infrastructure.*

[b] *The CTH JB bridge over Fox River has a 2021 NBI Bridge Condition Rating of 5 (Fair Condition).*

*Source: SEWRPC*

about water flows at their dams while other operators rarely or never contact adjacent operators.[47] This section will discuss best management practices and describe potential opportunities for communication and coordination among dam operators, municipalities, and other entities as recommended by FEMA, WDNR, and long-time dam operators in the Fox River watershed.

### Best Practices from FEMA and the WDNR

FEMA and the Dam Safety Program of the WDNR provide information regarding best practices for dam safety and operational guidance. This subsection describes best practices for communication and coordination as outlined by these agencies.

#### *FEMA: Lessons Learned from Edenville and Sanford*

While devastating to the local communities, the failures of the Edenville and Sanford dams along the Tittabawassee River in Michigan in 2020 provide multiple lessons on the importance of communication and coordination among dam owners prior to, during, and following a severe flooding event.[48] In May 2020, intense rainfall over several days caused the Edenville dam to fail, sending large volumes of water downstream along the Tittabawassee River toward the Sanford dam, which also failed from the large flows. Over 4,000 structures were flooded which resulted in millions of dollars in damage, but due to the timely action of dam operators and emergency management officials there were no casualties reported. A 2022 FEMA after-incident report provided multiple recommendations and ongoing challenges for communicating, coordinating, and managing water levels in jurisdictions with dams.[49] These recommendations and challenges are summarized below:

- Increasingly intensive precipitation events with climate change combined with aging infrastructure are increasing flooding and dam failure risks. The Edenville and Sanford dam failures were preceded by several days of historic regional rainfall across their contributing watersheds. Consequently, a watershed approach should be utilized when planning for dam safety and flooding risk.

- Working relationships and established trust between dam operators, emergency management officials, first responders, and other stakeholders is essential. Relationships should be established during non-emergency times and strengthened through frequent communication, participating in emergency management tabletop exercises, and reciprocal tours of dam and emergency management facilities.

- Share and coordinate dam Inspection, Operation, and Maintenance plans (IOMs), Emergency Action Plans (EAPs), and other operation guidance and high-water protocols between dam operators and emergency management officials. Develop secure, robust, and timely methods to share data and other information prior to, during, and following flooding events.

- Using multiple communication methods, including informal methods like text-messaging, between key personnel from multiple agencies can be very helpful for relaying information quickly.

- Enhance modeling for flooding and dam failure scenarios to create inundation maps and determine roads and structures that are likely to be flooded at various river stages. Share results with communities that have heightened flooding risks.[50]

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[47] *"Adjacent" in this context refers to dam operators communicating with the nearest upstream and downstream dam operators.*

[48] *Michigan Dam Incident Response Review: An Analysis of the 2020 Edenville and Sanford Dam Failure Response, Federal Emergency Management Agency, April 2022.*

[49] Ibid.

[50] *Inundation maps can be created using tools like the Hydrologic Engineering Center – River Analysis System (HEC-RAS) (www.hec.usace.army.mil/software/hec-ras) and the Decision Support System for Water Infrastructural Security (DSS-WISE™) (dsswiseweb.ncche.olemiss.edu).*

### *WDNR Dam Safety Guidelines*

The WDNR Dam Safety program mandates regular inspections of dams; regulates water level operating orders and temporary drawdowns; permits dam repairs, removal, and transfers; and maintains records of basic dam information, inspections, IOMs, EAPs, design plans, and other documentation.[51] This program also provides information and best practices to dam owners through newsletters, links to informational videos, as well as guides and templates to develop IOMs and EAPs. Summarized recommendations regarding monitoring, communication, and coordination from the IOM and EAP guides are as follows:[52,53]

- Monitor river flow, precipitation, water level, gate operation, and dam seepage daily to weekly.

- Dam operators may need to release water in advance of anticipated high flows. These releases should be communicated to downstream dam operators and property owners with enough notice for these entities to respond to the water level changes.

- Records regarding dam maintenance, gate operation, precipitation, and water levels should be maintained.

## Dam Data Review

### *Dam Age*

Currently, records for the completion dates of dam components are not being documented and maintained in a central location for dams in the Fox River watershed. When considering the age of a dam, the age of each major component of the dam must be assessed, such as the gates, physical structure, and embankments. Often the age depends on the date of the most recent reconstruction or upgrade, which may pertain to one or more of the dam components. Knowing the age of the dam components can be helpful in considering the planned lifespan of the dam and the potential failure risk, because older dams may have a higher risk of failing. It is recommended that accurate records be kept of the completion date for any major dam maintenance, upgrade, or replacement for any integral dam components.

### *Spillway Capacity*

A second important factor connected to potential dam failure risk due to age is whether the spillway has adequate capacity. Spillway capacities can become insufficient over time due to changing land use in the surrounding watershed, as well as from increased severity of rainfall events due to climate change. These changes can result in higher flows that may exceed the spillway design capacity, increasing the likelihood of dam failure. It is recommended that spillway capacities be recorded for all dams, and that these records be maintained. When updated design storm flow estimations are available from new hydrological analyses, these updated flows should be compared to the recorded spillway capacity of the dam.

If a dam is found to have an insufficient spillway capacity for its hazard rating as described in Table 3.8, the WDNR will require that the dam be modified to increase spillway capacity to come into compliance with NR 333. The current dam modification project at Echo Lake dam provides a good example of how spillway capacity requirements can be addressed while incorporating additional community benefits into the project design. During a dam failure analysis that was completed in 2015, it was found that the Echo Lake dam spillway does not have sufficient total spillway capacity to pass the 0.2-percent-annual-probability (500-year recurrence interval) event, which is the statutory requirement for dams with a significant hazard rating. To address this need, the City of Burlington plans to modify the Echo Lake dam by replacing the current gate with three gates, adding a reinforced earthen berm, and stabilizing the impoundment shoreline. The dam modifications have an estimated cost of $3.5 million, while the entire project has an expected cost

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[51] *For more information on the WDNR Dam Safety Program, see the Program webpage at the following link: dnr.wisconsin.gov/topic/Dams.*

[52] A Guide to Writing Inspection, Operation, and Maintenance Plans, *Wisconsin Department of Natural Resources Dam Safety/Floodplain Management. This guide can be accessed at the following link: dnr.wi.gov/topic/dams/documents/FinalIOMGuidebook.pdf.*

[53] Emergency Action Plan (EAP) Guidebook, *Wisconsin Department of Natural Resources Dam Safety/Floodplain Management, June 2019. This guide can be accessed at the following link: dnr.wi.gov/topic/Dams/documents/EAPWritingGuidebook.pdf.*

of $9.1 million (2023 dollars). The project plan also incorporates park improvements such as dredging the impoundment and adding walking trails, boat launches, and a flexible performance area. The WDNR has approved modeling showing that the proposed upgrades would allow the dam to contain floodwaters up to the point of dam submergence at slightly less than the 0.5-percent-annual-probability (200-year recurrence interval) event peak flow. With the dam being capable of containing floodwaters up to the point of submergence, the dam would be in compliance with NR 333. The City of Burlington plans to complete the dam structure modifications by 2025.

***Operational Storage***

While none of the main dams in the Fox River watershed were designed for flood mitigation, Commission staff assessed the theoretical storage capacity of each main dam based on the dam operation water level ranges (see Table 3.7) and the surface area of the impoundment. As a point of comparison, Commission staff determined the amount of rainfall across the watershed for each main dam that would be equivalent to the computed storage volume of the respective impoundment. The results of this analysis are in Appendix D. While it was found that most of the main dams had minimal or no storage capacity within their operating water level range, a few dams did have notable potential for rainfall runoff storage. The conceptual analysis showed that Silver Lake has potential storage equivalent to three inches of rainfall over its contributing watershed area, while Geneva Lake has an equivalent storage of two inches and Little Muskego Lake has an equivalent storage of 1.5 inches.

The capacity of Silver Lake to store runoff from a substantial rainfall event is due to a combination of the contributing drainage area being relatively small, while the size of the impoundment is large, and the operating range is larger than most dams in the Fox River watershed. The ability of Lake Geneva to conceptually store a two-inch event is primarily due to the large size of the lake compared to its smaller drainage area size. Little Muskego Lake also has a larger lake size compared to its drainage area, as well as having a larger operating range.

This analysis did not account for rainfall runoff losses from infiltration, interception, evaporation, or isolated storage on the landscape. These losses would divert a portion of the rainfall from entering the impoundment, and as such, inclusion of these losses in the analysis may yield higher rainfall totals that the respective impoundments could store. To include these losses in the analysis, detailed modeling would be needed to assess the soils, land use, temporal considerations of the flow across the landscape, and other factors for each watershed.

Currently none of the main dams in the Fox River watershed are operated for flood mitigation. The dams are managed to comply with operating orders and to maintain lake conditions suitable for the desired recreational activities. As such, operators generally do not attempt to hold back excess flows during a flood event, nor do they lower water levels preceding a forecasted storm to maximize storage capacity during the event. This storage capacity assessment was an initial analysis on the availability of storage potential. To use any of the main dams for storage during a rainfall event and for flood mitigation, it is recommended that a detailed assessment be completed.

**Case Study: Wind Lake and Rochester Dams**

Dam operators within the Fox River watershed are already implementing some of the FEMA- and WDNR-recommended best management practices to varying degrees. For example, Mr. Thomas Halter, operator of the Rochester and Wind Lake dams, has practiced and advocated for improving water level monitoring, communication, and coordination of water level management throughout the Middle Fox subwatershed since beginning operations on the Rochester dam in 1994. Commission staff met with Mr. Halter at the Commission office on March 30, 2022, to discuss his dam operations and the Fox River Watershed Mitigation Plan. Mr. Halter summarized his insights regarding dam operation using the acronym "CADET," which stands for Communication, Awareness, Data, Experience, and Timing. The following subsection recommends practices to promote water level management using the CADET principles.

***Communication***

Regular communication is essential to establish trust, share information, and cooperatively manage water levels throughout the Middle Fox watershed. For example, Mr. Halter regularly communicates with Mr. Thomas Zagar, operator of the Big Muskego dam upstream of Wind Lake, and Mr. Robert Anders, operator of the Waterford dam downstream of Wind Lake, regarding water levels and gate operation. He also communicates with Mr. Peter Riggs, Public Works Director of the City of Burlington, regarding water levels and flows leaving the Rochester dam, which is downstream of all three dams.

Recommendations for communication are as follows:

- Establish working relationships with upstream and downstream dam operators, emergency management officials, public works directors, wastewater treatment facility directors, public health officials, National Weather Service staff, and other stakeholders within your subwatershed. Participate in tabletop exercises with these stakeholders to develop methods to communicate about rising water levels and plan for strategies to reduce risks to vulnerable communities and critical infrastructure.

- Maintain updated contact information between dam operators, emergency management officials, public works directors, and other stakeholders in each subwatershed. Establish priority communication lists and methods and create backup plans to communicate in case the preferred option fails.

- Share and coordinate dam Emergency Action Plans (EAPs), particularly for dams that are immediately adjacent to each other. The possibility of a failure of an upstream dam causing failures and increased flooding downstream should be addressed in the EAPs of both dams.[54] Ensure that all dam EAPs within the watershed use the same numeric rating system for their Emergency Levels.[55]

- Frequently communicate with and, if feasible, coordinate water level management with dam operators for adjacent dams. Ensure that both operators have access to and are referencing the same sources of information using the same units and referenced to the same datums to avoid confusion during emergency events. This information should be put into the context of historical records to indicate water levels that are below, at, and above normal conditions.

***Awareness***

Awareness of weather conditions as well as conditions on the ground, such as soil moisture levels, frozen soils, etc. can provide a basis for understanding how precipitation events will affect water levels. Intense rainfall on frozen soils will result in more rapid runoff and a more immediate rise in water levels than would the same rainfall on damp soils in mid-summer. Additionally, weather conditions such as wind and atmospheric pressure can influence water level gage readings while winter ice formation during winter can disrupt gage measurements.

Recommendations for awareness are as follows:

- Monitor and stay alert to changing weather conditions by subscribing to National Weather Service (NWS) weather alerts, using the FEMA Integrated Public Alert & Warning System, and checking weather websites with real-time data, such as those described in Section 2.6.[56]

- As feasible and within the bounds of water level operating orders, adjust water levels to prepare for forecasted weather information and moderate flows downstream of the dam. These adjustments should be completed in coordination with upstream and downstream dam operators as necessary.

- Understand the relationships between soil and groundwater conditions with forecasted weather conditions. For example, precipitation is more likely to runoff on soils that are frozen or completely saturated. Be vigilant of these conditions within the dam's contributing watershed to better anticipate and mitigate extreme water level events. Online tools, such as the Runoff Risk Advisory

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[54] FEMA, 2022, *op. cit.*

[55] *In its review of dam EAPs within the Fox River watershed, Commission staff noted that some EAPs have reversed numeric emergency ratings, where a rating of 1 could indicate a non-emergency event in one EAP and indicate the highest level of emergency where dam failure is imminent in another EAP. This holds true for some dams adjacent to each other, such as Honey Lake and Echo Lake dams in the White River subwatershed.*

[56] *For more information on the FEMA Integrated Public Alert & Warning System, see www.fema.gov/emergency-managers/practitioners/integrated-public-alert-warning-system.*

Forecast, provide current conditions and forecasts of soil temperature, moisture, and runoff risk.[57] The NWS also utilizes this information to produce its spring flood outlook narratives.[58]

- Blockages created by debris and ice jams can impound the water upstream and downstream of the dam, limiting the volume of water that can be discharged, and clogging the control mechanisms of the dam itself. The channel upstream of the dam should be monitored for such blockages, and they should be removed as soon as possible. Furthermore, ice formation on stream and lake gages can disrupt the transmission of streamflow and water level data used for decision-making during winter months. Use of camera devices that broadcast to the internet may be useful in monitoring upstream and downstream conditions as well as roughly estimating water levels when gages are not in operation.

- Remain aware of hydrologic and land modification activities within the watershed to understand how they may affect the volume and timing of water flows arriving at the dam from precipitation events. Such activities may include dredging of waterways, developing large areas with impervious surface, and development in and near floodplains upstream and downstream of the dam. Annual communication between dam operators and upstream lake districts, public works directors, and WDNR Waterways program staff about major projects may suffice.

### *Data*

Near real-time monitoring of water levels is paramount to managing impoundment levels and responding quickly to rapidly changing conditions. For example, dam operators within the Middle Fox subwatershed reference lake level gages on Wind Lake and Big Muskego Lake as well as stream gages on the Fox River at Waukesha, Waterford, and Rochester. These gages report water levels and discharge information in near real-time to USGS websites. Additionally, dam operators in the Middle Fox subwatershed source real-time weather information from a network of rain gages across the Middle Fox watershed as well as alerts from the National Weather Service office in Sullivan, WI.

Recommendations for data collection and sharing are as follows:

- Monitor and record surface water elevations of the impounded waterbody as well as dam gate operations. Host these observations on a secure website and/or share these observations with stakeholders upstream and downstream of the impoundment. This data can supplement USGS lake gage data, at the locations shown on Map 4.9. Ensure that the elevations are tied to a vertical datum and report this datum with the elevation measurements. Have all shared measurements converted to a common vertical datum, shared language, and/or symbology as needed.

- Reference available near real-time surface water gages with flow data or water level data, located upstream and downstream of the dam, if any such gages exist. Subscribe to the USGS water alert service to receive email and/or text alerts when gages attain user-defined thresholds.[59]

- Check precipitation gages and weather forecasts from various sources, including those described in Sections 2.6 and 2.7, to stay aware of weather conditions and adjust water levels as feasible.

- If available in the area of interest, utilize the NWS River Forecast tools to keep informed of expected water level ranges over the next seven to ten days and three months.[60] If feasible, adjust water levels to accommodate heavier than anticipated rainfall while minimizing flood likelihoods downstream of the dam.

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[57] *The Runoff Risk Advisory Forecast from the Wisconsin Manure Management Advisory System can be accessed at the following link: www.manureadvisorysystem.wi.gov/runoffrisk/index.*

[58] *The NWS Spring Flood Outlooks can be accessed at the following link: www.weather.gov/mkx/SpringFloodOutlook.*

[59] *To subscribe to USGS Water Alerts, follow the instructions on the following webpage: accounts.waterdata.usgs.gov/wateralert/my-alerts.*

[60] *The NWS River Forecast seven to ten day tools available at water.weather.gov/ahps2/forecasts.php?wfo=mkx while the three month outlook tool is available at water.weather.gov/ahps2/long_range.php?wfo=mkx&percent=50.*

- Consider installing groundwater monitoring wells and/or soil moisture monitoring equipment in and around earthen dams to monitor for dam seepage between dam inspections.

***Experience***

It takes time to develop experience in synthesizing information about weather, water flows, and the timing to fill and drain the dam impoundments. Years of experience are necessary to witness a variety of events and gain a better understanding of operation triggers and how a dam system responds. These experiences should be documented and communicated to new dam operators to facilitate transition of this important responsibility.

Recommendations for experience are as follows:

- Dam operators should regularly update their IOMs, EAPs, and other dam operational guidance documents to ensure that best practices are being utilized and documented. Key observations and metrics that are essential for dam operations, such as streamflow gages, should be documented and communicated with the agencies responsible for funding and maintaining these systems.

- Dam operators should maintain their records of water levels, weather conditions, and gate operations along with context and explanations regarding their decision-making. These records should be maintained with the entity that owns and operates the dam, so that these valuable insights can be passed on to future operators.

- Current dam operators should be directly involved in the hiring and training of deputy and replacement dam operators to help pass on the valuable on-the-job experience they have gained. Ideally deputy and replacement operators would shadow the current operator for a period to be able to gain first-hand experience with them in the field.

***Timing***

Understanding the timing between precipitation events and runoff increasing water levels and flows within the watershed is critical to informing responsive dam operation. In his nearly three decades of experience operating the Rochester dam, Mr. Halter has gained a thorough understanding of the timing of water level changes in response to precipitation events of varying intensity within the Middle Fox watershed. He also understands the impact of ground conditions on water level changes during a precipitation event as well as the extent to which water levels change in response to gate operations. Watercourse morphology can also have a significant impact on this timing. As an example, Mr. Halter estimated that recent dredging of the Wind Lake Canal reduced the travel time of Wind Lake dam releases to Rochester Dam from around eight hours to two hours.

Recommendations for timing are as follows:

- Understanding the timing of water releases and travel time of flows is critical to mitigating high flows. This understanding comes partly from the experience of monitoring upstream water levels and gate operations and partly from awareness of activities that can affect the hydrology of the contributing watershed to the dam. Dam operators should note these activities through regular communication with subwatershed stakeholders.

- Timing of flows from dam releases should be monitored, documented, and shared with adjacent dam operators to better understand how these releases impact downstream areas.

**Subwatershed Networks**

The more intensive monitoring and coordinated operations by dam operators in the Middle Fox subwatershed are an example of what could be achieved in other parts of the Fox River watershed. It is the understanding of Commission staff that some dam operators and other water level managers within the watershed are using similar resources and practices as operators within the Middle Fox subwatershed to varying degrees.[61] There remain multiple challenges and obstacles to overcome in building out a network of monitoring, information

[61] *As another example, the dam operators of the Wambold Dam and Eagle Spring Lake communicate with the operator of the downstream Mukwonago dam within the Mukwonago subwatershed regarding water levels and dam operations.*

sharing, and capacity to coordinate water level management in other parts of the watershed. These challenges include an inadequate number and distribution of stream and lake water level gages, little to no communication between some upstream and downstream water managers in the watershed, and general insularity of water management operations during non-emergency conditions. Sharing information and coordinating efforts between key stakeholders, such as dam operators, lake districts, municipalities, and wastewater treatment facilities (which are typically located near receiving streams), would help to reduce flood risks. This section describes these entities within each subwatershed of the Fox River watershed and suggests opportunities to share relevant information and potentially coordinate water level management (see Table 4.3).

### *Upper Fox*

The Upper Fox subwatershed incorporates the northernmost parts of the watershed including the Fox River headwaters near Menomonee Falls, the Pewaukee River, Pewaukee Lake, Poplar Creek, and the Fox River mainstem to Waukesha (see Map 4.10). The only main dams within this subwatershed are the Pewaukee Lake dam, which is owned and operated by the Village of Pewaukee, and the Barstow (Saratoga) dam in downtown Waukesha, which is owned and operated by the City of Waukesha. Both dams are operable and have some manner to adjust their impoundment's water level within a range. Major municipalities in this watershed that could be affected by flooding on the Fox River and its major tributaries include the Cities of Pewaukee and Waukesha as well as the Village of Pewaukee. Wastewater treatment facilities within this subwatershed include the Village of Sussex Regional Wastewater facility, the City of Waukesha Clean Water Plant, and the Fox River Water Pollution Control Center.

The EAPs for the Pewaukee Lake and Barstow (Saratoga) dams do not list any dam operators on their emergency contact checklists. Additionally, the Emergency Level system used for the Pewaukee dam is the inverse of the Barstow dam's system (i.e., Level 1 is lowest threat for Pewaukee while Level 1 is highest threat for Barstow), which may confuse communication during an emergency. The Pewaukee dam EAP does not include notification of any downstream communities aside from the Village of Pewaukee within its emergency contact flowchart, although these notifications may occur through WEM. As the only real-time water flow data available in the subwatershed is on the Fox River downstream of the Barstow dam, the Pewaukee Lake dam operators should consider sharing their water level observations with other key entities in the watershed.

### *Mukwonago River*

This subwatershed constitutes a northwestern portion of the watershed drained by the Mukwonago River that contains several sizable dammed lakes, including Eagle Spring Lake, Lake Beulah, and the Phantom Lakes (see Map 4.11). The municipalities that may be most affected by flooding within this subwatershed include the Village of Mukwonago and the Town of Mukwonago. The only wastewater treatment facility, the Mukwonago Wastewater Treatment Facility, is located near the Mukwonago River upstream of the confluence with the Fox River. There is a real-time streamflow gage on the Mukwonago River just downstream of the Phantom Lakes outlet dam. This gage is too far downstream to provide any pertinent information for dam operators within the subwatershed, although it may be a useful data source for the Middle and Lower Fox subwatersheds. Both the Eagle Spring and Lake Beulah dams have operable gates.

The EAPs and IOMs for the Eagle Spring and Mukwonago dams list contact information for the other dams within the watershed and the Mukwonago dam also lists contact information for the downstream Waterford dam in the Middle Fox subwatershed.[62] The 2015 EAP for Lake Beulah does not list any contact information for the Village of Mukwonago, Waukesha County Emergency Management, or the Mukwonago dam operator despite the relatively proximity of the Lake Beulah and Mukwonago dams. While the EAPs for both the Eagle Spring and Lake Beulah dams describe monitoring water levels, these levels do not appear to be shared with downstream dam operators.

### *Middle Fox*

This subwatershed incorporates the confluences of the outlets of the sizable dammed lakes of Little Muskego, Big Muskego, and Wind Lake with the mainstem of the Fox River, which is itself dammed at Waterford and at Rochester (see Map 4.12). Municipalities with multiple flooded structures within this subwatershed include the City of Muskego and the Towns of Norway and Waterford. Many of these structures are located

[62] *Notably, the 2021 version of the Mukwonago EAP listed a Walworth County Engineer as the principal contact for the Lake Beulah outlet dam rather than the current dam operator assigned by the Lake Beulah Management District.*

## Table 4.3
## Fox River Subwatershed Networks

| Subwatershed | Organization Type | Organization | Website |
|---|---|---|---|
| Upper Fox | County | Waukesha County | www.waukeshacounty.gov/emergencypreparedness/emergency-mgmt-home |
| | Municipality | City of Pewaukee | www.cityofpewaukee.us/206/Public-Works |
| | Municipality | City of Waukesha | www.waukesha-wi.gov/government/departments/public-works.php |
| | Municipality | Village of Pewaukee | www.villageofpewaukee.com/Department-of-Public-Works |
| | Treatment Facility | City of Waukesha Clean Water Plant | www.waukesha-wi.gov/government/departments/clean-water-plant.php |
| | Treatment Facility | Fox River Water Pollution Control Center | www.ci.brookfield.wi.us/19/Public-Works |
| | Treatment Facility | Village of Sussex Regional Wastewater | www.villagesussex.org/Home/Components/FacilityDirectory/FacilityDirectory/36 |
| | Dam Owner/Operator | Pewaukee Lake Dam: Village of Pewaukee | www.villageofpewaukee.com/Department-of-Public-Works |
| | Dam Owner/Operator | Barstow Dam: City of Waukesha | www.waukesha-wi.gov/government/departments/public-works.php |
| Mukwonago | County | Waukesha County | www.waukeshacounty.gov/emergencypreparedness/emergency-mgmt-home |
| | County | Walworth County | www.co.walworth.wi.us/268/Emergency-Management |
| | Municipality | Village of Mukwonago | www.villageofmukwonago.gov/public-works-department |
| | Municipality | Town of Mukwonago | www.townofmukwonago.us/departments/public-works |
| | Treatment Facility | Mukwonago Wastewater Treatment Facility | www.villageofmukwonago.gov/utilities-department/pages/sanitary-sewer-utility |
| | Dam Owner/Operator | Wambold and Kroll Dams: Eagle Spring Lake Management District | www.eaglespringlake.us/eagle-spring-lake-management-district/contacts |
| | Dam Owner/Operator | Beulah Lake Dam: Lake Beulah Management District | lbmd.org/town-board |
| | Dam Owner/Operator | Mukwonago Dam: Village of Mukwonago | www.villageofmukwonago.gov/public-works-department |
| Middle Fox | County | Racine County | www.racinecounty.com/departments/emergency-management |
| | County | Walworth County | www.co.walworth.wi.us/268/Emergency-Management |
| | County | Waukesha County | www.waukeshacounty.gov/emergencypreparedness/emergency-mgmt-home |
| | Municipality | City of Burlington | www.burlington-wi.gov/160/Street-Department |
| | Municipality | City of Muskego | www.cityofmuskego.org/138/Public-Works |
| | Municipality | Town of Norway | www.townofnorway.org/departments/public_works.php |
| | Municipality | Town of Waterford | www.tn.waterford.wi.gov/contact |
| | Treatment Facility | Town of Norway Sanitary District No. 1 | www.townofnorway.org/services/norway_sanitary_district.php |
| | Treatment Facility | Western Racine County Sewerage District | www.racinecounty.com/departments/public-works-and-development-services/western-racine-county-sewerage-district |
| | Dam Owner/Operator | Little Muskego Lake Dam: City of Muskego | www.cityofmuskego.org/138/Public-Works |
| | Dam Owner/Operator | Big Muskego Lake Dam: City of Muskego | www.cityofmuskego.org/138/Public-Works |
| | Dam Owner/Operator | Wind Lake Dam: Racine County | www.racinecounty.com/departments/public-works-and-development-services/public-works |
| | Dam Owner/Operator | Waterford Dam: Racine County | www.racinecounty.com/departments/public-works-and-development-services/public-works |
| | Dam Owner/Operator | Rochester Dam: Racine County | www.racinecounty.com/departments/public-works-and-development-services/public-works |
| | Dam Owner/Operator | Eagle Lake Dam: Racine County | www.racinecounty.com/departments/public-works-and-development-services/public-works |
| | Other | Southeast Fox River Commission | www.sewfrc.org |
| | Other | Waterford Waterway Management District | waterfordwwmd.com/commissioners |
| | Other | Norway-Dover Drainage District | www.racinecountydrainage.com/contact |
| | Other | Waterford Drainage District | www.racinecountydrainage.com/contact |

