Appendix C

Land and Water Resources Inventory

C Land and Water Resources Inventory

This section of the Zumbro River Comprehensive Watershed Management Plan (Plan) summarizes the physical land, water, and natural resources within the planning area. The planning area boundary – all within the State of Minnesota – follows the boundary of the Zumbro River watershed (HUC 07040004) and a portion of the Mississippi River Lake Pepin watershed (HUC 07040001, see Figure C-1). The planning area drains approximately 1421 square miles of the Zumbro River watershed and 233 square miles of the Mississippi River Lake Pepin watershed. The planning area includes portions of Dodge, Goodhue, Olmsted, Rice, Steele, and Wabasha Counties, as described in Table C-C-1.

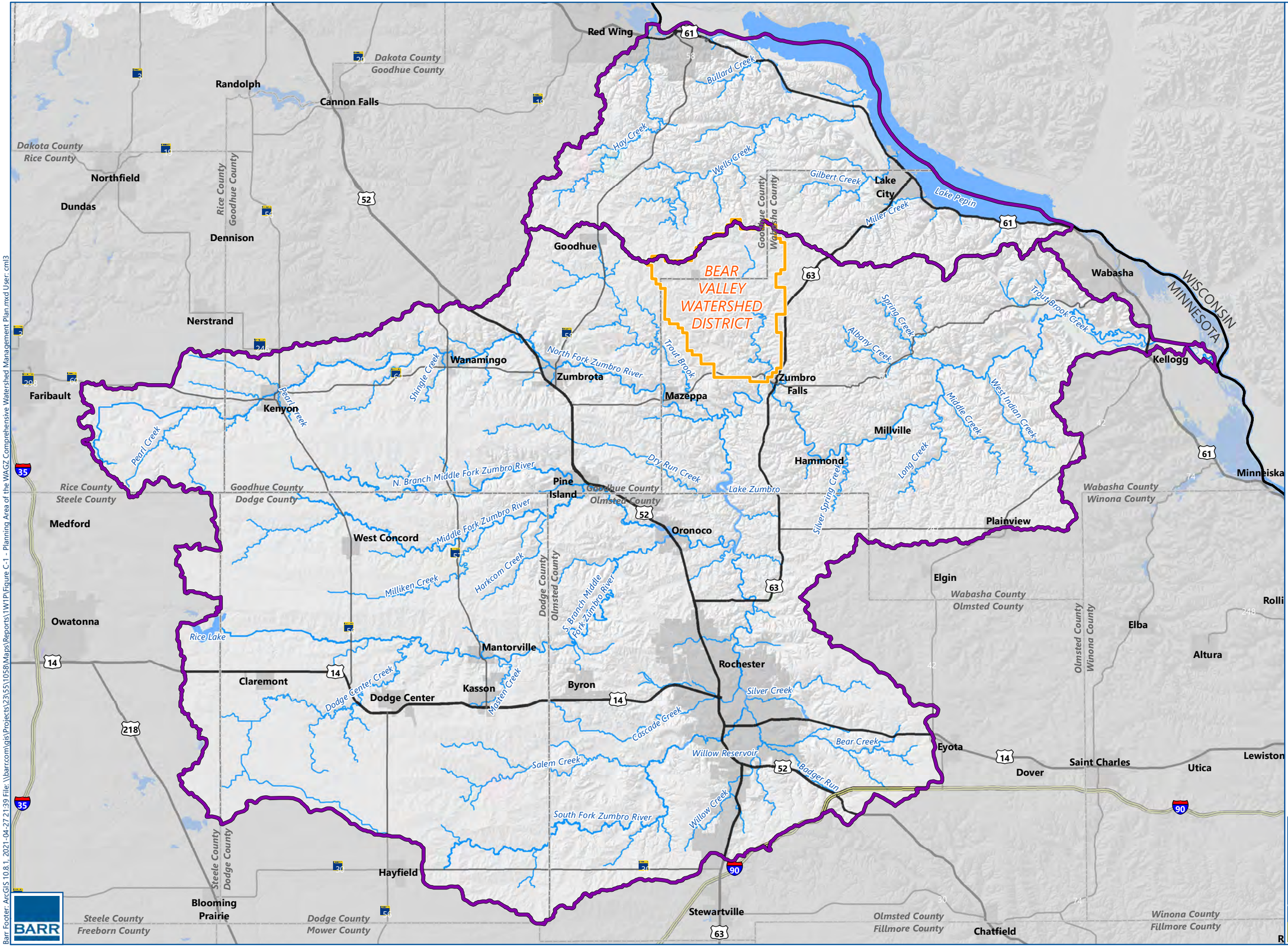
Table C-C-1 Counties located within the planning area

County	Area within Zumbro Watershed (mi^2)	Area within Mississippi River Lake Pepin Watershed (mi^2)	Percent of Planning Area within County (%)	Percent of County within Planning Area (%)
Dodge	364	0	22.0%	82.9%
Goodhue	277	169	27.0%	57.2%
Olmsted	370	0	22.4%	56.5%
Rice	47	0	2.8%	9.1%
Steele	26	0	1.6%	6.0%
Wabasha	336	64	24.2%	72.8%
Total	1421	233	100.0%	NA

Data presented in this section includes:

- Topography and drainage patterns
- Climate and precipitation
- Land cover and land use
- Soils
- Geology and groundwater
- Surface water resources (streams, lakes, and wetlands)
- Surface water quality
- Water quantity and flooding
- Wildlife habitat and rare features

Information presented in this section is a compilation intended for summary purposes. Much of the data presented herein is based on more complete data documented in other sources. These sources are referenced in the appropriate subsections of this section.



PLANNING AREA OF THE WAGZ COMPREHENSIVE WATERSHED MANAGEMENT PLAN

WAGZ Comprehensive Watershed Management Plan

FIGURE C-1

BARR

Barr Footer: ArcGIS 10.8.1, 2021-04-27 21:39 File: \\barrcom\gis\Projects\23\55\1058\Maps\Reports\1W1P\Figure C-1 - Planning Area of the WAGZ Comprehensive Watershed Management Plan.mxd User: cml3

C.1 Topography and Drainage Patterns

The topography of the Zumbro River watershed includes gently rolling terrain in the western and central portions of the watershed transitioning to hills, bluffs, and ravines in the eastern portion of the watershed. The topography of the Mississippi River Lake Pepin portion of the planning area is characterized by rolling hills, ravines, and bluffs similar to the downstream part of the Zumbro River watershed.

Figure C-2 presents elevation information within the planning area based on the National Elevation Dataset (NED) in NAVD88 datum. Elevations in the Zumbro River watershed range from over 1,350 feet above mean sea level (ft MSL) in the southwest portion of Dodge County to less than 700 ft MSL at the watershed outlet to the Mississippi River. Elevations in the Mississippi River Lake Pepin portion of the watershed range from about 1,150 ft MSL along the southwestern watershed boundary to less than 700 ft MSL at Lake Pepin and along the Mississippi River.

C.1.1 Drainage Patterns

The planning area includes the area tributary to the Zumbro River and areas in Goodhue and Wabasha Counties that drain towards Lake Pepin and the Mississippi River along the border between Minnesota and Wisconsin. The western half of the Zumbro River watershed generally flows west to east, before flowing north and east towards the Mississippi River in the east. The Mississippi River Lake Pepin watershed generally drains from the southwest to the northeast. The entire planning areas is ultimately tributary to the Mississippi River.

Within the two major watersheds comprising the planning area, the Minnesota Department of Natural Resources has further delineated subwatersheds at the HUC12 level for natural resource planning and management purposes (see Figure C-3). HUC12 watersheds define the smallest federal drainage units. Watershed delineation data maintained by the Minnesota Department of Natural Resources (MDNR) is available from: https://www.mngeo.state.mn.us/chouse/water_watersheds.html

For the purposes of this Plan, the HUC12 subwatersheds have been grouped into 8 planning subwatersheds corresponding to the MDNR HUC10 level watershed delineations, including five in the Zumbro watershed and three in the Mississippi River Lake Pepin watershed (see Figure C-3). The HUC10 planning level subwatersheds coincide with the subwatershed delineations used to organize implementation strategies in the *Zumbro River Watershed Restoration and Protection Strategy Report* (Zumbro WRAPS) (MPCA, 2017) and the *Mississippi River Lake Pepin Watershed Restoration and Protection Strategy Report* (Mississippi-Pepin WRAPS) (MPCA, 2015). The HUC10 and HEC12 level subwatersheds are presented in Figure C-3 and are summarized in Table 3-2.

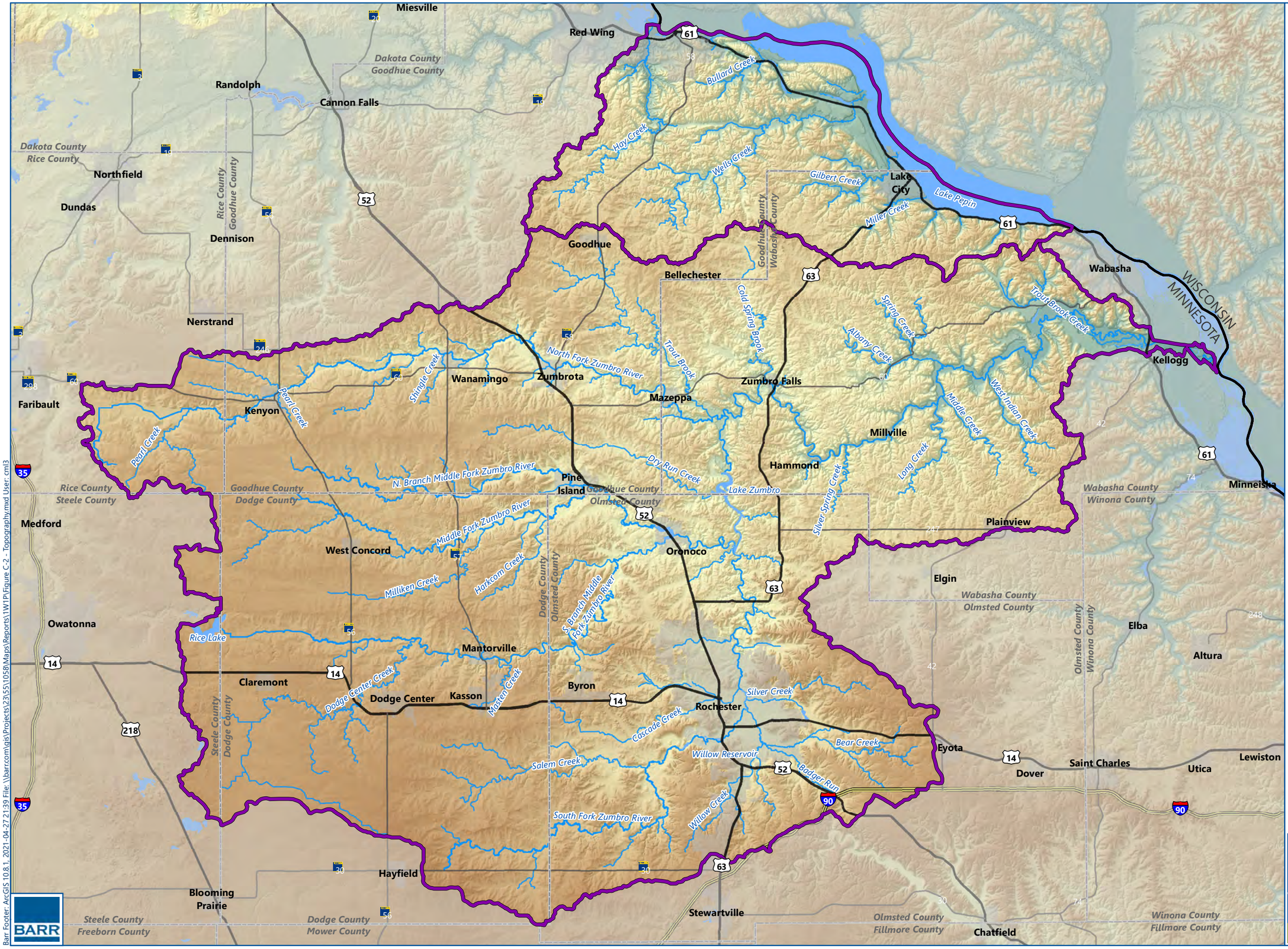
Table C-C-22 Subwatersheds within the planning area

Major Watershed	Planning Subwatershed (HUC10)	HUC10 Number	HUC10 Drainage Area (mi^2)	HUC12 Subwatershed Name	HUC12 Number	HUC12 Drainage Area (mi^2)
Mississippi River Lake Pepin	Hay Creek	0704000104	71.2	Hay Creek	070400010401	47.5
				Bullard Creek	070400010402	16.0
				City of Red Wing-Mississippi River	070400010403	7.6
Mississippi River Lake Pepin	Wells Creek	0704000106	71.9	Upper Wells Creek	070400010601	33.4
				Lower Wells Creek	070400010602	38.5
Mississippi River Lake Pepin	Lake Pepin	0704000107	77.3	Gilbert Creek	070400010703	25.0
				Miller Creek	070400010704	17.5
				Lake Pepin	070400010705	34.8
Zumbro River	South Fork Zumbro River	0704000401	353.5	Headwaters South Fork Zumbro River	070400040101	18.7
				Town of Rock Dell-S. Fork Zumbro R	070400040102	58.5
				Salem Creek	070400040103	62.2
				Willow Creek	070400040104	29.5
				Badger Run	070400040105	16.3
				Bear Creek	070400040106	35.7
				Silver Creek	070400040107	19.6
				City of Rochester-S. Fork Zumbro R	070400040108	18.6
				Cascade Creek	070400040109	38.6
				South Fork Zumbro River	070400040110	55.9
Zumbro River	South Branch Middle Fork Zumbro River	0704000402	216.3	Rice Lake-S. Br. Middle Fork Zumbro R	070400040201	42.4
				Headwaters Dodge Center Creek	070400040202	43.4
				Dodge Center Creek	070400040203	47.0
				Masten Ck-S. Br. Middle Fork Zumbro R	070400040204	33.8
				S. Br. Middle Fork Zumbro River	070400040205	49.7
Zumbro River	Middle Fork Zumbro River	0704000403	218.4	Headwaters Middle Fork Zumbro River	070400040301	29.3

Table C-C-22 Subwatersheds within the planning area

Major Watershed	Planning Subwatershed (HUC10)	HUC10 Number	HUC10 Drainage Area (mi²)	HUC12 Subwatershed Name	HUC12 Number	HUC12 Drainage Area (mi²)
				County Ditch Number One	070400040302	15.7
				City of Concord-Middle Fork Zumbro R	070400040303	23.8
				Milliken Creek	070400040304	31.3
				Harkcom Creek-Middle Fork Zumbro R	070400040305	29.0
				North Branch Middle Fork Zumbro River	070400040306	58.6
				Middle Fork Zumbro River	070400040307	30.7
Zumbro River	North Fork Zumbro River	0704000404	180.3	Headwaters North Fork Zumbro River	070400040401	46.5
				Pearl Creek-North Fork Zumbro River	070400040402	40.9
				Shingle Creek-North Fork Zumbro River	070400040403	37.1
				Trout Brook	070400040404	55.8
Zumbro River	Zumbro River	0704000405	453.5	North Fork Zumbro River	070400040405	59.8
				Dry Run Creek	070400040501	30.0
				Zumbro Lake-Zumbro River	070400040502	34.8
				Cold Creek	070400040503	45.9
				City of Zumbro Falls-Zumbro River	070400040504	39.4
				Long Creek	070400040505	32.9
				Middle Creek	070400040506	17.9
				Silver Spring Creek-Zumbro River	070400040507	34.5
				Hungry Hollow	070400040508	27.5
				Spring Creek	070400040509	36.5
				West Indian Creek	070400040510	26.9
				Hope Coulee-Trout Brook	070400040511	21.6
				Zumbro River	070400040512	45.9

* HUC12 delineation includes portions in Wisconsin; drainage area based on Minnesota areas only



Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses from Public Water Inventory (PWI). Ponds, lakes, subwatersheds from National Hydrography Dataset (NHD). Topography from National Elevation Dataset (NED).