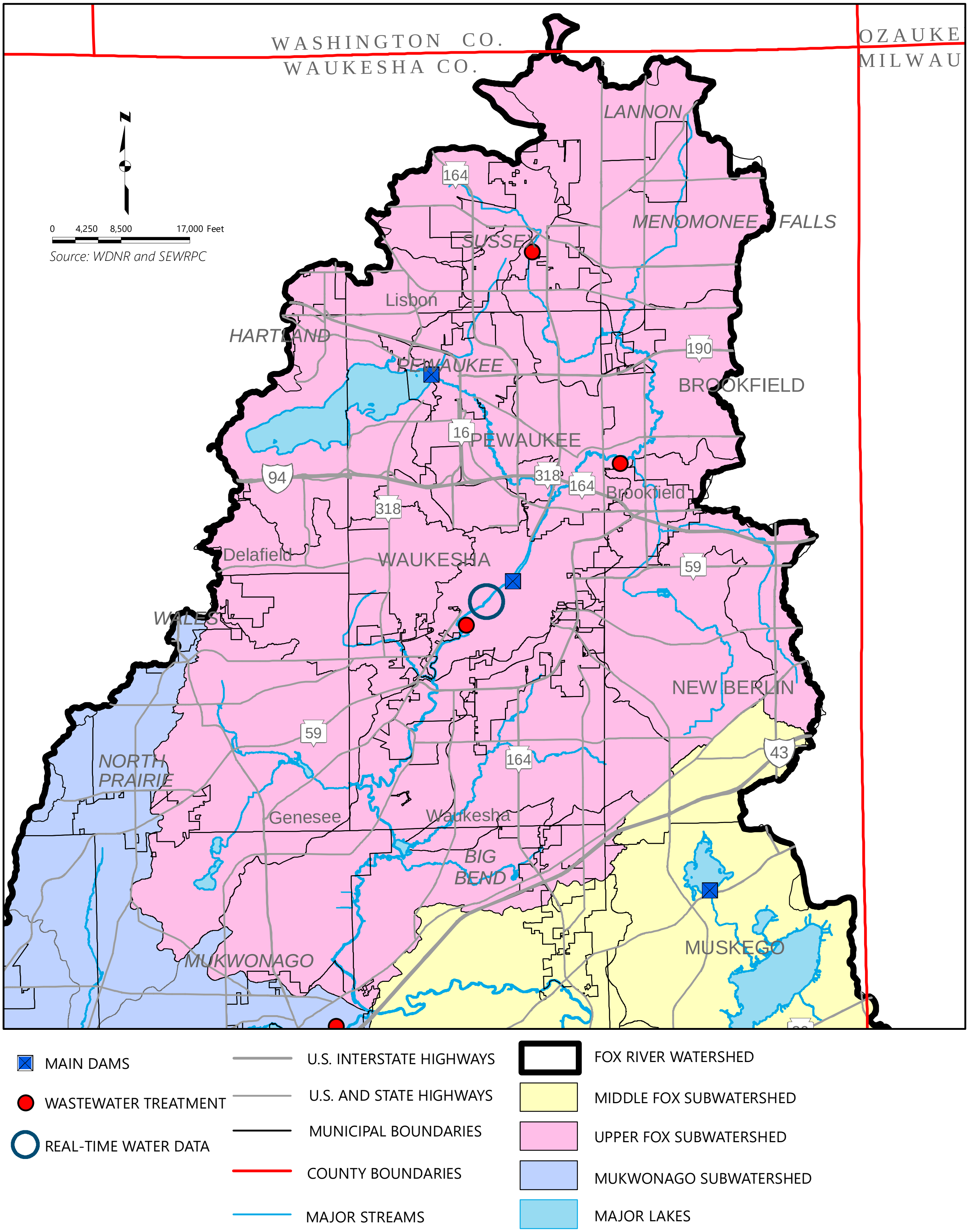
**Table continued on next page.**

## Table 4.3 (Continued)

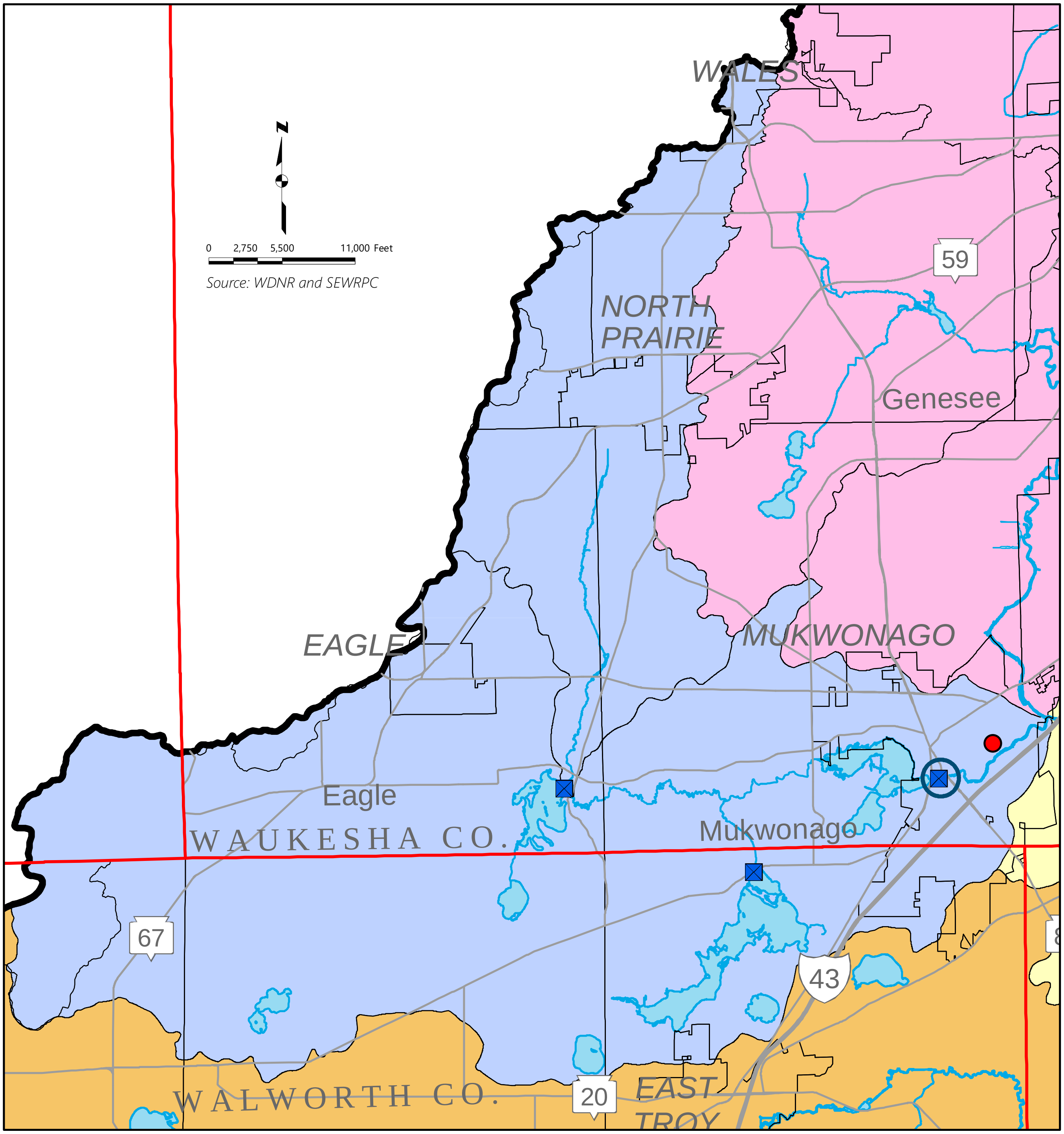
| Subwatershed | Organization Type | Organization | Website |
|---|---|---|---|
| Middle Fox (continued) | Other | Eagle Lake Management District | www.eaglelakemd.org/board-memebrs |
| | Other | Little Muskego Lake District | www.cityofmuskego.org/440/Little-Muskego-Lake-District |
| | Other | Wind Lake Management District | www.wlmd.org/wlmd_board.html |
| White River | County | Racine County | www.racinecounty.com/departments/emergency-management |
| | County | Walworth County | www.co.walworth.wi.us/268/Emergency-Management |
| | Municipality | City of Burlington | www.burlington-wi.gov/160/Street-Department |
| | Municipality | City of Lake Geneva | www.cityoflakegeneva.gov/264/Public-Works-Department |
| | Municipality | Town of Burlington | townofburlington.com/emergency-government |
| | Treatment Facility | Burlington Wastewater Treatment Plant | www.burlington-wi.gov/165/Wastewater-Division |
| | Treatment Facility | East Troy Wastewater Treatment Plant | easttroywi.gov/dpw |
| | Treatment Facility | Lake Geneva Wastewater Treatment Facility | www.lgutilitycommission.com/wastewaterutility |
| | Dam Owner/Operator | Geneva Lake Dam: Geneva Lake Level Corporation | genevalakelevel.com/about |
| | Dam Owner/Operator | Lake Como Dam: Town of Geneva | townofgenevawi.com/contact-us |
| | Dam Owner/Operator | Lauderdale Lakes Dam: Lauderdale Lakes Management District | www.lauderdalelakedistrict.com/lake-district-commissioners |
| | Dam Owner/Operator | Echo Lake Dam: City of Burlington | www.burlington-wi.gov/160/Street-Department |
| | Dam Owner/Operator | Honey Lake Dam: Honey Lake Protection and Rehabilitation District | honeylakedistrict.org/district-contacts |
| | Other | Southeast Fox River Commission | www.sewfrc.org |
| Lower Fox | County | Kenosha County | www.kenoshacounty.org/511/Emergency-Management |
| | County | Racine County | www.racinecounty.com/departments/emergency-management |
| | County | Walworth County | www.co.walworth.wi.us/268/Emergency-Management |
| | County | Lake County, IL | www.lakecountyil.gov/2228/Emergency-Management-Agency |
| | County | McHenry County, IL | www.mchenrycountyil.gov/county-government/departments-a-i/emergency-management |
| | Municipality | City of Burlington | www.burlington-wi.gov/160/Street-Department |
| | Municipality | Village of Salem Lakes | www.villageofsalemlakes.org/index.asp?SEC=6611BEC7-5EA4-4842-8AD2-EBA494384511&Type=B_BASIC |
| | Municipality | Town of Burlington | townofburlington.com/emergency-government |
| | Treatment Facility | Burlington Wastewater Treatment Plant | www.burlington-wi.gov/165/Wastewater-Division |
| | Treatment Facility | Village of Salem Lakes Utility District | www.villageofsalemlakes.org/index.asp?SEC=6611BEC7-5EA4-4842-8AD2-EBA494384511&Type=B_BASIC |
| | Dam Owner/Operator | Echo Lake Dam: City of Burlington | www.burlington-wi.gov/160/Street-Department |
| | Dam Owner/Operator | Bohner Lake Dam: Racine County | www.racinecounty.com/departments/public-works-and-development-services/public-works |
| | Dam Owner/Operator | Silver Lake Dam: Private ownership | N/A |
| | Dam Owner/Operator | Stratton Dam, IL: Illinois Department of Natural Resources | www2.illinois.gov/dnr/WaterResources/Pages/ContactUs.aspx |
| | Dam Owner/Operator | Algonquin Dam, IL: Illinois Department of Natural Resources | www2.illinois.gov/dnr/WaterResources/Pages/ContactUs.aspx |
| | Other | Southeast Fox River Commission | www.sewfrc.org |
| | Other | Fox Waterway Agency, IL | www.foxwaterway.com/contact-us |

*Source: SEWRPC*

**Map 4.10**
**Upper Fox Subwatershed: Dams, Gages, Hydrology, and Key Stakeholders**

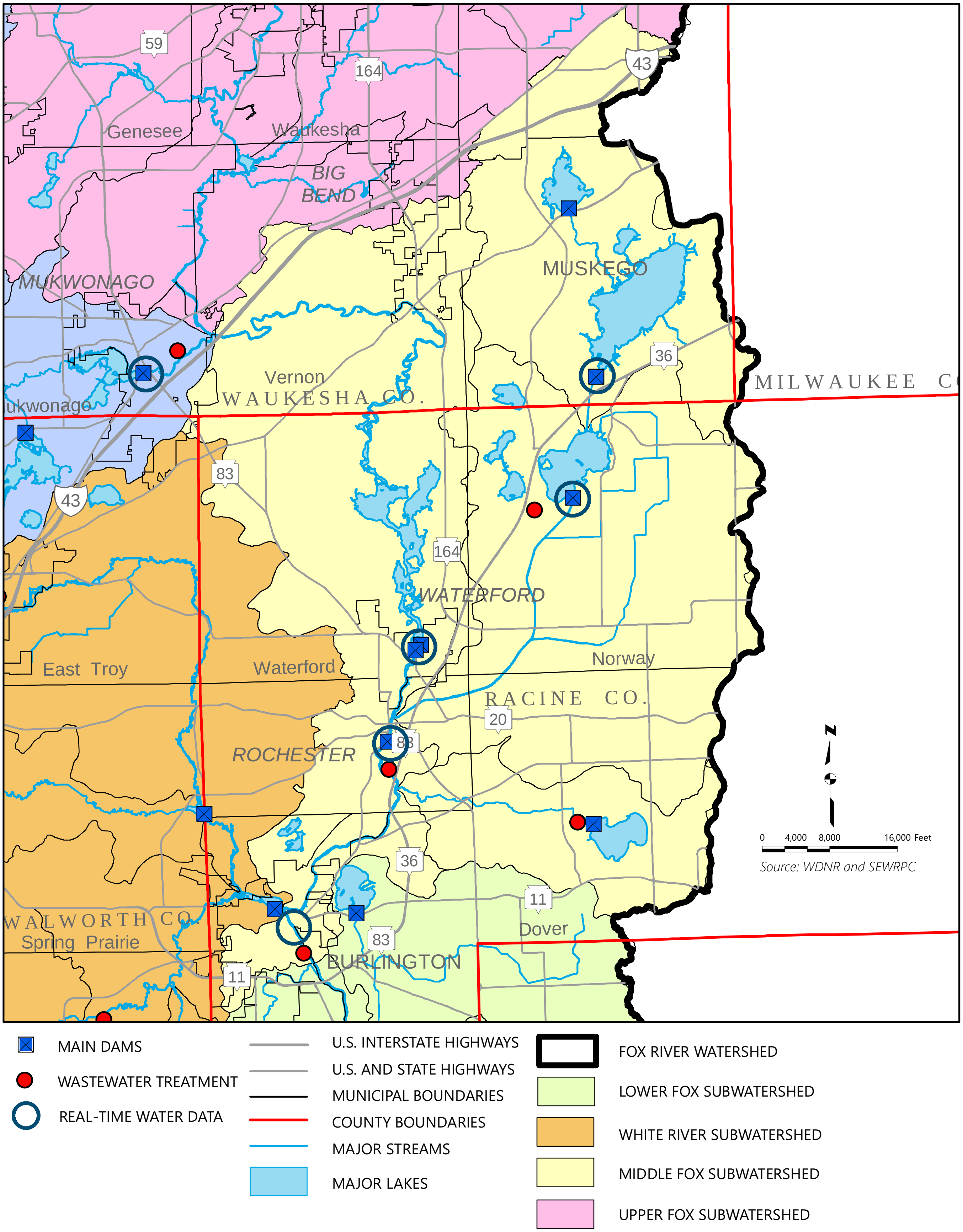


**Map 4.11**
**Mukwonago Subwatershed: Dams, Gages, Hydrology, and Key Stakeholders**




MAIN DAMS
WASTEWATER TREATMENT
REAL-TIME WATER DATA
U.S. INTERSTATE HIGHWAYS
U.S. AND STATE HIGHWAYS
MUNICIPAL BOUNDARIES
COUNTY BOUNDARIES
MAJOR STREAMS
MAJOR LAKES
FOX RIVER WATERSHED
WHITE RIVER SUBWATERSHED
MIDDLE FOX SUBWATERSHED
UPPER FOX SUBWATERSHED
MUKWONAGO SUBWATERSHED

## Map 4.12
## Middle Fox Subwatershed: Dams, Gages, Hydrology, and Key Stakeholders



upstream of dams with operable gates, particularly along Buena, Tichigan, and Wind Lakes. The Middle Fox subwatershed is served by four wastewater treatment facilities in the subwatershed: the Town of Norway Sanitary District No. 1, the Western Racine County Sewerage District, the Eagle Lake Sewer Utility, and the Burlington Water Pollution Control Facility. Other key stakeholders in this subwatershed include the Southeast Fox River Commission, the Waterford Waterway Commission, the Norway-Dover Drainage District, the Waterford Drainage District, Racine County, and the lake districts (see Table 4.3).

As discussed earlier in this section, this subwatershed has the most water level monitoring and coordination between dam operators within the Wisconsin portion of the Fox River watershed. Real-time USGS water level gages located at the Big Muskego outlet to Wind Lake, on the Wind Lake outlet to the Wind Lake Canal, and on the Fox River at the Waterford and Rochester dams provide data that operators use to inform their gate operations. Additionally, dam operators reference the USGS streamflow gages on the Mukwonago River at Mukwonago as well as on the Fox River at Waukesha. Tom Halter, operator of the Rochester dam, also communicates with the City of Burlington regarding water levels and gate operations on the Fox River mainstem.[63] Notably, the IOM for the Rochester dam states that the operator should notify the McHenry Dam (also known as the Stratton dam) in McHenry, Illinois regarding changes to the Rochester dam gate levels. Located as the central subwatershed of the Fox River watershed within Wisconsin, these communication and coordination efforts should be expanded to the immediately adjacent subwatersheds and those in northern Illinois wherever feasible. Plans should be made to document and continue these practices through future generations of dam operators in the subwatershed.

***White River***

Three major streams, the White River, Honey Creek, and Sugar Creek, drain this extensive subwatershed covering much of the southwestern Fox River watershed in Wisconsin (see Map 4.13). These streams all converge within a few miles of Burlington, WI; the confluence of Honey and Sugar Creeks occurs directly downstream of the Honey Lake impoundment, and the confluence of the White River and Honey Creek occurs in the Echo Lake impoundment in Burlington. Other main dams in this subwatershed include those impounding large lakes far upstream in the watershed, such as the Lauderdale Lakes dam, the Lake Como dam, and the Geneva Lake dam. These dams are operated by the Lauderdale Lakes Management District, Town of Geneva, and the Geneva Lake Level Corporation, respectively. The municipalities most affected by flooding within this subwatershed include the Cities of Burlington and Lake Geneva as well as the Town of Burlington. Three major wastewater treatment facilities are located within the subwatershed: the Lake Geneva Wastewater Treatment Facility, the East Troy Wastewater Treatment Plant, and the Burlington Wastewater Treatment Plant.

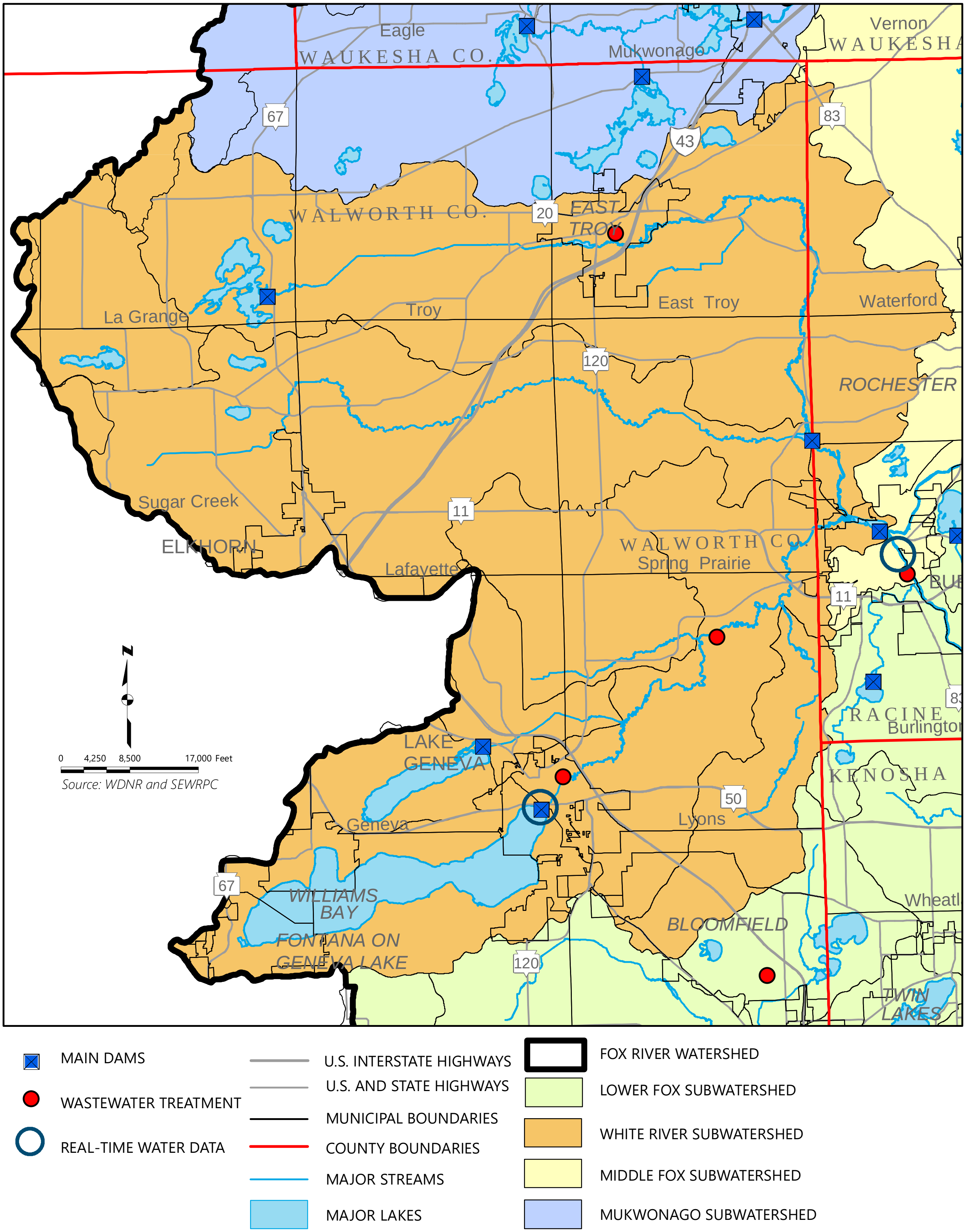
There is only one real-time streamflow gage and one real-time lake elevation gage within the subwatershed, both of which are located at the outlet of Geneva Lake to the White River. There is no public, real-time lake level information for the Lauderdale Lakes, Lake Como, Honey Lake, or any lake upstream in the watershed. Consequently, the City of Burlington has little real-time water level information from its contributing watershed to inform their management of the Echo Lake dam. These upstream dam operators should consider implementing a system to share real-time lake level and gate operation information with downstream operators and the City of Burlington. Additionally, stakeholders within this subwatershed should advocate for installing a real-time streamflow gage on Honey and Sugar Creeks, as suggested in Section 4.1.

While the Echo Lake dam EAP does list the upstream dams in its watershed, the emergency contact flow chart indicates that notification of these dam operators would be routed through Walworth County Emergency Management. The Lauderdale Lakes, Geneva Lake, and Honey Lake dams do not list any contact information for each other nor the Echo Lake dam in their emergency contact checklists or flow charts. Additionally, the Honey Lake and Geneva dams utilize a different Emergency Level system than the Echo Lake dam in Burlington, which may lead to confusion regarding dam and water level conditions.[64] These EAPs should be updated with relevant contact information and adopt a shared Emergency Level system to enhance communication throughout this subwatershed.

[63] *Personal communication between Commission staff and Tom Halter on March 30, 2022.*

[64] *The Geneva Lake EAP utilizes an "Alert" condition indicating that dam failure is imminent while the "Warning" condition indicates that a potentially hazardous situation is developing at the dam. The Honey Lake EAP has an inverse Emergency Level system of the Echo Lake dam, where Honey Lake labels dam failure as an Emergency Level 3 while the Echo Lake dam labels dam failure as an Emergency Level 1.*

**Map 4.13**
**White River Subwatershed: Dams, Gages, Hydrology, and Key Stakeholders**



***Lower Fox***

The Lower Fox subwatershed consists of the Fox River mainstem as it flows through western Racine and Kenosha Counties and southern Walworth County into the Chain of Lakes in Lake and McHenry Counties in northern Illinois (see Map 4.14). With the removal of the Wilmot dam in 1992, there are no direct controls on Fox River water levels between the Rochester dam in the Middle Fox subwatershed and the Stratton dam in McHenry County. This subwatershed contains tributaries such as Hoosier, New Munster Creek, and Peterson Creeks, which contribute relatively low streamflow compared to the Fox River mainstem at their confluences. While there are several dams impounding lakes within the subwatershed, none of these dams have operable gates and the lakes do not have substantial flood storage capacity. The NWS stream gage for the Fox River at Burlington publishes relatively current water level information and produces a forecast with exceedance probabilities for the river stage three months into the future. Although there are several impounded lakes within the subwatershed, none of these lakes post daily or weekly water level information for other stakeholders to reference.

Several municipalities in this subwatershed have numerous structures within the 1-percent-annual-probability floodplain, particularly the City of Burlington, Village of Salem Lakes, and the Town of Burlington. These municipalities are served by the Burlington Wastewater Treatment Plant and the Village of Salem Lakes Utility District. Additionally, there are thousands of structures adjacent to the Fox River and the Chain of Lakes in northern Illinois that could be impacted by water levels in this subwatershed.[65] Consequently, this subwatershed also includes key stakeholders with jurisdiction and management responsibilities over flooding and water levels within northern Illinois.

***Coordination with Illinois Stakeholders***

The Illinois Department of Natural Resources (IL DNR) operates the Stratton and Algonquin dams on the Fox River in northern Illinois. Their 2012 publication, *Operation of the Stratton and Algonquin Dams*, describes how streamflow from the USGS Fox River at New Munster (Wilmot) gage was utilized for daily operations to mitigate flooding along the Chain of Lakes in Illinois. The gages for the Fox River at Waukesha and Mukwonago River at Mukwonago are also referenced to inform management decisions. The IL DNR uses recorded precipitation from USGS and NWS gages within the Fox River watershed to populate a hydrologic model of the Chain of Lakes that informs operation of the Stratton and Algonquin dams.[66] Model output is compared with recorded streamflow from the Fox River at New Munster gage as well as the National Weather Service river stage forecast when determining gate operations. Additionally, the IL DNR maintains a webpage with updated information on operation of the Stratton and Algonquin dams as well as current and forecasted conditions for precipitation, streamflow, lake levels, and drought.[67]

The Fox Waterway Agency is a special unit of local government created by the Illinois General Assembly that has jurisdiction over the Fox River and the interconnecting lakes within Lake and McHenry Counties from the border with Wisconsin to the Algonquin Dam.[68] The Agency is responsible for creating and enforcing rules and ordinances for recreational boating within its jurisdictions, including the establishment of restricted areas, speed limits, no-wake zones, and special regulations during flood and overflow conditions.[69] These special regulations include setting no-wake zones or closing zones to any recreational boating during times of high water, as determined by water level measurements at the Stratton Lock and Dam tailwater, Johnsburg, and Fox Lake gages operated by the IL DNR. Other activities within the Agency's purview include enhancing recreational opportunities, environmental quality, and tourism while reducing flooding damage within the Fox River waterway. To pursue its goals, the Agency can levy user fees, employ personnel, purchase property and equipment, apply for and receive grant funding, and enter into agreements with the State of Illinois, the State

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[65] *Fox River Flood Commission Report for Public Act 100-0730, Illinois Department of Natural Resources, 2019.*

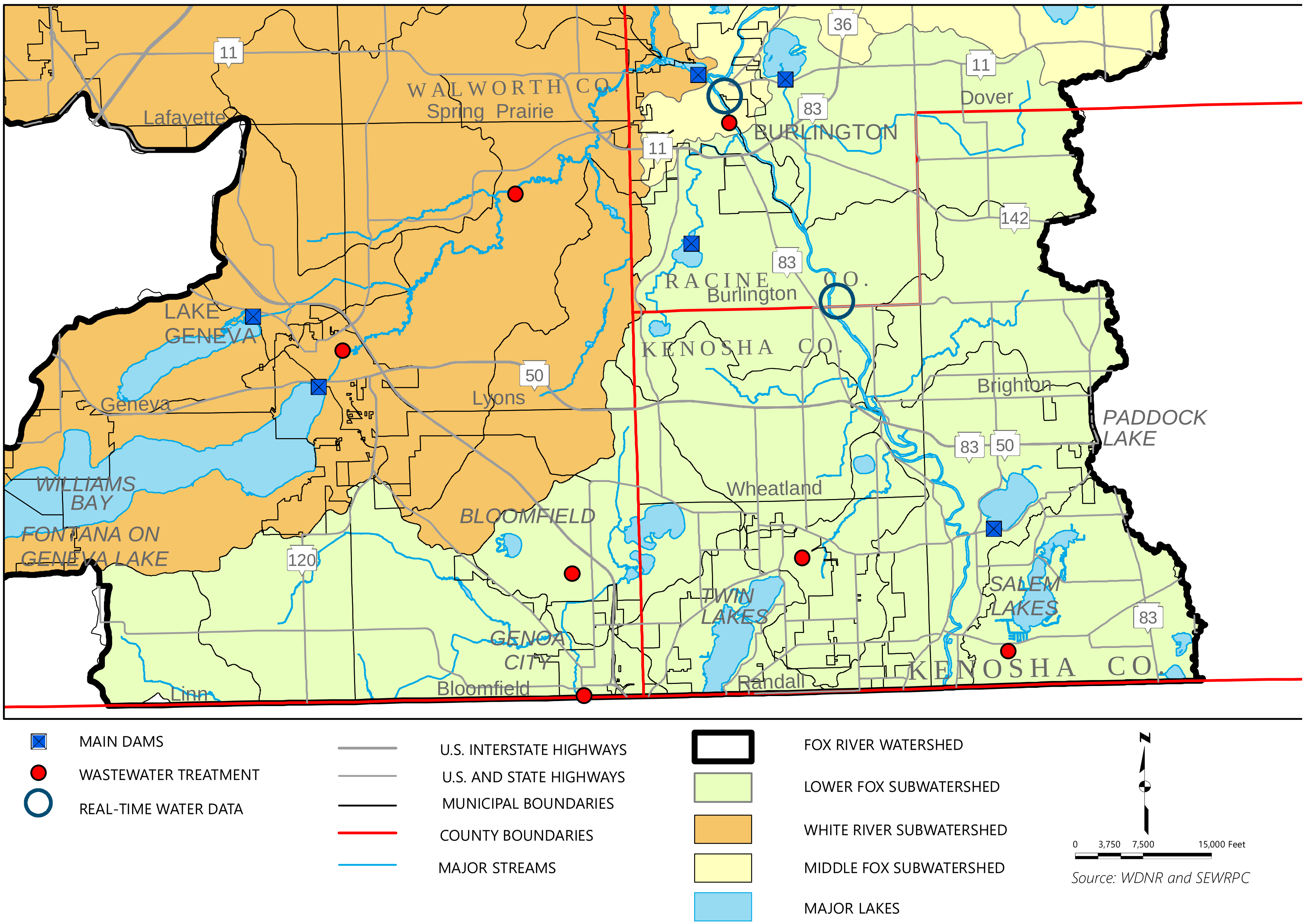
[66] Ibid.

[67] *For more information, see www2.illinois.gov/dnr/WaterResources/Pages/StrattonOperationsUpdate.aspx and www2.illinois.gov/dnr/WaterResources/Documents/FoxRiverStatusUpdate.pdf.*

[68] *For more information on the creation and jurisdiction of the Fox Waterway Agency, see 615 ILCS 90, Fox Waterway Agency Act at the following link: www.ilga.gov/legislation/ilcs/ilcs3.asp?ActID=1798&ChapterID=47.*

[69] *Fox Waterway Agency, Code of Rules and Regulations, January 2023. www.foxwaterway.com/wp-content/uploads/2023/01/Master-Ordinance-Book-Jan-2023.pdf.*

## Map 4.14
## Lower Fox Subwatershed: Dams, Gages, Hydrology, and Key Stakeholders




Source: WDNR and SEWRPC

of Wisconsin, or other local units of government.[70] Its jurisdiction over the Fox River beginning at the state line as well as its responsibilities and capacities to fund efforts that reduce flooding damages makes the Fox Waterway Agency an important stakeholder for flood mitigation efforts within the Lower Fox subwatershed.

Dam operators and public works departments of Counties and municipalities within the subwatershed, as well as the Rochester dam operator, should communicate regarding water levels and dam operation with the IL DNR, the Fox Waterway Agency, and Lake and McHenry Counties in northern Illinois.[71,72] Opportunities for greater communication and coordination between water management entities in Wisconsin and northern Illinois are discussed in Section 4.4.

## 4.3 HAZARD MITIGATION PLAN COMPONENT FOR DROUGHT

A drought is a prolonged period of unusually constant dry weather that persists long enough to cause deficiencies in surface water or groundwater resources. This section describes strategies to mitigate this type of hazard. When drought events 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 several years, the direct and indirect impacts can be significant.[73]

Ultimately, drought is about the sufficiency of water, and communities have always depended on water for their economic and physical survival. Stresses on the water resources of the Fox River watershed include a growing population, increased competition for available water, loss of groundwater recharge areas due to development, and the potential effects of a changing climate. The entire Fox River watershed has groundwater as their drinking and irrigation water supply.

Droughts can have the greatest impact on agricultural producers. It should be noted that even droughts of limited duration can significantly reduce crop growth and yields, adversely affecting farm income. More substantial events can decimate croplands and result in total loss, negatively impacting individual producers and the local economy.

Although nothing can prevent a drought, measures can be taken to reduce the potential loss and impacts caused by droughts wherever they may occur in the Fox River watershed. The following measures to reduce vulnerability to drought events have been identified as viable for this plan.

**Groundwater Recharge Area Protection**

During times of drought, groundwater contributions can make up a substantial portion of the baseflow in a river or stream. Groundwater is also the main source of public water supply in the Fox River watershed. Maintaining adequate groundwater supply during times of drought is very important for the health of the watershed, and for this reason it is recommended to protect areas of high and very high groundwater recharge potential within the Fox River watershed from inappropriate development. Protecting high groundwater recharge areas can also help mitigate flood risks, as high infiltration decreases surface water runoff. The groundwater recharge potential throughout Southeastern Wisconsin was originally analyzed and mapped by Commission staff for SEWRPC Technical Report No. 47,[74] using a soil-water balance model that considered topography, soil hydrologic group, soil available water storage, and land use. Map 4.15 shows areas characterized as "high" and "very high" groundwater recharge potential within the Fox River watershed. These areas represent areas that have the greatest ability to infiltrate precipitation to the groundwater.

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[70] *615 ILCS 90, Fox River Waterway Agency Act,* op. cit.

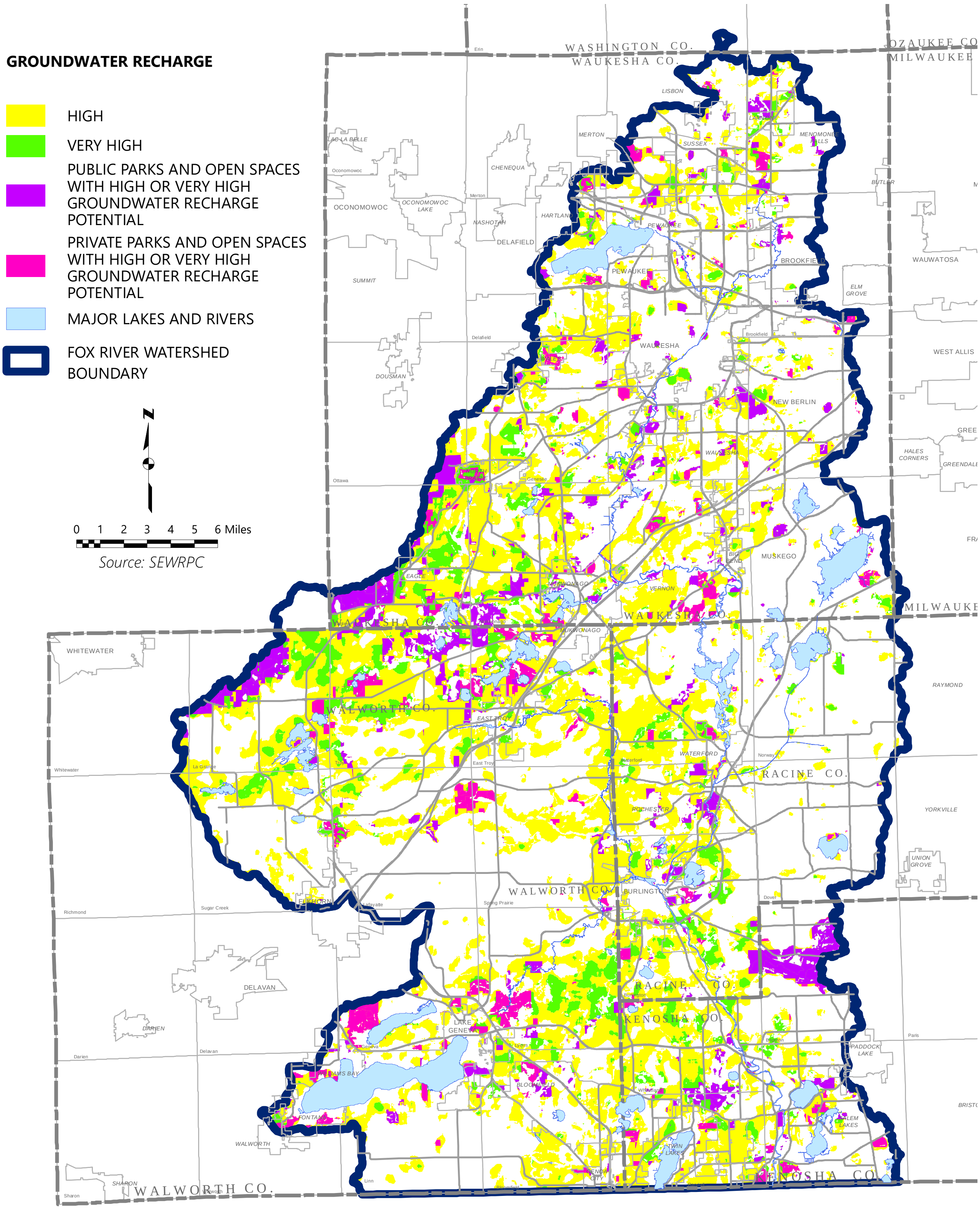
[71] *The 2019 Fox River Flood Commission Report for Public Act 100-0730 recommended that entities in Illinois should coordinate flood reduction opportunities with Wisconsin organizations with jurisdiction in the Fox River watershed, such as WDNR. For more information, see the following: www2.illinois.gov/dnr/WaterResources/Documents/FRCC_FoxRiverFloodCommissionReport_Dec2019_Redacted.pdf.*

[72] *The Fox Waterway Agency maintains a webpage dedicated to flooding resources, which can be accessed via the following: www.foxwaterway.com/flood-prep-list.*

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

[74] *SEWRPC Technical Report No. 47*, Groundwater Recharge in Southeastern Wisconsin Estimated by a GIS-based Water-Balance Model, *June 2008.*

**Map 4.15**
**Groundwater Recharge Areas of Special Importance in the Fox River Watershed**



Within the high and very high groundwater recharge potential areas, it is recommended that public parks and open spaces be protected from development, to preserve their role in recharging groundwater within the watershed. Because these lands are already under public ownership, communities have the ability to prioritize their protection. Public parks and open spaces with high and very high groundwater recharge potential are highlighted in purple on Map 4.15.

Additionally, it is recommended that communities prioritize the acquisition and protection of privately owned parks and open spaces in areas of high and very high groundwater potential, as funding becomes available. This will ensure that those areas are not developed in the future. Privately owned parks and open spaces with high and very high groundwater recharge potential are highlighted in pink on Map 4.15.

**Best Management Practices for Drought Resilience**

As noted in Section 3.4, drought can have profound impacts on crop growth and can cause major crop losses. Several agricultural best management practices may improve crop resilience during drought times. It is recommended that agricultural best management practices be considered for their potential to improve drought resilience. Several agricultural best management practices that can help improve drought resilience are summarized below. It should be noted that agricultural practices that increase infiltration may also provide some benefit in mitigating flood risk, particularly because a significant portion of the Fox River watershed is used for agricultural purposes.

***Cover Crops***

Cover crops such as rye or barley can be planted on unused fields or in rotation with cash crops to increase the drought resilience of cash crops on that field in future years. Cover crops can promote drought resilience by increasing organic matter in the soil, thus increasing the soil's water-holding capacity. Cover crop root systems can also boost water infiltration into soil via macropores created by roots and earthworms. During drought times, crop root systems tend to grow shallower than in wetter years, but soil macropores left behind by cover crops can encourage root systems of future crops to grow deeper, giving them access to soil moisture deeper in the ground. Cover crops can also boost drought resistance by stimulating mycorrhizal fungi growth in the soil, which can help future crops access moisture and nutrients by forming a network of filaments that help the crop roots draw water and nutrients from the soil.[75] In addition to drought resistance, cover crops may also provide supplemental benefits such as reduced soil erosion and helping to control pests and weeds. Some cover crops such as legumes and clover can also increase soil nutrients for future crops by "fixing" nitrogen (converting atmospheric nitrogen into forms usable by plants such as nitrites and nitrates). It is recommended that county land conservationist staff encourage use of cover crops to farmers where practicable.

***No-Till Farming***

No-till farming practices can also improve drought resilience for crops. Conventional tilling loosens and removes any plant matter covering the soil and can disrupt natural soil structures and microorganisms, and heavy tilling machinery can cause soil compaction. No-till farming can preserve the soil structure and ecosystem by avoiding tilling in the spring and by spreading crop residue evenly over fields in the fall. A healthier uncompacted soil structure contains more macropores that increase infiltration, and increased organic matter can help retain soil moisture. Crop residue can also reduce evaporation of water from the soil, which also helps a field maintain its yields during drought conditions. No-till farming can also provide supplemental benefits such as decreased soil erosion, improving soil biology, and saving money and time from not needing to plow using expensive machinery. It is recommended that county land conservationist staff encourage no-till practices in agricultural fields in the Fox River watershed.

***Rotational Grazing***

Rotational grazing could also improve drought resilience for grazing operations in the Fox River watershed. This practice involves moving livestock to different pastures to avoid overgrazing certain areas and to allow pasture vegetation time to regenerate. Rotational grazing can improve drought resilience by allowing pasture plants to grow deeper root systems, so the plants can reach deeper soil moisture during droughts. Deeper root systems also increase rain infiltration depths into the soil. Additionally, when a pasture is not

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[75] *Sustainable Agriculture Research and Education Technical Bulletin, "Cover Crop Economics: Opportunities to Improve Your Bottom Line in Row Crops", June 2019.*

overgrazed, the longer grass can provide additional shade to the soil and reduce evaporation. Besides improving drought resilience, rotational grazing can also reduce soil erosion, increase plant diversity, improve manure distribution in the pasture, and enhance livestock health. It is recommended that rotational grazing be considered for its feasibility in grazing pastures in the Fox River watershed.

**Drought Index Monitoring**

The National Integrated Drought Information System (NIDIS),[76] run by the National Oceanic and Atmospheric Association (NOAA), offers a variety of tools to help communities better understand their current and future drought risks. The NIDIS displays the U.S. Drought Monitor, which provides mapped drought locations and ratings (D0 to D4, as described in Chapter 3) across the United States. Their data is updated weekly, every Thursday. Historical drought data is also available and represented via graphs and maps. Quarterly climate impact and drought outlook reports are also available as written reports and as webinars. The NIDIS also provides the opportunity to sign up for email updates regarding changes in drought status, and 1-month and 3-month drought outlook predictions. It is recommended that NIDIS data and outlook reports be consulted to help prepare for possible impending drought. These tools can help a community become more aware of their current drought situation and plan for future conditions in order to better allocate water use and resources.

**Surface Water Withdrawals and Management**

As noted above, agriculture is likely to be one of the sectors most affected by drought within the Fox River watershed. While most agricultural operations in the watershed typically do not rely on irrigation, prolonged drought may cause water stress to crops and consequently producers may look to utilize irrigation from surface water sources.[77] Surface water withdrawals are regulated by the WDNR under Section 30.18 of *Wisconsin Statutes*.[78] Under normal conditions, no person may withdraw surface waters from any stream for the purpose of agricultural irrigation without an individual permit. Also under normal circumstances no person may withdraw water from any lake if the withdrawal would result in a water loss averaging two millions gallons per day over a thirty day period above the authorized base level of water loss without an individual permit. Following an approval of an individual permit by WDNR, individuals may withdraw surface waters from streams and lakes to the amount specified on the permit and may use that water to irrigate on their riparian lands as well as any lands contiguous to their own riparian lands. The WDNR maintains the right to revoke permits if the withdrawal is determined to be detrimental to the stream or lake. It is recommended that jurisdictions with large agricultural sectors educate farmers on the permitting process for surface water withdrawals during times of drought where irrigation may be necessary to avoid crop loss.

The aforementioned rules regarding surface water withdrawals were temporarily modified during the 2012 drought, during which Governor Scott Walker signed Executive Order 75 to declare the 2012 drought condition to be a natural disaster and, among other items, temporarily suspend elements of Section 30.18 and expedite the surface water withdrawal permitting process for agricultural irrigation permits.[79] Agricultural permittees were granted temporary, 30-day permits to withdraw water from surface water sources to sustain crop yields. Under this executive order, the WDNR still retained the right to revoke the permit if the withdrawal was deemed to cause unduly adverse effects to the surface water source.

***City of Waukesha Diversion***

Until 2023, The City of Waukesha used a deep groundwater aquifer for its municipal supply.[80] The treated wastewater was discharged into the Fox River which contributed substantially to its baseflow. Following a court order to comply with radium standards for its groundwater supply, the City applied for a diversion of Lake Michigan water in 2013. This application was approved by the Great Lakes Compact Council in

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[76] For more information, see *www.drought.gov*.

[77] *In addition to cultivated crops, sod and turf farms may also utilize irrigation and at least three agricultural operations were permitted to withdraw surface waters within the Fox River watershed in 2021 per WDNR records.*

[78] *For more information, see docs.legis.wisconsin.gov/document/statutes/30.18.*

[79] *For more information see docs.legis.wisconsin.gov/code/executive_orders/2011_scott_walker/2012-75.pdf.*

[80] *For more information, see the WDNR "City of Waukesha Diversion" webpage at dnr.wisconsin.gov/topic/wateruse/waukesha.html as well as the Waukesha Water Utility website at waukesha-water.com.*

2016 with a plan for the City to purchase Lake Michigan water from the City of Milwaukee and return the treated wastewater to the Root River in the Lake Michigan basin. As a result of this diversion, the City will no longer use their deep and shallow groundwater wells and their contributions to the Fox River through the treated wastewater discharge would potentially diminish significantly, which may stress baseflows in the Fox River particularly during drought conditions. However, the reduced withdrawal from the aquifers near Waukesha may over time increase baseflow in the Fox River and surrounding tributaries. Consequently, it is recommended that streamflow monitoring should occur in the Fox River mainstem near Waukesha and its nearby tributaries to evaluate how this Lake Michigan diversion affects river baseflows.

## 4.4 POTENTIAL WATERSHED COORDINATION EFFORTS

The following section describes potential coordination efforts that could be developed across the Wisconsin portion of the Fox River watershed as well as between Wisconsin and Illinois. This section includes a description of other flood monitoring and mitigation programs within Wisconsin and other states as examples that could be emulated for the Fox River watershed. Additionally, this section includes a description of a similar flood mitigation planning effort along the Fox River in Illinois and provides recommendations on how these efforts could be complementary to each other.

### Fox River Watershed Communications Planning

During the preparation of this plan, Waukesha County Emergency Management embarked on a separate project focused on improving flood disaster response communications within the Wisconsin portion of the Fox River watershed. With assistance from the Lafayette Group, Inc. and the Cyber Infrastructure and Security Agency, Emergency Management hosted a workshop on January 24, 2023 at the Waukesha County Technical College. Many of the stakeholders mentioned in this plan, such as dam operators, public works directors, County emergency management staff, WDNR dam engineers, meteorologists and hydrologists from the National Weather Service, and Commission staff, were invited to attend the workshop and discuss best practices for communications regarding flooding in the Fox River watershed.

Key goals for this workshop were to compile an understanding of current communication practices and capacities between stakeholders within the Fox River watershed, discuss potential opportunities to enhance these practices and capacities, identify gaps and missing information regarding communication, and to collectively participate in a mock flood scenario. Discussions at and following the workshop will help inform a separate communication planning effort being led by Waukesha County Emergency Management and the Lafayette Group, Inc. While the communication details addressed in that forthcoming plan are beyond the scope of this hazard mitigation plan, there are common goals of increasing communication between watershed stakeholders, providing more comprehensive monitoring and modeling information to dam operators, and ensuring that emergency management staff are kept up-to-date as potential flood- or dam-related emergency situations arise.

### Flood Management Program Examples

In discussing how to reduce flood risks in the Fox River watershed, it can be helpful to consider what other programs exist within Wisconsin and across the United States to emulate features of these programs. Unfortunately, many of these flood management programs have only received more intense focus and funding following severe flooding disasters that resulted in casualties and billions of dollars in damages. This subsection reviews a few of these programs and highlights features that could provide some value if implemented within the Fox River watershed.

#### *Yahara Chain of Lakes*

The Yahara Chain of Lakes refers to five large lakes (Mendota, Monona, Wingra, Waubesa, and Kegonsa) that are connected via the Yahara River in Dane County, WI. Several large municipalities, such as the Cities of Madison, Middleton, Monona, and Stoughton, have extensive urban areas near and along the shorelines of these lakes. Consequently, severe flooding events like those that occurred during the summer of 2018 affect thousands of people and costs millions of dollars in damages. Water levels along the entire Yahara Chain of Lakes are managed by the Dane County Land and Water Resources Department, WDNR, the City of Stoughton, and the other municipalities within the watershed. As detailed in the Dane County Lake Level Management Guide for the Yahara Lakes, the water level operating orders are set and regulated by WDNR while the Dane County Land and Water Resources Department and the City of Stoughton operate the dams within the watershed.[81] These entities coordinate the water levels within the Yahara Chain of Lakes and notify the engineers within the adjacent municipalities via constant updates during periods of high water and weekly updates during normal operation periods.[82,83]

Dam operations are in part informed through meteorological forecasts as well as multiple stream gages providing real-time information on water levels within the watershed, which are visible via the Integrated Nowcast/Forecast Operation System (INFOS).[84] A County-designated technical work grouped utilized INFOS to evaluate how the lake levels would have been affected during the 2018 flooding if adaptation and mitigation scenarios had been in place, such as utilizing Lake Mendota for flood storage, managing Lake Mendota at the one-percent-annual flood level, removing all dams, modifying downstream constrictions, and rerouting flow.[85] In 2020, Dane County passed County Resolution 419 to affirm that the Land and Water Resources Department could 1) manage lake levels proactively within their operating ranges as guided by weather forecasts, 2) that flood control was their primary objective during high water periods, 3) that projects including aquatic plant management and dredging could be used to improve management during flood conditions, and 4) that dam operational changes would be published on their website.[86]

***Iowa Flood Center***

Following devastating floods in 2008, the Iowa state legislature founded and funded the Iowa Flood Center, a University of Iowa program designed to work with the Iowa Department of Natural Resources and other state and federal agencies to study and mitigate flooding in Iowa.[87] Under this program, the Iowa Flood Center has developed several frameworks and tools, including the Iowa Watershed Approach, the Iowa Flood Information System, updated statewide floodplain mapping, community flood inundation mapping, and establishing real-time stream gage sensors throughout the state. While the scale of the Iowa Flood Center is beyond the scope of this plan, there are individual projects that could be emulated within the Fox River watershed.

Iowa Watershed Approach

The Iowa Watershed Approach is an effort to create networks of engaged watershed stakeholders that work together to reduce flood risk, increase flood resilience, and enhance water quality among other goals. There are nine watersheds chosen as project sites for the Iowa Watershed Approach. Each of the nine watersheds forms a Watershed Management Authority, develops a watershed plan, and implements projects to reduce flood risk and enhance flood resilience.[88,89] The Watershed Management Authority acquires and allocates funding towards the projects recommended in the watershed management plan, providing a consistent foundation for these projects to be completed. Many of the watersheds have invested in utilizing state-of-the-art conservation planning tools, such as the Agricultural Conservation Planning Framework, to model sites where best management practices would be most effective at reducing flooding and improving water

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[81] *Dane County Lake Level Management Guide for the Yahara Lakes, Dane County Land and Water Resources Department, updated August 2019.*

[82] Ibid.

[83] *Current water levels, dam status, and weekly planned operations are also made available to the public on the Dane County Land and Water Resources Department webpage: lwrd.countyofdane.com/lake-levels.*

[84] *INFOS uses real-time water level and meteorological forecasts as inputs into a suite of hydrologic models that predict water level changes in the Yahara Chain of Lakes over the coming week. For more information regarding INFOS Yahara, see the following link: www.infosyahara.org.*

[85] *2018 Yahara Chain of Lakes Flooding, 2019, op. cit.*

[86] *For more information on Dane County 2020 Res-419, see the following link: dane.legistar.com/LegislationDetail.aspx?ID=4858549&GUID=5DCB88A8-59FF-46EC-8FC1-AF35E92BF77A.*

[87] *The Iowa Flood Center website can be accessed at the following link: iowafloodcenter.org.*

[88] *Established by the Iowa state legislature in 2010, a Watershed Management Authority is an intergovernmental agreement to collaboratively undertake flood planning, educate residents regarding flood risks, enhance water quality, and allocate funding. More information regarding Watershed Management Authorities can be found at the following link: www.iowadnr.gov/Environmental-Protection/Water-Quality/Watershed-Management-Authorities.*

[89] *More information on the Iowa Watershed Approach can be found at the following link: iowawatershedapproach.org.*

quality.[90] Completed projects include creating wetlands, farm ponds, and water and sediment control basins in upland areas of the nine watersheds to release water more slowly into rivers and streams. Additional projects include reconnecting these rivers and streams to their floodplains to slow floodwaters and improve water quality. The watershed plans, completed projects, event calendars, and other resources are posted on websites dedicated to each Watershed Management Authority to share information with the public and keep stakeholders engaged and updated with progress in implementing planned projects.[91]

Iowa Flood Information System

The Iowa Flood Information System (IFIS) is an interactive web tool that provides real-time information on streamflow, flood conditions and alerts, precipitation, reservoir levels, groundwater levels, and soil moisture as well as flood forecasts and community scenario plans across Iowa.[92] While many of the stream gages are managed by USGS, there are also numerous stream sensors funded and operated through the Iowa Flood Center itself. As a single source of real-time and consistent water level data, this tool has become the foundation of Iowa's flood monitoring, awareness, and planning. Water level managers across Iowa can access the information and inform their decision-making and coordination using a shared set of data. Municipalities can use the community scenario plans to understand which areas are most vulnerable to flooding, at what water levels these areas may be affected, and consequently develop emergency management plans to address these areas during a flood event.

#### ***North Carolina Flood Inundation Mapping and Alert Network***

North Carolina operates the Flood Inundation Mapping and Alert Network (FIMAN), which is an interactive web tool that shows real-time streamflow, flooding, and weather information similar to Iowa's IFIS.[93] Like IFIS, many of the stream gages are operated by municipalities and emergency management agencies in addition to gages operated by the USGS. FIMAN also includes a flooding scenario tool where users can simulate different levels of flood severity and see the extent of the floodwaters and the structures that would be affected. Created following severe flooding from Hurricanes Ivan and Francis in 2004, the tool is frequently used by the public during hurricane season and had over 40 million visits during Hurricane Florence in 2018.[94]

### Bi-State Collaboration for the Fox River Watershed

Reducing flood risk and enhancing water level monitoring and management are common goals for both the Illinois and Wisconsin portions of the Fox River watershed. The severe flooding in 2017 that was formative for the development of this hazard mitigation plan also spurred the creation of a similar study on the Illinois portion of the watershed, entitled "Fox River Flood Commission Report for Public Act 100-0730."[95] As described in that report, the area with the greatest number of potentially flooded structures anywhere in the entire Fox River watershed is along the Chain of Lakes just a few miles downstream from the Illinois-Wisconsin border. Both this report and operational guidance for the Stratton and Algonquin dams describe how precipitation and streamflow gages in Wisconsin are used to monitor for high water flows and flood risks along the Chain of Lakes. Additionally, Nippersink Creek, which originates in southeastern Walworth and southwestern Kenosha Counties, is the largest tributary of the Fox River in Illinois. Consequently, maintaining this monitoring infrastructure in Wisconsin is essential to mitigate flooding damage and casualties in Illinois.

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[90] *As an example, an interactive map of the Agricultural Conservation Planning Framework modeling results for the Middle Cedar watershed in Iowa can be viewed at the following link: www.arcgis.com/home/webmap/viewer.html?webmap=de7027ba6d444692b9114227a2f7fc74.*

[91] *For example, the Middle Cedar Watershed Management Authority website can be viewed here: www.middlecedarwma.com.*

[92] *The Iowa Flood Information System can be accessed via the following link: ifis.iowafloodcenter.org/ifis/app.*

[93] *The North Carolina FIMAN tool can be accessed via the following link: fiman.nc.gov.*

[94] *Catherine Kozak, "Gauges Added to Improve Flood Prediction," Coastal Review, April 2020.*

[95] Fox River Flood Commission Report for Public Act 100-0730, *Illinois Department of Natural Resources Office of Water Resources, December 2019. This report can be accessed via the following link: www2.illinois.gov/dnr/WaterResources/Documents/FRCC_FoxRiverFloodCommissionReport_Dec2019_Redacted.pdf.*

The Fox River Flood Commission report indicates that lack of comprehensive watershed planning within Illinois and Wisconsin and inconsistent regulations across communities within the two states were shortfalls for flood control.[96] Consequently, the Flood Commission recommended the establishment of the Fox River Flood Coalition, an organization intended to carry out recommendations in the Report, whose tasks would include addressing flood control coordination between Illinois and Wisconsin. The report suggests coordinating efforts with WDNR to look for opportunities to fund and implement flood control projects. Fox River Flood Coalition members expressed their willingness to coordinate efforts and collaborate on projects to Commission staff during the preparation of this report.[97] Individual organizations of the Fox River Flood Coalition, such as the Fox Waterway Agency, have the capacity and jurisdiction to implement flood mitigation measures and enter into agreements with the State of Wisconsin.

**Recommendations for Watershed Collaboration**

Through the examples described earlier in this section as well as ongoing communication with dam operators, public works directors, emergency management officials, and other stakeholders, it is clear that more regular and structured communication between watershed stakeholders is desired to reduce flood risk and enhance collaborative efforts. Section 4.2 describes the current state, as understood by Commission staff, of communication between stakeholders as well as potential opportunities for increased communication and collaboration within subwatersheds of the Wisconsin portion of the Fox River watershed.

The following are recommendations to improve communication and collaboration within the entire Fox River watershed:

- The creation of a watershed stakeholder network as outlined in this hazard mitigation plan and the forthcoming communications plan led by Waukesha County emergency management. This network can share information regarding developments that may affect flooding or flood mitigation efforts in the watershed, collaborate and cost-share on flood mitigation projects, and maintain regularly updated lists of contact information for watershed stakeholders.

- Collaboration between the watershed stakeholder network in Wisconsin with the Fox River Flood Coalition in Illinois. As discussed above, flood management along the Fox River in northern Illinois is dependent on monitoring and flood mitigation efforts occurring in Wisconsin.

- Development or enhancement of existing tools to publish real-time streamflow, lake levels, weather, and soil condition data along with road networks, floodplains, critical infrastructure, and other relevant information. This application could emulate existing examples from other states, such as the Iowa IFIS, the North Carolina FIMAN, the Harris County Flood Warning System, or it could further enhance the Wisconsin DHS RAFT tool.

## 4.5 SUMMARY OF HAZARD MITIGATION STRATEGIES

This chapter provided many recommendations to help mitigate flood, dam, and drought hazards in the Fox River watershed. A summary of these recommendations is included in Table 4.4. Some of the recommendations in this chapter were repeated, so where possible they were consolidated.

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[96] Ibid.