TOPOGRAPHY
WAGZ Comprehensive Watershed Management Plan

FIGURE C-2

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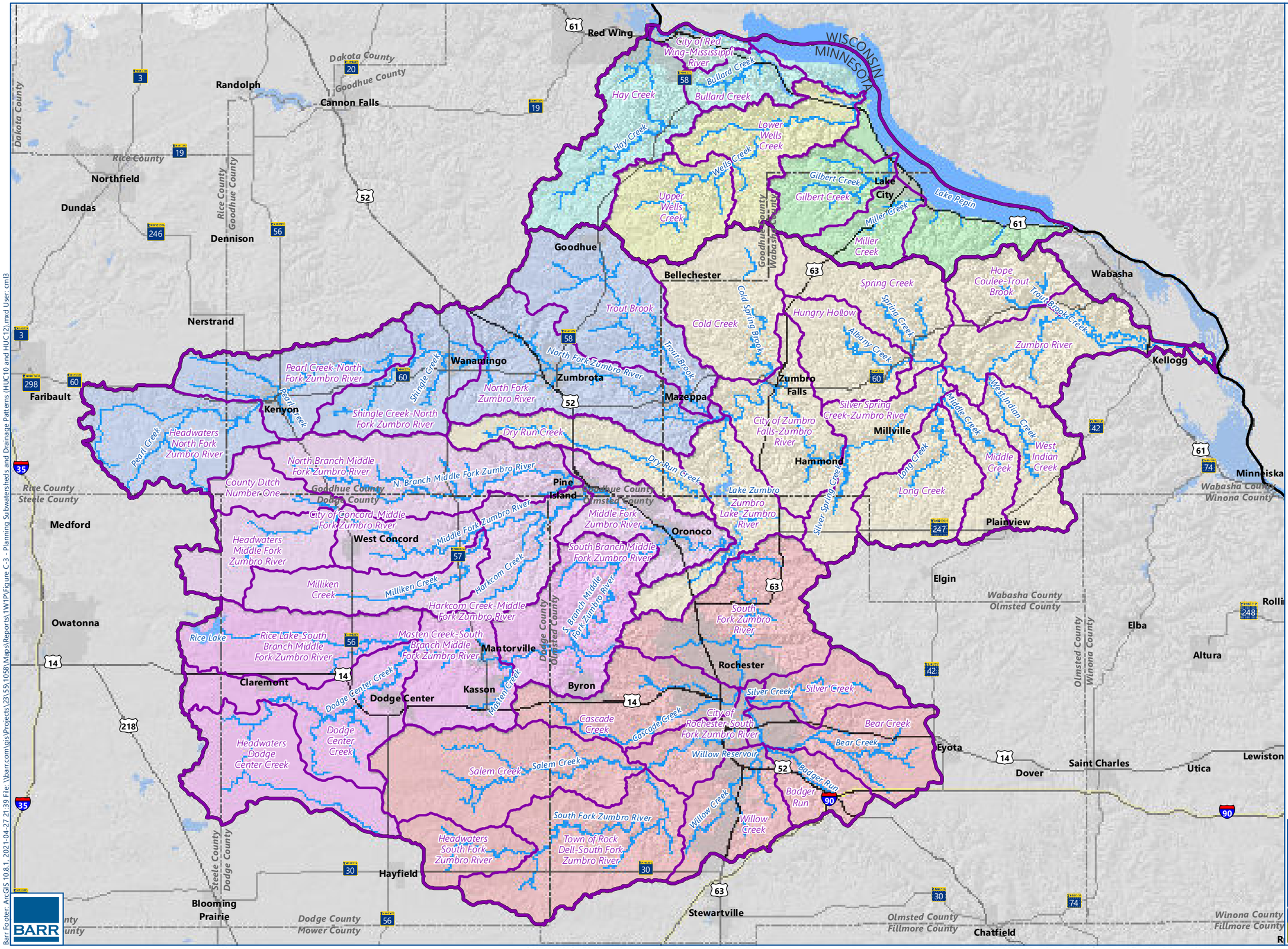
Barr Footer: ArcGIS 10.8.1, 2021-04-27 21:39 File: \\barrcom\gis\Projects\23\55\1058\Maps\Reports\1W1P\Figure C-2 - Topography.mxd User: cml3


Red Wing
City of Red Wing-Mississippi River
Bullard Creek
Hay Creek
Lower Wells Creek
Wells Creek
Upper Wells Creek
Gilbert Creek
Lake City
Miller Creek
Lake Pepin
WISCONSIN
MINNESOTA
Goodhue County
Wabasha County
Dakota County
Goodhue County
Randolph
Cannon Falls
Rice County
Northfield
Dundas
Rice County
Goodhue County
Dennison
Nerstrand
Goodhue
Bellechester
Trout Brook
Cold Creek
Cold Spring Brook
Hungry Hollow
Spring Creek
Albany Creek
Hope Coulee-Trout Brook
Trout Brook Creek
Wabasha
Kellogg
Zumbro River
Zumbro Falls
Millville
Silver Spring Creek-Zumbro River
City of Zumbro Falls-Zumbro River
Wanamingo
Zumbrota
North Fork Zumbro River
Mazeppa
Pearl Creek-North Fork Zumbro River
Shingle Creek
North Fork Zumbro River
Faribault
Kenyon
Pearl Creek
Shingle Creek-North Fork Zumbro River
Headwaters North Fork Zumbro River
Dry Run Creek
Hammond
Dry Run Creek
Lake Zumbro
Zumbro Lake-Zumbro River
Long Creek
Silver Spring Creek
Middle Creek
West Indian Creek
Middle Creek
Minneiska
Wabasha County
Winona County
Rice County
Steele County
Medford
North Branch Middle Fork Zumbro River
County Ditch Number One
Goodhue County
Dodge County
City of Concord-Middle Fork Zumbro River
N. Branch Middle Fork Zumbro River
Pine Island
Goodhue County
Olmsted County
Middle Fork Zumbro River
Oronoco
Plainview
West Concord
Headwaters Middle Fork Zumbro River
Middle Fork Zumbro River
South Branch Middle Fork Zumbro River
Milliken Creek
Harkcom Creek
Harkcom Creek-Middle Fork Zumbro River
Dodge County
Olmsted County
S. Branch Middle Fork Zumbro River
Elgin
Wabasha County
Olmsted County
Owatonna
Rice Lake
Rice Lake-South Branch Middle Fork Zumbro River
Masten Creek-South Branch Middle Fork Zumbro River
Mantorville
South Fork Zumbro River
Rochester
Olmsted County
Winona County
Elba
Altura
Claremont
Dodge Center
Kasson
Byron
Dodge Center Creek
Masten Creek
Silver Creek
Silver Creek
Cascade Creek
Cascade Creek
City of Rochester-South Fork Zumbro River
Bear Creek
Bear Creek
Willow Reservoir
Eyota
Dover
Saint Charles
Utica
Lewiston
Headwaters Dodge Center Creek
Dodge Center Creek
Salem Creek
Salem Creek
Badger Run
Badger Run
Willow Creek
Willow Creek
South Fork Zumbro River
Headwaters South Fork Zumbro River
Town of Rock Dell-South Fork Zumbro River
Hayfield
Stewartville
Chatfield
Olmsted County
Fillmore County
Winona County
Fillmore County
Steele County
Dodge County
Blooming Prairie
Dodge County
Mower County
Rice County
Steele County
Study Area
Pond or Lake
Municipal Boundary
County Boundary
State Boundary
Subwatersheds (HUC12)
Major Subwatersheds (HUC10)
Hay Creek
Lake Pepin
Lower Wells Creek
Middle Fork Zumbro River
North Fork Zumbro River
South Branch Middle Fork Zumbro River
South Fork Zumbro River
Zumbro River
Data sources:
MN DNR Level 04 Major Watersheds.
Watercourses from Public Water Inventory (PWI).
Ponds and lakes from National Hydrography Dataset (NHD).
0
2.5
5
Miles
PLANNING SUBWATERSHEDS AND DRAINAGE PATTERNS (HUC10 AND HUC12)
WAGZ Comprehensive Watershed Management Plan
FIGURE C-3
BARR
Barr Footer: ArcGIS 10.8.1, 2021-04-27 21:39 File: \\barr.com\gis\Projects\23\55\1058\Maps\Reports\1W1P\Figure C-3 - Planning Subwatersheds and Drainage Patterns (HUC10 and HUC12).mxd User: cml3

C.2 Climate and Precipitation

Because of its location near the center of the North American continent, the Zumbro River watershed has a continental climate characterized by moderate precipitation (normally sufficient for crops), wide daily temperature variations, and large seasonal variations in temperature (warm humid summers, and cold winters with moderate snowfall).

Climate data for the 1981-2010 climate normal period, as reported by the National Oceanic and Atmospheric Administration (NOAA), is summarized in Table C-C-3 for weather stations in Zumbrota (Station 219249), Red Wing (Station 216817), and at Rochester International Airport (Station 14925).

Table C-C-3 Summary of climate data for select locations in the planning area (1981-2010)

Statistic	Zumbrota (Station 219249)	Rochester Int'l Airport (Station 14925)	Red Wing (Station 216817)
Average Annual Temperature	43.6°F	45.4°F	45.4°F
Average Minimum Monthly Precipitation	0.8" (February)	0.8" (February)	0.9" (February)
Average Maximum Monthly Precipitation	4.9" (August)	4.7" (June)	4.6" (August)
Average Annual Precipitation	33.97"	33.02"	33.43"
May-September Precipitation	21.35" (63% of annual)	20.83" (63% of annual)	20.48" (61% of annual)
Average First Freeze Date	September 24	October 5	NA
Average Last Freeze Date	May 12	April 28	NA
Growing Season	133 days	159 days	NA

Source: climate data obtained from NOAA at: https://www.ncdc.noaa.gov/cdo-web/datatools

The data in Table C-C-3 show similarities in precipitation among the three selected stations. Average annual precipitation (1981-2010) ranges from approximately 32 inches in the northwest part of the planning area to 34 inches in the southeast part (MDNR, 2020a). Average annual lake evaporation is about 33 inches according to the Minnesota Hydrology Guide (NRCS, 1975).

Additional climate information can be obtained from a number of sources, such as the following:

- For a range of Minnesota climate information: http://climateapps.dnr.state.mn.us/index.htm
- For climate normal (1981-2010) data: https://www.ncdc.noaa.gov/cdo-web/datatools/normals

C.2.1 Precipitation-Frequency Data (Atlas 14)

While average weather poses little risk to human health and property, extreme precipitation events may result in flooding that threatens infrastructure and public safety. NOAA published Atlas 14, Volume 8, in 2013. Atlas 14 is the primary source of information regarding rainfall amounts and frequency in Minnesota. Atlas 14 provides estimates of precipitation depth (i.e., total rainfall in inches) and intensity (i.e., depth of rainfall over a specified period) for durations from 5 minutes up to 60 days. Atlas 14 supersedes publications Technical Paper 40 (TP-40) and Technical Paper 49 (TP-49) issued by the National Weather Bureau (now the National Weather Service) in 1961 and 1964, respectively. Atlas 14 improvements in precipitation estimates include denser data networks, longer (and more recent) periods of record, application of regional frequency analysis, and new techniques in spatial interpolation and mapping. Comparison of precipitation depths between TP-40 and Atlas 14 indicates increased precipitation depths for more extreme (i.e., less frequent) events.

Snowmelt and rainstorms occurring during snowmelt in early spring are significant in this region. The volumes of runoff generated, although they occur over a long period, can have significant impacts where the contributing drainage area is large. Runoff from spring snowmelt is not provided in Atlas 14. The Soil Conservation Service (now the National Resource Conservation Service (NRCS)) *National Engineering Handbook*, Hydrology, Section 4, presents maps of regional runoff volume. This information is summarized in the *Minnesota Hydrology Guide*, published by the USDA's Soil Conservation Service (now the NRCS) in 1975. Table 3-3 lists selected rainfall and snowmelt runoff events for the region.

Table C-C-44 Selected Precipitation and Runoff Events Used for Design Purposes

Type	Frequency	Duration	Depth (in) at Rochester (Station 21-7004)	Depth (in) at Zumbrota (Station 21-7004)	Depth (in) at Red Wing (Station 21-6817)
Rainfall[1]	2-year	24 hour	2.94	2.93	2.89
	5-year	24 hour	3.72	3.72	3.61
	10-year	24 hour	4.47	4.48	4.32
	25-year	24 hour	5.65	5.68	5.45
	50-year	24 hour	6.68	6.73	6.46
	100-year	24 hour	7.81	7.88	7.57
	10-year	10 day	7.35	7.00	6.90
	100-year	10 day	11.2	10.6	10.3
Snowmelt[2]	10-year	10 day	4.3		
	25-year	10 day	5.2		
	50-year	10 day	5.9		
	100-year	10 day	6.5		

Note(s):
(1) NOAA Atlas 14 – Volume 8. Stations noted in table heading
(2) Snowmelt depth reported as liquid water based on *Minnesota Hydrology Guide* (USDA Soil Conservation Service)

C.2.2 Climate Trends and Future Precipitation

Even with wide variations in climate conditions, climatologists have found four significant recent climate trends in the Upper Midwest (NOAA, 2013):

- Warmer winters—decline in severity and frequency of severe cold
- Higher minimum temperatures
- Higher dew points
- Changes in precipitation trends – more rainfall is coming from heavy thunderstorm events and increased snowfall

According to NOAA's 2013 assessment of climate trends for the Midwest, annual and summer precipitation amounts in the Midwest are trending upward, as is the frequency of high intensity storms. Higher intensity precipitation events typically produce more runoff than lower intensity events with similar total precipitation amounts; higher rainfall intensities are more likely to overwhelm the capacity of the land surface to infiltrate and attenuate runoff. Increased precipitation is correlated with increased average and peak flows observed in the watershed (see Section C.9). NOAA climate normal data indicates the following local trends:

- Rochester International Airport station – the average annual precipitation has increased from 30.20 inches (1971-2000 average) to 33.02 inches (1981-2010 average), a 9 percent increase

- Red Wing station – the average annual precipitation has increased from 31.50 inches (1961-1990 average) to 33.43 inches (1981-2010 average), a 7 percent increase

- Zumbrota station – the average annual precipitation has increased from 30.90 inches (1961-1990 average) to 33.97 inches (1981-2010 average), a 10 percent increase

The study of long-term extreme weather trends found that precipitation amounts are predicted to increase significantly over what is historically used in floodplain assessments and infrastructure design. Recent work completed by the University of Minnesota (Moore et al., 2016) provides information useful to consider long-term extreme weather trends in the region. A range of estimates for the mid-21st century 100-year 24-hour rainfall event were identified. The lower estimate for the mid-21st century 100-year 24-hour rainfall estimate was approximately 7.3-inches, which is similar to the current mean 100-year 24-hour rainfall depth published in Atlas 14 (7.8-inches). The middle estimate is 10.2 inches, which is similar to the upper limits of the Atlas 14 90-percent confidence limits for the 100-year 24-hour rainfall depth (10.4-inches). Upper estimates of mid-21st century 100-year 24-hour rainfall exceed the 90-percent confidence limits of Atlas 14.

The Partnership recognizes recent precipitation trends and expects that increases in precipitation amount and intensity may continue. The Partnership has developed this Plan, including goals and implementation activities, with consideration for these trends.

C.3 Land Cover and Land Use

Historically, the land within the planning area was covered by prairie, oak savanna, and maple-basswood woodlands. Pre-settlement vegetation data is available from the MDNR. Pre-settlement vegetation within the Zumbro River watershed consisted primarily of prairie, concentrated in the western half of the watershed, interspersed with oak openings and barrens and brush prairie. Big woods areas of oak, maple, basswood, and hickory and river bottom forest were also present adjacent to the Zumbro River and its tributary branches. Pre-settlement vegetation in the Mississippi River Lake Pepin watershed was mostly comprised of oak openings and barrens, with portions of Big Woods forest and brush prairie also present.

Table C-C-~~5~~5 Summary of Land Use/Land Cover within the Planning Area

Land Cover	Zumbro River Watershed		Mississippi River Lake Pepin Watershed		Planning Area	
	Square Miles	Percent of Watershed	Square Miles	Percent of Watershed	Square Miles	Percent of Watershed
Barren Land	1.1	0.1%	0.2	0.1%	1.3	0.1%
Cultivated Crops	798.1	56.2%	77.3	33.2%	875.4	52.9%
Deciduous Forest	135.9	9.6%	59.1	25.4%	195.0	11.8%
Developed, High Intensity	3.9	0.3%	0.5	0.2%	4.5	0.3%
Developed, Low Intensity	35.2	2.5%	4.9	2.1%	40.1	2.4%
Developed, Medium Intensity	13.2	0.9%	1.5	0.6%	14.7	0.9%
Developed, Open Space	75.1	5.3%	10.6	4.5%	85.7	5.2%
Emergent Herbaceous Wetlands	4.9	0.3%	0.5	0.2%	5.4	0.3%
Evergreen Forest	1.5	0.1%	0.4	0.2%	1.9	0.1%
Hay/Pasture	165.0	11.6%	29.7	12.7%	194.7	11.8%
Herbaceous (grassland)	163.7	11.5%	25.3	10.9%	189.0	11.4%
Mixed Forest	0.1	0.0%	0.0	0.0%	0.1	0.0%
Open Water	6.6	0.5%	20.7	8.9%[1]	27.2	1.6%[1]
Shrub/Scrub	0.3	0.0%	0.3	0.1%	0.5	0.0%
Woody Wetlands	16.2	1.1%	1.9	0.8%	18.1	1.1%

Source: Minnesota Land Cover Classification Dataset (MLCCD)
~~(1)~~(2) Includes a portion of the Lake Pepin water surface within Minnesota

Much of the modern landscape in the planning area has been modified by agriculture and human development. Remaining natural prairies are limited to the steep slopes of the blufflands along the Mississippi River, Zumbro River, and their tributaries (see Section C.10). Current land cover based on the Minnesota Land Cover Classification Dataset (MLCCD) is presented in Figure C-4 and Table C-C-5.

Table C-C-5 presents land cover/land use for both the Zumbro River watershed and the Mississippi River Lake Pepin watershed. Land cover/land use is generally similar between the two major watersheds, with the exceptions that:

- The Zumbro River watershed contains a higher percentage of cropland (56% versus 33%)

- The Mississippi River Lake Pepin watershed contains a higher percentage of deciduous forest (25% to 10%)
- The Mississippi River Lake Pepin watershed contains a higher percentage of open water (9% to less than 1%) owing to the presence of Lake Pepin and the Mississippi River

C.3.1 Agricultural Land Use

Within the planning area, land use is predominantly cropland (52% of the overall area), with rangeland (grassland and pasture) occupying an additional 23%. Row crop agriculture and scattered livestock operations are primarily located in the western half of the planning area and the areas north and south of the Zumbro River in the eastern half of the planning area. As slopes increase to the east (see Figure C-2) cropland transitions to pasture lands. Within the wide valleys of the eastern blufflands, there is a more even mixture of grain and rangeland operations and increasing amounts of forested, wetland and natural areas (MPCA, 2017). Cropland within the planning area is predominately planted in corn, forage for livestock and soybeans (USDA 2012).

The Natural Resources Conservation Service (NRCS) estimates that there are 2,730 farms in the Zumbro River watershed; 8% are larger than 1000 acres, 42% are less than 180 acres, and 50% are of medium size – 180 to 1000 acres (NRCS, 2016). Analysis by the NRCS suggests a similar breakdown of farm size within the Mississippi River Lake Pepin watershed, although a precise breakdown along the study area boundary is not available.

There are approximately 2,300 active, registered Animal Feedlot Operations (AFO) in the planning area, including about 2,000 in the Zumbro River watershed and 300 in the Mississippi River Lake Pepin watershed. About half of the AFOs in the planning area are primarily beef cattle and another quarter of the AFOs are dairy. Wabasha County and Goodhue County rank as the state's fourth and sixth leading dairy producers, respectively (USDA, 2012). Wabasha County and Goodhue County also ranks as the state's ninth and tenth leading cattle producers, by head, respectively (MDA 2018).

C.3.2 Urban Land Use

Although much of the planning area is covered by cropland, pasture, and forest, the planning area also includes several urbanized area. The Zumbro River watershed includes the City of Rochester in Olmsted County. Rochester is Minnesota's third largest city (population approximately 117,000 per census data). Other, smaller rural population centers (i.e., population greater than 1,000) in the Zumbro River watershed include:

- Byron
- Dodge Center
- Kasson
- Mantorville
- Pine Island
- Wanamingo
- Zumbrota

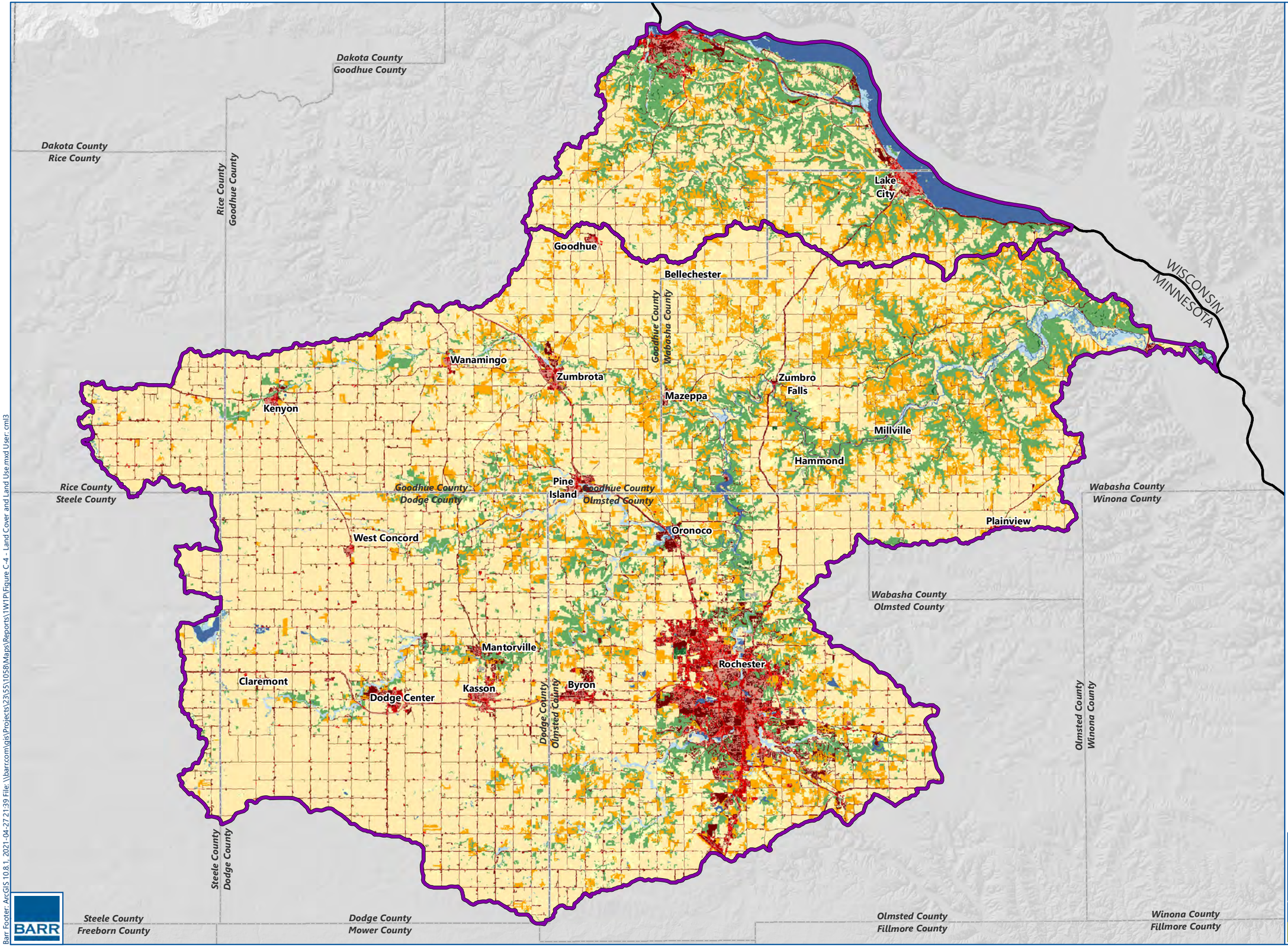
Urban centers in the Mississippi River Lake Pepin watershed include a portion of the City of Red Wing in Goodhue County (total population about 16,000 per 2010 census) and Lake City in Wabasha County (population about 5,000 per 2010 census).

Development and growth of urban and rural population centers within the planning area has been modest over the past 10 years (Minnesota Department of Administration population data, 2019), with the exception of growth in and around the City of Rochester (City of Rochester, 2018). Between 2000 and 2015, the population of Rochester increased from 86,000 to 110,000. An estimated 55,000 new residents (and 50,000 new jobs) are anticipated by 2040 (City of Rochester, 2018). The expected growth in Rochester will drive development, redevelopment, and land use changes over the life of this Plan. The City of Rochester Comprehensive Plan 2040, adopted by the City in May 2018, outlines a vision, principles, and policies to guide the future growth of the City.

C.3.3 Land Use Considerations

Land use and land cover are important considerations for managing surface water, groundwater, and upland natural resources. The hard or impervious surface areas associated with each land use greatly affect the amount of runoff generated from an area. Significant changes in land use can increase runoff due to added impervious surfaces, soil compaction and changes to drainage patterns. Row crops, such as corn and soy beans, increase the risk of erosion and of elevated total suspended solids levels in streams because the land can be without vegetation cover for major periods of time due to the short Minnesota growing season.

Additional urbanization is expected to accompany growing populations within the watershed, concentrated in Rochester and the surrounding area. Outside of this area, it is expected that the land use in the planning area will remain primarily agricultural during the life of this Plan.



Study Area
County Boundary
State Boundary

NLCD 2011

- Barren Land
- Cultivated Crops
- Deciduous Forest
- Developed, High Intensity
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, Open Space
- Emergent Herbaceuous Wetlands
- Evergreen Forest
- Hay/Pasture
- Herbaceuous
- Mixed Forest
- Open Water
- Shrub/Scrub
- Woody Wetlands

Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Land cover from National Land Cover Database 2011.

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LAND COVER AND LAND USE

WAGZ Comprehensive Watershed Management Plan

FIGURE C-4

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C.4 Soils

Soils within the planning area consist of varying combinations of loess, till, and outwash (Cummins and Grigal, 1980). Soil types (grouped according to soil parent material) are presented in Figure C-5. The western third of the Zumbro River watershed is located within the Western Corn Belt Plains ecoregion (ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources). Rich organic glacial prairie soils provide a rich medium for cultivation in the western agricultural portion of the watershed, comprised of Central Iowa and Minnesota Till Prairie. Soils in this area are predominantly loess or loamy sediments over gray till (see Figure C-5).

Moving east, soils transition to the karst region and Northern Mississippi Valley Loess Hills (MPCA, 2017). The eastern part of the Zumbro River watershed and the Mississippi River Lake Pepin watershed lie within the Driftless Area ecoregion and includes Eastern Iowa and Minnesota Till Prairie and blufflands. Karst features occur with increasing slopes and more dramatic topography and are generally concentrated in the eastern two-thirds of the watershed corresponding to the Driftless Area ecoregion. Soils in the eastern part of the watershed include a mix of loess and till in upland areas and colluvium (loose, unconsolidated sediments that have been deposited at the base of hillslopes) and outwash adjacent to streams and rivers.

Local surface soils greatly affect the suitability of the land for agricultural production. Soils in the western part of the Zumbro River watershed are generally of high quality for agricultural production. Figure C-6 presents the crop productivity index (CPI) for agricultural land use in the planning area. CPI ratings provide a relative ranking of soils based on their potential for intensive crop production and can be used to rate the potential yield of one soil against that of another soil over time. Ratings range from 0 to 100; higher numbers indicate higher production potential. Degraded soils may be subject to increased runoff and erosion (see Section 3.2.4). Soil erosion risk in the planning area is presented in Figure C-7.

The thickness of the surficial soil in the planning area general decreases from west to east, decreasing from between 100 to 200 feet thick in the west (Dodge, Rice, and Steele Counties) to less than 100 feet in the east, with significant areas of exposed bedrock in Olmsted and Wabasha Counties (Olson and Mossler, 1982).

More detailed information about the soils present in the planning area are available from the NRCS soil survey dataset. The NRCS updates information presented in soil surveys on a continuing schedule. The NRCS. The most current information may be found on the NRCS soil survey webpage at: https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

Infiltration capacities of soils affect the amount of direct runoff resulting from rainfall. The higher the infiltration rate is for a given soil, the lower the runoff potential. Conversely, soils with low infiltration rates produce high runoff volumes and high peak discharge rates. According to the NRCS soil surveys, most of the underlying soils in the planning area are classified as hydrologic soil group B, with moderate infiltration rates. Some soils, primarily in western Goodhue and Dodge Counties, are classified as group C with moderately low infiltration rates. While hydrologic soil group mapping is useful for generally assessing infiltration capacity, field verification of infiltration rates is recommended to obtain reliable data.

Dakota County
Goodhue County

Dakota County
Rice County

Rice County
Goodhue County

Goodhue County
Wabasha County

WISCONSIN
MINNESOTA

Rice County
Steele County

Goodhue County
Dodge County

Goodhue County
Olmsted County

Wabasha County
Winona County

Wabasha County
Olmsted County

Dodge County
Olmsted County

Olmsted County
Winona County

Steele County
Dodge County

Steele County
Freeborn County

Dodge County
Mower County

Olmsted County
Fillmore County

Winona County
Fillmore County

Study Area
Watercourses
Pond or Lake
County Boundary
State Boundary

Soil Parent Material

Alluvium
Gray Colluvium and Outwash
Gray Outwash
Gray Till
Gray Till, Outwash, and Residuum
Loess
Loess and Loess over Gray Till
Loess or Loamy Sediments and Erosional Lag over Dense Gray Till
Loess or Loamy Sediments over Dense Gray Till
Loess, Gray Till, Sandstone and Limestone, Residuum
Mixed gray and red outwash

Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses from Public Water Inventory (PWI). Ponds, lakes, subwatersheds from National Hydrography Dataset (NHD). Soil Parent Material from Soil and Land Surfaces from the University of Minnesota - Department of Soil, Water and Climate.

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SOIL TYPES
WAGZ Comprehensive Watershed Management Plan

FIGURE C-5

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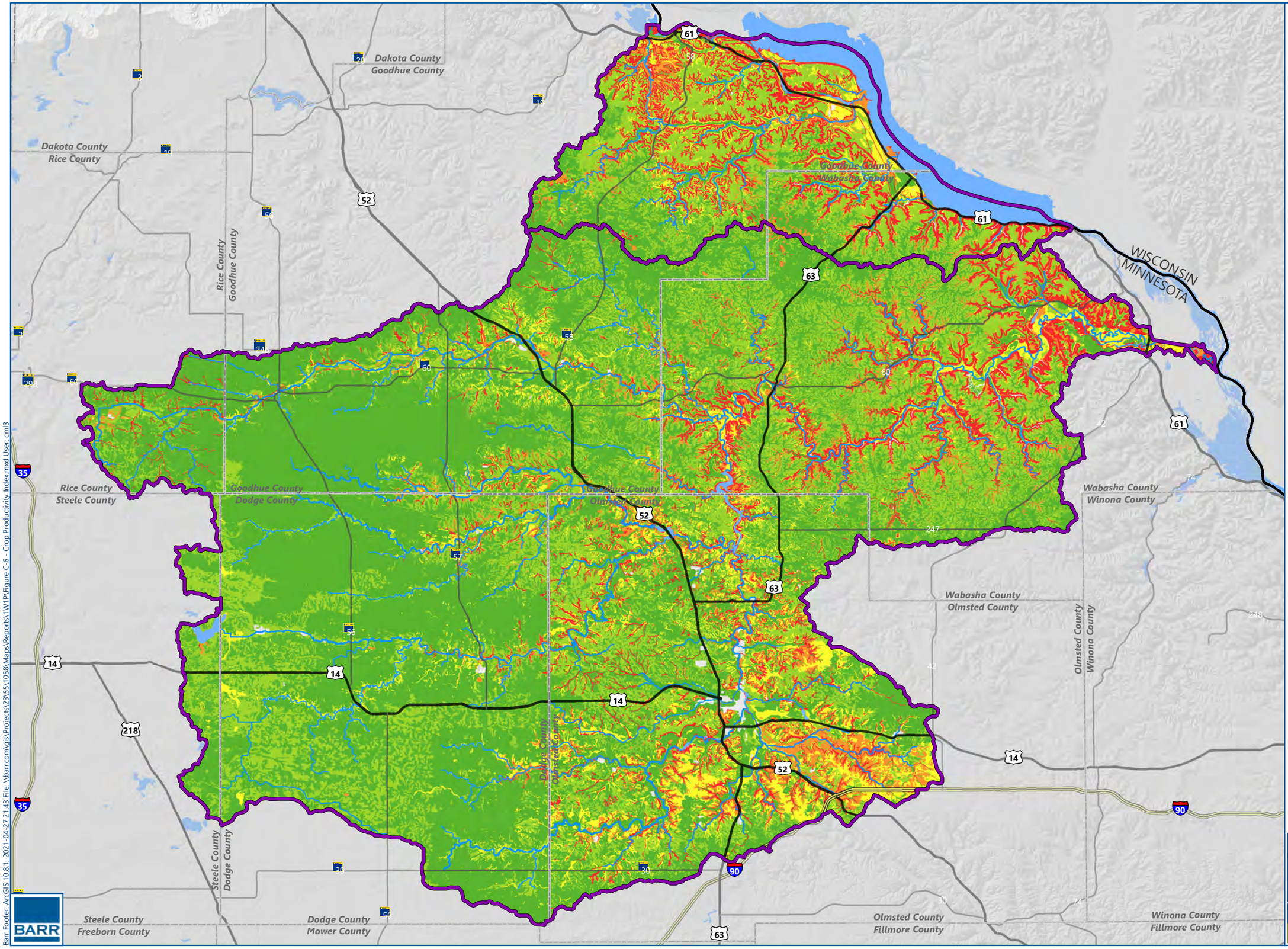
Barr Footer: ArcGIS 10.8.1, 2021-04-27 21:48 File: \\barrcom\gis\Projects\23\55\1058\Maps\Reports\1W1P\Figure C-5 - Soil Types.mxd User: cml3



Study Area
Watercourses
Pond or Lake
County Boundary
State Boundary

Crop Productivity Index

Less Productive
More Productive

Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses from Public Water Inventory (PWI). Ponds, lakes, subwatersheds from National Hydrography Dataset (NHD). Crop Productivity Index from USDA NRCS Gridded Soil Survey Geographic Database.

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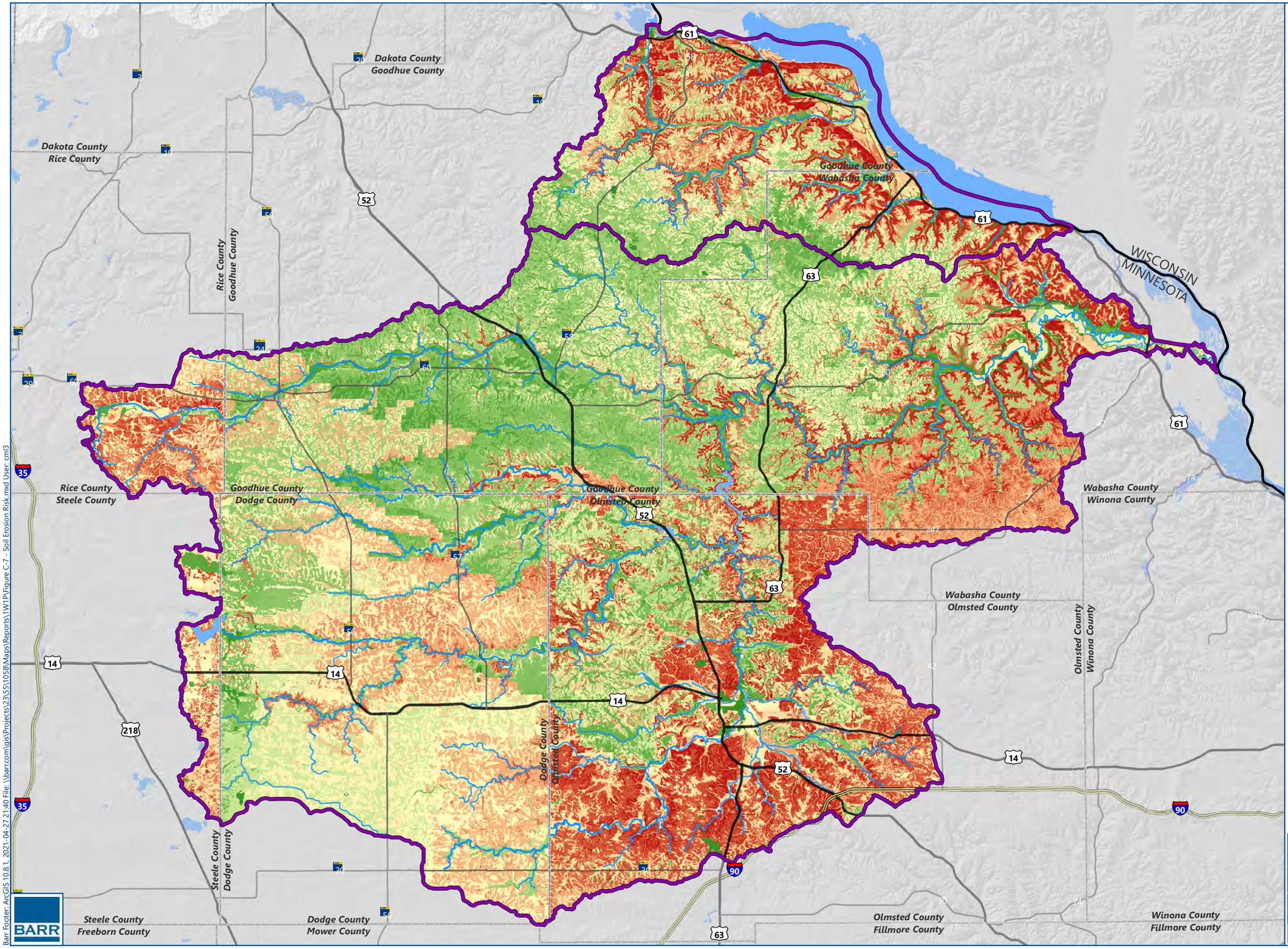
CROP PRODUCTIVITY INDEX
WAGZ Comprehensive Watershed Management Plan
FIGURE C-6

Barr Footer: ArcGIS 10.8.1, 2021-04-27 21:43 File: \\barrcom\gis\Projects\23\55\1058\Maps\Reports\1W1P\Figure C-6 - Crop Productivity Index.mxd User: cml3

BARR



Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses from Public Water Inventory (PWI). Ponds, lakes, subwatersheds from National Hydrography Dataset (NHD). Soil Erosion Risk from the Minnesota Board of Water and Soil Resources (BWSR).