[97] *Commission staff (Thomas Slawski and Justin Poinsatte) discussed the Fox River Flood Coalition and potential opportunities for collaborations with Wisconsin entities with Fox River Flood Coalition representatives (Joe Keller, Fox Waterway Agency) via an email exchange and a virtual meeting on November 8, 2022.*

**Table 4.4**
**Summary of Hazard Mitigation Recommendations for the Fox River Watershed Mitigation Plan**

| Action | Associated Hazard |
|---|---|
| Flood Storage Areas Preservation and Enhancement | |
| Implement and enforce existing floodplain zoning ordinances. | Flooding |
| Pass more restrictive floodplain ordinances than the minimum statewide and national requirements. | Flooding |
| During new floodplain modeling efforts, counties in the Fox River watershed can consider representing large storage areas to incorporate as Flood Storage Districts. | Flooding |
| Preserve existing floodplain areas, particularly those near urban development and those along streams with large contributing drainage areas. | Flooding |
| Increase connectivity between a stream or river and its surrounding floodplain, particularly around incised streams and where the stream has been cut off from the natural floodplain. | Flooding |
| Implement and enforce existing wetland management regulations. | Flooding |
| Implement protection measures for wetlands of less than 5 acres which are currently not part of a wetland conservancy zoning district. | Flooding |
| Preserve wetlands with priority on areas with large flood storage size, proximity to riparian zones, and locations that are advantageous to attenuating floodwater in the watershed. | Flooding |
| Restore wetlands in areas with the most potential for wetland functionality. | Flooding |
| Obtain privately-owned flood storage areas through voluntary acquisitions to place them in protective ownership. | Flooding |
| Employ green infrastructure such as retention and detention ponds, bioswales, and rain barrels and rain gardens to increase stormwater storage in the watershed. | Flooding |
| Evaluate the feasibility of naturalizing the Wind Lake Canal, including reconnecting the canal to the adjacent floodplain and wetland restoration. | Flooding |
| Evaluate the feasibility of increasing hydraulic connectivity between the Fox River and its floodplain and backwaters from Silver Lake to Wilmot in Kenosha County, using publicly owned land. | Flooding |
| Additional Floodplain Mapping | |
| Consider developing floodplain maps for reaches not currently mapped, especially near current or planned development. | Flooding |
| Consider refining floodplain maps to Zone AE where Zone A mapping exists, especially near current or planned development. | Flooding |
| Additional Gaging Locations | |
| Install additional stream gages in the Fox River watershed, including gages on Honey Creek, Sugar Creek, the White River, and on the Fox River approximately two miles downstream of the confluence with the Mukwonago River. | Flooding, Dams, Drought |
| Add rain gages at the recommended USGS stream gage locations shown on Map 4.9, as well as at the existing USGS stream gage location in the City of Waukesha. | Flooding, Dams, Drought |
| Invest in quality assurance practices on USGS rain gage sites. | Flooding, Dams, Drought |
| Report rainfall data in near real-time online at Waukesha County Airport and East Troy Municipal Airport, and report rainfall data both day and night at Waukesha County Airport. | Flooding, Dams, Drought |
| Weather Underground rain gages should be consulted where current gaps in rain gage data exist. | Flooding, Dams, Drought |
| Removal of Structures in Floodplain | |
| Review the structures mapped in the floodplain within a municipality based on the latest topographic contour data to identify which structures have the highest risk of the deepest flooding. | Flooding |
| Assess the potential structural damage costs that could be incurred from flooding, based on anticipated depth of flooding and tax assessment data. | Flooding |
| Develop a plan to voluntarily acquire and demolish structures in the floodplain gradually as opportunities arise and funding becomes available, with particular emphasis on removing repetitive- and severe repetitive-loss properties from the floodplain. | Flooding |
| Use voluntarily acquired land where structures have been removed as open space for additional public recreational, ecological, or environmental purposes when possible. | Flooding |
| Roadway Flooding Protection | |
| Impacted communities should evaluate the list of flooded major roadways and mitigate risks when possible, prioritizing maintenance, repair, or replacement of roadways, bridges, and culverts with poor structural ratings. | Flooding |
| Streambank Erosion Control | |
| Investigate streambank erosion sites listed in Table 4.2 to further analyze the erosion and potential harm to nearby infrastructure. | Flooding |
| Develop a schedule to monitor the deterioration of identified erosion sites. | Flooding |

**Table continued on next page.**

### Table 4.4 (Continued)

| Action | Associated Hazard |
|---|---|
| Streambank Erosion Control (continued) | |
| Develop plans to stabilize streambank erosion to protect nearby infrastructure where needed. | Flooding |
| Dam Operator Communication | |
| Dam operators should record and communicate flow releases to downstream dam operators and property owners with enough notice for these entities to respond to the water level changes. | Dams |
| Maintain updated contact information and establish working relationships between dam operators and other stakeholders within the watershed. Participate in tabletop exercises with stakeholders to help plan protocols to reduce risks to vulnerable communities and critical infrastructure. | Dams |
| Impoundment water level information should be shared amongst dam operators, using the same units and datums, with context to describe if current water levels are high, low, or at normal conditions. | Dams |
| Dam operators should regularly update their IOMs, EAPs, and other dam operational guidance documents, and share these documents with adjacent dam operators. | Dams |
| Awareness of Current Conditions for Dam Management | |
| Subscribe to National Weather Service (NWS) weather alerts and the FEMA Integrated Public Alert & Warning System, and check precipitation gages and weather forecasts to stay aware of impending weather conditions. If available, utilize the NWS River Forecast tools to keep informed of expected water level ranges over the next six days and three months. | Flooding, Dams |
| Dam operators should be aware of and understand local soil and groundwater conditions to better anticipate high flow events. Consider installing groundwater monitoring wells and/or soil moisture monitoring equipment in and around earthen dams to monitor for dam seepage between inspections. | Dams |
| A dam's upstream channel and impoundment should be monitored for blockages from debris and ice jams, and if observed they should be removed as soon as possible. | Dams |
| Remain aware of hydrologic and land modification activities upstream of the dam to understand how they may affect the volume and timing of flows from precipitation events. | Dams |
| Data Collection for Dam Management | |
| Record and maintain data on the ages of main dam components and spillway capacities for all dams, with the data kept current in a central location such as with the WDNR. | Dams |
| Maintain adequate dam spillway capacity per NR 333 and modify the dam when necessary to provide sufficient spillway capacity. | Dams |
| Enhance modeling for flooding and dam failure scenarios to create inundation maps and determine roads and structures that are likely to be flooded at various river stages. Share results with communities that have heightened flood risks. | Dams |
| Reference available near real-time surface water gages located upstream and downstream of dam, if any such gages exist. Subscribe to the USGS water alert service to receive email and/or text alerts when gages attain user-defined thresholds. | Dams |
| Cultivate Dam Experience | |
| Dam operators should maintain their records of water levels, weather conditions, and gate operations along with context and explanations regarding their decision-making. These records should be maintained with the entity that owns and operates the dam, so that these valuable insights can be passed on to future operators. | Dams |
| Current dam operators should be directly involved in the hiring and training of deputy and replacement dam operators to help pass on valuable on-the-job experience. Ideally deputy and replacement operators would shadow the current operator for a period to be able to gain first-hand experience with them in the field. | Dams |
| Dam Operation Timing | |
| Dam operators should build awareness and understanding of the timing of water releases and travel time of flows upstream and downstream of their dam. | Dams |
| Timing of flows from dam releases should be monitored, documented, and shared with adjacent dam operators to better coordinate these releases to moderate water flows. | Dams |
| Region-Specific Dam Operation | |
| Dam operators in each of the five major subwatersheds in the plan should coordinate their efforts for water levels, gate operation, and maintain contact information with adjacent stakeholders and with appropriate entities in Illinois. | Dams |
| An in-depth assessment should be completed to analyze the potential for dams in the Fox River watershed to be used for flood control purposes. | Flooding, Dams |
| Groundwater Recharge Area Protection | |
| Protect areas of high and very high groundwater recharge potential within the Fox River watershed from inappropriate development. | Flooding, Drought |

**Table continued on next page.**

**Table 4.4 (Continued)**

| Action | Associated Hazard |
|---|---|
| Groundwater Recharge Area Protection (continued) | |
| Protect from development public parks and open spaces that have high or very high groundwater recharge potential. | Flooding, Drought |
| Prioritize the voluntary acquisition and protection of privately owned parks and open spaces in areas of high and very high groundwater potential, as funding becomes available. | Flooding, Drought |
| Best Management Practices for Drought Resilience | |
| Encourage use of cover crops on agricultural fields within the Fox River watershed. | Flooding, Drought |
| Encourage no-till agricultural practices in the watershed. | Flooding, Drought |
| Consult NIDIS data and outlook reports to prepare for possible impending drought. | Drought |
| Jurisdictions with large agricultural sectors should educate farmers on the permitting process for surface water withdrawals during times of drought where irrigation may be necessary to avoid crop loss. | Drought |
| Streamflow monitoring should occur on the Fox River mainstem near Waukesha and its upstream tributaries to evaluate how the transition to Lake Michigan drinking water affects baseflow and flood stages. | Flooding, Drought |
| Watershed Collaboration | |
| Create a watershed stakeholder network as outlined in this hazard mitigation plan and the forthcoming communications plan led by Waukesha County Emergency Management. | Flooding, Dams, Drought |
| Collaborate between the watershed stakeholder network in Wisconsin and the Fox River Flood Coalition in Illinois. | Flooding, Dams, Drought |
| Develop or enhance existing tools to publish real-time streamflow, lake levels, weather, and soil condition data along with watershed road networks, floodplains, critical infrastructure, and other relevant information. | Flooding, Dams, Drought |

*Source: SEWRPC*

# PLAN IMPLEMENTATION 5

The hazard mitigation plan described in this report is designed to attain, to the maximum extent practicable, the recommendations set forth in Chapter 4 of this report. In a practical sense, however, the plan is not complete until the steps to convert the plan into action policies and programs have been specified. This chapter presents the plan implementation strategies envisioned and includes information on plan adoption, maintenance, and revision.

## 5.1 PLAN REFINEMENT, REVIEW, AND ADOPTION

As described in Chapter 1, in July 2021 the Southeastern Wisconsin Regional Planning Commission (SEWRPC) agreed to prepare a Fox (Illinois) River Watershed Pre-Disaster Mitigation Plan on behalf of the Waukesha County Department of Emergency Management, conducted in cooperation with the Federal Emergency Management Agency (FEMA) and the Wisconsin Department of Military Affairs, Division of Emergency Management. The plan set forth in this report began in 2022 and was prepared under the guidance of a Local Planning Team (LPT) comprised of representatives of the communities within the Fox River watershed, as well as dam operators; and agency representatives knowledgeable in hazard mitigation matters. The LPT met four times during the plan preparation period to provide input on the types of hazards to be considered, the appropriate mitigation strategies, and to review and refine the draft report chapters. Entities that participated in LPT activities are listed in Table 1.1.

As draft chapters of the plan were completed, copies were placed in downloadable form on a webpage available on the SEWRPC website. On this webpage members of the public could ask questions and submit comments on the draft plan update.

Following plan completion, the plan will be considered for adoption by Waukesha County. An example plan adoption resolution is provided in Appendix E. Copies of the plan will also be shared with each of the local units of government in the watershed recommending they also adopt the plan. In addition, Waukesha County Department of Emergency Management staff and SEWRPC staff will be available to meet with communities on an individual basis to review the plan and consider adoption and implementation steps.

## 5.2 PLAN IMPLEMENTATION STRATEGIES

An important step in implementing this mitigation plan is its formal adoption by municipalities located within the Fox River watershed. Upon formal adoption, the plan becomes an important guide to hazard mitigation and related management decisions for participating local units of government, supplementary to their county’s all-hazards mitigation plan. Such adoption serves to signify agreement with and official support of the plan recommendations and enables government officials and staff to begin integrating the plan recommendations into the other ongoing municipal programs, such as land use and public works development planning and programming.

Realization of this plan will require a long-term commitment to the objectives of the plan and a high degree of communication and coordination among various county and community departments and other bodies, including the Hazard Mitigation Local Planning Team; networks of dam operators; intergovernmental task forces or other committees that may be created in the future to help address common hazard mitigation issues; other concerned units and agencies of government and their respective officials and staffs; area developers and lending institutions; businesses, industry, and institutions; and concerned private citizens in undertaking the substantial investments and series of actions needed to implement this plan. Close cooperation with WEM and FEMA will also be essential. It is recommended that the local units of government incorporate the analyses performed and mitigation strategies recommended into other local planning efforts, such as those related to stream and river protection, land and water conservation, and comprehensive planning, where appropriate.

## 5.3 TECHNICAL AND FINANCIAL SOURCES

It is important for the units of government, agencies, and private organizations working within the Fox River watershed to effectively utilize all available sources of financial and technical assistance for the timely implementation of the mitigation measures recommended in this plan. In addition to utilizing current tax revenue sources, such as property taxes, fees, and State-shared taxes, the local units of government in the watershed can also make use of revenue sources, such as borrowing, special taxes and special assessments, areawide assessments, contributions in aid of major construction, impact fees, establishment of stormwater utilities, State and Federal grants, grants from foundations, and gifts. In addition to their regular resources, private organizations working in the watershed can also make use of State and Federal grants, grants from foundations, and gifts.

Because funding programs and opportunities are constantly changing, the staff of county and local units of government will need to monitor potential funding sources and programs. Some of the programs provided in this chapter may not be available under all envisioned conditions in the Fox River watershed or to its residents and/or property owners for a variety of reasons, including, for example, eligibility requirements or lack of funds at a given time in Federal and/or State budgets. Nonetheless, the list of sources and programs provided below can provide a starting point for identifying possible funding for implementing potential hazard mitigation plan recommendations. Table 5.1 also provides additional information about funding sources by federal, state, and local resources, including the entity or group qualified for the program, types of projects or activities that can be funded, and the assistance or cost-share provided from that program. The following are the main funding programs available for the hazard mitigation projects in this plan, while the full listing is included in Table 5.1.

**U.S. Federal Emergency Management Agency Programs (FEMA)**

FEMA provides several pre-disaster or non-emergency disaster assistance programs to states, tribal governments, and to local governments. These preparedness grants support citizens and first responders, as well as improve the capability to prepare for, protect against, respond to, recover from, and mitigate high-consequence disasters and emergencies. These funding programs are administered through Wisconsin Emergency Management (WEM). For projects in this plan to become eligible for FEMA funding, counties should include this plan as an appendix to their county's all hazards mitigation plan. Individual projects from this plan can be adopted as addendums to a current county all hazards mitigation plan to become eligible for FEMA funding prior to a county's next hazard mitigation plan update.

**U.S. Army Corps of Engineers (USACE)**

The Army Corps of Engineers programs are potential sources of funding for implementing the flood management recommendations of this plan. To be eligible for funding, the plan components must meet specific Corps economic feasibility and other criteria.

**U.S. Department of Agriculture - Farm Service Agency (FSA)**

The U.S. Department of Agricultural Farm Service Agency (USDA-FSA) oversees several voluntary conservation-related programs that provide direct and indirect hazard mitigation benefits. These programs, as listed below, work to address a large number of farming- and ranching-related issues including drinking water protection, reducing soil erosion, preserving wildlife habitat, preserving, and restoring forest and wetlands, and aiding farmers whose farms have been damaged by natural disasters, including flooding and drought.

**U.S. Department of Agriculture - Natural Resources Conservation Service (NRCS)**

The U.S. Department of Agricultural Natural Resources Conservation Service (USDA-NRCS) provides farmers and ranchers with financial and technical assistance to voluntarily install conservation measures to help the environment and agricultural operations concurrently.

**U.S. Fish and Wildlife Service (USFWS)**

The USFWS's *National Fish Passage Program* provides financial and technical assistance in support of fish passage projects. This program works to restore rivers and conserve aquatic resources by removing or bypassing barriers, including obsolete and dangerous dams, ultimately eliminating public safety hazards, and restoring river ecosystems. The program also works with transportation agencies and others to improve road stream crossings so that the streams can flow naturally beneath them.

## Table 5.1
## Potential Funding Sources for Hazard Mitigation Projects in the Fox River Watershed

| Administrator of Grant Program | Name of Funding Program | Eligibility | Types of Projects and Funding Eligibility Criteria | Assistance Provided |
|---|---|---|---|---|
| Federal Funding Programs | | | | |
| U.S. Economic Development Administration (EDA) | Disaster Supplemental Funding | Municipalities impacted by a Presidentially declared disaster | • To plan and implement community resilience projects against future disasters | Varies, based on the circumstances of proposed projects; In general, 80 percent Federal cost-share; 20 percent local match |
| EDA | Public Works (PW) and Economic Adjustment Assistance (EAA) Programs | States, municipalities, tribal governments, higher education institutions, economic development districts, and nonprofit organizations | • The PW supports the construction, expansion, or upgrade of public infrastructure and facilities<br>• EAA supports the design and implementation of strategies to help communities that have experienced or are under the threat of serious damage to their underlying economic base | $150,000 to $1 million for EAA awards, with an average award of $650,000; $600,000 to $3 million for PW awards, with an average award of $1.4 million; Cost-share: 50 percent federal; 50 percent local |
| U.S. Department of Homeland Security-Federal Emergency Management Agency (FEMA) | Hazard Mitigation Grant Program | State agencies and participating National Flood Insurance Program (NFIP) communities; federally recognized tribes, tribal agencies, private nonprofits, and local government/communities | • Floodproofing<br>• Relocation of structures<br>• Elevation of structures<br>• Property acquisition<br>• Conformity with approved state and local mitigation plan<br>• Plan preparation<br>• Safe room construction<br>• Construction or modification of dikes, levees, floodwalls, seawalls, groins, jetties, breakwaters, and stabilized sand dunes | 75 percent Federal cost-share assistance; 12.5 percent State match and 12.5 percent local match required |
| FEMA | Flood Mitigation Assistance Grant Program | State agencies and participating NFIP communities; federally recognized tribes, tribal agencies, local governments/communities | • Elevation, relocation, or demolition of insured structures<br>• Acquisition<br>• Dry floodproofing<br>• Minor structural projects<br>• Beach nourishment activities<br>• Projects must be consistent with the goals and objectives identified in the State, tribal, or local mitigation plans | Funding is appropriated by Congress; 75 percent Federal cost-share assistance; 25 percent local match required; two types of grants: Planning grant and project grant |
| FEMA | Public Assistance Grant Program | State, tribal, territorial, and local governments; certain types of private nonprofit organizations | • Rebuilding infrastructure damaged during a flood<br>• Building infrastructure for portions of a community that are to be relocated outside of floodplains<br>• Limited assistance with structural elevation and relocation | 75 percent Federal cost-share assistance; the State determines the local match |
| FEMA | National Training and Education Division | State and local first responders; private sector and tribal entities | • Provides preparedness training and exercise support to first responders in the event of a manmade or natural catastrophic event<br>• Provides educational services in 18 professional disciplines | Provides over 150 training courses for first responders |

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**Table 5.1 (Continued)**

| Administrator of Grant Program | Name of Funding Program | Eligibility | Types of Projects and Funding Eligibility Criteria | Assistance Provided |
|---|---|---|---|---|
| FEMA | Building Resilient Infrastructure and Communities (BRIC) | Applicants: states, territories, and Tribal governments<br><br>Sub-applicants: local and tribal governments and state and tribal agencies | • Capability- and capacity-building activities<br>• Hazard mitigation projects<br>• Management costs | Funding is appropriated by Congress; 75 percent Federal cost-share assistance provided (small, impoverished communities may be eligible for up to 90 percent federal cost-share); 25 percent State or local match is required |
| U.S. Army Corps of Engineers (USACE) | Water Resources Development and Flood Control Acts (WRDA) | Local governments | • Water resources planning assistance<br>• Emergency streambank and shoreline protection | 50 percent for studies and 65 percent for project implementation of Federal cost-share assistance; 35 to 50 percent local match is required |
| USACE | Continuing Authorities Program (CAP) - Flood Risk Management Program | Local governments and special authorities | • Assistance for planning, design, and construction of structural and non-structural flood control projects<br>• Projects are not limited to any particular type of improvement | Feasibility study is 100 percent federally funded up to $100,000; 50 percent local match required for any costs exceeding $100,000; 65 percent federal cost share for project implementation with 35 percent local match required |
| USACE | Section 14 of the 1946 Flood Control Act - Emergency Streambank and Shore Protection Program | Local governments | • Bank protection of highways, highway bridges, essential public works, churches, hospitals, schools, and other nonprofit public services from flood induced erosion | Federal share cannot exceed $5,000,000 for a given project; cost-share program with local match of 35 percent for design and construction required |
| USACE | Section 205 of the 1948 Flood Control Act - Flood Damage Reduction Program | State and local units of government | • Projects designed to reduce the impact of flood events<br>• Projects must be designed and constructed by the Corps | 50 to 65 percent Federal cost-share assistance above $100,000 and cannot exceed $10 million; 35 to 50 percent local match is required |
| USACE | Section 208 of the 1954 Flood Control Act - Snagging and Clearing for Flood Risk Management Program | State and local units of government | • Removal of obstructions that restrict flood flows of navigable waters<br>• Projects must be designed and constructed by the Corps | Federal share cannot exceed $500,000 for a given project; cost-share program with local match of 35 percent for design and preparation; construction cost varies between 30 percent and 65 percent federal share |

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**Table 5.1 (Continued)**

| Administrator of Grant Program | Name of Funding Program | Eligibility | Types of Projects and Funding Eligibility Criteria | Assistance Provided |
|---|---|---|---|---|
| USACE | Section 206 of the Flood Control Act of 1960 - Floodplain Management Services Program | State, regional, and local governments; federally recognized Native American Tribes; other non-federal public agencies | • Floodplain delineation<br>• Flood hazard evaluation<br>• Dam break analysis<br>• Stormwater management<br>• Flood risk reduction | 100 percent federal cost-share assistance provided; entities may provide voluntary contributions |
| USACE | Section 13 of the Rivers and Harbors Act of 1962 - Hurricane and Storm Damage Reduction Program | State agencies and local units of government | • Beach nourishment<br>• Floodproofing<br>• Other structural and nonstructural storm damage reduction projects | Federal share cannot exceed $5,000,000 for a given project; cost-share program with local contribution of 35 percent for design and construction required |
| USACE | Section 206 of the Water Resources Development Act of 1996 - Aquatic Ecosystem Restoration | State and local units of government | • Modification of hydrology in and along water bodies | Planning costs after $100,000 is 50 percent cost-shared. Design and implementation are cost-shared 65 percent federal and 35 percent non-federal |
| USACE | Section 519 of Water Resources Development Act of 2000 – Illinois River Basin Restoration | State and local units of government | • Sedimentation management<br>• Aquatic and riparian habitat restoration<br>• Naturalize hydrologic regimes and conditions<br>• Water and sediment quality | 65 percent Federal cost-share assistance, 35 percent non-Federal assistance |
| U.S. Department of Agriculture - Farm Services Agency (USDA-FSA) | Conservation Reserve Program | Individual landowners in a 10- or 15-year contract | • Riparian buffers<br>• Trees<br>• Windbreaks<br>• Grassed waterways<br>• Farmer must have owned or operated the land for at least 12 months prior to the previous program sign-up period | 50 percent Federal cost-share assistance; 50 percent local match from individual; an annual rental payment for the length of the contract is also provided |
| USDA-FSA | Emergency Conservation Program | Individual private landowners | • Grading and shaping farmland<br>• Restoring conservation structures<br>• Redistribution of eroded soil<br>• Debris removal<br>• Projects must be in response to a natural disaster | Up to 75 percent Federal cost-share assistance, the remaining is determined by the committee reviewing the application |
| USDA-FSA | Emergency Farm Loans | Owner or land operator located in within a County designated as a declared natural disaster emergency with at least a 30 percent crop production loss | • Restore or replace essential property<br>• Pay all or part of production costs<br>• Pay essential family living expenses<br>• Reorganize the family farming operation<br>• Refinance certain non-real estate operating debts | Producers can borrow up to 100 percent of actual production or physical losses to a maximum amount of $500,000. |
| USDA-FSA | Emergency Forest Restoration Program | Individual non-industrial private forest landowners | • Restore privately owned forests damaged by natural disasters | Funding and technical assistance provided under a 10-15 year contract |

**Table continued on next page.**

**Table 5.1 (Continued)**

| Administrator of Grant Program | Name of Funding Program | Eligibility | Types of Projects and Funding Eligibility Criteria | Assistance Provided |
|---|---|---|---|---|
| USDA-FSA | Farmable Wetland Program | Individual agricultural landowners in 10- or 15- year contracts | • Restore currently farmed wetland | Visit the local FSA office for assistance provided |
| USDA-FSA | Noninsured Disaster Assistance Program | Landowners or tenants that experienced direct damaging weather or adverse natural occurrence to crops during the eligible crop coverage period before or during harvest | • Protecting non-insurable crops against natural disasters, including drought, freeze, hail, excessive moisture, or excessive wind, flood, and excessive heat, or insect infestation. | NAP provides basic coverage equivalent to the catastrophic level risk protection plan of insurance coverage, which is based on the amount of loss that exceeds 50 percent of expected production at 55 percent of the average market price for the crop. |
| U.S. Department of Agriculture - Forest Service | Community Forest and Open Space Conservation Program | Tribal entities, local governments, and qualified conservation nonprofit organizations | • Projects aimed to acquire and establish forests that will provide community and economic benefits through active forest management, clean water, wildlife habitat, educational opportunities, and public access for recreation | Program pays up to 50 percent of project costs and requires a 50 percent non-federal match |
| U.S. Department of Agriculture, Farm Services Agency - Natural Resources Conservation Service (USDA-NRCS) | Agricultural Conservation Easement Program- *Wetlands Reserve Easements* | Local government and individual landowners | • Purchase agricultural land easements that protect the conservation values of eligible land<br>• Wetland protection, restoration, and enhancement | Permanent easement: NRCS pays 100 percent of easement value and 75 to 100 percent of restoration cost; 30-year easement: NRCS pays 50 to 75 percent of easement value and 50 to 75 percent of restoration cost |
| USDA-NRCS | Conservation Stewardship Program | Individual landowners in a five-year contract | • Filter strips<br>• Riparian Buffers<br>• Wildlife corridors<br>• Stream habitat improvement | Payments for maintaining and/or enhancing natural resources not to exceed $40,000 per year or $200,000 over a five-year period |
| USDA-NRCS | Watershed Protection and Flood Prevention Program | State, tribal, and local units of governments | To help plan and implement authorized watershed projects for the purpose of:<br>• Flood prevention<br>• Watershed protection<br>• Public recreation<br>• Public fish and wildlife<br>• Agricultural water management<br>• Municipal and industrial water supply<br>• Water quality management | Cost-share rates vary depending on the type of measure and the purpose to which the cost is allocated; total average annual monetary benefits equal $2.2 billion |

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**Table 5.1 (Continued)**

| Administrator of Grant Program | Name of Funding Program | Eligibility | Types of Projects and Funding Eligibility Criteria | Assistance Provided |
|---|---|---|---|---|
| USDA-NRCS | Emergency Watershed Protection Program – *Floodplain Easement Option* | Individual landowners provided they have a local sponsor such as a local unit of government | • Sale of agricultural floodprone lands to NRCS for floodplain easements<br>• Land must have a history of repeated flooding (at least twice in the past 10 years)<br>• Landowner retains most of the rights as before the sale<br>• NRCS has authority to restore the floodplain function and value | The USDA pays the landowner the lowest of three options: a geographic rate, the fair market value of the land, or an offer made by the landowner; 75 percent Federal cost-share assistance; 25 percent local match is required |
| USDA-NRCS | Emergency Watershed Protection Program - *Recovery Assistance* | Individual landowners provided they have a local sponsor such as a local unit of government | • Debris removal<br>• Reshaping and protection of eroded streambanks<br>• Repair levees and structures<br>• Repair damaged drainage facilities | Up to 75 percent Federal cost-share assistance; 25 percent local match is required |
| USDA-NRCS | Environmental Quality Incentives Program | Agricultural producers, owners of non-industrial private forestland, Indian Tribes, and those with an interest in the agricultural or forestry operations | • Animal waste management practices<br>• Soil erosion and sediment control practices<br>• Nutrient management<br>• Groundwater protection<br>• Habitat improvement | Up to 75 percent Federal cost-share assistance; 25 percent local match is required |
| U.S. Department of the Interior - National Park Service | Rivers, Trails, and Conservation Assistance Program | Municipalities | • Supports community-led natural resource conservation and outdoor recreation projects, including natural-based flood control measures, such as riverbank restoration | Free of service, no cost and no cost-share requirements |
| U.S. Fish and Wildlife Service (USFWS) | North American Wetlands Conservation Act (Grants Program) | Private or public organizations | • Land acquisition<br>• Restoration, management, and enhancement of wetland ecosystems and other habitat for migratory birds and other fish and wildlife | Applicants must match their grant request at no less than a 1-to-1 ratio; requests for small grants may not exceed $100,000 |
| USFWS | National Fish Passage Program | Individuals, nonprofit or national organizations, and local governments | • Restore fish passage<br>• Develop community infrastructure resilience<br>• Rebuild fish populations<br>• Improve recreational and commercial fisheries<br>• Restore free flowing waters | On average the program contributes about $70,000 per project. There is no upper limit to project funding. Generally, a 50 percent match is required from federal or non-federal sources |
| USFWS | Partners for Fish and Wildlife Habitat Restoration Program | Private landowners | • Livestock fencing<br>• Alternate water supply/construction<br>• Streambank stabilization<br>• Restoration of in-stream aquatic habitat planting<br>• Prescribed burning<br>• Native grass and forb planting<br>• Wetland restoration<br>• Riparian reforestation | Full cost-share and technical assistance; individual projects cannot exceed $25,000 |