SOIL EROSION RISK
WAGZ Comprehensive Watershed Management Plan

FIGURE C-7

Barr Footer: ArcGIS 10.8.1, 2021-04-27 21:40 File: \\barrcom\gis\Projects\23\55\1058\Maps\Reports\1W1P\Figure C-7 - Soil Erosion Risk.mxd User: cml3

C.5 Geology and Groundwater

The bedrock underlying the planning area is part of the Upper and Lower Ordovician Series, which formed 375-450 million years ago (Jirsa et al., 2011). The south and west portions of the planning area are underlain by Upper Ordovician limestone, shaley limestone, and dolostone. The north and east portions of the planning area are underlain by the Lower Ordovician Series, which includes dolostone, sandy to silty dolostone, and sandstone, including the Prairie du Chein group. Between these two formations is Middle Ordivician shale, dolomitic limestone, and sandstone, including Decorah shale and St. Peter sandstone.

The river and creek valleys in the north and east of the planning area are underlain by Upper Cambrian bedrock and the Middle and Upper Cambrian bedrock (along the Mississippi River). The Upper Cambrian formation includes sandstone, siltstone, shale, and dolostone, including Jordan Sandstone. The Middle and Upper Cambrian formation also includes Wonewoc sandstone and Mt. Simon sandstone.

More information about geology is available in the Geologic Atlas of Goodhue, Rice, and Wabasha Counties; atlases for other counties are in progress (Dodge and Olmsted Counties) or not yet started (Steele County). County geologic atlases are available from the Minnesota Geological Survey (MGS) at: https://www.dnr.state.mn.us/waters/groundwater_section/mapping/index.html.

C.5.1 Hydrogeology

Groundwater is an important resource within the planning area because it is the source of drinking water for all watershed residents. The infiltration of water from the ground surface to the surficial and, ultimately, bedrock aquifers (i.e., groundwater recharge) is critical for sustaining groundwater resources. The potential for groundwater recharge varies across the watershed, based on local soils, geology, and land use characteristics. Estimated recharge rates within the planning area are presented in Figure C-8.

The depth of the surficial aquifer (i.e., water table) varies within the planning area, from less than 10 feet below the ground surface in the southwest to over 50 feet in the bluff areas in the northeast (Adams, 2016). Some residential wells in the planning area draw water from the surficial aquifer, although most residential wells in the planning area draw water from the following bedrock aquifers (MDH, 2016):

- Galena-Maquoketa
- St. Peter-Prairie du Chein-Jordan
- Tunnel City-Wonewoc (formerly Franconia-Ironton-Galeville)

Nearly all of the municipalities in the planning area rely on groundwater from bedrock aquifers for their drinking water supply. Rochester Public Utilities provides drinking water to their residents from 31 wells ranging from 400 to 1,000 feet deep that draw water primarily from the Jordan aquifer and multi-formations including Prairie du Chein-Jordan, Prairie du Chein-Wonewoc, Jordan-Wonewoc, and Prairie du Chein-Mt. Simon aquifers.

Several municipalities have developed wellhead protection plans (WHPPs) under the guidance of the Minnesota Department of Health (MDH). WHPPs are intended to limit the potential for groundwater contamination of public water supply wells and include the delineation and vulnerability assessment of

Drinking Water Supply Management Areas (DWSMAs). Figure C-9 presents the extent of DWSMAs and active wells within the planning area.

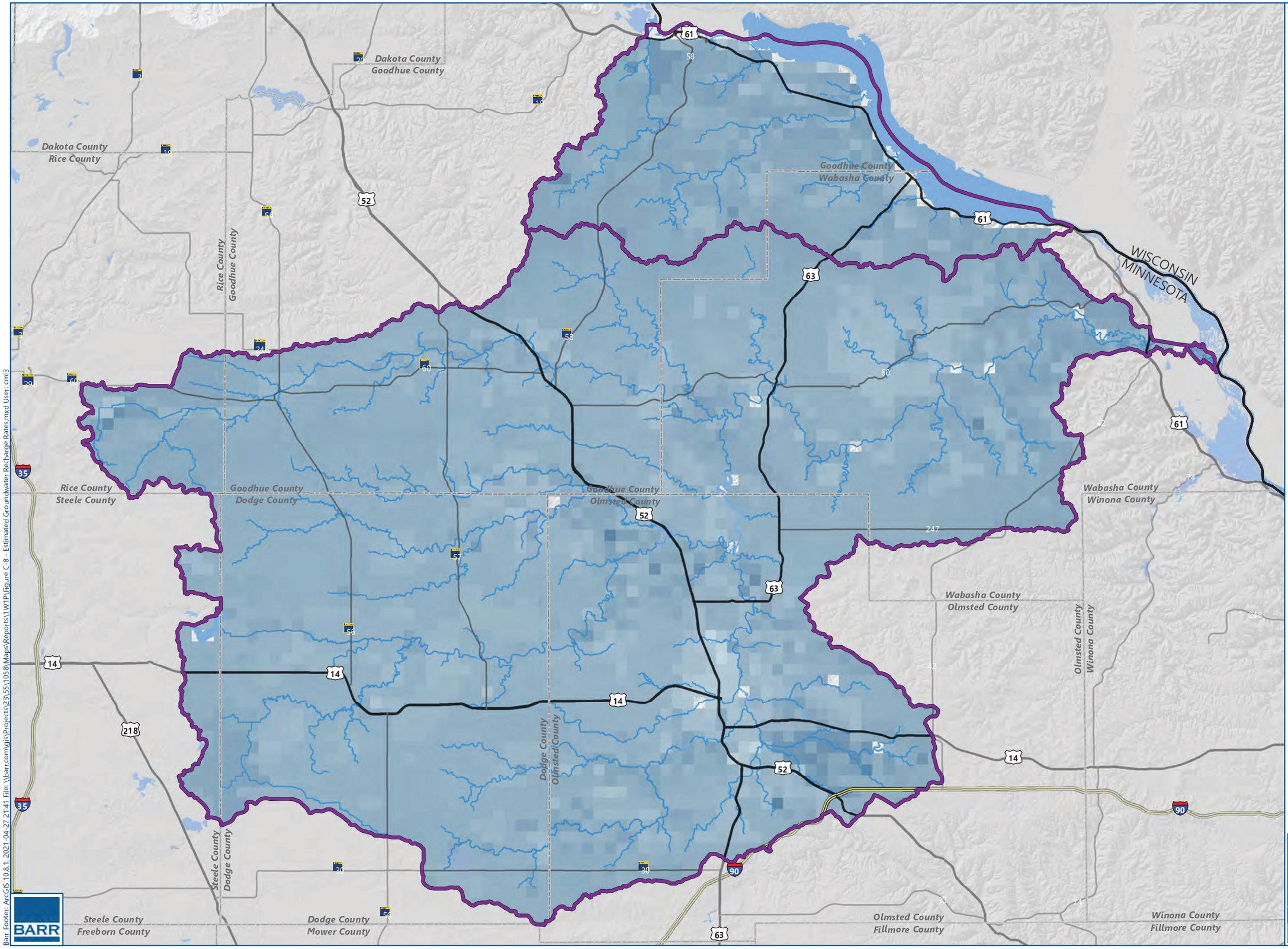
Table C-C-6 lists the number and depths of wells for select municipalities and non-community systems in the planning area and the status of each entity's Wellhead Protection Plan (WHPP). In addition to these systems, the Minnesota Department of Health (MDH) also conducted source water assessments for privately owned water supply systems that serve water to the public, such as campgrounds, churches, golf courses, industrial facilities, etc.

Table C-C-66 Municipal and non-municipal community well depths and WHPP status for select communities

Municipality/Entity	County	Number of Wells	Depths of Wells (feet)	Aquifer(s)	DWSMA vulnerability	Status of WHPP
Goodhue	Goodhue	2	440, 700	Jordan, Tunnel City-Wonewoc	low	starting amendment in 2021~~completed~~
Goodhue County Electric Coop	Goodhue	6	300 - 496	Wonewoc, Mt. Simon	Moderate/low	not started~~not started~~
MN Correctional Facility – Red Wing	Goodhue	2	470, 593	Mt. Simon	moderate	In progress~~not started~~
Pine Island	Goodhue	2	452, 555	PDC, Jordan	Moderate/high	completed~~completed~~
Twin Fawn Mobile Home Park	Goodhue	2	unknown	QWTA?	high	In progress~~not started~~
Oronoco	Olmsted	2	334, 400	Jordan	Low/moderate/high	completed~~in progress~~
Rochester	Olmsted	31	400 - 1000	Shakopee, Jordan, Tunnel City, Wonewoc, Mt. Simon	Moderate/high	completed~~in progress~~
Clearwater Well Company	Olmsted	1	384	Jordan	low	Not started~~completed~~
Briarwood Subdivision	Olmsted	1	412	Jordan	low	In progress~~not started~~
Chester Heights	Olmsted	1	600	Jordan	Moderate/high	not started~~not started~~
Sunrise Mobile Home Park	Olmsted	1	389	Jordan	low	In progress~~not started~~
Zumbro Ridge Estate	Olmsted	2	395, 410	Jordan	Low/high	not started~~not started~~
Lake City	Wabasha	4	130 - 163	Quaternary Water Table Aquifer	high	completed~~completed~~
Zumbro Falls	Wabasha	1	336	Jordan	Moderate/high	completed~~completed~~
Kellogg	Wabasha	2	141, 166	Quaternary Water Table Aquifer	Moderate/high	starting amendment in 2021~~completed~~
Millville	Wabasha	1	186	PDC-Jordan	Moderate/high	completed~~completed~~
Plainview	Wabasha	2	411, 444	Jordan	Moderate/high	completed~~completed~~
Hiawatha Estates I, II, III	Wabasha	2	400	Tunnel City-Wonewoc	low	In progress~~not started~~
Claremont	Dodge	2	250, 314	Stewartville-Cummingsville	low	completed~~completed~~
Dodge Center	Dodge	2	868, 913	Jordan	low	completed~~completed~~
Kasson	Dodge	3	807, 828, 852	PDC-Jordan	low	completed~~completed~~
Mantorville	Dodge	1	750	Jordan	low	completed~~completed~~
West Concord	Dodge	2	803, 821	Jordan	low	completed~~completed~~
Bellechester	Goodhue	2	450, 550	Tunnel City-Lone Rock	low	completed~~completed~~
Kenyon	Goodhue	2	657, 710	Jordan	low	completed~~completed~~

Red Wing	Goodhue	5	630 - 665	Mt. Simon	low	completed~~completed~~
Wanamingo	Goodhue	2	590, 600	Jordan	Low/moderate	completed~~completed~~
Zumbrota	Goodhue	3	404 - 479	Jordan	low	completed~~completed~~
Byron	Olmsted	2	698, 706	Jordan	low	completed~~completed~~
Country Home Trailer Park	Olmsted	1	500	Jordan	low	not started~~not started~~
Hallmark Terrace Mobile Home Park	Olmsted	1	413	Jordan	low	not started~~not started~~
Kings Park – Hyland Addition	Olmsted	1	478	Jordan	low	not started~~not started~~
Oronoco Estates MHC, LLC	Olmsted	1	398	Jordan	low	not started~~not started~~
Hammond	Wabasha	1	500	Wonewoc	low	completed~~completed~~
Mazeppa	Wabash	2	567, 720	Tunnel City, Wonewoc, Mt. Simon	low	completed~~completed~~

Source: MDH response to Plan update notification



Study Area
Watercourses
Pond or Lake
County Boundary
State Boundary

Mean Groundwater Recharge

1996 - 2010 (in/km^2/year)
High : 18
Low : 0

Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses from Public Water Inventory (PWI). Ponds, lakes, subwatersheds from National Hydrography Dataset (NHD). Groundwater recharge data from Mean Annual Potential Groundwater Recharge Rates from 1996 - 2010 for Minnesota, U.S. Geological Survey.

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ESTIMATED GROUNDWATER RECHARGE RATES
WAGZ Comprehensive Watershed Management Plan
FIGURE C-8

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Red Wing
Dakota County
Goodhue County
Randolph
Cannon Falls
Dakota County
Rice County
Northfield
Rice County
Goodhue County
Dundas
Dennison
Goodhue
Lake City
Bellechester
Wabasha
WISCONSIN
MINNESOTA
Nerstrand
Goodhue County
Wabasha County
Kellogg
Wanamingo
Zumbrota
Zumbro Falls
Faribault
Mazeppa
Kenyon
Millville
Hammond
Minneiska
Rice County
Steele County
Goodhue County
Dodge County
Pine Island
Goodhue County
Olmsted County
Wabasha County
Winona County
Medford
West Concord
Oronoco
Plainview
Elgin
Wabasha County
Olmsted County
Owatonna
Olmsted County
Winona County
Elba
Altura
Mantorville
Rochester
Claremont
Kasson
Byron
Dodge Center
Dodge County
Olmsted County
Eyota
Dover
Saint Charles
Utica
Lewiston
Steele County
Dodge County
Hayfield
Blooming Prairie
Steele County
Freeborn County
Dodge County
Mower County
Stewartville
Olmsted County
Fillmore County
Chatfield
Winona County
Fillmore County

Study Area
Watercourses
Pond or Lake
Municipal Boundary
County Boundary
State Boundary
DWSMA Boundary
Active Wells (CWI)

MPARS Active Water Appropriations Permits

- Agricultural Irrigation
- Heating/Cooling
- Industrial Processing
- Non-Crop Irrigation
- Power Generation
- Special Categories
- Water Level Maintenance

Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses from Public Water Inventory (PWI). Ponds and lakes from National Hydrography Dataset (NHD). Active Wells from MN County Well Index (CWI). MPARS Active WA Permits from MN DNR. DWSMA from Minnesota Department of Health (MDH).

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DRINKING WATER SUPPLY MANAGEMENT AREAS, WELLS, AND GROUNDWATER APPROPRIATIONS

WAGZ Comprehensive Watershed Management Plan

FIGURE C-9

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Barr Footer: ArcGIS 10.8.1, 2021-04-27 21:40 File: \\barr.com\gis\Projects\23\55\1058\Maps\Reports\1W1P\Figure C-9 - Drinking Water Supply Management Areas, Wells, and Groundwater Appropriations.mxd User: cml3

C.5.2 Groundwater Quality

The quality of groundwater resources within the planning area is important to preserving public health and quality of life. Groundwater quality data is collected by several entities within the watershed, including, but not limited to:

- Minnesota Department of Agriculture (MDA)
- Minnesota Department of Health (MDH)
- Minnesota Department of Natural Resources (MDNR)
- Minnesota Pollution Control Agency (MPCA)
- United States Geological Survey (USGS)
- Partner Counties

Groundwater monitoring locations and data are available from the MPCA's Environmental Data Access (EDA) website at: https://pca-gis02.pca.state.mn.us/eda_groundwater/index.html

Public water suppliers are required to perform periodic water quality monitoring. Owners of private wells are not required to monitor well water quality. The MDH, Minnesota Department of Agriculture (MDA) and other organizations promote the sampling of private wells through education and subsidized sampling programs. The MDH maintains a database of water quality results from sampling of private and public wells. Contaminants of primary concern in groundwater include arsenic, nitrates, and bacteria.

In 2006, nine southeast Minnesota counties (including Dodge, Goodhue, Olmsted, Rice, and Wabasha Counties) coordinated planning to develop a Volunteer Nitrate Monitoring Network (VNMN) to monitor long term trends of nitrate concentrations in private drinking water wells in southeastern Minnesota. From 2006 until 2012 the project included nine counties and multiple state agencies funded by the EPA 319 Program and the MPCA Clean Water Partnership (CWP) Program. Sampling began in 2008. In 2013, the program was changed to incorporate more analytes in selected wells, but no longer sampled the entire network for nitrate. In 2014, the MDA coordinated with the County Water Planners and Southeast Minnesota Water Resources Board (SEMNWRB) to continue sampling all of the wells in the network on an annual basis to determine long term trends and keep the original network intact where possible. Results through 2015 are summarized in the MDH report *Southeast Minnesota Domestic Well Network 2016 Data Report* (MDH, 2016). Annual reports are available from MDA at: https://www.mda.state.mn.us/southeast-minnesota-volunteer-nitrate-monitoring-network

The MDA, in coordination with counties and SWCDs, also conducted a township well testing program. Through this program, nitrate testing was performed to townships that are vulnerable to groundwater contamination and have significant row crop production. Several townships within the planning area participated in the program. Results from township testing for nitrate may be used by private homeowners for information on their wells. MDA township testing was performed in Olmsted County in 2014, Dodge County in 2016, ~~and~~ Goodhue, Rice, and Wabasha Counties in 2017, and Steele County in 2018 (note that areas of Rice County and Steele County included in township testing are located outside the planning area). Additional information regarding the MDA's township well testing and the most recent township testing results are available at: https://www.mda.state.mn.us/township-testing-program

Groundwater quality data collected through MDH and MDA programs indicate that nitrate concentrations in groundwater are a concern within the planning area (see Section 3.2.1). Nitrate concentrations from ~~2017~~ 2019 private well testing for counties within the planning area is summarized in Table C-C-7. The State of Minnesota health risk limit (HRL) for nitrate-nitrogen is 10 mg/L. Wells with results in the range of 3 to 10 mg/L are considered impacted but safe for drinking; the water is above natural levels of nitrate but below the HRL. Naturally occurring background concentrations of nitrate are generally considered less than 3 mg/L but have been observed as low as less than 1 mg/L (Dubrovsky, et al., 2010).

Table C-C-7~~7~~ Well nitrate monitoring results (2019) by county

County	Total Wells[1]	Mean Nitrate-N (mg/L)	Percent of Wells <3 mg/L	Percent of Wells 3<10 mg/L	Percent of Wells ≥10 mg/L
Dodge	39	0.1	97.4%	2.6%	0.0%
Goodhue	48	2.8	60.4%	35.4%	4.2%
Olmsted	51	2.0	80.4%	13.7%	5.9%
Rice	37	0.8	91.9%	2.7%	5.4%
Steele	--[2]	--[2]	--[2]	--[2]	--[2]
Wabasha	25	5.7	36.0%	48.0%	16.0%

Source: Volunteer Nitrate Monitoring Network 2019 Results (previously SEMNWRB and now administered by Olmsted County

(1) Wells are reported by county and may include wells not located within the planning area

(2) Steele County results not reported by SEMNWRB and is no longer included in the program; 2018 township testing data is available from MDA but is limited to areas located outside the planning area

The data presented in Table C-C-7 represents sampling of357 private drinking water wells. Results from 2019 are similar to previous years with 70% of nitrate results <3 mg/L, 22% in the 3<10 mg/L range, and 9% ≥10 mg/L (MDA 2019).

From 2015 to 2019. MDA sampled wells in 44 townships in Dodge, Goodhue, Rice, Wabasha, and Olmsted Counties for the presence of pesticides through its private well pesticide sampling (PWPS) project. Results of this effort are summarized in Table C-C-8. The MDA annual water quality monitoring reports including nitrate and pesticide water quality data and long-term trends are available at: www.mda.state.mn.us/monitoring

Table C-C-88 Well pesticide monitoring results (2017-2019) by county

County (years sampled)	Number of townships sampled	Number of wells sampled	Total wells with pesticide detection	Detection frequency	Number of pesticides and degradates detected	Health ref. values (HRLs) exceeded (compound)
Dodge (2017-2018)	7	108	78	72%	24	0
Goodhue (2018-2019)	16	384	290	76%	39	0
Wabasha (2018-2019)	14	476	391	82%	37	0
Olmsted (2019)	7	93	76	82%	22	4 (total cyanazine)

Source: MDA PWPS project; Olmsted County was also sampled in 2015 but 2019 results are presented due to recency.

C.5.3 Groundwater Sensitivity to Pollution

The MDNR assessed the sensitivity of near-surface materials and the uppermost bedrock surface to groundwater contamination for much of the planning area (Adams, 2016). The MDNR defines a sensitive area as a geologic area characterized by natural features where there is significant risk of groundwater degradation from activities conducted at or near the land surface. The MDNR designated five classes of sensitivity for the bedrock surface (very high, high, moderate, low, and very low). The MDNR has designated five classes of surface material sensitivity based on vertical travel times (high: hours to a week, moderate: a week to weeks, low: weeks to months, very low: months to a year, and ultra-low: more than a year); these classes are superseded by special conditions including karst, surface bedrock, disturbed lands, and peatlands. This information is documented in the Minnesota Hydrogeology Atlas (MHA) and is available from the MDNR at:
https://www.dnr.state.mn.us/waters/groundwater_section/mapping/status_mha.html

The pollution sensitivity of near surface materials is presented in Figure C-10. Groundwater sensitivity to pollution in the planning area is significantly affected by the presence of karst features (i.e., limestone that has been eroded, increasing groundwater conductivity) throughout the eastern two thirds of the planning area. Karst bedrock and other features (e.g., sinkholes, springs) in the planning area are presented in Figure C-11.

Because of the sensitivity of near surface material to pollution, the State of Minnesota has restricted the application of nitrogen fertilizer on cropland in the fall or on frozen soils will be restricted in vulnerable groundwater areas. This includes areas with vulnerable groundwater (mapped at the quarter section level) and in DWSMAs that have nitrate-nitrogen concentrations at or in excess of 5.4 mg/L nitrate-nitrogen. Vulnerable areas for Part 1 of the rule are defined as:

- coarse textured soils based on USDA NRCS soils maps
- shallow bedrock based on USDA NRCS soils maps; or
- karst geology based on MN DNR map (see Figure C-10 and Figure C-11).

Areas within a DWSMA which are low risk to groundwater contamination in the MDH Wellhead Protection Plan are exempt from fall application restrictions. Vulnerable areas where fall nitrogen fertilizer application is restricted are overlaid on Figure C-10.

The MDNR and MDH have further estimated the pollution sensitivity of wells based on the sensitivity of near surface materials and well characteristics. The pollution sensitivity of wells is classified by MDNR/MDH as low, medium, or high and is presented in Figure C-12.

Study Area
Watercourses
Pond or Lake
County Boundary
State Boundary
Areas of Fall Nitrogen Application Restrictions

Pollution Sensitivity of Near-Surface Materials

High
Moderate
Low
Very low
Bedrock at or near surface
Karst
Water

Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses from Public Water Inventory (PWI). Ponds and lakes from National Hydrography Dataset (NHD). Pollution Sensitivity from MN DNR County Geologic Atlas Program. Areas of Fall N Appliication Restriction from MDA.

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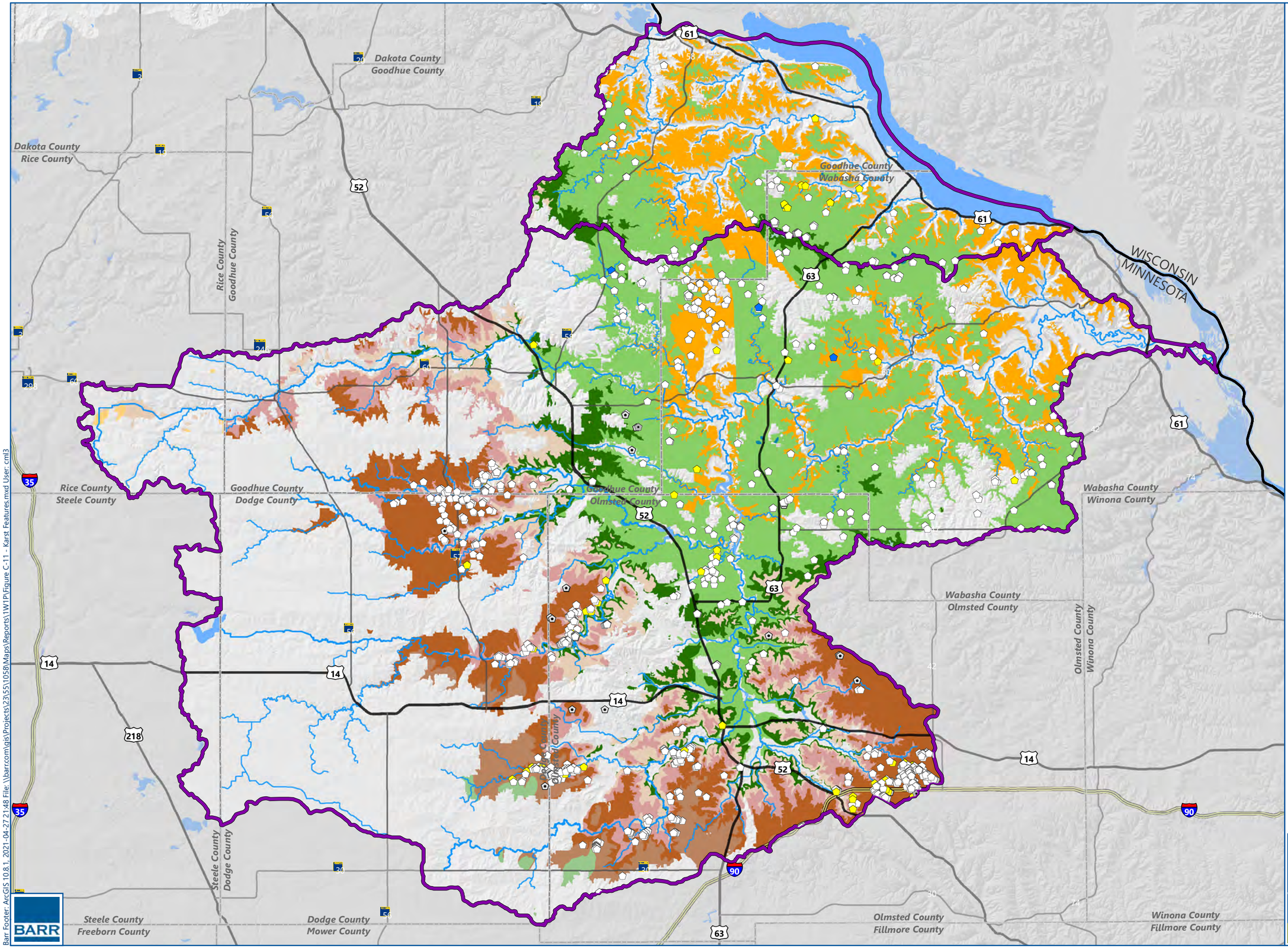
POLLUTION SENSITVITY OF NEAR SURFACE MATERIALS
WAGZ Comprehensive Watershed Management Plan
FIGURE C-10

Barr Footer: ArcGIS 10.8.1, 2021-04-27 21:40 File: \\barrcom\gis\Projects\23\55\1058\Maps\Reports\1W1P\Figure C-10 - Pollution Sensitivity of Near Surface Materials.mxd User: cml3



Study Area
Watercourses
Pond or Lake
County Boundary
State Boundary

Karst Features

Stream Sink/Sieve
Sinkhole
Surface Tile Inlet
Surface Tile Outlet
Miscellaneous

Surface Carbonate Karst and Sandstone Features

Cummingsville Formation
Decorah, Platteville, Glenwood, St. Peter
Galena / Prosser Fm
Galena / Stewartville Fm
Galena, Winnipeg, Red River
Maquoketa and Dubuque
Oneota Dolomite
Platteville and Glenwood Formations
Prairie du Chien Group
Shakopee Formation
St. Peter Sandstone
Stewartville and Cummingsville

Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses from Public Water Inventory (PWI). Ponds and lakes from National Hydrography Dataset (NHD). Karst Feature Inventory Points from University of Minnesota, Department of Geology and Geophysics; Minnesota Department of Natural Resources, Ecological and Water Resources Division. Surface Carbonate Karst and Sandstone Features from the Ecological and Water Resources Divsion, County Geologic Atlas Program.

N

0 2.5 5
Miles

KARST FEATURES
WAGZ Comprehensive Watershed Management Plan

FIGURE C-11

BARR

Study Area
Watercourses
Pond or Lake
County Boundary
State Boundary

Pollution Sensitivity of Wells

High
Moderate
Low

Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses from Public Water Inventory (PWI). Ponds and lakes from National Hydrography Dataset (NHD). Pollution Sensitivity from Minnesota Department of Health (MDH).

N

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Miles

POLLUTION SENSITVITY OF WELLS
WAGZ Comprehensive Watershed Management Plan
FIGURE C-12

Barr Footer: ArcGIS 10.8.1, 2021-04-27 21:48 File: \\barr.com\gis\Projects\23\55\1058\Maps\Reports\1W1P\Figure C-12 - Pollution Sensitivity of Wells.mxd User: cml3

BARR

C.6 Surface Waters

The planning area is characterized by the Zumbro River and its tributaries, numerous streams, wetlands, ponds, and other surface waters. Figure C-13 presents surface water features within the planning area.

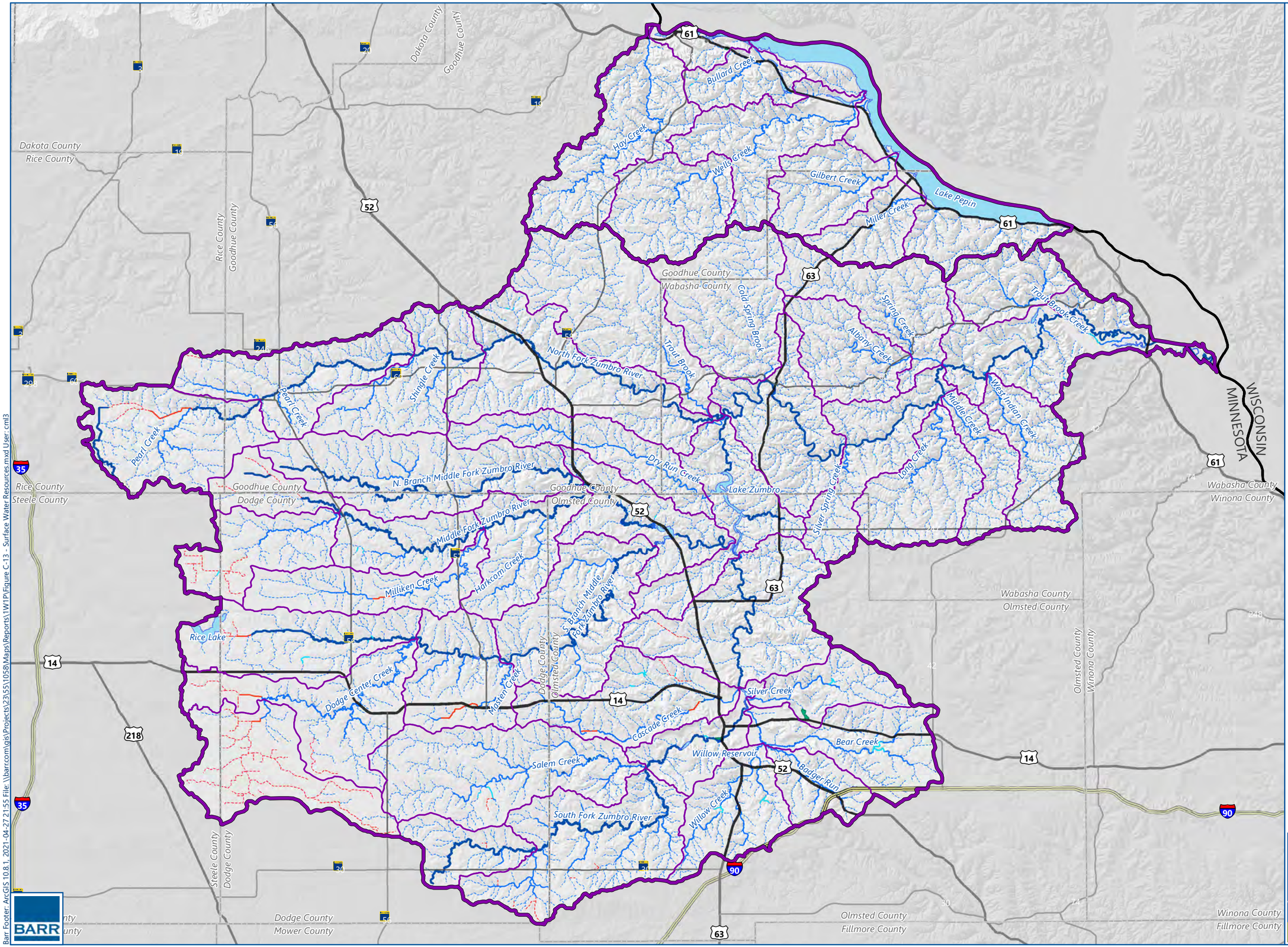
C.6.1 MDNR Public Waters

The MDNR designated many of the streams, rivers, lakes, basins, and wetlands within the watershed as "public waters" to indicate those lakes, wetlands, and watercourses that full under MDNR regulatory jurisdiction. MDNR public waters are all water basins and watercourses, natural or altered, that meet the criteria set forth in Minnesota Statutes, Section 103G.005, subd. 15 that are identified on public water inventory (PWI) maps and lists authorized by Minnesota Statutes, Section 103G.201. In addition to public water lakes, this includes:

- Public water wetlands – MDNR public waters wetlands include all type 3, type 4, and type 5 wetlands (as defined in U.S. Fish and Wildlife Service Circular No. 39, 1971 edition) that are 10 acres or more in size in unincorporated areas or 2 ½ acres or more in size in incorporated areas (see Minnesota Statutes Section 103G.005, subd. 15a and 17b).

- Public water watercourses – MDNR public waters include natural and altered watercourses with a total drainage area greater than two square miles (see Minnesota Statutes Section 103G.005, subd. 15a9). This definition can include ditches that are privately held and not under the jurisdiction of the county drainage system.