**Table continued on next page.**

**Table 5.1 (Continued)**

| Administrator of Grant Program | Name of Funding Program | Eligibility | Types of Projects and Funding Eligibility Criteria | Assistance Provided |
|---|---|---|---|---|
| USFWS - National Fish and Wildlife Foundation (NFWF) | Acres for America Program | State and local units of government, nonprofit organizations, Indian Tribes, educational institutions | • Acquisition of permanent easement for conservation of habitat | $3.5 million available nationally annually; minimum 1:1 match ratio required; higher local match preferred |
| USFWS - NFWF | Five-star and Urban Waters Restoration Grant Program | Nonprofit organizations, local governments, municipal governments, Indian tribes, educational institutions | • Wetland restoration projects<br>• Riparian restoration projects<br>• Coastal and forest restoration projects<br>• Projects must be part of a larger watershed project<br>• Projects must have at least five contributing parties | $2,000,000 available nationally annually; project awards range from $20,000 to $50,000, average award $30,000; 1:1, non-federal match ratio required, higher local match preferred |
| U.S. Department of Housing and Urban Development | Community Development Block Grant Recovery Grant Program | Local governments | • Public Facilities Grants to fund tornado shelters and safe houses<br>• Housing Grants to fund the rehabilitation of housing to meet current building codes<br>• Funds continuous training course for the building code authority | No matching requirements; Amounts awarded vary based on assessed community needs |
| U.S. Small Business Administration | Disaster Loan Program | Homeowners, renters, and businesses | • Property repair<br>• Property replacement<br>• Meeting building code requirements<br>• Involuntary relocations out of a special flood hazard area | Low interest loans |
| U.S. Environmental Protection Agency (EPA) | Clean Water State Revolving Fund | States and municipalities for construction and technical assistance on publicly owned treatment works or nonpoint source pollution management systems | • Projects that support decentralized wastewater treatment systems; stormwater management; water conservation; watershed pilot projects; and water reuse | Most assistance that municipalities is for loans that need to be repaid 100 percent to the CWSRF |
| EPA | Drinking Water State Revolving Fund | States and municipalities | • Construction of drinking water infrastructure projects, including modifications to ensure system capacity during flooding, and planning for flooding events | Individual states allocate funds to prioritized projects. Most assistance is for loans that have to be repaid 100 percent to the DWSRF |
| EPA | Environmental Education Local Grants | Local educational institutions, environmental agencies, and nonprofit organizations | • Improving air quality<br>• Clean and safe water<br>• Safety of chemicals<br>• Land revitalization<br>• Flooding projects | 75 percent cost-share provided for a Federal total of $50,000 to $100,000 |

**Table continued on next page.**

## Table 5.1 (Continued)

| Administrator of Grant Program | Name of Funding Program | Eligibility | Types of Projects and Funding Eligibility Criteria | Assistance Provided |
|---|---|---|---|---|
| EPA | Environment-al Justice Small Grants Program | Incorporated nonprofit organizations —including, but not limited to, environmental justice networks, faith-based organizations, and tribal organizations | • Community-driven projects that engage, educate, and empower communities to better understand local environmental and public health issues and develop strategies for addressing those issues | Up to $75,000 depending on availability of funds |
| EPA | Targeted Watershed Grants | Watershed organizations nominated by State Governors or Tribal leaders | • Watershed-based projects to protect water resources (i.e., wetland restoration)<br>• Training and technical assistance to local partnerships | 75 percent maximum Federal cost-share assistance; Minimum 25 percent non-Federal match |
| EPA | Section 319 of the 1987 Amendments to the Clean Water Act - Nonpoint Source Grant Program | States and municipalities | • Technical assistance; financial assistance; education; training; technology transfer demonstration projects; and regulatory programs aimed at reducing or eliminating water quality impairments and improvements in water quality and habitat | Depends on the State. Cost-share is 60 percent Federal and 40 percent nonfederal |
| U.S. Department of Transportation (USDOT) | Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Transportation Grants | State, local, and tribal governments | • Construction, design, and/or planning projects that will have a significant impact on roads, bridges, transit, rail, ports, or intermodal transportation systems. | Greater than $10 million; A match is required. |
| | | State Funding Programs | | |
| Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) | Producer-Led Watershed Protection Grants | Producer-Led Groups | • Provides support to groups to deliver cost share programs, on-farm demonstration and research projects, and education and outreach efforts on conservation systems and in innovative practices that improve water quality | $40,000 per group |
| DATCP | Soil and Water Resource Management Program | Individual landowners | • Wetland restoration<br>• Filter strip, riparian buffers<br>• Subsurface drainage<br>• Well abandonment | Program funds 70 percent of the cost of conservation project |
| Wisconsin Department of Administration-Division of Energy | Community Development Block Grant Program-Emergency Assistance Program | Local governments | • Repair of public infrastructure<br>• Housing rehabilitation to low-and moderate-income homeowners<br>• Business assistance | 75 percent Federal cost-share assistance; 25 percent local match required; maximum grant award equals $500,000 |

**Table continued on next page.**

**Table 5.1 (Continued)**

| Administrator of Grant Program | Name of Funding Program | Eligibility | Types of Projects and Funding Eligibility Criteria | Assistance Provided |
|---|---|---|---|---|
| Wisconsin Department of Transportation (WisDOT) | Disaster Damage Aids | Local governments. Road must be closed or rendered impassable due to the disaster damage or damaged caused by government emergency response units | • Road repair and maintenance to any highway that is not on the State Trunk Highway System | 1. For claims with final costs, applicant receives 75 percent of replacement costs plus 50 percent of improvement costs<br>2. For claims ≤ $15,000, applicant may accept payment equal to 75 percent of WisDOT's estimate for all repairs (replacement and improvement), which may include final costs if available.<br>3. For claims submitted for damage by any governmental unit in response to the disaster, applicant receives 70 percent of replacement.<br>4. If Federal-aid is granted for damage reimbursement, it shall be in lieu of aid otherwise available under DDA. |
| WisDOT | Emergency Relief Program | Roadway or roadway structure damage on Federal-Aid highways (Major collectors and above) resulting from a natural disaster. Governor's State of Emergency Declaration required | • Repair physical damage<br>• Debris removal<br>• Traffic control and detour signing | Emergency repairs are 100 percent covered if done within 180 days of the event, otherwise paid on prorated basis. Permanent restorations projects are 90/10 (Interstate) or 80/20 (non-Interstate). |
| WisDOT | Local Bridge Improvement Program | Local governments | • Rehabilitate and replace very deficient existing local bridges on Wisconsin's local highway systems | Total funds available is $131,002,555 |
| WisDOT | Local Roads Improvement Assistance | Local governments | • County highway improvement<br>• Town road improvement<br>• Municipal street improvement | Pays up to 50 percent of total eligible costs, with local governments providing the balance |
| Wisconsin Emergency Management | Hazard Mitigation Grant Program | State and local units of government, tribal governments, and eligible private, non-profit organizations | • Mitigation Planning<br>• Technical Assistance<br>• Mitigation Projects | 75 percent Federal cost-share assistance; 25 percent local match |
| Wisconsin Public Service Commission | Telecommunications, Water, Energy Divisions | Local governments | • Incorporate disaster resilience into regulation development, land use practices and environmental impacts of public utilities | General Utility Assistance |

**Table continued on next page.**

## Table 5.1 (Continued)

| Administrator of Grant Program | Name of Funding Program | Eligibility | Types of Projects and Funding Eligibility Criteria | Assistance Provided |
|---|---|---|---|---|
| University of Wisconsin-Cooperative Extension | Extension Disaster Education Network | Local governments | • Provides community education and public information programs promoting hazard awareness and mitigation concepts | Education and Information provided through the University of Wisconsin System |
| Wisconsin Board of Commissioners of Public Lands | State Trust Fund Loan Program | Municipalities and school districts | • Any public purpose including infrastructure | Loans at competitive rates |
| Wisconsin Department of Natural Resources (WDNR) | County Conservation Aids | County and tribal governments participating in the county fish and wildlife programs | • Development projects (new trails, new fish cribs, stream crossing, etc.)<br>• Habitat projects (burning, prairie planting, stream restoration, streambank stabilization, etc.)<br>• Stocking projects ( fish stocking and wildlife stocking)<br>• Maintenance projects (repairs to trails and culverts, flowage maintenance, accessibility upgrades, etc.) | 50 percent state cost-share |
| WDNR | Dam Removal Grant Program | Counties, cities, villages, towns, lake districts, and private dam owners | • Dam removal planning<br>• Dam removal<br>• Restoration of impoundment | State covers 100 percent of project costs up to $50,000 |
| WDNR | Knowles-Nelson Stewardship Program | Local units of governments and qualified nonprofit organizations | • Acquisition of land and easements for conservation and recreation<br>• Developing and improving recreational facilities<br>• Streambank protection<br>• Restoring fish and wildlife habitat | 50 percent cost-share assistance provided |
| WDNR | Land and Water Conservation Fund Program | State agencies and local units of government | • Planning for acquisition of parks<br>• Land acquisition for parks and open space<br>• Supporting facilities that enhance recreational opportunities | 50 percent cost-share assistance provided |
| WDNR | Municipal Dam Grant Program | Cities, towns, villages, counties, tribes, and lake districts | • Dam maintenance<br>• Dam repair<br>• Dam modification or abandonment<br>• Dam removal | 50 percent cost-share assistance provided |
| WDNR | Municipal Flood Control Grants | Cities, villages, towns, tribes, and metropolitan sewerage districts | • Structure and land acquisition<br>• Structure floodproofing<br>• Riparian restoration<br>• Flood storage<br>• Stormwater storage/detention<br>• Flood mapping | 50 percent cost-share assistance provided |
| WDNR | Surface Water Grant Program | Counties, cities, local units of government, lake associations, natural resource agencies, and town sanitary districts | • Habitat protection<br>• Reduce runoff<br>• Best management projects<br>• Comprehensive planning<br>• Education and outreach | Cost-share, DNR provides 67 percent cost-share for planning grants and 75 percent for management grants |

**Table continued on next page.**

**Table 5.1 (Continued)**

| Administrator of Grant Program | Name of Funding Program | Eligibility | Types of Projects and Funding Eligibility Criteria | Assistance Provided |
|---|---|---|---|---|
| WDNR | Urban Forestry Grant and Urban Forestry Catastrophic Grants | Cities, villages, towns, counties, tribes and 501(c)(3) nonprofit organizations | • Depends based on whether Regular Grant, Startup Grant, or Catastrophic Storm Grant.<br>• Community tree management, maintenance or education within Wisconsin cities, villages or other areas of concentrated development | Competitive cost-share grants of up to $25,000 |
| WDNR | Urban Nonpoint Source and Storm Water Management Grant Program | Cities, villages, towns, counties, regional planning commissions, tribal governments, and lake, sewage, or sanitary districts | • Stormwater Planning<br>• Education and Information activities<br>• Ordinance development and enforcement<br>• Training<br>• Construction of structural stormwater BMPs<br>• Storm sewer rerouting and removal<br>• Streambank stabilization | Planning grants – cost share up to 70 percent and reimbursement amount cannot exceed $85,000<br>Construction grants – cost share up to 50 percent and reimbursement amount cannot exceed $150,000 |
| WDNR | Wisconsin Forest Landowner Grant Program | Non-industrial private forest owners of at least 10 contiguous acres of forest but not more than 500 acres | • Stewardship plan preparation<br>• Tree planting<br>• Forest health improvement<br>• Soil and water protection and improvement<br>• Wetland and riparian protection<br>• Wildlife habitat enhancement<br>• Threatened and endangered resource maintenance and enhancement | Reimburses up to 50 percent of cost of eligible practices |
| Kenosha County, WEM and FEMA | Fox River Flood Mitigation Program via FEMA's HMGP | Structures within the 100-year floodplain of the Fox River with the Towns of Salem and Wheatland and the Village of Silver Lake of Kenosha County | • Projects that help reduce flood damage and potential for injury by acquiring and demolishing residential structures and relocating displaced residents from the floodplain of the Fox River | 75 percent of the buyout cost is paid by FEMA, the rest is paid by state and/or local government |

*Source: SEWRPC*

**U.S. Department of Housing and Urban Development**

*Community Development Block Grant (CDBG) programs*, funded by the U.S. Department of Housing and Urban Development, are administered by the Wisconsin Department of Administration. The Community Development Block Grant Emergency Assistance Program is a special program that the Wisconsin Department of Administration, Division of Energy, Housing and Community Resources activates to assist local units of government that have recently experienced a natural or man-made disaster.

**U.S. Environmental Protection Agency (USEPA)**

USEPA's mission is to protect human health and the environment. USEPA has several programs that provide grants to state environmental programs, local units of government, nonprofit organizations, and educational institutions.

**Wisconsin Department of Transportation (WisDOT)**

WisDOT programs assist local governments with needed improvements to local roads, highways and bridges.

**Wisconsin Department of Natural Resources (WDNR)**

The WDNR administers a number of grant programs that may serve as potential funding sources for flood mitigation efforts by County and local communities.

**Other Potential Funding Sources**

A variety of other potential funding sources exist which may provide funds for implementation efforts related to this plan's recommended hazard mitigation alternatives. These additional funding programs are listed in Table 5.1.

## 5.4 PLAN MONITORING AND REEVALUATION STRATEGIES

For a hazard mitigation plan to be successful it must not only be implemented; it must be reviewed. Plan review is best accomplished through a formal, periodic process designed to measure and assess progress in implementation, changes in outside circumstances that may affect the plan and efforts to implement it, and changes to the plan or the implementation process.

**Plan Review**

It is recommended that the LPT periodically review and update this plan and the status of its implementation at least once every ten years. Additionally, the plan should be reviewed following any major flooding or drought disasters that affect the Fox River watershed. Based upon this review, the hazard mitigation plan should be updated or revised as needed based upon the experiences with, circumstances, and consequences of the hazard. In this regard, the post-disaster review effort should be coordinated with the emergency operations program administered by each county in the watershed in partnership with the local units of government. Recent emergency operations experiences may indicate a need for refined mitigation actions that could be incorporated into the plan.

Any revisions would be proposed, considered, and adopted in the form of formal amendments to the hazard mitigation plan. This review process should be coordinated and conducted by the LPT, with invitations for input and coordination to all concerned county officials and staff, all units and agencies of government involved in plan implementation and concerned private parties within the Fox River watershed. The LPT, in its review process, should periodically examine the plan and the efforts to implement it with respect to:

- Whether any flooding or drought hazards affecting the Fox River watershed have changed and if so, how they have changed
- The degree and extent of progress made in implementing previously identified hazard mitigation recommendations
- Whether any existing plan recommendations need modification or new plan recommendations are needed
- Whether applicable funding programs have changed

Updating efforts should be led by the Coordinator of the Waukesha County Emergency Management Agency in partnership with other departments from Kenosha, Racine, Walworth, and Waukesha Counties. As part of the updating process, the Coordinator will reconstitute the LPT to oversee development of the updated plan. In addition, at appropriate times during the updating process, members of the public and adjacent communities should be provided with opportunities to review and submit questions and comment on the plan update.

### *Annual Monitoring*

It is recommended that each County Emergency Management Agency oversee the development and maintenance of a tracking and archiving system for all future detailed hazard mitigation activities undertaken by or for each county or the local units of government concerned.

### *Incorporating Existing Planning Mechanisms*

Racine, Kenosha, Walworth, and Waukesha Counties currently utilize comprehensive land use planning, land use regulations, neighborhood planning, and building codes to guide and control development in each county. It is recommended that the counties integrate hazard mitigation strategies into these existing regulations where applicable. In addition, each county may request that participating local municipalities address hazards in their comprehensive plans and land use regulations. It is recommended that each county conduct periodic reviews of their comprehensive plan and land use policies, analyze any plan amendments, and provide technical assistance to other local municipalities in implementing these requirements.

# APPENDICES

# APPENDIX A

# PRELIMINARY FEMA FLOODPLAIN MAPPING

**Table A.1**
**Flooded Structure Count in Most Recent[a] Floodplains by Municipality and Structure Type**

| Municipality | Residential | Commercial | Agricultural | Manufactured Homes | Community Utility | Government | Other | Total Structures |
|---|---|---|---|---|---|---|---|---|
| Kenosha County | | | | | | | | |
| Town of Brighton | -- | -- | -- | -- | -- | -- | -- | -- |
| Town of Randall | 8 | -- | -- | -- | -- | -- | -- | 8 |
| Town of Wheatland | 45 | 3 | -- | -- | -- | -- | -- | 48 |
| Village of Salem Lakes | 162 | 2 | -- | 17 | 1 | -- | 1 | 183 |
| Village of Twin Lakes | 4 | -- | -- | -- | -- | -- | -- | 4 |
| Kenosha County Total | 219 | 5 | -- | 17 | 1 | -- | 1 | 243 |
| Racine County | | | | | | | | |
| City of Burlington | 50 | 16 | -- | -- | -- | -- | 2 | 68 |
| Town of Burlington | 30 | -- | 3 | 69 | -- | -- | -- | 102 |
| Town of Dover | 8 | -- | -- | -- | 3 | -- | -- | 11 |
| Town of Norway | 273 | 3 | 10 | -- | 1 | -- | -- | 287 |
| Town of Waterford | 132 | -- | -- | -- | -- | -- | -- | 132 |
| Village of Rochester | 3 | -- | -- | -- | -- | -- | 1 | 4 |
| Village of Waterford | 3 | 1 | -- | -- | -- | -- | 1 | 5 |
| Racine County Total | 499 | 20 | 13 | 69 | 4 | -- | 4 | 609 |
| Walworth County | | | | | | | | |
| City of Lake Geneva | -- | 1 | -- | -- | -- | -- | -- | 1 |
| Town of Bloomfield | 3 | 2 | -- | -- | -- | -- | -- | 5 |
| Town of East Troy | 1 | 1 | 1 | -- | -- | -- | -- | 3 |
| Town of Geneva | 26 | 4 | -- | -- | -- | -- | -- | 30 |
| Town of La Grange | 6 | -- | -- | -- | -- | -- | -- | 6 |
| Town of LaFayette | 4 | 2 | 1 | -- | -- | -- | -- | 7 |
| Town of Linn | 5 | -- | -- | -- | -- | -- | -- | 5 |
| Town of Lyons | 11 | 2 | 2 | 4 | -- | -- | -- | 19 |
| Town of Spring Prairie | 3 | -- | 1 | -- | -- | -- | -- | 4 |
| Town of Sugar Creek | 1 | -- | 1 | -- | -- | -- | -- | 2 |
| Town of Troy | 1 | -- | -- | -- | -- | -- | -- | 1 |
| Village of Bloomfield | 9 | 1 | 1 | -- | -- | -- | -- | 11 |
| Village of East Troy | 1 | 2 | -- | -- | -- | -- | -- | 3 |
| Village of Fontana | 3 | 1 | -- | -- | -- | -- | -- | 4 |
| Village of Genoa City | 3 | -- | -- | -- | -- | -- | -- | 3 |
| Village of Williams Bay | -- | -- | -- | -- | 2 | -- | -- | 2 |
| Walworth County Total | 77 | 16 | 7 | 4 | 2 | -- | -- | 106 |

**Table continued on next page.**

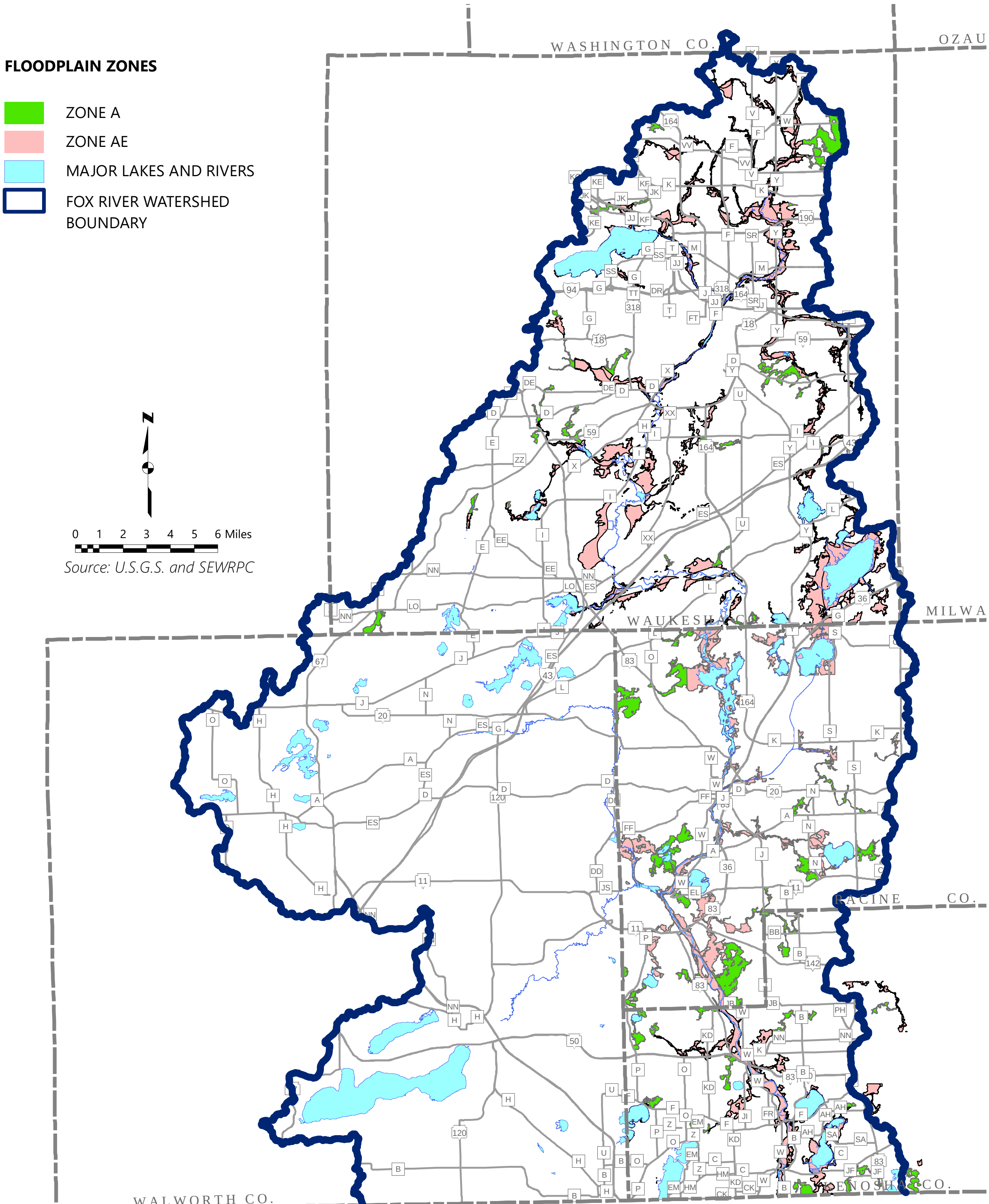
**Table A.1 (Continued)**

| Municipality | Residential | Commercial | Agricultural | Manufactured Homes | Community Utility | Government | Other | Total Structures |
|---|---|---|---|---|---|---|---|---|
| Waukesha County | | | | | | | | |
| City of Brookfield | 3 | 1 | -- | -- | -- | -- | -- | 4 |
| City of Muskego | 44 | 5 | -- | -- | -- | -- | 1 | 50 |
| City of New Berlin | 28 | 9 | -- | -- | -- | -- | 4 | 41 |
| City of Pewaukee | 29 | 1 | -- | -- | -- | -- | -- | 30 |
| City of Waukesha | 49 | 11 | -- | -- | 3 | 1 | 5 | 69 |
| Town of Brookfield | 7 | 1 | -- | -- | -- | -- | -- | 8 |
| Town of Delafield | 1 | -- | -- | -- | -- | -- | -- | 1 |
| Town of Eagle | 30 | -- | -- | -- | -- | -- | -- | 30 |
| Town of Genesee | -- | -- | -- | -- | -- | -- | -- | -- |
| Town of Mukwonago | 38 | -- | -- | -- | -- | -- | -- | 38 |
| Village of Big Bend | 1 | -- | -- | -- | -- | -- | 1 | 2 |
| Village of Lannon | -- | 3 | -- | -- | -- | -- | 2 | 5 |
| Village of Menomonee Falls | 7 | -- | -- | -- | -- | -- | -- | 7 |
| Village of Mukwonago | 12 | 1 | -- | -- | -- | -- | 1 | 14 |
| Village of Pewaukee | 24 | 25 | -- | -- | -- | 4 | 10 | 63 |
| Village of Sussex | 3 | 2 | -- | -- | -- | 3 | -- | 8 |
| Village of Vernon | 4 | 5 | -- | -- | -- | -- | -- | 9 |
| Village of Waukesha | 2 | -- | -- | -- | -- | -- | -- | 2 |
| Waukesha County Total | 282 | 64 | 0 | 0 | 3 | 8 | 24 | 381 |
| Total | 1,034 | 105 | 10 | 90 | 11 | 8 | 29 | 1,290 |

[a] *This analysis is based on the most current floodplain map drafts available at the time of analysis. Preliminary draft floodplains were used for Kenosha County (published March 28, 2022), Racine County (published December 23rd, 2022), and Waukesha County (published September 15, 2022). Effective floodplain mapping was used for Walworth County (effective April 6, 2022).*

*Source: SEWRPC*

## Map A.1
## Preliminary 100 - Year Floodplains in the Fox River Watershed



# APPENDIX B

## RAIN GAGES DATA

## Table B.1
## Details of Regional Sub-Daily Rain Gages

| Rain Gage Name | Gage Ownership | Location | County | Record Frequency | Online Data Availability | Notes |
|---|---|---|---|---|---|---|
| | | | | | | |
| **Gages inside of the Fox River Watershed in Wisconsin** | | | | | | |
| 05545750 Fox River Near New Munster, WI | NWS/USGS Cooperative | USGS Site | Kenosha, WI | 15 Min | USGS[a] | Not available during winter season |
| Burlington Municipal Airport WBAN: 72205904866 | Public | Airport | Racine, WI | 20 Min | NCEI[b] | |
| 424425088133001 FOX RIVER PRECIP STN | USGS | USGS Site | Racine, WI | 15 Min | USGS[a] | Currently data unreliable (April 2023) |
| 424555088124801 WATERFORD DAM PRECIP STN | USGS | USGS Site | Racine, WI | 15 Min | USGS[a] | |
| 424848088083101 WIND LAKE PRECIP STN | USGS | USGS Site | Racine, WI | 15 Min | USGS[a] | Not available during winter season |
| East Troy Municipal Airport | Private | Airport | Walworth, WI | 1 Hr | Unavailable Online | |
| Waukesha County Airport WBAN: 72640904897 | Public | Airport | Waukesha, WI | 20 Min | NCEI[b] | Does not monitor between 5am and 8pm |
| WS1227 Muskego Municipal Garage | MMSD | MMSD Site | Waukesha, WI | 5 Min | MMSD[c] | |
| 425109088075001 MUSKEGO LAKE PRECIP STN | USGS | USGS Site | Waukesha, WI | 15 Min | USGS[a] | Currently data unreliable (April 2023) |
| | | | | | | |
| **Gages outside of the Fox River Watershed in Wisconsin** | | | | | | |
| Dodge County Airport WBAN: 72650904898 | Public | Airport | Dodge, WI | 20 Min | NCEI[b] | |
| Horicon Wildlife Area AQS ID 55 027 0001 | NWS/DNR Cooperative | WDNR Site | Dodge, WI | 1 Hr | WDNR[d] | Not available during winter season |
| 05425912 BEAVERDAM RIVER AT BEAVER DAM, WI | NWS/USGS Cooperative | USGS Site | Dodge, WI | 15 Min | USGS[a] | Not available during winter season |
| 05423500 SOUTH BRANCH ROCK RIVER AT WAUPUN | NWS/USGS Cooperative | USGS Site | Fond du Lac, WI | 15 Min | USGS[a] | Not available during winter season |
| Watertown Municipal Airport WBAN: 72646454834 | Public | Airport | Jefferson, WI | 20 Min | NCEI[b] | |
| 05426000 CRAWFISH RIVER AT MILFORD, WI | NWS/USGS Cooperative | USGS Site | Jefferson, WI | 15 Min | USGS[a] | Not available during winter season |
| 05426031 Rock River at Jefferson, WI | NWS/USGS Cooperative | USGS Site | Jefferson, WI | Unknown | USGS[a] | Not available during winter season |
| 05427235 LAKE KOSHKONONG NEAR NEWVILLE, WI | NWS/USGS Cooperative | USGS Site | Jefferson, WI | 15 Min | USGS[a] | Not available during winter season |
| Kenosha Regional Airport WBAN: 72650504845 | FAA Owned NWS Calibrated | Airport | Kenosha, WI | 1 Hr | NCEI[b] | |
| Chiwaukee Prairie AQS ID 55 059 0019 | NWS/DNR Cooperative | WDNR Site | Kenosha, WI | 1 Hr | WDNR[d] | Not available during winter season |
| Milwaukee Mitchell International Airport WBAN: 72640014839 | NWS | Airport | Milwaukee, WI | 1 Hr | NCEI[b] | |
| Timmerman Airport WBAN: 72640594869 | Public | Airport | Milwaukee, WI | 20 Min | NCEI[b] | Does not monitor between 9am and 8pm |
| WS1201 South Shore WRF | MMSD | MMSD Site | Milwaukee, WI | 5 Min | MMSD[c] | |
| WS1202 City of Milwaukee Fire Station 37 | MMSD | MMSD Site | Milwaukee, WI | 5 Min | MMSD[c] | |
| WS1203 City of Milwaukee Police Station 2 | MMSD | MMSD Site | Milwaukee, WI | 5 Min | MMSD[c] | |
| WS1204 City of Milwaukee Fire Station | MMSD | MMSD Site | Milwaukee, WI | 5 Min | MMSD[c] | |
| WS1206 City of Milwaukee Police Station | MMSD | MMSD Site | Milwaukee, WI | 5 Min | MMSD[c] | |
| WS1207 MPS Madison High School | MMSD | MMSD Site | Milwaukee, WI | 5 Min | MMSD[c] | |
| WS1209 City of Milwaukee Fire Station 38 | MMSD | MMSD Site | Milwaukee, WI | 5 Min | MMSD[c] | |
| WS1211 Jones Island WRF | MMSD | MMSD Site | Milwaukee, WI | 5 Min | MMSD[c] | |
| WS1216 MPS Alcott Elementary | MMSD | MMSD Site | Milwaukee, WI | 5 Min | MMSD[c] | |
| WS1220 Hales Corners Village Hall | MMSD | MMSD Site | Milwaukee, WI | 5 Min | MMSD[c] | |
| WS1221 MMSD Maintenance Facility | MMSD | MMSD Site | Milwaukee, WI | 5 Min | MMSD[c] | |
| WS1222 MMSD Maintenance Facility | MMSD | MMSD Site | Milwaukee, WI | 5 Min | MMSD[c] | |
| WS1224 MMSD Pump Station PS0502 | MMSD | MMSD Site | Milwaukee, WI | 5 Min | MMSD[c] | |
| WS1225 Shorewood DPW | MMSD | MMSD Site | Milwaukee, WI | 5 Min | MMSD[c] | |
| WS1226 Franklin Public Works Yard | MMSD | MMSD Site | Milwaukee, WI | 5 Min | MMSD[c] | |