The MDNR uses county-scale maps to show the general location of the public waters and public waters wetlands (lakes, wetlands, and watercourses) under its regulatory jurisdiction. These maps are commonly known as Public Waters Inventory (PWI) maps. The regulatory "boundary" of these waters and wetlands is called the ordinary high-water level (OHWL). Public waters within the planning area are presented in Figure C-13. PWI maps are available from the MDNR website at: https://www.dnr.state.mn.us/waters/watermgmt_section/pwi/maps.html


Study Area
Subwatersheds (HUC12)
County Boundary
State Boundary
MDNR Public Waters
River Centerline
Stream (Perennial)
Stream (Intermittent)
Ditch (Perennial)
Ditch (Intermittent)
Connector
Public Water Basin
Public Water Wetland
Lake Pepin
Lake Zumbro
Rice Lake
Willow Reservoir
Bullard Creek
Hay Creek
Wells Creek
Gilbert Creek
Miller Creek
Trout Brook Creek
Cold Spring Brook
Spring Creek
Albany Creek
West Indian Creek
Middle Creek
Long Creek
Silver Spring Creek
Dry Run Creek
North Fork Zumbro River
Trout Brook
Shingle Creek
Pearl Creek
N. Branch Middle Fork Zumbro River
Middle Fork Zumbro River
Milliken Creek
Harkcom Creek
S. Branch Middle Fork Zumbro River
Dodge Center Creek
Master Creek
Cascade Creek
Silver Creek
Bear Creek
Badger Run
Willow Creek
Salem Creek
South Fork Zumbro River
Dakota County
Goodhue County
Rice County
Wabasha County
Olmsted County
Dodge County
Steele County
Winona County
Fillmore County
Mower County
WISCONSIN
MINNESOTA
Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses, Public Water Basins, and Public Water Wetland from Public Water Inventory (PWI). Ponds and lakes from National Hydrography Dataset (NHD).
N
0
2.5
5
Miles
SURFACE WATER RESOURCES
WAGZ Comprehensive Watershed Management Plan
FIGURE C-13
Barr Footer: ArcGIS 10.8.1, 2021-04-27 21:55 File: \\barrcom\gis\Projects\23\55\1058\Maps\Reports\1W1P\Figure C-13 - Surface Water Resources.mxd User: cml3
BARR

C.6.2 Rivers and Streams

The Zumbro River is the defining surface water feature within the Zumbro River watershed, draining approximately 1,420 square miles before discharging to the Mississippi River near Kellogg, MN. The Zumbro River watershed is subdivided into 5 major subwatersheds (HUC10 level) according to its major tributary forks (see also Figure C-3), which include:

- Zumbro River (main stem downstream of the South Fork and Middle Stem)
- South Fork Zumbro River
- North Fork Zumbro River
- Middle Fork Zumbro River
- South Branch Middle Fork Zumbro River

In addition, there are several named streams tributary to the Zumbro River and its multiple forks. Significant named streams in the watershed, divided among the five major River reaches, are listed in Table C-C-9.

Table C-C-~~9~~9 Streams within the Zumbro River Watershed (by major Zumbro River segment)

Zumbro River	South Fork Zumbro River	North Fork Zumbro River	Middle Fork Zumbro River	South Branch Middle Fork Zumbro River
• Cold Creek • Dry Run Creek • Long Creek • Middle Creek • Silver Spring Creek • Spring Creek • Trout Brook • West Indian Creek	Badger Run • Bear Creek • Cascade Creek • Salem Creek • Silver Creek • Willow Creek	• Pearl Creek • Shingle Creek • Trout Brook (Mazeppa Creek)	• Harkcom Creek • Milliken Creek	• Dodge Center Creek • Masten Creek

Streams in the Zumbro River watershed are primarily classified by the MDNR as warm water. The presence of groundwater springs in the eastern part of the watershed supplies cold water to the following cold-water streams: Mazeppa Creek, Cold Creek, Spring Creek, and Trout Brook. Significant portions of these streams are classified as wild (naturally reproducing) or semi-wild trout waters (MPCA, 2017) (see also Section C.10).

The Mississippi River Lake Pepin watershed is bounded on the north by Lake Pepin, which is a flow-through lake on the Mississippi River. The watershed drains an area of 233 square miles via several named creeks tributary to the Mississippi River and Lake Pepin. Significant named streams in the watershed, divided among the three HUC10 watersheds, are listed in Table C-C-10.

Table C-C-1010 Streams within the Mississippi River-Lake Pepin Watershed (by HUC10 watershed)

Hay Creek	Wells Creek	Lake Pepin
• Hay Creek • Bullard Creek	• Wells Creek	• Gilbert Creek • Miller Creek

Most of the stream reaches in the Mississippi River Lake Pepin watershed are classified as cold-water streams by the MDNR, and several are classified as trout waters (see also Section C.10).

Rivers and streams within the planning area are presented in Figure C-13. In addition to the perennial streams shown in Figure C-13, there are additional intermittent stream reaches throughout the watershed, located upstream of the perennial stream reaches.

The MPCA lists several of the river and stream reaches within the planning area as impaired due to stressors impacting stream uses for aquatic recreation, aquatic life, and an aquatic consumption (see Section C.8.6).

C.6.3 Drainage Systems

In addition to the natural streams and rivers, there are several altered watercourses and ditches within the planning area, concentrated in Dodge, Rice, and Steele Counties. Many ditches were constructed in the early 1900s to aid in land development for agriculture. The goal of these ditches is to remove water from agricultural lands. Many of the drainage ditches within the watershed are identified as MDNR public waters and shown on Figure C-13.

Ditches identified as public waters may be part of private drainage systems or public drainage systems (also known as judicial or county ditches). Public drainage systems administered under Chapter 103E of Minnesota Statutes are under the jurisdiction of a drainage authority (e.g., county, watershed district). The land associated with an open ditch that is part of a public drainage system remains privately held. Some ditches identified by the MDNR as public waters due to their drainage area are part of private drainage systems and are not under the jurisdiction of the county drainage system.

Generally, the counties maintain jurisdiction over the ditches. For any new ditches or ditch improvements, the land adjacent to public ditches is required by the MNDR to include a buffer strip of permanent vegetation that is usually 1-rod (16.5 feet) wide on each side (Minnesota Statutes, Section 103E.021). Additional requirements for public drainage systems are included in Minnesota Statutes 103E.015, 103E.215, 103E.411, and 103E.701 Subdivision 6.

C.6.4 Lakes

Figure C-13 presents the public waters lakes located in the planning area. Significant lakes within the watershed include:

- Lake Zumbro
- Rice Lake
- Silver Lake
- Lake Pepin (downstream of the Mississippi River Lake Pepin watershed)
- Foster Arend Lake
- Will Creek Reservoir (WR-6A)

Of those listed above, only Rice Lake and Lake Pepin are naturally occurring lakes; the others are the result of impoundments. In addition to the above-named impoundments, there are many smaller impoundments located throughout the planning area. Local stakeholders continue to work to increase and improve connectivity between impoundments and their respective streams, while maintaining the integrity and public value of existing structures.

The following subsections summarize information about the lakes listed above. Table C-C-11 provides some key morphometric and lake classification statistics for lakes in the planning area. Additional information is available from the MDNR LakeFinder website at: https://www.dnr.state.mn.us/lakefind/index.html

C.6.4.1 Lake Zumbro

Lake Zumbro (public water ID 55-0004) is located near the town of Oronoco downstream of the confluence of the South Fork, Middle Fork, and South Branch Middle Fork of the Zumbro River. Lake Zumbro is a 600-acre reservoir created by a hydroelectric dam (Lake Zumbro Dam) located on the north side of the lake. The drainage area to Lake Zumbro is approximately 853 square miles and includes portions of Dodge, Goodhue, Olmsted, Steele, and Wabasha Counties (and less than 1 square mile of Rice County) and the City of Rochester. The lake has a maximum depth of 43 feet. There is a public boat launch at Ponderosa Campground on the northwest side of the lake in addition to several private access points.

Lake Zumbro dam was constructed from 1917-1919 and is currently owned and operated by Rochester Public Utilities (RPU). The dam is managed as "run-of-the-river" (i.e., what flows in must flow out) to minimize water level fluctuations, although water levels may fluctuate by several feet. The ordinary high water (OHW) level is 915 feet (NGVD29 datum). RPU monitors lake levels; data is available in real time at: https://www.rpu.org/education-environment/lake-zumbro-water-level.php

The large ratio of watershed to lake area has contributed to excessive nutrient and sediment loading to Lake Zumbro. The MPCA listed Lake Zumbro on its impaired waters list for excessive nutrients/ eutrophication and for mercury in fish tissue (see Section C.8.6). Over time, sediment accumulation within the lake has altered lake bathymetry and reduced the volume of the lake. In 2019, a dredging project began to remove accumulated sediment from Lake Zumbro.

The Lake Zumbro Improvement Association (LZIA) is a volunteer organization of watershed residents concerned about the restoration and management of Lake Zumbro. The LZIA monitors water clarity in the lake. In 2006, the LZIA established a new non-profit organization, Lake Zumbro Forever, Inc. (LZFI) "dedicated to the restoration and preservation of the beauty, environmental character, recreational quality, hydroelectric capacity, and regional value of Lake Zumbro." LZFI pursues funding for improvement projects and cooperates with LGUs regarding lake management activities.

C.6.4.2 Rice Lake

Rice Lake (public water ID 74-0001) is a shallow lake located in Steele County in the far western part of the planning area. Rice Lake forms the headwaters of the South Branch Middle Fork Crow River. The lake is approximately 600 acres in area and drains a tributary watershed of about 4,500 acres that includes portions of Steele and Dodge Counties. Rice Lake has a maximum depth of about 7 feet and an average depth of about 3 feet. The OHW level is 1238.2 feet (NGVD29 datum). Periodic water level measurements for Rice Lake date back to 1938; water levels during the open water period have been monitored approximately twice monthly since 2004. Public boat access to Rice Lake is available at Rice Lake State Park on the north side of the lake.

The MPCA listed Rice Lake as impaired for aquatic recreation due to excessive nutrients/ eutrophication (see Section C.8.6).

C.6.4.3 Lake Pepin

Lake Pepin is a flow-through lake located on the Mississippi River straddling the Minnesota and Wisconsin border. Lake Pepin is approximately 40 square miles in area and stretches for about 22 miles from the City of Red Wing to the City of Wabasha. The watershed area tributary to the Mississippi River (and Lake Pepin) at this location is approximately 47,000 square miles and includes the Upper Mississippi River, Minnesota River, St. Croix River, and Cannon River watersheds.

Lake Pepin has an average depth of about 21 feet and a maximum depth of about 60 feet. Lake Pepin is a popular recreational lake, used for boating, fishing, and swimming. Public boat access and beach access are located at several locations in Lake City. Frontenac State Park is also located on the west shore of Lake Pepin within the planning area.

C.6.4.4 Silver Lake

Silver Lake (public water ID 55-0003) is a reservoir formed by the Silver Lake dam, originally constructed from 1935 to 1936. The dam is currently operated by Rochester Public Utilities (RPU). Silver Lake has an approximate surface area of 50 acres and maximum depth of 11 feet. The lake slows the flow of the South Fork Zumbro River, resulting in sediment deposition upstream of the dam. Periodic dredging has been performed to maintain depth and recreational functions.

Silver Lake Park is a popular recreational location adjacent to Silver Lake and includes trails, non-powered boat access, and fishing pier. Many fish species are present, including sunfish, bullhead, largemouth bass, and northern pike.

C.6.4.5 Foster Arend Lake

Foster Arend Lake (public water ID 55-0019) is an artificial lake created from a sand and gravel mine pit. The City purchased the land in 1981 to convert to park space. Foster Arend Lake is complete surrounded by a City park with swimming beaches, a fishing pier, trails, and picnic facilities. The MDNR stocks Foster Arend Lake with brook trout and/or rainbow trout annually. Bluegill and largemouth bass are also present in strong numbers.

C.6.4.6 Willow Creek Reservoir (WR-6A)

Willow Creek Reservoir (public water ID 55-0021) is a 60-acre impoundment located on Willow Creek on the southwest side of the City of Rochester. The reservoir is surrounded by a walking trail. A fishing pier is located by on the east side of the lake.

The MPCA listed Willow Creek reservoir as impaired for aquatic consumption by the MPCA due to mercury in fish tissue (see Section C.8.6).

Table C-C-1111 Summary of lake characteristics in the planning area

Category	Lake Zumbro	Rice Lake	Willow Creek Reservoir	Lake Pepin	Silver Lake	Foster Arend Lake
MDNR Lake ID	55-0004-00	74-0001-00	55-0021-00	25-0001-00	55-0003-00	55-0019-00
MPCA 7050 use classification	2B aquatic life; 3C industrial use	2B aquatic life; 3C industrial use	2B aquatic life; 3C industrial use	2B aquatic life; 3C industrial use	2B aquatic life; 3C industrial use	NA
Total surface area	600-700 acres (varies with water level)	609 acres	60 acres	40 square miles	50 acres	17.7 acres
Watershed area	853 square miles	4,352 acres	~5,600 acres	~47,000 square miles	259 square miles	--
Watershed to lake area ratio	~800:1	7.1:1	93:1	~1,200:1	~3,300:1	--
Mean depth	--	3.0 ft (0.9 m)	--	21 ft (6.4 m)	2 ft (0.6 m)	
Maximum depth	43 ft (2.4 m)	6.9 ft (2.1 m)	22 ft (6.7 m)	56 ft (17.1 m)	11 ft (3.4 m)	42 ft (12.9 m)
Shoreline length	22.8 miles	1.2 miles	2.2 miles	117 miles	3.0 miles	0.7 miles
Impairments (stressor) [1]	Aquatic consumption (mercury in fish); Aquatic life (excess nutrients/ eutrophication)	Aquatic life (excess nutrients/ eutrophication)	Aquatic consumption (mercury in fish)	Aquatic life (excess nutrients/ eutrophication)	NA	NA

Source: Zumbro River TMDL Report (MPCA, 2018); MDNR LakeFinder

(1) Listed impairments do not include Mississippi River impairments for reaches including Lake Pepin

C.6.5 Wetlands

Wetlands in the planning area are important community and ecological assets. These resources provide significant wildlife habitat and refuge, while also supplying, recreational, runoff retention, and water quality treatment benefits. Many wetlands in the planning area, concentrated in the western portion of the Zumbro River watershed, have been drained for agricultural development prior to the establishment of regulations protecting wetlands (MPCA, 2016); approximately 87% of presettlement wetlands in the Zumbro River watershed have been lost (MPCA., 2017). However, many wetland areas remain throughout the watershed, concentrated in riparian areas adjacent to river and stream channels.

Nationally, the U.S. Fish and Wildlife Service (USFWS) is responsible for mapping wetlands across the country, including those in Minnesota. Using the National Aerial Photography Program (NAPP), in conjunction with limited field verification, the USFWS identifies and delineates wetlands, produces

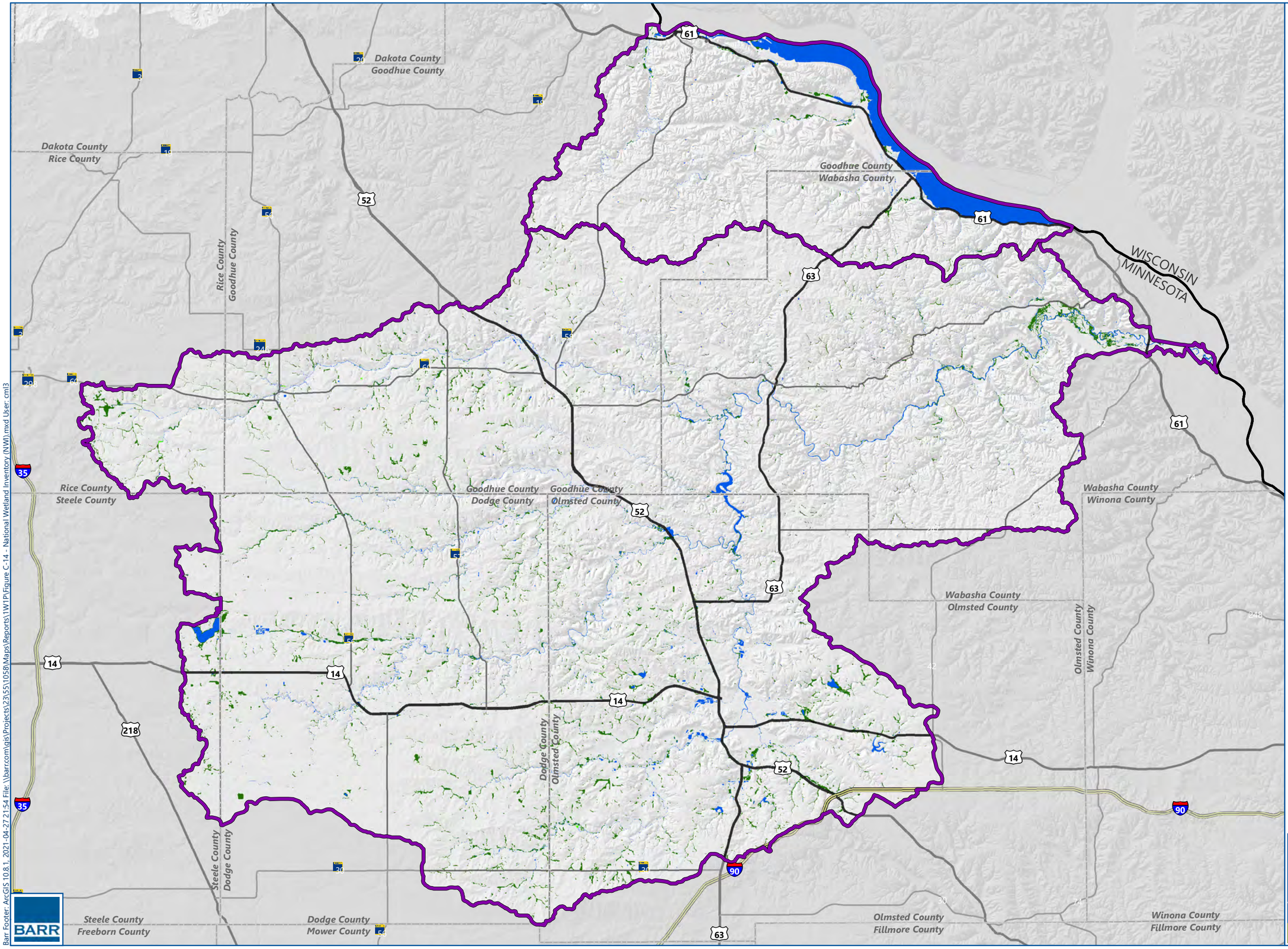
detailed maps on the characteristics and extent of wetlands, and maintains a national wetlands database as part of the National Wetlands Inventory (NWI). The NWI is periodically updated based on available imagery.