**Table continued on next page.**

## Table B.1 (Continued)

| Rain Gage Name | Gage Ownership | Location | County | Record Frequency | Online Data Availability | Notes |
|---|---|---|---|---|---|---|
| | | | | | | |
| **Gages outside of the Fox River Watershed in Wisconsin** | | | | | | |
| WS1229 MMSD Pump Station PS0302 | MMSD | MMSD Site | Milwaukee, WI | 5 Min | MMSD[c] | |
| 040870876 UNDERWOOD CR ON BIKE PATH/Rt 100 | USGS | USGS Site | Milwaukee, WI | 5 Min to 15 Min | USGS[a] | Currently data unavailable (April 2023) |
| 040871475 WILSON PARK CREEK @ GMIA OUTFALL #7 | USGS | USGS Site | Milwaukee, WI | 5 Min | USGS[a] | |
| Grafton AQS ID 55 089 0008 | NWS/DNR Cooperative | WDNR Site | Ozaukee, WI | 1 Hr | WDNR[d] | Not available during winter season |
| WS1214 Cedarburg | MMSD | MMSD Site | Ozaukee, WI | 5 Min | MMSD[c] | |
| Batten International Airport WBAN: 72642494818 | FAA Owned NWS Calibrated | Airport | Racine, WI | 1 Hr | NCEI[b] | |
| 04087233 Root River Canal Near Franklin, WI | NWS/USGS Cooperative | USGS Site | Racine, WI | 15 Min | USGS[a] | Not available during winter season |
| Southern Wisconsin Regional Airport WBAN:72641594854 | Public | Airport | Rock, WI | 20 Min | NCEI[b] | Does not monitor between 5am and 8pm |
| 05430175 YAHARA RIVER NEAR FULTON, WI | NWS/USGS Cooperative | USGS Site | Rock, WI | 15 Min | USGS[a] | Not available during winter season |
| West Bend Municipal Airport WBAN: 72641304875 | Public | Airport | Washington, WI | 20 Min | NCEI[b] | |
| WS1228 Germantown Public Works Yard | MMSD | MMSD Site | Washington, WI | 5 Min | MMSD[c] | |
| WS1218 Menomonee Falls Village Hall | MMSD | MMSD Site | Waukesha, WI | 5 Min | MMSD[c] | |
| Waukegan National Airport WBAN: 72534714880 | FAA | Airport | Lake, IL | 1 Hr | NCEI[b] | |
| 05527800 Des Plaines River @ Russell, IL | Uncertain | USGS Site | Lake, IL | 15 Min | USGS[a] | |
| 05528000 Des Plaines River Near Gurnee, IL | Uncertain | USGS Site | Lake, IL | 15 Min | USGS[a] | |
| 420910087490701 NB Chicago River at Deerfield, IL | Uncertain | USGS Site | Lake, IL | 5 Min | USGS[a] | |
| 421002087512501 WF of NB Chicago R at Deerfield, IL | Uncertain | USGS Site | Lake, IL | 5 Min | USGS[a] | |
| 05548105 Nippersink Creek Wonder Lake, IL | Uncertain | USGS Site | McHenry, IL | 15 Min | USGS[a] | |
| 05548280 Nippersink Creek Spring Grove, IL | Uncertain | USGS Site | McHenry, IL | 15 Min | USGS[a] | |
| 421747088270701 44N7E-17.8h1 (WOOD-08-01) | Uncertain | USGS Site | McHenry, IL | Unknown | USGS[a] | Currently equipment malfunction (April 2023) |
| 422834088255800 Hebron, IL | Uncertain | USGS Site | McHenry, IL | 5 Min | USGS[a] | |
| Chicago Rockford International Airport WBAN: 72543094822 | Public | Airport | Winnebago, IL | 1 Hr | NCEI[b] | |
| 421140088595600 Kishwaukee River Perryville, IL | Uncertain | USGS Site | Winnebago, IL | 15 Min | USGS[a] | |

[a] https://waterdata.usgs.gov/

[b] https://www.ncdc.noaa.gov/cdo-web/datatools/lcd

[c] https://www.mmsd.com/about-us/milwaukee-rain-facility-information

[d] https://airquality.wi.gov/Report/HourlyReports

## Table B.2
## Rainfall Data During July 2017 Storm Event from Sub-Daily Rain Gages

| County | Rain Gage Name and/or Designation | Rain Gage Location | Rain Gage Operator | Maximum 1-Hour Precipitation (Inches) | Estimated Annual Probability of Occurrence of Maximum 1-Hour Precipitation[a] (Percent) | Maximum 2-Hour Precipitation (Inches) | Estimated Annual Probability of Occurrence of Maximum 2-Hour Precipitation[a] (Percent) | Maximum 3-Hour Precipitation (Inches) | Estimated Annual Probability of Occurrence of Maximum 3-Hour Precipitation[a] (Percent) | Maximum 6-Hour Precipitation (Inches) | Estimated Annual Probability of Occurrence of Maximum 6-Hour Precipitation[a] (Percent) | Maximum 12-Hour Precipitation (Inches) | Estimated Annual Probability of Occurrence of Maximum 12-Hour Precipitation[a] (Percent) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Racine | WBAN:04866 | Burlington Municipal Airport | NWS Cooperator | 2.27 | ~4 | 2.82 | 4 to 10 | 3.87 | ~2 | 4.88 | 1 to 2 | 7.33 | ~0.2 |
| Kenosha | Fox River Near New Munster, WI (05545750) | -- | USGS | 2.17 | 4 to 10 | 3.59 | 1 to 2 | 4.51 | 0.5 to 1 | 5.13 | 1 to 2 | 7.82 | < 0.2 |

## Table B.3
## Rainfall Data During July 2017 Storm Event from Daily Rain Gages

| COUNTY | Rain Gage Name and/or Designation | Rain Gage Location | Rain Gage Operator | Maximum 24-Hour Precipitation (Inches) | Estimated Annual Probability of Occurrence of Maximum 24-Hour Precipitation[a] (Percent) | Maximum 48-Hour Precipitation (Inches) | Estimated Annual Probability of Occurrence of Maximum 48-Hour Precipitation[a] (Percent) | Maximum 72-Hour Precipitation (Inches) | Estimated Annual Probability of Occurrence of Maximum 72-Hour Precipitation[a] (Percent) | Maximum 5-Day Precipitation (Inches) | Estimated Annual Probability of Occurrence 0f Maximum 5-Day Precipitation[a] (Percent) | Maximum 10-Day Precipitation (Inches) | Estimated Annual Probability of Occurrence of Maximum 10-Day Precipitation[a] (Percent) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Racine | USC00471205 (BGTW3) | BURLINGTON-WWTP | NWS Cooperator | 4.95c | 2 to 4c | 7.95 | 0.2 to 0.5 | 8.06 | 0.5 to 1 | 9.18 | 0.2 to 0.5 | 9.85 | 0.5 to 1 |
| Racine | WBAN:04866 | Burlington Municipal Airport | NWS Cooperator | 7.35 | 0.2 to 0.5 | 7.35 | 0.5 to 1 | 8.58 | 0.2 to 0.5 | 8.8 | 0.5 to 1 | -- | -- |
| Racine | USC00477314 | ROCHESTER-WWTP | NWS Cooperator | 4.38 | 4 to 10 | 7.03 | 0.5 to 1 | 7.03 | 1 to 2 | 8.83 | ~0.5 | 9.85 | 0.5 to 1 |
| Walworth | WI-WW-2 | Lake Geneva 0.6 ENE | NWS CoCoRaHS | 5.24 | 2 to 4 | 5.97 | 2 to 4 | 6.68 | 2 | 7.41 | 1 to 2 | 7.71 | ~4 |
| Walworth | USC00476420 | PELL LAKE-WWTP | NWS Cooperator | 3.5 | 10 to 20 | 4.9 | 4 to 10 | 4.91 | ~10 | 5.73 | 4 to 10 | 6.19 | 10 to 20 |
| Walworth | WI-WW-1 | East Troy 2.5 NNE | NWS CoCoRaHS | 3.65 | 10 to 20 | 4.6 | 4 to 10 | 5.42 | 4 to 10 | 6.37 | ~4 | -- | -- |
| Waukesha | USC00478937 (WCCW3) | WAUKESHA-WWTP | NWS Cooperator | 4.16 | 4 to 10 | 4.4 | ~10 | 4.58 | 10 to 20 | 4.82 | 10 to 20 | 5.12 | 20 to 50 |
| Waukesha | WI-WK-4 | Waukesha 2.1 SSW | NWS CoCoRaHS | 3.05 | 20 to 50 | 3.96 | 10 to 20 | 3.96 | 20 to 50 | 4.14 | 20 to 50 | -- | -- |
| Waukesha | WI-WK-20 | Mukwonago 0.5 N | NWS CoCoRaHS | 3.13 | 20 to 50 | 3.73 | 20 to 50 | 3.8 | 20 to 50 | 4.4 | 20 to 50 | 5.63 | 20 to 50 |
| Waukesha | WI-WK-22 | Pewaukee 3.8 WSW | NWS CoCoRaHS | 2.97 | 20 to 50 | 4.32 | 10 to 20 | 4.32 | 10 to 20 | 4.72 | 10 to 20 | 5.37 | 20 to 50 |
| Waukesha | WI-WK-34 | Mukwonago 5.3 W | NWS CoCoRaHS | 4.42 | 4 to 10 | 5.27 | 4 to 10 | 7.45 | 1 to 2 | 8.3 | 0.5 to 1 | 10.3 | 0.5 to 1 |
| Waukesha | WI-WK-37 | Waukesha 2.0 NNW | NWS CoCoRaHS | 3.37 | 10 to 20 | 4.5 | ~10 | 4.5 | 10 to 20 | 4.84 | 10 to 20 | 5.32 | 20 to 50 |
| Waukesha | WI-WK-43 | Waukesha 7.2 SSW | NWS CoCoRaHS | 2.5 | 50 to 100 | 2.85 | 50 to 100 | -- | -- | -- | -- | -- | -- |
| Waukesha | WI-WK-51 | Waukesha 1.6 NW | NWS CoCoRaHS | 4.6 | ~4 | 4.6 | 4 to 10 | 4.94 | 4 to 10 | 4.96 | 10 to 20 | 5.41 | 20 to 50 |
| Kenosha | Fox River Near New Munster, WI - 05545750 | -- | USGS | 7.92 | < 0.2 | 7.94 | 0.2 to 0.5 | 8.88 | 0.2 to 0.5 | 9.13 | ~0.5 | 9.41 | ~1 |

# APPENDIX C

## INFRASTRUCTURE DATA

**Table C.1**
**Identified Major Roadway Flooding Locations**
**FEMA Effective Floodplain**

| Road Name | Flooding Source | 1% AP (100-Year) Flood Depth (feet) | County |
|---|---|---|---|
| CTH F / Silver Lake Rd | Unnamed trib to Fox River | 0.9 | Kenosha |
| CTH W | Fox River | 1 | Kenosha |
| CTH W | Fox River | 1.2 | Kenosha |
| 296th Ave | Fox River | 1.8 | Kenosha |
| STH 83 | Fox River | 1.75 | Kenosha |
| CTH W / 328th Ave | Fox River | 3.4 | Kenosha |
| CTH J1 | Bassett Creek | 0.5 | Kenosha |
| Bassett Rd | Bassett Creek | 0.5 | Kenosha |
| 288th Ave / County Line Road | Unnamed trib to Hoosier Creek Canal | 2.5 | Kenosha |
| CTH W / 328th Ave | Fox River | 1.5 | Kenosha |
| Burmeister Rd | Goose Lake Branch Canal | 3.9 | Racine |
| CTH S / E Wind Lake Rd | Wind Lake Drainage Canal | 1.6 | Racine |
| Marsh Rd | Unnamed trib to Fox River | 0.5 | Racine |
| Marsh Rd | Unnamed trib to Fox River | 0.5 | Racine |
| Church Rd | Eagle Creek | 0.4 | Racine |
| CTH A / Plank Rd | Eagle Creek | 0.3 | Racine |
| Church Rd & Church Dr | Eagle Creek | 4.7 | Racine |
| CTH J / English Settlement Rd | Hoosier Creek Canal | N/A | Racine |
| Fish Hatchery Rd | Spring Brook | 0.7 | Racine |
| Fish Hatchery Rd | Spring Brook | 2.8 | Racine |
| Fish Hatchery Rd | Spring Brook | 3.5 | Racine |
| Maple Rd | Long Lake Channel | 2.2 | Racine |
| Springfield Rd | Ore Creek | 0.5 | Walworth |
| USH 12 | Unnamed Trib 3 to Sugar Creek | 0.2 | Walworth |
| Hodunk Rd. | Unnamed Trib 2 to Sugar Creek | 3.8 | Walworth |
| STH 120 | Unnamed Trib 1 to Sugar Creek | 0.5 | Walworth |
| CTH NN | Unnamed Trib 1 to Como Creek | 1.4 | Walworth |
| STH 120 | Ore Creek | 0.3 | Walworth |
| STH 36 | Ore Creek | 1.7 | Walworth |
| USH 12 Westbound | Bloomfield Creek | 0.7 | Walworth |
| USH 12 Eastbound | Bloomfield Creek | 0.8 | Walworth |
| Bloomfield Rd | Pell Lake Tributary 2 | 1.5 | Walworth |
| CTH U | Pell Lake Tributary | 0.2 | Walworth |
| CTH U | East Branch Nippersink Creek | 1.2 | Walworth |
| Twin Lakes Rd (CTH B) | East Branch Nippersink Creek | 1 | Walworth |
| CTH D | Honey Creek | 0.6 | Walworth |
| Powers Lake Rd | East Branch Nippersink Creek | 0.4 | Walworth |
| CTH G | Pewaukee Lake Tributary 2 | N/A | Waukesha |
| Calhoun Rd | Poplar Creek | 1.4 | Waukesha |
| CTH KE | West Branch Pewaukee Lake Trib | N/A | Waukesha |

**Table continued on next page.**

**Table C.1 (Continued)**

**FEMA Effective Floodplain**

| Road Name | Flooding Source | 1% AP (100-Year) Flood Depth (feet) | County |
|---|---|---|---|
| CTH SS | Pewaukee Lake Tributary 2 | N/A | Waukesha |
| Capitol Dr (CTH JJ) | Pewaukee Lake Tributary | 1 | Waukesha |
| CTH D | Genesee Creek | N/A | Waukesha |
| N Barker Rd (CTH Y) | Poplar Creek | 0.6 | Waukesha |
| Cleveland Ave | Unnamed Trib 3 to Poplar Creek | N/A | Waukesha |
| CTH X | Jericho Creek | 1 | Waukesha |
| Lannon Rd (CTH Y) | Fox River | 0.8 | Waukesha |
| Mill Rd | Fox River | 1.7 | Waukesha |
| Good Hope Rd | Fox River | 0.8 | Waukesha |
| Main St (CTH F) | Fox River | 1 | Waukesha |
| Lannon Rd | Fox River | 0.2 | Waukesha |
| CTH E | Mukwonago River | 3.2 | Waukesha |
| CTH LO | Jericho Creek | 1.6 | Waukesha |
| Sandy Beach Dr (Woods Road) | Quietwood Creek | 0.1 | Waukesha |
| CTH LO | Mukwonago River | 3.3 | Waukesha |
| Rd X | Spring Brook | N/A | Waukesha |
| Edgewood Ave | Artesian Brook | N/A | Waukesha |
| CTH I | Fox River | 0.1 | Waukesha |
| STH 18 | Fox River | 2.7 | Waukesha |
| Barker Rd (CTH Y) | Fox River | 2.7 | Waukesha |
| Lannon Rd (CTH Y) | Fox River | 0.4 | Waukesha |
| Marcy Rd | Unnamed Trib 4 to Fox River | N/A | Waukesha |
| Calhoun Rd | Calhoun Creek | 0.3 | Waukesha |
| Southwest Ave | Pebble Brook Tributary | 1.4 | Waukesha |
| CTH E | Jericho Creek | 0.7 | Waukesha |
| CTH K | Sussex Creek Tributary 1 | 2.2 | Waukesha |
| CTH F | Sussex Creek | 0.3 | Waukesha |
| Waukesha Ave | East Branch Sussex Creek | 0.01 | Waukesha |
| CTH VV | Sussex Creek | 2.7 | Waukesha |
| Calhoun Rd | Poplar Creek | 0.3 | Waukesha |

**Table continued on next page.**

**Table C.1 (Continued)**

**FEMA Preliminary Floodplain**

| Road Name | Flooding Source | 1% AP (100-Year) Flood Depth (feet) | County |
|---|---|---|---|
| CTH W / 328th Ave | Fox River | 2.1 | Kenosha |
| CTH J1 | Bassett Creek | 0.1 | Kenosha |
| CTH F / Silver Lake Rd | Unnamed trib to Fox River | 0.9 | Kenosha |
| CTH W / 328th Ave | Fox River | 3.1 | Kenosha |
| STH 83 | Fox River | 1.7 | Kenosha |
| 296th Ave | Fox River | 2 | Kenosha |
| CTH W | Fox River | 1.5 | Kenosha |
| CTH W | Fox River | 1.1 | Kenosha |
| 288th Ave / County Line Road | Unnamed trib to Hoosier Creek Canal | 3.1 | Kenosha |
| CTH KD / 352nd Ave | New Munster Creek | 1.3 | Kenosha |
| CTH B / 288th Ave | Peterson Creek | 0.6 | Kenosha |
| Bassett Rd | Bassett Creek | 0.2 | Kenosha |
| Marsh Rd | Unnamed trib to Fox River | 0.6 | Racine |
| CTH J / English Settlement Rd | Hoosier Creek Canal | 3.4 | Racine |
| Marsh Rd | Unnamed trib to Fox River | 1 | Racine |
| Milwaukee Ave | Unnamed Tributary 4 to Fox River | 4.3 | Racine |
| Fisherman Rd / Oakwood St | Spring Brook | 1.5 | Racine |
| STH 75 / S Beaumont Ave | East Eagle Lake Ditch | 0.4 | Racine |
| Fish Hatchery Rd | Spring Brook | 0.7 | Racine |
| Fish Hatchery Rd | Spring Brook | 2.8 | Racine |
| Fish Hatchery Rd | Spring Brook | 3.5 | Racine |
| CTH W / Browns Lake Dr | Unnamed Tributary 8 to Fox River | 0.3 | Racine |
| Church Rd & Church Dr | Eagle Creek | 4.6 | Racine |
| CTH S / E Wind Lake Rd | Wind Lake Drainage Canal | 1.6 | Racine |
| Burmeister Rd | Goose Lake Branch Canal | 3.9 | Racine |
| CTH JB / 31st St | Unnamed Tributary 7 to Fox River | 5 | Racine |
| CTH A / Plank Rd | Eagle Creek | 1.4 | Racine |
| Maple Rd | Long Lake Channel | 2.2 | Racine |
| CTH XX | Mill Brook | 0.9 | Waukesha |
| CTH I | Unnamed Trib to Calhoun Creek | 1.7 | Waukesha |
| CTH LO | Jericho Creek | 1.6 | Waukesha |
| CTH E | Jericho Creek | 0.7 | Waukesha |
| CTH LO | Mukwonago River | 3.3 | Waukesha |
| CTH X | Jericho Creek | 1 | Waukesha |
| Edgewood Ave | Horseshoe Brook | 0.9 | Waukesha |
| Lannon Rd (CTH Y) | Fox River | 0.8 | Waukesha |
| CTH I | Fox River | 0.7 | Waukesha |
| STH 18 | Fox River | 2.3 | Waukesha |
| Barker Rd (CTH Y) | Fox River | 1.5 | Waukesha |
| Lannon Rd (CTH Y) | Fox River | 2.3 | Waukesha |
| Marcy Rd | Unnamed Trib 4 to Fox River | 1.9 | Waukesha |

**Table continued on next page.**

**Table C.1 (Continued)**
**FEMA Preliminary Floodplain**

| Road Name | Flooding Source | 1% AP (100-Year) Flood Depth (feet) | County |
|---|---|---|---|
| Edgewood Ave | Artesian Brook | 1.1 | Waukesha |
| CTH XX | Pebble Brook Split Flow | 0.3 | Waukesha |
| Marcy Rd | Unnamed Trib 2 to Fox River | 1.3 | Waukesha |
| CTH E | Mukwonago River | 3.2 | Waukesha |
| Good Hope Rd | Willow Springs Creek | 0.3 | Waukesha |
| Calhoun Rd | Calhoun Creek | 0.3 | Waukesha |
| CTH Y | Fox River Trib 2 | 0.2 | Waukesha |
| CTH V | Fox River Trib 2 | 0.5 | Waukesha |
| Mill Rd | Willow Springs Creek | 0 | Waukesha |
| Calhoun Rd | Poplar Creek | 0.3 | Waukesha |
| CTH K | Sussex Creek Tributary 1 | 2.2 | Waukesha |
| CTH F | Sussex Creek | 0.3 | Waukesha |
| Cleveland Ave | Unnamed Trib 3 to Poplar Creek | 3.7 | Waukesha |
| CTH I | Pebble Brook | 0.2 | Waukesha |
| Southwest Ave | Pebble Brook Tributary | 1.6 | Waukesha |
| STH 59 | Pebble Brook Tributary | 0.4 | Waukesha |
| STH 83 | South Branch Genesee Creek | 0.1 | Waukesha |
| Calhoun Rd | Poplar Creek | 1.4 | Waukesha |
| Capitol Dr (CTH JJ) | Pewaukee Lake Tributary | 1 | Waukesha |
| CTH KE | West Branch Pewaukee Lake Trib | 0.6 | Waukesha |
| N Barker Rd (CTH Y) | Poplar Creek | 0.6 | Waukesha |
| CTH D | Genesee Creek | 0.3 | Waukesha |

Note: No FEMA preliminary floodplain exists for Walworth County at the time of this study. For the lastest information on roadway flooding in Walwoth County, use the FEMA effective floodplain table in this appendix.

*Source: SEWRPC*

## Table C.2
## Available Bridge Condition Ratings for Roadways Identified to Flood During the 1-Percent-Annual-Probability Flood Event

| | | | | | NBI Ratings | | | | | | 1% AP Floodplain | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Effective | Preliminary |
| Roadway | Watercourse | County | Built Year | Inspection | Deck | Superstructure | Substructure | Culvert | Channel | Waterway | Flood Depth (ft) | Flood Depth (ft) |
| CTH LO | Jericho Creek | Waukesha | 2003 | 2020 | N | N | N | 7 | 8 | 8 | 1.6 | 1.6 |
| CTH XX | Pebble Brook | Waukesha | 1980 | 2021 | N | N | N | 4 | 8 | 8 | No Flooding | 0.3 |
| STH 83 | South Branch Genesee Creek | Waukesha | 2020 (Repair Wings) | 2020 | 7 | 7 | 7 | N | 7 | 7 | No Flooding | 0.1 |
| CTH Y | Poplar Creek | Waukesha | 2004 | 2020 | 7 | 7 | 8 | N | 7 | 8 | 0.6 | 0.6 |
| CTH JJ | Pewaukee Lake Trib | Waukesha | 1940 | 2021 | N | N | N | 4 | 7 | 3 | 1 | 1 |
| CTH VV | Sussex Creek | Waukesha | 2017 | 2020 | N/A | 9 | 9 | N | 8 | 8 | 2.7 | -1.7 |
| CTH Y (Lannon Rd) | Fox River | Waukesha | 2013 | 2020 | 8 | 8 | 8 | N | 7 | 8 | 0.8 | 0.8 |
| Mill Rd | Fox River | Waukesha | 1999 | 2020 | 7 | 7 | 7 | N | 8 | 6 | 1.7 | No Flooding |
| CTH F | Fox River | Waukesha | 1970 | 2020 | N | N | N | 6 | 8 | 6 | 1 | No Flooding |
| CTH J | Hoosier Creek Canal | Racine | 2008 | 2020 | 7 | 7 | 8 | N | 7 | 8 | Zone A Flooding | Zone A Flooding |
| CTH S | Wind Lake Drainage Canal | Racine | 2006 | 2020 | 7 | 7 | 8 | N | 7 | 8 | 1.6 | 1.6 |
| STH 83 NB | Fox River | Kenosha | 1986/2010 (Concrete Overlay) | 2020 | 7 | 7 | 6 | N | 5 | 9 | 1.75 | 1.75 |
| STH 83 SB | Fox River | Kenosha | 1986/2010 (Concrete Overlay) | 2020 | 7 | 8 | 7 | N | 5 | 9 | 1.75 | 1.75 |
| CTH W | Fox River | Kenosha | 1930 | 2022 | N | N | N | 5 | 8 | 8 | 3.4 | 3.4 |
| CTH B | East Branch Nippersink Creek | Walworth | 1989 | 2020 | 5 | 5 | 6 | N | 6 | 8 | 1 | 1 |
| CTH U | East Branch Nippersink Creek | Walworth | 2021 | 2021 | 9 | 9 | 8 | N | 9 | 9 | 1.2 | 1.2 |
| STH 120 | Ore Creek | Walworth | 1995 | 2021 | 7 | 7 | 8 | N | 8 | 8 | No Flooding | 0.3 |
| STH 36 | Ore Creek | Walworth | 1977/1997/2004/2014 (Overlay and Repairs) | 2021 | 6 | 5 | 6 | N | 5 | 8 | Zone A Flooding | 1.7 |
| Hodunk Rd | Sugar Creek | Walworth | 1971/2014 (Repairs) | 2020 | N | N | N | 7 | 8 | 8 | No Flooding | 3.8 |
| CTH D | Honey Creek | Walworth | 1983 | 2020 | 5 | 5 | 7 | N | 8 | 8 | 0.6 | 0.6 |

| Condition Rating | Description |
|---|---|
| N | NOT APPLICABLE |
| 9 | EXCELLENT CONDITION |
| 8 | VERY GOOD CONDITION - no problems noted. |
| 7 | GOOD CONDITION - some minor problems. |
| 6 | SATISFACTORY CONDITION - structural elements show some minor deterioration. |
| 5 | FAIR CONDITION - all primary structural elements are sound but may have minor section loss, cracking, spalling, or scour. |
| 4 | POOR CONDITION - advanced section loss, deterioration, spalling, or scour. |
| 3 | SERIOUS CONDITION - loss of section, deterioration, spalling, or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present. |
| 2 | CRITICAL CONDITION - advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken. |
| 1 | "IMMINENT" FAILURE CONDITION - major deterioration or section loss present in critical structural components, or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic but corrective action may put bridge back in light service. |
| 0 | FAILED CONDITION - out of service, beyond corrective action. |

**Figure 1.5.4-1: FHWA General Rating Guidelines for NBI Inspections**

## Table C.3
## Bridges and Culverts Over Watercourses Managed by Wisconsin Department of Transportation in the Fox River Watershed