Figure C-14 shows the location of NWI wetlands within the planning area. Wetlands in the planning area are concentrated in the south and east Zumbro River watershed, with a few wetlands in the northwest Zumbro River watershed or Mississippi River Lake Pepin watershed. In total, there are approximately 22,000 acres of wetlands in the Zumbro River watershed (about 2% of the total area) and 1,300 acres of wetlands in the Mississippi River Lake Pepin watershed (not including portions of Lake Pepin classified as wetland). An extensive corridor of floodplain wetlands occurs along the lower reaches of the Zumbro River near the Mississippi River, accounting for a large percentage of the watershed's wetland area (MPCA, 2016).

The NWI classifies wetlands in the planning area are classified as emergent wetlands, forested or shrub wetlands, or pond, lake, or riverine wetlands. Freshwater forested/shrub wetland occur throughout the planning area adjacent to streams and rivers (see Figure C-14). There may be additional wetlands (especially those smaller than 0.5 acre) in the watershed that are not included in the NWI.

More information about the NWI is available from the USFWS at: https://www.fws.gov/wetlands/

Additional information about updates to the NWI in Minnesota is available from the MDNR at: https://www.dnr.state.mn.us/eco/wetlands/nwi_proj.html



Study Area

County Boundary

State Boundary

National Wetlands Inventory

Freshwater Forested/Shrub Wetland

Freshwater Emergent Wetland

Freshwater Pond, Lake, River

Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses from Public Water Inventory (PWI). Wetlands from MN DNR National Wetlands Inventory (NWI) East Central Update.

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Miles

NATIONAL WETLAND INVENTORY (NWI)

WAGZ Comprehensive Watershed Management Plan

FIGURE C-14

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C.7 Watershed Monitoring

Several agencies, LGUs, and other stakeholders have focused monitoring efforts in the Zumbro River watershed and Mississippi River Lake Pepin watershed. Several types of monitoring are taking place including stage, flow, continuous and discrete water chemistry, pollutant load monitoring, fish IBI, and macroinvertebrate IBI monitoring. Below is a summary of the monitoring efforts that are being carried out in the planning area. Monitoring locations are presented in Figure C-15. Additional discussion of watershed monitoring planned as part of the implementation of this Plan is included in Section 6.

C.7.1 Hydrologic Monitoring

There are 16 continuous stage and flow monitoring sites in the planning area (see Figure C-15), including 15 within the Zumbro River watershed and one on Wells Creek in the Mississippi River Lake Pepin watershed. Fourteen of these sites are currently active. These stream gages are summarized in Table C-C-12. Stream gages within the Zumbro River are operated in cooperative partnerships of the MPCA, MDNR, City of Rochester, and/or United States Geologic Survey (USGS). Live and historical data can be found for these gages online at https://www.dnr.state.mn.us/waters/csg/index.html

Besides monitoring stream flow, stream gages are very critical in assisting with pollutant load monitoring and flood prediction. Several of the stream gages located within the planning area are linked to the National Weather Service (NWS) Advanced Hydrologic Prediction Service (AHPS) to assist in predicting peak flood stage resulting from storm events. More information about AHPS is available from the NWS at: https://water.weather.gov/ahps/

Table C-C-1212 Summary of stream gages within the planning area

Stream/River	Site Description	MDNR ID	USGS ID	Period of Record	Drainage Area (square miles)
Bear Creek	Bear Creek at Rochester, US14	41051001	05372930	1981-2019	78.4
Cascade Creek	Cascade Creek at Rochester, 45th Ave SW	41065002	05372983	2013-2019	17.9
	Cascade Creek at Rochester, 7th St NW	41064001	05372990	1981-2019	38.2
Silver Creek	Silver Creek at Rochester, Silver Creek Dr NE	41050001	05372950	1981-2019	17.7
	Silver Creek near Rochester, Silver Creek Rd NE	41050002	--	2014-2016	--
Wells Creek	Wells Creek near Frontenac, US61	38006002		2009-2019	68.0
Middle Fork Zumbro River	Middle Fork Zumbro River near Oronoco,5th St	41071003	--	2012-2019	206
North Fork Zumbro River	North Fork Zumbro River near Wanamingo, CR30	41010001	05373720	1998-2019	106
	North Fork Zumbro River near Mazeppa, CSAH7	41006001	--	2012-2019	240
South Branch Middle Fork Zumbro River	South Br Mid Fork Zumbro River near Post Town, CR103	41067002	--	2011-2017	190
	South Branch Middle Fork Zumbro River near Oronoco,5th St	41071002	--	2012-2019	219
South Fork Zumbro River	South Fork Zumbro River near Rochester, CR104	41061002	--	2011-2019	141
	South Fork Zumbro River at Rochester, US14	41061001	05372800	1981-2019	155
	South Fork Zumbro River at Rochester, MN	41063001	05372995	1981-2019	303
Zumbro River	Zumbro River at Zumbro Falls, MN	41031002	05374000	1909-2019	1,150
	Zumbro River at Kellogg, US61	41043001	05374900	1975-2019	1,418

Source: MPCA/MDNR Cooperative Stream Gaging website: https://www.dnr.state.mn.us/waters/csg/index.html

C.7.2 Water Quality and Biological Monitoring

Several different agencies also conduct water chemistry and biological monitoring in the planning area. Through its Major Watershed Load Monitoring Program (MWLMP), the MPCA conducts (or coordinates with partners to conduct) annual pollutant load monitoring at continuous flow gaging locations (see Table C-C-12) within the planning area. The MPCA (or its partners) sample for total suspended solids (TSS), total phosphorus (TP), dissolved ortho-phosphorus (DOP), nitrate and nitrite, and total Kjeldahl

nitrogen (TKN). Approximately over 30-35 samples per year are collected at each site over a wide variety of flow conditions and rain events. The MPCA (or its partners) compiles and analyzes all of the streamflow and pollutant concentration data using FLUX32 software. The final products are annual load concentrations for each parameter at each site that can be compared from year to year and analyzed for long term trends (MPCA 2012, MPCA 2016).

The MPCA's on-going monitoring performed through MWLMP is designed to measure and compare regional differences and long-term trends in water quality. In the case of impaired waters, the data collected through these efforts will be used to aid in the development of TMDL studies, WRAPS studies, and implementation of plans, assist watershed modeling efforts, and provide information to watershed research projects.

Various Partners have performed targeted monitoring of resources on a limited basis in support of specific studies and/or projects (e.g., reservoirs in Olmsted County). Recently, the MDNR, MPCA, and Olmsted County have coordinated to perform monitoring of Cascade Creek following constructed improvements.

Water quality and biological monitoring data are available from the MPCA's Environmental Data Access (EDA) website at: https://www.pca.state.mn.us/quick-links/eda-surface-water-data

C.7.2.1 Citizen and local monitoring

Citizen monitoring is an important component of the watershed monitoring approach. The MPCA coordinates two programs aimed at encouraging citizen surface water monitoring: the Citizen Lake Monitoring Program (CLMP) and the Citizen Stream Monitoring Program (CSMP). Sustained citizen monitoring can provide the long-term picture needed to help evaluate current status and trends. Citizen-collected data helps agency staff interpret the results from intensive monitoring efforts, which occur less frequently. It also allows interested parties to track any water quality changes that occur in the years between the intensive monitoring events. Coordinating with volunteers to focus monitoring efforts where it will be most effective for planning and tracking purposes will help local citizens/governments see how their efforts are being used to inform water quality management decisions and affect change. The MPCA used citizen monitoring data for assessment in the Mississippi River Lake Pepin watershed and Zumbro Lake watershed (MPCA 2012, MPCA 2016).

The MPCA also passes through funding via Surface Water Assessment Grants (SWAGs) to local groups such as counties, soil and water conservation districts (SWCDs), watershed districts, nonprofits, and educational institutions to monitor lake and stream water quality. Several of the Partners have used SWAG grants to perform water quality monitoring of streams in the past; collected data is entered into the MPCA system.

C.7.2.2 Stream Water Chemistry Monitoring

During the MPCA's most recent intensive monitoring efforts within the planning area, five stream locations in the Mississippi River Lake Pepin watershed and 13 locations in the Zumbro River watershed were monitored for water chemistry by the MPCA or its partners. Monitoring was performed primarily

from 2008-2009 for the Mississippi River Lake Pepin watershed and from 2012-2013 in the Zumbro River watershed. Stream water chemistry monitoring locations were generally located near subwatershed outlets. For trout streams, additional water chemistry monitoring was performed in upstream reaches (e.g., Hay Creek, Wells Creek). Additionally, citizen volunteers enrolled in the CSMP observed physical water characteristics at 33 stream stations in the Zumbro River watershed and submitted data to MPCA in 2014. Stream water chemistry monitoring locations are presented in Figure C-15.

Additional details regarding monitoring locations, parameters, and results are included in the *Mississippi River Lake Pepin Watershed Monitoring and Assessment Report* (MPCA, 2012) and the *Zumbro River Watershed Monitoring and Assessment Report* (MPCA 2016).

C.7.2.3 Stream biological monitoring

The MPCA completed the biological monitoring component of the intensive watershed monitoring in 2008-2009 in the Mississippi River Lake Pepin watershed and in 2012 for the Zumbro River watershed. Fifteen locations were monitored for biological parameters in the Mississippi River Lake Pepin watershed and 70 locations were monitoring for biological parameters in the Zumbro River watershed (including five locations originally established in 2002).

To measure the health of aquatic life at each biological monitoring station, the MPCA calculates indices of biological integrity (IBIs), specifically Fish and Invertebrate IBIs, based on monitoring data collected for each of these communities. The MPCA developed a fish and macroinvertebrate classification framework to account for natural variation in community structure, which is attributed to geographic region, watershed drainage area, water temperature, and stream gradient. The MDNR also performs fishery surveys of several trout streams located within the planning area (see also Section C.10.4).

As part of the MPCA's intensive watershed monitoring, mercury was analyzed in fish tissue samples collected from the Zumbro River and 4 lakes, including Lake Zumbro. Polychlorinated biphenyls (PCBs) were measured in fish from the Zumbro River and10 lakes. In addition, fish from the Zumbro River and Lake Zumbro were tested for perfluorochemicals (PFCs) between 2007 and 2010. The MPCA analyzed mercury and PCBs in fish tissue samples collected from Wells and Hay Creeks in 2008 and 2010.

Additional detail regarding biological monitoring locations, parameters, and results are included the *Mississippi River Lake Pepin Watershed Monitoring and Assessment Report* (MPCA, 2012) and the *Zumbro River Watershed Monitoring and Assessment Report* (MPCA 2016).

C.7.2.4 Lake Water Quality Monitoring

The Zumbro River watershed has 17 lakes at least 10 acres in size. Lake Zumbro and Silver Lake were monitored for water clarity by citizens enrolled in the CLMP in partnership with MPCA. The MPCA and its partners have also collected lake water chemistry data for Lake Zumbro and Rice Lake. Monitoring methods were consistent among monitoring groups and are described in the document entitled *MPCA Standard Operating Procedure for Lake Water Quality* (MPCA 2018). The lake water quality assessment standard requires eight observations/samples within a 10-year period for phosphorous, chlorophyll-a, and Secchi depth (clarity) (MPCA 2017).

The only lake in the Mississippi River Lake Pepin watershed is Lake Pepin. Due to the size and complexity of this basin and the ongoing work developing a TMDL, assessment of Lake Pepin monitoring and water quality results is outside of the scope of this document. More information can be found at: https://www.pca.state.mn.us/water/tmdl/lake-pepin-watershed-work-groups-tmdl-project

Additional detail regarding lake monitoring locations, parameters, and results are including the *Mississippi River Lake Pepin Watershed Monitoring and Assessment Report* (MPCA, 2012) and the *Zumbro River Watershed Monitoring and Assessment Report* (MPCA 2016).

C.7.2.5 Groundwater Monitoring

Through the Ambient Groundwater Monitoring Program, the MPCA has sampled 6 domestic wells and 10 monitoring wells within the Zumbro River watershed. The Minnesota Department of Agriculture (MDA) coordinates groundwater quality monitoring through its township testing program (TTP) (see Section C.5.2). The MDA also monitors pesticides in groundwater through a network of monitoring wells through its private well pesticide sample (PWPS) project. Southeast Minnesota, including the Zumbro River watershed, is one of two areas the MDA monitors more intensively due to the vulnerable geology. The Minnesota Department of Health (MDH) also coordinates voluntary well testing programs to monitor groundwater for nitrate and other contaminants.

The MDA samples 11 sites in the Zumbro River watershed including one spring, one monitoring well, and nine domestic wells. Twenty different pesticides or pesticide breakdown products (or degradates) have been detected in the wells and the spring. None have exceeded human health reference values. Monitoring of the MDA's sites in the watershed is expected to continue. More information is available at: http://www.mda.state.mn.us/monitoring

As part of the MDA PWPS project, wells in 44 townships in Dodge, Goodhue, Wabasha, and Olmsted Counties were sampled between 2015 and 2019. Samples were analyzed for 22 compounds in 2015 and 125 compounds beginning in 2016. The chemistry data is available on a township summary basis for the wells (well locations are not shared due to privacy issues).

Recent groundwater quality monitoring results are summarized in see Section C.5.2.

C.8 Surface Water Quality

The water quality of surface water resources within the planning area is important to the recreational, economic, and ecological functions of those resources. Historically, surface water quality data in the planning area has been collected by entities including, but not limited to:

- Minnesota Pollution Control Agency (MPCA)
- United States Geological Survey
- Counties and Soil and Water Conservation Districts (SWCDs)

Water quality monitoring programs within the planning area are summarized in Section C.7.2. Surface water monitoring locations are presented in Figure C-15. Monitoring locations and data are also available

from the MPCA's Environmental Data Access (EDA) website at: https://www.pca.state.mn.us/quick-links/eda-surface-water-data

Much of the surface water quality information summarized in this section is based on the *Zumbro River Watershed Restoration and Protection Strategy Report* (Zumbro WRAPS) (MPCA 2017) and the *Mississippi River Lake Pepin Watershed Restoration and Protection Strategy Report* (Mississippi Pepin WRAPS) (MPCA 2015).

C.8.1.1 Watershed Restoration and Protection Strategies (WRAPS)

The MPCA completed Watershed Restoration and Protection Strategies (WRAPS) studies for the Mississippi River Lake Pepin watershed and the Zumbro River watershed in 2015 and 2017, respectively. The WRAPS studies consider available data and assessments to identify water resources not meeting applicable water quality standards (i.e., impaired waters) and outline strategies to restore impaired waters and protect waters that are not impaired.

The MPCA performed intensive watershed monitoring for the planning area prior to completing the WRAPS studies (see Section C.7.2). The MPCA use this data to assess surface waters in the planning area for support of aquatic life, aquatic recreation, and fish consumption, where sufficient data was available. Not all lakes and stream reaches (identified by unique "assessment unit identifiers," or AUIDs) could be assessed due to insufficient data, modified channel condition, or their status as limited resource value waters.

Information from the Zumbro WRAPS and Mississippi Pepin WRAPS is summarized in this document. Additional information may be obtained from the MPCA website at: https://www.pca.state.mn.us/water/watersheds/zumbro-river and https://www.pca.state.mn.us/water/watersheds/mississippi-river-lake-pepin

C.8.2 Surface Water Quality Assessments

The Zumbro and Mississippi Pepin WRAPS include assessments of stream and lake water quality to evaluate if those resources are achieving designated uses. Designated uses include a waterbody's ability to support aquatic life, aquatic recreation, and aquatic consumption. The state of Minnesota, consistent with the Clean Water Act, adopted water quality standards corresponding to a waterbody's designated uses. Minnesota water quality standards are published in Minnesota Rules 7050, available at: https://www.revisor.mn.gov/rules/7050/

Minnesota water quality standards applicable to the waterbodies assessed as part of the Zumbro and Mississippi Pepin WRAPS, as well as the methodology for comparing data to those standards, are described in the *Mississippi River Lake Pepin Watershed Monitoring and Assessment Report* (MPCA, 2012) and the *Zumbro River Watershed Monitoring and Assessment Report* (MPCA 2016). Waterbodies that fail to meet water quality standards applicable to its designated uses are identified by the MPCA as "impaired" for that use and placed on the MPCA's impaired waters 303(d) list. Individual waterbodies may be impaired for multiple uses or may be impaired for a single designated use due to multiple stressors (see Section C.8.4). Impaired waterbodies within the planning area are presented in Figure C-16. The MPCA

further classifies stream reaches that "nearly impaired," "barely impaired," or "nearly exceptional" based on water quality data; these reaches are identified in Figure 3-6.