**2021 NBI Dateset**

| | | | | | | Condition Rating | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Structure Number | County | Waterbody | Road | Location | Year Built | Deck | Superstructure | Substructure | Channel | Culvert | Structure Minimum | Inspection Date (MMYY) |
| STRUCTURE_NUMBER_008 | | FEATURES_DESC_006A | FACILITY_CARRIED_007 | LOCATION_009 | YEAR_BUILT_027 | DECK_COND_058 | SUPERSTRUCTURE_COND_059 | SUBSTRUCTURE_COND_060 | CHANNEL_COND_061 | CULVERT_COND_062 | | DATE_OF_INSPECT_090 |
| P30091300000000 | Kenosha | BR FOX RIVER | CTH JB | 1.7M W JCT STH 75 | 1940 | N | N | N | 5 | 7 | 7 | 520 |
| P30091400000000 | Kenosha | BR FOX RIVER | CTH W | 0.2M N JCT CTH K | 1930 | N | N | N | 8 | 5 | 5 | 520 |
| B30011900000000 | Kenosha | CAMP LAKE CANAL | LRD 286TH AVE | 0.2 M SOUTH OF CTH W | 2010 | 8 | 8 | 9 | 8 | N | 8 | 520 |
| B30004100000000 | Kenosha | FOX RIVER | CTH JB | 0.8M W JCT CTH W | 1969 | 5 | 8 | 5 | 7 | N | 5 | 520 |
| B30005100000000 | Kenosha | FOX RIVER | STH 50 WB-STH 83 N | 2.4M W JCT CTH B | 1986 | 7 | 7 | 6 | 5 | N | 6 | 720 |
| B30005700000000 | Kenosha | FOX RIVER | STH 50 EB-STH 83 S | 0.8M E JCT STH 83 TO N | 1989 | 7 | 8 | 7 | 5 | N | 7 | 620 |
| B30025800000000 | Kenosha | FOX RIVER | CTH C | 0.2M W JCT CTH B | 1936 | 7 | 7 | 6 | 8 | N | 6 | 520 |
| B30066800000000 | Kenosha | FOX RIVER | CTH F | 0.2M W JCT CTH B | 1929 | 7 | 8 | 5 | 7 | N | 5 | 520 |
| P30091500000000 | Kenosha | NEW MUNSTER CREEK | CTH KD | 0.1M N JCT STH 50 | 1993 | N | N | N | 7 | 8 | 8 | 520 |
| B51009300000000 | Racine | CN RR/FOX RIVER | STH 11 NB | 0.15 MI E OF STH 83 | 2007 | 7 | 7 | 8 | 8 | N | 7 | 719 |
| B51009400000000 | Racine | CN RR/FOX RIVER | STH 11 SB | 0.15 MI E OF STH 83 | 2007 | 7 | 7 | 8 | 8 | N | 7 | 719 |
| B51011500000000 | Racine | CROSS CANAL | CTH S | 1.0M N WASHINGTON AVE. | 2006 | 7 | 7 | 8 | 7 | N | 7 | 1020 |
| B51012000000000 | Racine | FOX R | LRD FOX ISLE DR | 0.1MI N OF STH 20 | 2007 | 7 | 7 | 8 | 8 | N | 7 | 520 |
| B51000100000000 | Racine | FOX RIVER | LRD JEFFERSON ST | 0.2M E JCT STH 83 TO S | 1949 | 6 | 5 | 5 | 8 | N | 5 | 520 |
| B51000500000000 | Racine | FOX RIVER | CTH W | 0.1M N JCT CTH A | 1955 | 5 | 5 | 6 | 8 | N | 5 | 1020 |
| B51004600000000 | Racine | FOX RIVER | STH 11 | FOX RIVER | 2003 | 7 | 8 | 7 | 7 | N | 7 | 520 |
| B51005600000000 | Racine | FOX RIVER | STH 36/STH 83 SB | 2.2 MI S JCT STH 20 | 1967 | 4 | 5 | 5 | 8 | N | 4 | 720 |
| B51006300000000 | Racine | FOX RIVER | LRD BRIDGE DR | 1.9M W JCT STH 164 | 1982 | 6 | 7 | 7 | 8 | N | 6 | 1020 |
| B51007800000000 | Racine | FOX RIVER | STH 36-STH 83 NB | 1.2M N JCT CTH W | 1996 | 7 | 7 | 7 | 8 | N | 7 | 418 |
| B51010200000000 | Racine | FOX RIVER | STH 36EB/STH83NB | 0.4 MI N CTH A | 2007 | 7 | 8 | 6 | 8 | N | 6 | 719 |
| B51010300000000 | Racine | FOX RIVER | STH 36WB/STH83SB | 0.4 MI N CTH A | 2007 | 6 | 8 | 8 | 8 | N | 6 | 719 |
| B51014900000000 | Racine | FOX RIVER | CTH D | .1M E JCT CTH W | 2016 | 7 | 9 | 7 | 8 | N | 7 | 1020 |
| B51015000000000 | Racine | FOX RIVER | STH 20/STH 83/MAIN | 1.3 MI E JCT STH 83 | 2020 | 8 | 9 | 9 | 9 | N | 8 | 420 |
| B51001400000000 | Racine | GOOSE LAKE BRANCH CANAL | LRD HANSON RD | 0.7M E JCT CTH S | 1997 | 6 | 6 | 8 | 8 | N | 6 | 1020 |
| B51001900000000 | Racine | GOOSE LAKE BRANCH CANAL | CTH K | 0.3M E JCT CTH S | 1938 | 6 | 5 | 5 | 8 | N | 5 | 1020 |
| B51005500000000 | Racine | GOOSE LAKE BRANCH CANAL | CTH G | 1.8M W JCT USH 45 | 1966 | 5 | 5 | 7 | 7 | N | 5 | 1020 |
| P51004900000000 | Racine | GOOSE LAKE BRANCH CANAL | LRD JACOBS RD | 0.3M S JCT CTH K | 1967 | 7 | 8 | 6 | 8 | N | 6 | 1020 |
| P51090300000000 | Racine | GOOSE LAKE BRANCH CANAL | LRD W OVERSON RD | 0.4M S JCT CTH K | 1964 | 3 | 8 | 4 | 8 | N | 3 | 1020 |
| B51008500000000 | Racine | HONEY CREEK | STH 20 | 4.7M E JCT IH-43 | 1995 | 6 | 7 | 7 | 7 | N | 6 | 420 |
| P51005200000000 | Racine | HONEY CREEK | LRD SPRING PRAIRIE | 1.1M N JCT STH 11 | 1965 | 4 | 4 | 6 | 7 | N | 4 | 1220 |
| B51009600000000 | Racine | HOOSIER CR | STH 11 BYPASS | 2.1M N JCT STH 38 | 2006 | N | N | N | 8 | 7 | 7 | 520 |
| B51008800000000 | Racine | HOOSIER CREEK | STH 142 | 0.7 MI E JCT STH 83 | 1999 | N | N | N | 6 | 6 | 6 | 420 |
| P51091000000000 | Racine | HOOSIER CREEK | LRD BREVER RD | 1.5M S JCT STH 142 | 1972 | 7 | 7 | 7 | 8 | N | 7 | 1220 |
| P51091100000000 | Racine | HOOSIER CREEK | LRD MT TOM RD | 0.7M W JCT CTH J | 1965 | 5 | 4 | 6 | 8 | N | 4 | 1220 |
| B51011800000000 | Racine | HOOSIER CREEK CANAL | CTH J | 1.1 M SOUTH OF STH 11 | 2008 | 7 | 7 | 8 | 7 | N | 7 | 1020 |
| B51007500000000 | Racine | MUSKEGO CANAL | LRD LOOMIS RD | 0.6M W JCT CTH S | 1991 | 7 | 8 | 7 | 8 | N | 7 | 1020 |
| B51008200000000 | Racine | SPRING BROOK | STH S PINE STREET | 4.3M N JCT CTH JB TO E | 1996 | N | N | N | 8 | 7 | 7 | 520 |
| B51009900000000 | Racine | SPRING BROOK | STH 11 EB | 0.5 MI N JCT STH 36 | 2008 | 7 | 7 | 8 | 8 | N | 7 | 518 |
| B51010000000000 | Racine | SPRING BROOK | STH 11 WB | 1.0 MI W JCT STH 83 | 2008 | 7 | 7 | 8 | 8 | N | 7 | 518 |
| B51000800000000 | Racine | WHITE RIVER | STH 36-MILWAUKEE A | 0.1M N JCT STH 83 TO S | 1956 | 6 | 6 | 6 | 8 | N | 6 | 520 |
| B51006500000000 | Racine | WHITE RIVER | LRD BRIDGE STREET | 0.1M N JCT STH 11 TO W | 1983 | 6 | 6 | 6 | 8 | N | 6 | 520 |
| P51005300000000 | Racine | WHITE RIVER | LRD BIENEMAN RD | 0.1M N JCT STH 11 | 1973 | 6 | 7 | 7 | 8 | N | 6 | 1220 |
| B51004200000000 | Racine | WIND LAKE DR CANAL | CTH K | 1.4M W JCT CTH S | 1975 | 5 | 6 | 6 | 7 | N | 5 | 1020 |
| B51005100000000 | Racine | WIND LAKE DRAINAGE CANAL | LRD E MAIN DR | 0.8M S JCT CTH K | 1965 | 4 | 6 | 4 | 8 | N | 4 | 1020 |
| B51005700000000 | Racine | WIND LAKE DRAINAGE CANAL | STH 36-STH 83 SB | 0.4M N JCT CTH D | 1967 | 5 | 6 | 6 | 6 | N | 5 | 420 |
| B51007300000000 | Racine | WIND LAKE DRAINAGE CANAL | STH 20 | 0.4M E JCT STH 36 | 1997 | 7 | 8 | 8 | 8 | N | 7 | 418 |
| B51007900000000 | Racine | WIND LAKE DRAINAGE CANAL | STH 36-STH 83 NB | 0.4M N JCT CTH D | 1996 | 7 | 8 | 7 | 8 | N | 7 | 420 |
| B51015200000000 | Racine | WIND LAKE DRAINAGE CANAL | LRD MALCHINE RD | 1.5M W JCT CTH S | 2016 | 8 | 8 | 8 | 8 | N | 8 | 1020 |
| B51012200000000 | Racine | WIND LAKE DRAINAGE CHNL | LRD N ROCHESTER ST | 0.1M N JCT CTH D | 2008 | 7 | 7 | 8 | 8 | N | 7 | 1020 |

**Table continued on next page.**

## Table C.3 (Continued)

| Structure Number | County | Waterbody | Road | Location | Year Built | Condition Rating: Deck | Superstructure | Substructure | Channel | Culvert | Structure Minimum | Inspection Date (MMYY) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STRUCTURE_NUMBER_008 | | FEATURES_DESC_006A | FACILITY_CARRIED_007 | LOCATION_009 | YEAR_BUILT_027 | DECK_COND_058 | SUPERSTRUCTURE_COND_059 | SUBSTRUCTURE_COND_060 | CHANNEL_COND_061 | CULVERT_COND_062 | | DATE_OF_INSPECT_090 |
| B51000900000000 | Racine | WINDLAKE DRAINAGE CANAL | LRD S WIND LAKE RD | 0.7M W JCT CTH S | 1957 | 5 | 5 | 6 | 8 | N | 5 | 1020 |
| B64003700000000 | Walworth | BR COMO CREEK | USH 12 EB | 4.0 MI E JCT IH 43 MILE P | 1967 | N | N | N | 7 | 7 | 7 | 720 |
| B64003800000000 | Walworth | BR COMO CREEK | USH 12 WB | 2.0 MI W JCT STH 120 | 1967 | N | N | N | 7 | 6 | 6 | 720 |
| P64090700000000 | Walworth | BR ORE CREEK | LRD HOSPITAL RD | 0.8M W JCT STH 36 | 1920 | 4 | 3 | 4 | 7 | N | 3 | 820 |
| B64008000000000 | Walworth | BR SUGAR CREEK | STH 120 | 2.8 MI N JCT STH 11 | 1995 | 7 | 7 | 8 | 7 | N | 7 | 419 |
| B64016800000000 | Walworth | BR WHITE R | STH 36 | 3.8 MI E JCT STH 120 | 2009 | N | N | N | 6 | 8 | 8 | 1019 |
| B64013000000000 | Walworth | BR. NIPPERSINK BROOK | LRD WESTSIDE ROAD | 2.0 MILES N. JCT CTH B | 2004 | 7 | 7 | 8 | 8 | N | 7 | 820 |
| B64003400000000 | Walworth | COMO CREEK | USH 12 | 5.0 MI E JCT IH 43 MILE P | 1967 | N | N | N | 8 | 6 | 6 | 720 |
| B64018200000000 | Walworth | COMO CREEK | STH 120 | 1.0 MI N JCT USH 12 | 2018 | 8 | 8 | 8 | 8 | N | 8 | 1020 |
| B64043800000000 | Walworth | COMO CREEK | CTH H | 0.3M N JCT CTH NN | 1941 | N | N | N | 5 | 6 | 6 | 820 |
| B64000300000000 | Walworth | E BR NIPPERSINK CREEK | CTH U | 0.6M N JCT CTH B | 1948 | 4 | 4 | 4 | 8 | N | 4 | 820 |
| B64002000000000 | Walworth | E BR NIPPERSINK CREEK | USH 12 | 0.3M E JCT CTH U | 1965 | N | N | N | 6 | 7 | 7 | 720 |
| B64006900000000 | Walworth | E BR NIPPERSINK CREEK | LRD TWIN LAKES RD | 0.6M W JCT CTH B | 1989 | 5 | 5 | 8 | 8 | N | 5 | 820 |
| P64092100000000 | Walworth | GREEN LAKE | LRD LAUDERDALE ROA | 0.5MI W JCT STH 67 | 1915 | 4 | 4 | 3 | 8 | N | 3 | 820 |
| B64000500000000 | Walworth | HONEY CREEK | CTH ES | 0.3M E JCT CTH N | 1949 | N | N | N | 7 | 6 | 6 | 820 |
| B64002100000000 | Walworth | HONEY CREEK | CTH N | 0.2M N JCT CTH ES | 1977 | N | N | N | 7 | 6 | 6 | 820 |
| B64011200000000 | Walworth | HONEY CREEK | IH 43 NB | 0.9 MI N JCT STH 120 | 1971 | N | N | N | 7 | 6 | 6 | 820 |
| B64011300000000 | Walworth | HONEY CREEK | IH 43 SB | 0.85 MI S JCT STH 20 | 1971 | N | N | N | 7 | 6 | 6 | 820 |
| B64014700000000 | Walworth | HONEY CREEK | CTH D | 0.1M W JCT CTH DD | 1983 | 5 | 5 | 7 | 8 | N | 5 | 820 |
| B64017300000000 | Walworth | HONEY CREEK | STH 20 | 1.5 MI E JCT IH 43 | 2010 | 7 | 8 | 8 | 9 | N | 7 | 1018 |
| B64019800000000 | Walworth | HONEY CREEK | CTH DD | 2.8M S JCT CTH D | 2017 | 7 | 7 | 9 | 8 | N | 7 | 820 |
| B64020300000000 | Walworth | HONEY CREEK | CTH G | 0.4 MI N JCT STH 43 | 2018 | 7 | 9 | 7 | 9 | N | 7 | 820 |
| P64005500000000 | Walworth | HONEY CREEK | LRD BELL SCHOOL RD | 1.3M N JCT STH 20 | 1930 | N | N | N | 7 | 6 | 6 | 820 |
| P64005600000000 | Walworth | HONEY CREEK | LRD HILL VALEY RD | 0.8M N JCT STH 20 | 1930 | N | N | N | 7 | 6 | 6 | 820 |
| P64090600000000 | Walworth | LAKE GENEVA TRIBUTARY | LRD LACKEY LANE (D | 1.5M N JCT CTH BB | 1930 | 6 | 6 | 4 | 6 | N | 4 | 820 |
| B64005500000000 | Walworth | N BR NIPPERSINK CREEK | LRD DARLING RD | 0.8M S JCT CTH B | 1985 | 5 | 5 | 6 | 7 | N | 5 | 820 |
| B64007300000000 | Walworth | N BR NIPPERSINK CREEK | CTH B | 2.8M W JCT CTH H TO E | 1989 | N | N | N | 7 | 7 | 7 | 820 |
| B64007400000000 | Walworth | NIPPERSINK CREEK | CTH B | 0.1M W JCT CTH H TO E | 1989 | 5 | 5 | 6 | 6 | N | 5 | 820 |
| B64007600000000 | Walworth | NIPPERSINK CREEK | LRD DARLING RD | 0.6M N JCT CTH H | 1992 | 5 | 5 | 7 | 7 | N | 5 | 820 |
| B64015500000000 | Walworth | NIPPERSINK CREEK | CTH H | 0.1M N JCT CTH B TO N | 1982 | 5 | 7 | 7 | 8 | N | 5 | 820 |
| B64017400000000 | Walworth | NIPPERSINK CREEK | LRD MOHAWK RD | 1.7M S JCT CTH B | 2011 | 7 | 7 | 8 | 9 | N | 7 | 820 |
| B64017500000000 | Walworth | NIPPERSINK CREEK | LRD MOHAWK RD | 2.2M S JCT CTH B | 2010 | 7 | 7 | 8 | 9 | N | 7 | 820 |
| P64090200000000 | Walworth | NIPPERSINK CREEK | LRD BISSEL RD | 1.5M S JCT CTH B | 1920 | 5 | 4 | 4 | 8 | N | 4 | 820 |
| B64006800000000 | Walworth | ORE CREEK | STH 36 | 0.7M N JCT STH 120 | 1986 | N | N | N | 6 | 8 | 8 | 319 |
| B64008100000000 | Walworth | ORE CREEK | STH 120 | 2.0 MI N JCT USH 12 | 1995 | 7 | 7 | 8 | 8 | N | 7 | 419 |
| B64066500000000 | Walworth | ORE CREEK | STH 36 | 2.5M N JCT STH 120 | 1929 | 6 | 5 | 6 | 5 | N | 5 | 320 |
| P64091800000000 | Walworth | ORE CREEK | LRD CHURCH STREET | 0.6M S JCT STH 36 | 1964 | N | N | N | 4 | 6 | 6 | 820 |
| B64017200000000 | Walworth | SAND CREEK | LRD SPRING VALLEY | 1.65M S JCT STH 36 | 2012 | 7 | 7 | 8 | 8 | N | 7 | 820 |
| P64091700000000 | Walworth | SAND CREEK | LRD WARREN RD | 3.6M N JCT STH 50 | 1971 | N | N | N | 6 | 7 | 7 | 820 |
| B64057400000000 | Walworth | SOUTHWICK CREEK | LRD GENEVA ST | 0.2M E JCT STH 67 | 1939 | 7 | 7 | 5 | 8 | N | 5 | 820 |
| B64016000000000 | Walworth | SPRING CREEK | STH 20 | 2.4 MI E JCT STH 20/IH 43 | 2002 | 7 | 8 | 7 | 8 | N | 7 | 319 |
| B64016200000000 | Walworth | STH 11 & WHITE RIVER | STH 36 | 5.7 M EAST OF STH 120 | 2009 | 6 | 7 | 6 | 7 | N | 6 | 1019 |
| B64000200000000 | Walworth | SUGAR CREEK | LRD POTTER RD | 1.3M W JCT CTH DD | 1999 | 7 | 8 | 7 | 8 | N | 7 | 820 |
| B64000900000000 | Walworth | SUGAR CREEK | CTH ES | 0.3M W JCT USH 12 | 2001 | 7 | 7 | 7 | 7 | N | 7 | 820 |
| B64006000000000 | Walworth | SUGAR CREEK | USH 12/STH 67 | 0.6 MI E JCT CTH A | 1966 | 4 | 4 | 6 | 6 | N | 4 | 320 |
| B64007000000000 | Walworth | SUGAR CREEK | LRD HODGES RD | 0.5M N JCT CTH ES | 1989 | 6 | 6 | 8 | 8 | N | 6 | 820 |
| B64009500000000 | Walworth | SUGAR CREEK | LRD HODUNK RD | 1.3 MI S JCT CTH D | 1971 | N | N | N | 8 | 7 | 7 | 820 |
| B64011000000000 | Walworth | SUGAR CREEK | IH 43 NB | 3.3 MI N JCT STH 11 | 1971 | N | N | N | 6 | 6 | 6 | 820 |
| B64011100000000 | Walworth | SUGAR CREEK | IH 43 SB | 4.8 MI S JCT STH 120 | 1971 | N | N | N | 6 | 6 | 6 | 820 |
| B64015800000000 | Walworth | SUGAR CREEK | LRD BOWERS ROAD | 0.9M S JCT CTH D | 1983 | 7 | 8 | 7 | 8 | N | 7 | 820 |

**Table continued on next page.**

## Table C.3 (Continued)

| Structure Number | County | Waterbody | Road | Location | Year Built | Condition Rating: Deck | Condition Rating: Superstructure | Condition Rating: Substructure | Condition Rating: Channel | Condition Rating: Culvert | Condition Rating: Structure Minimum | Inspection Date (MMYY) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STRUCTURE_NUMBER_008 | | FEATURES_DESC_006A | FACILITY_CARRIED_007 | LOCATION_009 | YEAR_BUILT_027 | DECK_COND_058 | SUPERSTRUCTURE_COND_059 | SUBSTRUCTURE_COND_060 | CHANNEL_COND_061 | CULVERT_COND_062 | | DATE_OF_INSPECT_090 |
| B64015900000000 | Walworth | SUGAR CREEK | CTH ES | 1.3M E JCT USH 12 | 1982 | 5 | 7 | 6 | 7 | N | 5 | 820 |
| B64018000000000 | Walworth | SUGAR CREEK | CTH DD | 2.5M N JCT STH 11 | 2019 | 7 | 9 | 8 | 9 | N | 7 | 820 |
| P64006200000000 | Walworth | SUGAR CREEK | LRD FOSTER RD | 0.9M S JCT CTH ES | 1970 | N | N | N | 5 | 7 | 7 | 820 |
| P64006700000000 | Walworth | SUGAR CREEK | LRD HARGRAVES RD | 1.5M S JCT CTH D | 1982 | 5 | 5 | 6 | 7 | N | 5 | 820 |
| P64090900000000 | Walworth | SUGAR CREEK | CTH H | 1.5M S JCT CTH A | 1973 | N | N | N | 8 | 8 | 8 | 820 |
| B64016700000000 | Walworth | TOMBEAU LAKE | LRD TOMBEAU RD | 1.6M E JCT CTH U | 2004 | 7 | 7 | 8 | 9 | N | 7 | 820 |
| B64019400000000 | Walworth | TRIB LAKE GENEVA | LRD SOUTH LAKE SHO | 0.5M E JCT STH 67 | 2016 | 7 | 9 | 9 | 9 | N | 7 | 820 |
| B64000700000000 | Walworth | W BR NIPPERSINK CREEK | STH 120 | 1.0M N JCT CTH B | 1954 | 5 | 5 | 6 | 8 | N | 5 | 519 |
| B64015600000000 | Walworth | W BR NIPPERSINK CREEK | CTH H | 1.0M N CTH B | 1982 | 6 | 7 | 7 | 7 | N | 6 | 820 |
| B64016600000000 | Walworth | WHITE R | LRD SHERIDAN SPRIN | 0.1 MI S OF BUCKBY ROAD | 2005 | 7 | 7 | 8 | 8 | N | 7 | 820 |
| B64003000000000 | Walworth | WHITE RIVER | USH 12 | 0.5 MI E JCT STH 120 | 1967 | N | N | N | 8 | 7 | 7 | 720 |
| B64007200000000 | Walworth | WHITE RIVER | LRD SPRING VALLEY | 0.7M E JCT STH 36 | 1989 | 5 | 8 | 7 | 8 | N | 5 | 820 |
| B64007500000000 | Walworth | WHITE RIVER | STH OLD STH 11 | 1.4M E JCT CTH DD | 1987 | 6 | 6 | 7 | 8 | N | 6 | 820 |
| B64016300000000 | Walworth | WHITE RIVER | STH 11 EB | 5.3 MI N JCT STH 120 | 2010 | 6 | 8 | 8 | 9 | N | 6 | 1019 |
| B64016400000000 | Walworth | WHITE RIVER | STH 11 WB | 3.1 MI W JCT STH 83 | 2010 | 7 | 8 | 8 | 8 | N | 7 | 1019 |
| B64017100000000 | Walworth | WHITE RIVER | LRD EDWARDS BOULEV | WALWORTH COUNTY CITY OF | 2010 | 7 | 8 | 7 | 7 | N | 7 | 820 |
| B64017600000000 | Walworth | WHITE RIVER | LRD WRIGLEY DR | 2.6M N JCT CTH BB | 2012 | 7 | 7 | 8 | 9 | N | 7 | 820 |
| B64019000000000 | Walworth | WHITE RIVER | LRD SHERIDAN SPRIN | 2.2 M S OF JCT STH 36 | 2015 | 8 | 8 | 8 | 9 | N | 8 | 820 |
| B64019900000000 | Walworth | WHITE RIVER | LRD MILL ST | 0.5M S JCT STH 36 | 2020 | 8 | 8 | 9 | 8 | N | 8 | 820 |
| B67009600000000 | Waukesha | BR FOX RIVER | STH 190 | 2.0M E JCT STH 164 TO N | 1930 | N | N | N | 7 | 5 | 5 | 1020 |
| B67014300000000 | Waukesha | BR FOX RIVER | CTH F (MAIN ST) | 1.8M E JCT CTH Y | 1970 | N | N | N | 8 | 6 | 6 | 420 |
| B67002200000000 | Waukesha | BR PEWAUKEE RIVER | LRD CAPITOL DR | 0.7M E JCT CTH KF | 2001 | 6 | 6 | 8 | 8 | N | 6 | 620 |
| B67017600000000 | Waukesha | BR PEWAUKEE RIVER | STH 16 | 2.7M E JCT CTH KE TO S | 1975 | N | N | N | 8 | 6 | 6 | 520 |
| B67005800000000 | Waukesha | BR POPLAR CREEK | IH 94 | 3.4M E JCT USH 18 | 1960 | N | N | N | 7 | 5 | 5 | 920 |
| B67007200000000 | Waukesha | BR POPLAR CREEK | IH 94 | 1.1M E JCT USH 18 TO E | 1961 | N | N | N | 6 | 6 | 6 | 919 |
| P67077200000000 | Waukesha | BROOKFIELD LAKE | LRD CORPORATE DR | 0.1M S JCT USH 18 | 1984 | 5 | 4 | 6 | 8 | N | 4 | 1020 |
| B67031600000000 | Waukesha | CALHOUN CR | IH RAMP TO IH 43 S | 0.1 MI S JCT MOORLAND RD | 2008 | N | N | N | 8 | 7 | 7 | 918 |
| B67031800000000 | Waukesha | CALHOUN CREEK | CTH I (BELOIT ROAD | 0.2M W OF JCT CTH O | 2009 | N | N | N | 6 | 4 | 4 | 1020 |
| B67029800000000 | Waukesha | CANDLEWOOD CR | LRD CHERRYWOOD DR | 0.2M N WOODS RD | 2004 | 7 | 7 | 9 | 6 | N | 7 | 1020 |
| B67000100000000 | Waukesha | DEER CREEK | LRD BROOKFIELD RD | 0.3M S JCT USH 18 | 1998 | N | N | N | 8 | 7 | 7 | 520 |
| B67031200000000 | Waukesha | DEER CREEK | LRD CALHOUN RD (N. | 0.5M S JCT USH 18 | 2008 | 7 | 7 | 8 | 9 | N | 7 | 1020 |
| B67031300000000 | Waukesha | DEER CREEK | LRD CALHOUN RD (S. | 0.5M S JCT USH 18 | 2008 | 7 | 7 | 8 | 9 | N | 7 | 1020 |
| B67037200000000 | Waukesha | DEER CREEK | LRD JOANNE DR (DEA | 0.6M S JCT USH 18 | 2016 | N | N | N | 6 | 8 | 8 | 1020 |
| P67074000000000 | Waukesha | DEER CREEK | LRD GLENDALE DR | 0.2M N JCT CTH D | 1968 | N | N | N | 5 | 6 | 6 | 1120 |
| P67074100000000 | Waukesha | DEER CREEK | LRD W ROGERS DR | 0.4M W JCT CTH O | 1967 | N | N | N | 7 | 7 | 7 | 1120 |
| P67074200000000 | Waukesha | DEER CREEK | LRD LINCOLN AVE | 0.4M W JCT CTH O | 1968 | N | N | N | 6 | 6 | 6 | 1120 |
| P67076700000000 | Waukesha | DEER CREEK | LRD JAMES DR | 0.1M N JCT RYERSON RD | 1983 | N | N | N | 6 | 7 | 7 | 1120 |
| P67077100000000 | Waukesha | DEER CREEK | CTH ES (NATIONAL A | 0.6M E JCT CTH O | 1980 | N | N | N | 7 | 5 | 5 | 1120 |
| P67077300000000 | Waukesha | DEER CREEK | LRD CORPORATE DR | 0.4M S JCT USH 18 | 1986 | 6 | 4 | 6 | 7 | N | 4 | 1020 |
| P67077900000000 | Waukesha | DEER CREEK | CTH D (CLEVELAND A | 0.1M W JCT CTH O | 1959 | N | N | N | 8 | 3 | 3 | 1020 |
| B67030600000000 | Waukesha | DRAINAGE DITCH | LRD POND VIEW CT R | 0.5 M W STEPPING STONE WA | 2006 | N | N | N | 6 | 7 | 7 | 620 |
| B67000800000000 | Waukesha | FOX RIVER | CTH L (FOREST HOME | .2M W JCT STH 164 | 1950 | 8 | 8 | 5 | 8 | N | 5 | 1120 |
| B67001800000000 | Waukesha | FOX RIVER | IH 94 WB | 1.6 MI W JCT USH 18 | 1957 | 7 | 7 | 7 | 8 | N | 7 | 519 |
| B67001900000000 | Waukesha | FOX RIVER | IH 94 EB | 0.4 MI E JCT CTH F | 1957 | 7 | 7 | 7 | 8 | N | 7 | 519 |
| B67003900000000 | Waukesha | FOX RIVER | LRD BARSTOW ST | 0.1M S JCT USH 18 | 1963 | 8 | 6 | 6 | 8 | N | 6 | 620 |
| B67008700000000 | Waukesha | FOX RIVER | STH 190 WB | 5.5 MI W JCT IH 41 | 1965 | 5 | 5 | 6 | 8 | N | 5 | 1020 |
| B67008800000000 | Waukesha | FOX RIVER | STH 190 EB | 2.1M E JCT STH 164 | 1965 | 5 | 5 | 6 | 8 | N | 5 | 1020 |
| B67009700000000 | Waukesha | FOX RIVER | CTH I (RIVER ROAD) | 1.9M S JCT CTH H | 1965 | 4 | 7 | 6 | 7 | N | 4 | 1120 |
| B67009900000000 | Waukesha | FOX RIVER | LRD MADISON ST | 0.1M E JCT USH 18 | 1968 | 5 | 6 | 5 | 7 | N | 5 | 720 |
| B67010100000000 | Waukesha | FOX RIVER | CTH H (RIVER ROAD) | 0.4M E JCT CTH X | 1966 | 7 | 7 | 7 | 7 | N | 7 | 1120 |

**Table continued on next page.**

## Table C.3 (Continued)

| | | | | | | Condition Rating | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Structure Number | County | Waterbody | Road | Location | Year Built | Deck | Superstructure | Substructure | Channel | Culvert | Structure Minimum | Inspection Date (MMYY) |
| STRUCTURE_NUMBER_008 | | FEATURES_DESC_006A | FACILITY_CARRIED_007 | LOCATION_009 | YEAR_BUILT_027 | DECK_COND_058 | SUPERSTRUCTURE_COND_059 | SUBSTRUCTURE_COND_060 | CHANNEL_COND_061 | CULVERT_COND_062 | | DATE_OF_INSPECT_090 |
| B67012700000000 | Waukesha | FOX RIVER | IH 43 SB | 5.3 MI S JCT STH 164 | 1971 | 6 | 7 | 6 | 8 | N | 6 | 520 |
| B67012800000000 | Waukesha | FOX RIVER | IH 43 NB | 2.0M N JCT STH 83 | 1971 | 7 | 7 | 7 | 8 | N | 7 | 819 |
| B67014700000000 | Waukesha | FOX RIVER | CTH ES | 0.5M E JCT CTH NN | 1971 | 8 | 7 | 7 | 8 | N | 7 | 1120 |
| B67015200000000 | Waukesha | FOX RIVER | STH 59 EB | 0.5M E JCT CTH X | 1974 | 5 | 6 | 6 | 7 | N | 5 | 619 |
| B67017500000000 | Waukesha | FOX RIVER | LRD WATERTOWN RD | 0.2M S JCT CTH M | 1971 | 5 | 5 | 6 | 6 | N | 5 | 1020 |
| B67017700000000 | Waukesha | FOX RIVER | LRD PRAIRIE AVE | 1.2M N JCT SUNSET DR | 1974 | 5 | 6 | 5 | 7 | N | 5 | 720 |
| B67019900000000 | Waukesha | FOX RIVER | LRD W SUNSET DR | 0.1M E JCT CTH X | 1981 | 6 | 6 | 6 | 7 | N | 6 | 720 |
| B67020000000000 | Waukesha | FOX RIVER | LRD WISCONSIN AVE | 0.4M S JCT USH 18 | 1982 | 6 | 6 | 6 | 8 | N | 6 | 720 |
| B67020500000000 | Waukesha | FOX RIVER | LRD EB-MORELAND BL | 1.1M E JCT STH 164 TO S | 1982 | 5 | 5 | 5 | 8 | N | 5 | 720 |
| B67020600000000 | Waukesha | FOX RIVER | CTH M | 0.1 M E JCT CTH Y | 1984 | 6 | 6 | 7 | 7 | N | 6 | 1120 |
| B67020700000000 | Waukesha | FOX RIVER | CTH Y (BARKER ROAD | 1.6M N JCT USH 18 | 1984 | 5 | 5 | 6 | 7 | N | 5 | 1120 |
| B67022600000000 | Waukesha | FOX RIVER | CTH K (LISBON RD) | 0.4M W JCT CTH Y | 1991 | 7 | 7 | 8 | 8 | N | 7 | 1020 |
| B67023000000000 | Waukesha | FOX RIVER | STH 59 WB | 0.4 MI W JCT CTH XX | 1996 | 7 | 7 | 7 | 7 | N | 7 | 619 |
| B67024800000000 | Waukesha | FOX RIVER | LRD WB-MORELAND BL | 1.1M W JCT STH 164 TO S | 1996 | 6 | 6 | 6 | 8 | N | 6 | 720 |
| B67028500000000 | Waukesha | FOX RIVER | LRD MILL ROAD | 0.8M E JCT CTH Y | 1999 | 7 | 7 | 7 | 8 | N | 7 | 1020 |
| B67031000000000 | Waukesha | FOX RIVER | CTH SR (SPRINGDALE | 0.2M S JCT CTH M | 2009 | 7 | 7 | 8 | 7 | N | 7 | 1020 |
| B67033500000000 | Waukesha | FOX RIVER | CTH VV (SILVER SPR | 0.1M W JCT CTH Y | 2013 | 7 | 7 | 8 | 7 | N | 7 | 1120 |
| B67033600000000 | Waukesha | FOX RIVER | CTH Y (LANNON RD) | 0.1M N JCT CTH VV | 2013 | 8 | 8 | 8 | 7 | N | 8 | 1120 |
| P67010000000000 | Waukesha | FOX RIVER | LRD CENTER DR | 1.9M S JCT CTH ES | 1961 | 5 | 4 | 6 | 7 | N | 4 | 1020 |
| P67071600000000 | Waukesha | FOX RIVER | LRD RIVER RD | 0.1M S JCT CTH K | 1950 | 4 | 3 | 3 | 5 | N | 3 | 1020 |
| P67090200000000 | Waukesha | FOX RIVER | LRD RIVER RD | 0.1M E JCT CTH Y | 1950 | N | N | N | 7 | 5 | 5 | 1020 |
| B67000700000000 | Waukesha | GENESEE CREEK | CTH X (SAYLESVILLE | 1.6M E JCT STH 83 | 2003 | 7 | 7 | 8 | 8 | N | 7 | 1020 |
| B67032000000000 | Waukesha | GENESEE CREEK | STH 59 EB | 0.1 MI E JCT STH 83 | 2011 | 7 | 7 | 9 | 9 | N | 7 | 919 |
| B67032100000000 | Waukesha | GENESEE CREEK | STH 59 WB | 0.1M E JCT STH 83 | 2011 | 8 | 7 | 9 | 9 | N | 7 | 919 |
| P67001500000000 | Waukesha | GENESEE CREEK | LRD OLD VILLAGE RD | 0.1M E JCT STH 83 | 1929 | 7 | 7 | 5 | 7 | N | 5 | 1020 |
| P67092000000000 | Waukesha | HORSESHOE BROOK | LRD EDGEWOOD AVE | 2.7M W JCT STH 164 | 1974 | N | N | N | 5 | 7 | 7 | 1020 |
| B67002300000000 | Waukesha | JERICHO CREEK | CTH NN | 0.2M W JCT CTH E | 2001 | 7 | 7 | 8 | 8 | N | 7 | 1020 |
| B67028300000000 | Waukesha | JERICHO CREEK | CTH LO | 0.1 MI W. OF CTH E | 2003 | N | N | N | 8 | 7 | 7 | 1020 |
| B67029900000000 | Waukesha | LINILAC CR | LRD JEWEL CREST DR | 0.2 M S JCT CTH HH | 2003 | 7 | 7 | 7 | 6 | N | 7 | 1020 |
| B67013900000000 | Waukesha | LINILAC CREEK | LRD MARTIN DR | 0.4M N JCT CTH HH | 1969 | 7 | 7 | 7 | 6 | N | 7 | 1120 |
| B67014200000000 | Waukesha | LINILAC CREEK | IH 43 | 1.1M N JCT CTH Y | 1968 | N | N | N | 6 | 6 | 6 | 919 |
| P67093000000000 | Waukesha | LITTLE MUSKEGO LAKE | LRD HARDTKE DR | 0.5 MI SE JCT MARTIN DRIV | 1960 | 7 | 7 | 5 | 7 | N | 5 | 1020 |
| P67092500000000 | Waukesha | MILL BROOK | LRD CENTER DRIVE | 0.4M N JCT CTH ES | 1990 | N | N | N | 6 | 7 | 7 | 1020 |
| B67002100000000 | Waukesha | MILL CREEK | STH 164 | 3.2 MI N JCT IH 43 | 1968 | N | N | N | 7 | 7 | 7 | 819 |
| P67005000000000 | Waukesha | MILL CREEK | LRD BIG BEND RD | 0.3M S CTH I (LAWNDALE) | 1932 | N | N | N | 5 | 3 | 3 | 1220 |
| B67002400000000 | Waukesha | MUKWONAGO RIVER | LRD HOLZ PKWY | 0.8M E JCT STH 83 | 2002 | 7 | 7 | 7 | 8 | N | 7 | 720 |
| B67020200000000 | Waukesha | MUKWONAGO RIVER | CTH I | 0.1M S JCT CTH LO | 1981 | 5 | 5 | 7 | 8 | N | 5 | 1020 |
| B67020400000000 | Waukesha | MUKWONAGO RIVER | CTH ES (MAIN ST) | 0.4M S JCT STH 83 | 1984 | 6 | 6 | 7 | 8 | N | 6 | 1020 |
| B67021600000000 | Waukesha | MUKWONAGO RIVER | STH 83-FRONT ST | 0.5M N JCT IH 43 | 1987 | 6 | 6 | 7 | 8 | N | 6 | 919 |
| P67092300000000 | Waukesha | MUKWONAGO RIVER | LRD BEULAH RD | 0.4M S JCT CTH LO | 1983 | 6 | 6 | 8 | 8 | N | 6 | 720 |
| B67010000000000 | Waukesha | MUSKEGO CANAL | STH 36 WB | 3.5M S JCT USH 45 TO S | 1967 | N | N | N | 8 | 7 | 7 | 520 |
| B67024100000000 | Waukesha | MUSKEGO CANAL | STH 36 EB | 7.5M N JCT STH 83 TO N | 1995 | N | N | N | 8 | 7 | 7 | 520 |
| P67073600000000 | Waukesha | MUSKEGO CANAL | LRD MUSKEGO DAM RD | 0.5M W JCT STH 36 | 1925 | 7 | 7 | 5 | 6 | N | 5 | 1020 |
| B67034800000000 | Waukesha | MUSKEGO CREEK | LRD WOODS RD | 0.9M E JCT CTH Y | 2015 | 8 | 8 | 8 | 7 | N | 8 | 1020 |
| P67073700000000 | Waukesha | MUSKEGO CREEK | LRD PIONEER RD | 0.2M S JCT CTH L | 1967 | N | N | N | 5 | 6 | 6 | 1020 |
| B67026800000000 | Waukesha | OCONOMOWOC RIVER | CTH E | 0.3 MI S JCT CTH Q | 2013 | N | N | N | 8 | 8 | 8 | 1020 |
| B67003600000000 | Waukesha | PEBBLE BROOK | STH 164 | 4.1 MI N JCT IH 43 | 1967 | N | N | N | 4 | 7 | 7 | 819 |
| P67092700000000 | Waukesha | PEBBLE BROOK | LRD GLENDALE RD | 0.9M W JCT STH 164 | 1984 | N | N | N | 5 | 6 | 6 | 1220 |
| B67019500000000 | Waukesha | PEBBLE BROOK CREEK | CTH XX (OAKDALE DR | 1.7M S JCT CTH I | 1980 | N | N | N | 8 | 4 | 4 | 1120 |
| B67026000000000 | Waukesha | PEBBLE BROOK CREEK | LRD BIG BEND RD | 0.5 M S JCT STH 59/164 | 1997 | 8 | 7 | 8 | 8 | N | 7 | 1220 |

Table continued on next page.

## Table C.3 (Continued)

| | | | | | | Condition Rating | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Structure Number | County | Waterbody | Road | Location | Year Built | Deck | Superstructure | Substructure | Channel | Culvert | Structure Minimum | Inspection Date (MMYY) |
| STRUCTURE_NUMBER_008 | | FEATURES_DESC_006A | FACILITY_CARRIED_007 | LOCATION_009 | YEAR_BUILT_027 | DECK_COND_058 | SUPERSTRUCTURE_COND_059 | SUBSTRUCTURE_COND_060 | CHANNEL_COND_061 | CULVERT_COND_062 | | DATE_OF_INSPECT_090 |
| B67022100000000 | Waukesha | PEBBLE CREEK | CTH D (SUNSET DR) | 0.6 M W JCT CTH X | 1990 | 7 | 7 | 8 | 7 | N | 7 | 1020 |
| B67035400000000 | Waukesha | PEBBLE CREEK | USH 18 WB | 1.25 MI N JCT STH 59 | 2019 | 7 | 9 | 9 | 9 | N | 7 | 1019 |
| B67035500000000 | Waukesha | PEBBLE CREEK | USH 18 EB | 1.95 MI S JCT USH 318 | 2019 | 8 | 9 | 9 | 9 | N | 8 | 1019 |
| B67037100000000 | Waukesha | PEBBLE CREEK | LRD MADISON ST. | 0.4 MI WEST OF CTH TT | 2016 | 8 | 8 | 9 | 8 | N | 8 | 720 |
| P67092200000000 | Waukesha | PEWAUKEE LAKE TRIB | CTH JJ (CAPITOL DR | 0.7M W JCT CTH KF | 1940 | N | N | N | 7 | 4 | 4 | 920 |
| B67022500000000 | Waukesha | PEWAUKEE LAKE TRIBUTARY | LRD GLACIER RD | 0.5M W JCT CTH KF | 1991 | 7 | 7 | 8 | 8 | N | 7 | 1020 |
| B67001200000000 | Waukesha | PEWAUKEE RIVER | IH 94 | 7.4M E JCT STH 83 TO N | 1957 | N | N | N | 6 | 5 | 5 | 520 |
| B67014100000000 | Waukesha | PEWAUKEE RIVER | CTH F (REDFORD BLV | 1.4M N JCT USH 18 | 1978 | N | N | N | 7 | 6 | 6 | 1020 |
| B67019400000000 | Waukesha | PEWAUKEE RIVER | CTH J (PEWAUKEE RO | 0.3M N JCT CTH JJ | 1980 | 6 | 6 | 7 | 8 | N | 6 | 1120 |
| B67024200000000 | Waukesha | PEWAUKEE RIVER | LRD CLARK ST | 0.1M N JCT WISCONSIN AVE | 1993 | 6 | 6 | 7 | 8 | N | 6 | 620 |
| B67024300000000 | Waukesha | PEWAUKEE RIVER | LRD OAKTON AVE | 0.7M W JCT STH 16 | 1993 | 6 | 6 | 7 | 7 | N | 6 | 620 |
| B67028100000000 | Waukesha | PEWAUKEE RIVER | STH 164 NB | 1.8MI N STH 190 | 2005 | 7 | 7 | 7 | 8 | N | 7 | 1119 |
| B67028200000000 | Waukesha | PEWAUKEE RIVER | STH 164 SB | 1.8 MI N JCT STH 190 | 2005 | 7 | 7 | 7 | 8 | N | 7 | 1119 |
| P67009400000000 | Waukesha | PEWAUKEE RIVER | LRD BUSSE RD | 0.6M N JCT CTH JJ | 1950 | N | N | N | 5 | 3 | 3 | 1020 |
| B67002000000000 | Waukesha | POPLAR CREEK | LRD DAVIDSON ROAD | 0.3M E JCT CTH Y | 2001 | 6 | 6 | 7 | 8 | N | 6 | 520 |
| B67004700000000 | Waukesha | POPLAR CREEK | IH 94 | 0.9M E JCT USH 18 TO E | 1961 | N | N | N | 7 | 6 | 6 | 520 |
| B67007100000000 | Waukesha | POPLAR CREEK | USH 18 | 0.2M E JCT CTH Y | 1961 | N | N | N | 5 | 6 | 6 | 520 |
| B67022700000000 | Waukesha | POPLAR CREEK | STH 59-GREENFIELD | 1.8 MI E JCT STH 164 | 1993 | N | N | N | 8 | 7 | 7 | 518 |
| B67025800000000 | Waukesha | POPLAR CREEK | LRD CTH Y (BARKER | 0.2 M N JCT STH 59 | 1997 | N | N | N | 8 | 7 | 7 | 1120 |
| B67027200000000 | Waukesha | POPLAR CREEK | CTH Y (BARKER RD) | 0.5M N JCT USH 18 | 2004 | 7 | 7 | 8 | 7 | N | 7 | 1020 |
| P67076400000000 | Waukesha | POPLAR CREEK | LRD ENTERPRISE AVE | 0.3M W JCT CTH Y | 1973 | 6 | 4 | 4 | 7 | N | 4 | 1020 |
| B67022400000000 | Waukesha | SAYLESVILLE CREEK | STH 59 | 1.4 MI E JCT STH 83 | 1991 | 7 | 7 | 7 | 8 | N | 7 | 719 |
| B67032600000000 | Waukesha | SPRING BROOK | STH 83 NB | 1.2 MI S JCT STH 59 | 2011 | 7 | 8 | 8 | 8 | N | 7 | 919 |
| B67032700000000 | Waukesha | SPRING BROOK | STH 83 SB | 1.2 MI S JCT STH 59 | 2011 | 8 | 8 | 9 | 9 | N | 8 | 919 |
| B67000900000000 | Waukesha | SPRING CREEK | LRD DUPLAINVILLE R | 1.9M N JCT CTH F | 1922 | 4 | 4 | 4 | 4 | N | 4 | 1020 |
| B67015000000000 | Waukesha | SPRING CREEK | LRD SILVER SPRING | 0.2M W JCT CTH F | 1971 | N | N | N | 6 | 6 | 6 | 1019 |
| B67027900000000 | Waukesha | SUSSEX CR | STH 164 NB | 0.5 MI N CTH VV (SILVER S | 2006 | 6 | 6 | 7 | 8 | N | 6 | 1020 |
| B67009800000000 | Waukesha | SUSSEX CREEK | STH CTH F | 0.5M N JCT STH 190 TO E | 1966 | N | N | N | 7 | 7 | 7 | 1120 |
| B67014900000000 | Waukesha | SUSSEX CREEK | LRD SILVER SPRING | 0.4M W JCT CTH F | 1971 | N | N | N | 6 | 6 | 6 | 920 |
| B67026500000000 | Waukesha | SUSSEX CREEK | CTH K (LISBON RD) | 0.3M W JCT STH 74 | 2007 | N | N | N | 8 | 7 | 7 | 1120 |
| B67028000000000 | Waukesha | SUSSEX CREEK | STH 164 SB | 3.7 MI S JCT CTH Q | 2006 | 7 | 7 | 7 | 8 | N | 7 | 1020 |
| B67037000000000 | Waukesha | SUSSEX CREEK | LRD MAIN ST | 75 FT W OF JCT SILVER SPR | 2017 | N | 9 | 9 | 8 | N | 9 | 620 |
| B67038900000000 | Waukesha | SUSSEX CREEK | LRD CLOVER DRIVE | 0.4M W JCT CTH F | 2019 | 9 | 9 | 9 | 9 | N | 9 | 920 |
| B67030200000000 | Waukesha | TRIB FOX RIVER | LRD TECHNOLOGY DR | 0.1M N JCT CTH VV | 2004 | N | N | N | 7 | 8 | 8 | 1020 |
| B67028800000000 | Waukesha | TRIB. TO MUKWONAGO RIVER | LRD MAPLE AVENUE | 0.3M SE OF STH 83 | 2004 | N | N | N | 8 | 7 | 7 | 720 |
| B67035200000000 | Waukesha | WETLANDS | USH 18 WB | 0.25 MI N JCT STH 59 | 2019 | 7 | 9 | 9 | 9 | N | 7 | 1019 |
| B67035300000000 | Waukesha | WETLANDS | USH 18 EB | 2.95 MI S JCT USH 318 | 2019 | 7 | 9 | 9 | 9 | N | 7 | 1019 |
| B67036000000000 | Waukesha | WETLANDS | USH 18 WB | 0.3 MI N JCT STH 59 | 2019 | 9 | 9 | 9 | 9 | N | 9 | 1019 |
| B67036100000000 | Waukesha | WETLANDS | USH 18 EB | 2.9 MI S JCT USH 318 | 2019 | 7 | 9 | 9 | 9 | N | 7 | 1019 |
| B67034900000000 | Waukesha | WILLOW CREEK | LRD SILVER MEADOWS | .5 MI E OF TOWN LINE RD | 2012 | N | 8 | 8 | 8 | N | 8 | 1020 |
| B67035600000000 | Waukesha | WILLOW CREEK | LRD LEGACY TRAIL | 500 E OF TOWN LINE RD | 2015 | 8 | 8 | 8 | 8 | N | 8 | 1020 |
| B67038300000000 | Waukesha | WILLOW CREEK | LRD AUGUSTA PARKWA | 500 FEET EAST OF INTERSEC | 2018 | 9 | 9 | 9 | 8 | N | 9 | 1020 |

Note: Lastest Bridge Inspection Reports as of May 2022 were reviewed for bridges rated Serious Condition (3) or worse.
Bridge P67077900000000 was discovered to have been replaced after the 2021 NBI dataset was compiled.
Structure P67077900000000 was replaced in 2021 and is now rated 8
Structure P67071600000000 is closed to traffic

Table continued on next page.

## Table C.3 (Continued)

| Condition Rating | Description |
|---|---|
| N | NOT APPLICABLE |
| 9 | EXCELLENT CONDITION |
| 8 | VERY GOOD CONDITION - no problems noted. |
| 7 | GOOD CONDITION - some minor problems. |
| 6 | SATISFACTORY CONDITION - structural elements show some minor deterioration. |
| 5 | FAIR CONDITION - all primary structural elements are sound but may have minor section loss, cracking, spalling, or scour. |
| 4 | POOR CONDITION - advanced section loss, deterioration, spalling, or scour. |
| 3 | SERIOUS CONDITION - loss of section, deterioration, spalling, or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present. |
| 2 | CRITICAL CONDITION - advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken. |
| 1 | "IMMINENT" FAILURE CONDITION - major deterioration or section loss present in critical structural components, or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic but corrective action may put bridge back in light service. |
| 0 | FAILED CONDITION - out of service, beyond corrective action. |

**Figure 1.5.4-1: FHWA General Rating Guidelines for NBI Inspections**

# APPENDIX D

## DAMS DATA

**Table D.1**
**Documented Dates for Most Recent Major Improvement to Main Dams in the Fox River Watershed**

| Dam Name | County | Most Recent Work Date[a] (Years Ago)[b] | Size | Hazard Rating | Source of Improvement Data |
|---|---|---|---|---|---|
| Barstow (Waukesha, Saratoga Mill) | Waukesha | 1992 (30 years ago) | Large | Low | WDNR Detailed Information sheet (plan approval date for repair/reconstruction) |
| Beulah | Walworth | 2015 (7 years ago) | Large | High | Construction update reports from Walworth County Public Works Department |
| Bohner | Racine | 2009 (13 years ago) | Small | Low | WDNR Detailed Information sheet (completion date of concrete repairs) |
| Browns Lake | Racine | 2005 (17 years ago) | Small | None (Est. Low) | WDNR Detailed Information sheet (plan approval date for repair/reconstruction) |
| Burlington (Echo Lake) | Racine | 1934 (88 years ago) | Large | Significant | Most current dam rebuild date listed in IOM |
| Como | Walworth | -- | Small | None | No data available |
| Eagle Lake | Racine | 2017 (5 years ago) | Large | Low | WDNR Detailed Information sheet (date of embankment repairs) |
| Eagle Springs Lake (Wambold) | Waukesha | 2016 (6 years ago) | Large | Significant | WDNR Detailed Information sheet (plan approval date for repair/reconstruction) |
| Geneva | Walworth | 2002 (20 years ago) | Large | Low | Date of dam reconstruction listed in EAP |
| Honey Lake | Walworth | 2018 (4 years ago) | Large | Low | WDNR Detailed Information sheet (plan approval date for repair/reconstruction) |
| Lauderdale Lakes | Walworth | 2016 (6 years ago) | Large | High | WDNR Detailed Information sheet (plan approval date for repair/reconstruction) |
| Little Muskego | Waukesha | 1994 (28 years ago) | Large | High | WDNR Detailed Information sheet (plan approval date for repair/reconstruction) |
| Mukwonago | Waukesha | 1972 (50 years ago) | Large | Low | Date of dam reconstruction listed in EAP |
| Muskego | Waukesha | 1990 (32 years ago) | Small | Low | WDNR Detailed Information sheet (plan approval date for repair/reconstruction) |
| Pewaukee | Waukesha | 2010 (12 years ago) | Large | High | Reconstruction date in SEWRPC staff memo |
| Rochester | Racine | 2012 (10 years ago) | Large | Low | Date of as-built plans and photos |
| Silver Lake | Kenosha | 1960 (62 years ago) | Small | Low | WDNR Detailed Information sheet (year complete date) |
| Waterford (Buena Lake) | Racine | 2016 (6 years ago) | Large | Significant | WDNR Detailed Information sheet (plan approval date for repair/reconstruction) |
| Wind Lake | Racine | 1971 (51 years ago) | Large | Low | Completion date listed in 2015 Graef inspection report |

Note: IOM means Inspection, Operation, and Maintenance plan and EAP means Emergency Action Plan.

[a] *Most recent major work dates are a best estimate based on a review of available documents. The source of dam work data varied among dams. It should be noted that identifying a single "age" for a dam can be difficult, while determining the completion dates for the separate major components of a dam, such as the gates, the dam structure, and embankments can be determined. Due to the relative sparseness of the data available, determining separate completion dates for the different major dam components for each dam was not possible for this report.*

[b] *The number of years ago listed is based on a date of 2022.*

*Source: Wisconsin Department of Natural Resources and SEWRPC*

**Table D.2**
**Main Dam Impoundment Storage and Conceptual Inches of Rainfall on Watershed for Calculated Storage**

| Dam Name | Low Dam Elevation[a] | High Dam Elevation | Impoundment Surface Area (ac) | Impoundment Storage (ac-ft) | Watershed Area (sq-mi) | Conceptual Inches of Precipitation on Watershed for Calculated Storage[b] |
|---|---|---|---|---|---|---|
| Barstow (Waukesha, Saratoga Mill) | | | 28 | ND[c] | 123 | |
| Beulah | 807.24 | 807.83 | 812 | 479 | 10 | 0.89 |
| Bohner | | | 135 | ND | 4 | |
| Browns Lake | | | 397 | NA[d] | 1 | |
| Burlington (Echo Lake) | | | 70 | ND | 282 | |
| Como | 849.15 | 849.35 | 955 | 191 | 8 | 0.43 |
| Eagle Lake | | | 529 | NA | 7 | |
| Eagle Spring Lake (Wambold) | 819.95 | 820.25 | 249 | 75 | 25 | 0.06 |
| Geneva | 854.34 | 854.92 | 5,401 | 3,133 | 29 | 2.06 |
| Honey Lake[e] | 767.80 | 769.50 | 40 | 68 | 72 | 0.02 |
| Lauderdale Lakes | 884.41 | 884.41 | 841 | NA | 13 | |
| Little Muskego[e] | 790.00 | 792.00 | 470 | 940 | 12 | 1.53 |
| Mukwonago | 787.83 | 787.83 | 483 | NA | 198 | |
| Muskego | 771.46 | 771.66 | 2,194 | 439 | 28 | 0.29 |
| Pewaukee[e] | 852.20 | 852.80 | 2,437 | 1,462 | 27 | 1.02 |
| Rochester | 765.00 | 766.50 | 46 | 69 | 443 | 0.00 |
| Silver Lake[f] | 97.64 | 99.64 | 516 | 1,032 | 6 | 3.30 |
| Waterford (Buena Lake) | 772.63 | 772.63 | 1144 | NA | 350 | |
| Wind Lake | 767.94 | 768.44 | 919 | 460 | 41 | 0.21 |

[a] *Elevations are in vertical datum NGVD29 unless otherwise noted.*

[b] *The calculation of conceptual inches of precipitation on each watershed for calculated storage does not include losses such as infiltration, interception, evaporation, and isolated storage as well as rainfall intensity.*

[c] *ND signifies no data is available for dam operating elevations.*

[d] *NA signifies either dam is operated to maintain a single water level elevation rather than within a range or that the dam has a fixed-crested weir.*

[e] *Elevation range is based on seasonal operations, where the winter elevation is the lower elevation and summer is the higher elevation.*

[f] *Silver Lake operating range is in a local datum.*

*Source: SEWRPC*

# EXAMPLE ADOPTION RESOLUTION FOR THE FOX (ILLINOIS) RIVER WATERSHED MITIGATION PLAN

# APPENDIX E

RESOLUTION NO. ________

Adoption of the Fox River (Illinois) Watershed Mitigation Plan

WHEREAS, ________________________ recognizes the threat that natural hazards pose to people and property; and

WHEREAS, undertaking hazard mitigation actions before disasters occur will reduce the potential for harm to people and property, economic disruption, and reduce the amount of taxpayer funds needed for future disaster assistance costs; and

WHEREAS, intergovernmental cooperation for purposes of hazard mitigation should be encouraged, and Waukesha County Emergency Management participated jointly in the planning process with local units of government within Kenosha, Racine, Walworth, and Waukesha Counties and with other local organizations, to create the Watershed Mitigation Plan, which was made available to review via a Legal Notice and a copy of which will reside permanently in the Waukesha County Department of Emergency Management Office; and

WHEREAS, this resolution required no budget modification,

NOW, THEREFORE, BE IT RESOLVED, that ____________________ hereby adopts the Fox River (Illinois) Watershed Mitigation Plan as an official plan; and

BE IT FURTHER HEREBY RESOLVED that the ____________________ clerk transmit a certified copy of this resolution to the Southeastern Wisconsin Regional Planning Commission.

Dated at ____________________, Wisconsin, this ___ day of __________, 2023

______________________________

(President, Mayor, or Chairman
of the Local Governing Body)