C.8.2.1 Stream Assessments

The WRAPS studies assessed streams for aquatic life, aquatic recreation, and fish consumption designated uses. Aquatic life use impairments include:

- Low fish index of biotic integrity (Fish IBI) – which means an unhealthy fish community is present
- Low macroinvertebrate (i.e., aquatic bugs) index of biotic integrity (Invert IBI) – which means an unhealthy macroinvertebrate community is present
- Turbidity/total suspended solids (T, TSS) levels too high to support fish or macroinvertebrate life

Aquatic recreation use impairments include:

- Fecal coliform (FC) – a type of bacteria, found in the intestinal tracts of warm-blooded animals
- *Escherichia coli* (*E. coli*) – a bacteria, found in the intestinal tracts of warm-blooded animals; E. coli is a specific type of fecal coliform
- Nutrients/eutrophication/biological indicators (Nutrients) – water clarity is reduced due to excessive growth of algae resulting from, typically, excessive phosphorus concentrations

Fish consumption impairments include:

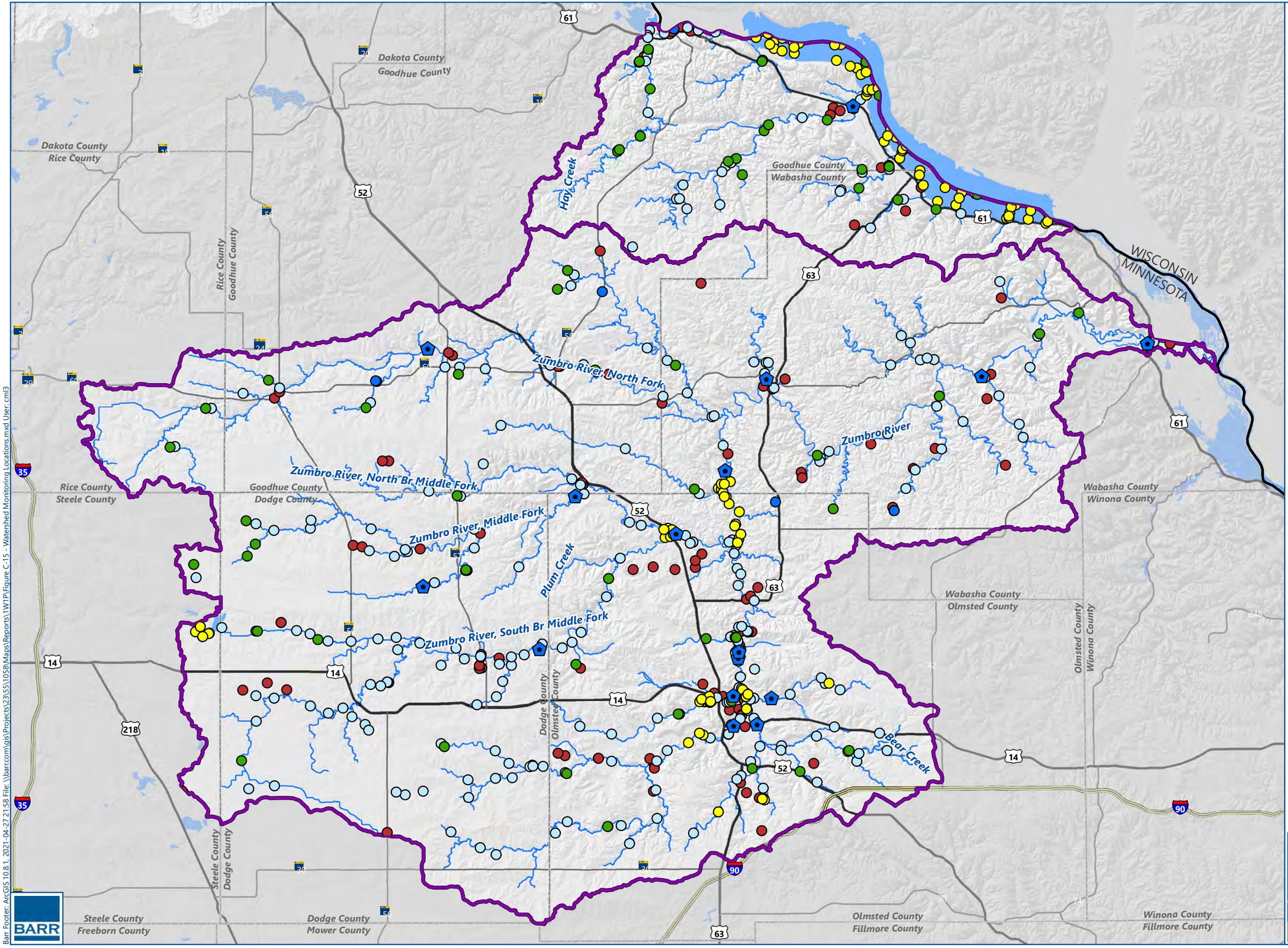
- Mercury in fish tissue (Hg-F) – fish tissue contains concentrations of mercury that pose a health risk if eaten
- Polychlorinated biphenyls in fish tissue (PCB-F) – fish tissue contains concentrations of polychlorinated biphenyls (PCBs) that pose a risk to health if eaten

The results of the stream assessments relative to aquatic life and aquatic recreation are presented in Table C-C-13 and are based on information published in the Zumbro and Mississippi Pepin WRAPS. Many of the subwatersheds listed in Table C-C-13 include several stream reaches and/or tributaries. A complete list of the stream reaches (AUIDs) identified as not supporting aquatic life and aquatic recreation uses is included in the WRAPS documents.

Table C-13 Stream aquatic life and aquatic recreation impairments from Zumbro River WRAPS and Mississippi River Lake Pepin WRAPS

HUC 10 Watershed	Subwatershed (from WRAPS)	Area (acres)	# Total AUIDs	# Assessed AUIDs	# Supporting Aquatic Life	# Supporting Aquatic Recreation	# Not supporting Aquatic Life	# Not supporting Aquatic Recreation	Insufficient Data	Delistings
South Fork Zumbro River 0704000401	Bear Creek	52,064	25	8	4	0	3	1	1	3
	Salem Creek	39,782	12	4	2	0	2	1	0	0
	Lower South Fork Zumbro River	84,860	28	9	1	0	5	1	3	2
	Upper South Fork Zumbro River	49,382	6	4	4	0	0	0	0	0
South Branch Middle Fork Zumbro River 0704000402	Dodge Center Creek	57,806	17	6	1	0	4	1	1	0
	South Branch Middle Fork Zumbro River	80,507	17	7	3	0	2	1	1	0
Middle Fork Zumbro River 0704000403	North Branch Middle Fork Zumbro River	37,460	12	2	2	0	0	0	1	1
	Lower Middle Fork Zumbro River	19,652	3	3	1	0	2	1	0	0
	Upper Middle Fork Zumbro River	82,535	23	7	4	0	3	1	0	0
North Fork Zumbro River 0704000404	Mazeppa Creek	35,661	16	1	0	0	1	1	0	0
	North Fork Zumbro River	117,876	50	12	5	0	7	1	0	0
Zumbro River 0704000405	Cold Creek	29,337	18	1	0	0	1	0	1	0
	Spring Creek	40,922	49	5	1	0	3	2	1	0
	Upper Zumbro River	66,647	42	6	4	0	0	2	3	0
	Lower Zumbro River	114,868	156	7	2	0	4	4	2	0
Zumbro River Watershed Totals		**909,359**	**474**	**82**	**34**	**0**	**37**	**17**	**14**	**6**
Hay Creek 0704000104	Hay Creek	30,483	2	2	0	0	0	1	0	2
	Bullard Creek	44,855	3	2	0	0	0	1	0	1
Wells Creek 0704000106	Wells Creek	34,498	1	1	0	0	0	1	0	2
Lake Pepin 0704000107	Miller Creek	11,377	1	1	0	0	0	1	0	1
	King Creek	27,061	1	1	0	0	0	0	0	0
	Gilbert Creek	23,938	3	1	0	0	1	1	0	2
Misssissippi River Lake Pepin Watershed Totals		**172,212**	**11**	**8**	**0**	**0**	**1**	**5**	**0**	**8**

Source: Zumbro River WRAPS (MPCA 2017) and Mississippi River Lake Pepin WRAPS (MPCA 2015)



Study Area
Watercourses
Pond or Lake
County Boundary
State Boundary
DNR/MPCA Stream Monitoring Locations

Monitoring Stations

MPCA Surface Water

- Biological
- Lake
- Stream

Other

- NPDES Discharge
- USGS Stream Gauge

Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses, Public Water Basins, and Public Water Wetland from Public Water Inventory (PWI). Ponds and lakes from National Hydrography Dataset (NHD). Monitoring Stations from the Minnesota Pollution Control Agency (MPCA). DNR/MPCA Stream Monitoring Locations from MN DNR and MPCA.

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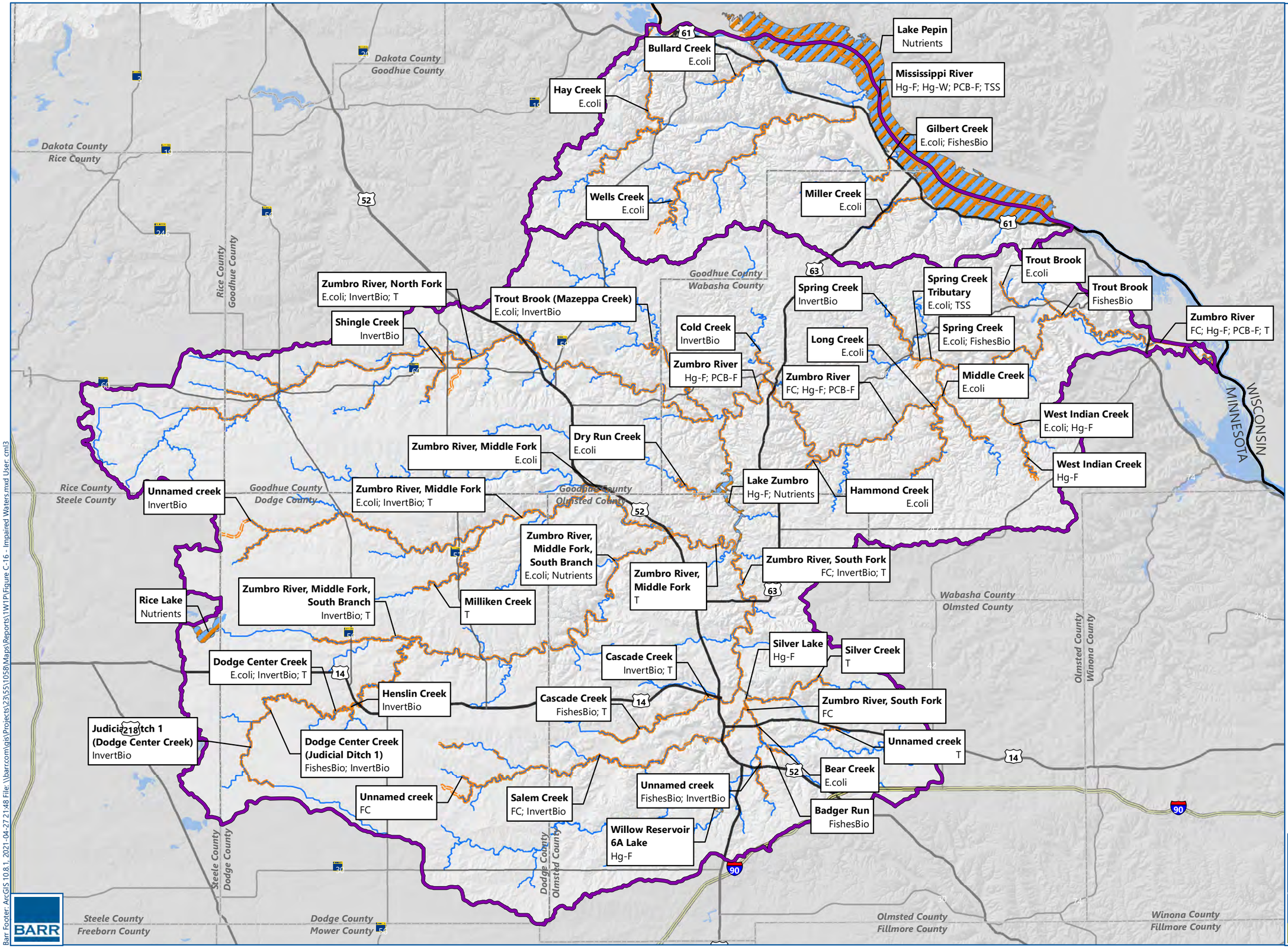
WATERSHED MONITORING LOCATIONS
WAGZ Comprehensive Watershed Management Plan

FIGURE C-15



Study Area
Watercourses
Pond or Lake
County Boundary
State Boundary
Impaired Streams (2018)
Impaired Lakes (2018)

Impairments:
FC = Fecal Coliform
Hg-F = Mercury in Fish Tissue
PCB-F = PCB in Fish Tissue
T = Turbidity
InvertBio = Invertebrate Bioassessments
FishesBio = Fishes Bioassessments

Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses, Public Water Basins, and Public Water Wetland from Public Water Inventory (PWI). Ponds and lakes from National Hydrography Dataset (NHD). Monitoring Stations from the Minnesota Pollution Control Agency (MPCA). DNR/MPCA Stream Monitoring Locations from MDNR and MPCA.

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IMPAIRED WATERS
WAGZ Comprehensive Watershed Management Plan

FIGURE C-16

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C.8.2.2 Lake Assessments

Lakes are assessed for aquatic recreation uses based on ecoregion specific water quality standards for total phosphorus (TP), chlorophyll-a (chl-*a*) (i.e., the green pigment found in algae), and Secchi transparency depth. To be listed as impaired, a lake must not meet water quality standards for TP and either chl-*a* or Secchi depth.

Seventeen lakes in the Zumbro River watershed are assessed in the Zumbro WRAPS; the results are summarized in Table C-C-14. The only lake in the Mississippi River Lake Pepin watershed is Lake Pepin, which was not assessed in the Mississippi Pepin WRAPS, owing to the complexity of the lake watershed and ongoing work related to the Lake Pepin TMDL (MPCA 2015). More information about Lake Pepin impairments is available from the MPCA at: https://www.pca.state.mn.us/water/tmdl/lake-pepin-excess-nutrients-tmdl-project

Table C-C-1414 Lake aquatic life and aquatic recreation impairments from Zumbro River WRAPS

HUC 10 Watershed	Subwatershed (WRAPS)	Area (acres)	Lakes > 10 acres	# Supporting Aquatic Life	# Supporting Aquatic Recreation	# Not supporting Aquatic Life	# Not supporting Aquatic Recreation	Insufficient Data	Delistings
South Fork Zumbro River 0704000401	Lower South Fork Zumbro River	84,860	9	0	0	0	0	0	0
	Bear Creek	52,064	3	0	0	0	0	0	0
	Upper South Fork Zumbro River	49,382	1	0	0	0	0	0	0
South Branch Middle Fork Zumbro River 0704000402	South Branch Middle Fork Zumbro River	80,507	1	0	0	0	1 (Rice Lake)	0	0
Zumbro River 0704000405	Lower Zumbro River	114,868	2	0	0	0	0	0	0
	Upper Zumbro River	66,647	1	0	0	0	1 (Lake Zumbro)	0	0
Zumbro River Watershed Totals		**909,440**	**17**	**0**	**0**	**0**	**2**	**0**	**0**

Source: Zumbro River WRAPS (MPCA, 2017)

Within the planning area, Rice Lake and Lake Zumbro were assessed and found to be impaired for aquatic recreation due to excessive nutrients/eutrophication (MPCA 2017). The nutrient impairment for Rice Lake is addressed in the Zumbro River Watershed TMDL (MPCA 2018). The nutrient impairment for Lake

Zumbro is not addressed by the most recent TMDL due to the lake's relatively recent impairment listing (2016) – the TMDL was already underway when the lake was listed.

C.8.3 Stream and River Water Quality Trends

The Zumbro WRAPS included a limited analysis of water quality trends in the South Fork Zumbro River north of Rochester (at CSAH 14). Water quality data collected at this location date back to 1973. Water quality trends for the South Fork Zumbro River are summarized in Table C-C-15. While several parameters show improvements over the period of record, concentrations of nitrate-nitrite and chloride have increased.

Table C-C-1515 Water quality trends in the South Fork Zumbro River (north of Rochester)

Parameter	Median Concentration (first 10 years)	Median Concentration (last 10 years)	Total Change, 1973-2008 (%)	Annual Change 1973-2008 (%)	Total Change 1995-2008 (%)	Annual Change 1995-2008 (%)
Total Suspended Solids	45 mg/L	16 mg/L	-64%	-2.9%	-42%	-6.7%
Total Phosphorus	0.9 mg/L	0.2 mg/L	-92%	-7.1%	--	--
Nitrate-Nitrite	3 mg/L	7 mg/L	+120%	+2.3%	--	--
Ammonia	0.5	<0.05 mg/L	-97%	-10.0%	--	--
Biochemical Oxygen Demand	5 mg/L	2 mg/L	-81%	-4.6%	--	--
Chloride	36 mg/L	54 mg/L	+186%	+3.0%	--	--

Source: Water Quality Trends for Minnesota Rivers and Streams at Milestone Sites (MPCA, 2014)

The MPCA also collected baseflow and storm flow water quality samples in West Indian Creek, a trout stream. Nitrate-nitrite concentrations in West Indian Creek show a statistically significant increase from 2007-2015 (MPCA 2017). Water quality collected from cold springs in southeastern Minnesota (not limited to the planning area) suggest potentially increasing nitrate-nitrate concentrations, although analysis of statistical significance is inconclusive (MPCA 2017). Assessment of stream water quality trends in the Mississippi River Lake Pepin watershed was not performed as part of the WRAPS study due to short periods of record (MPCA 2015).

C.8.4 Stressor Identification

To develop appropriate strategies for restoring or protecting waterbodies, the stressors and/or sources impacting or threatening them must be identified and evaluated.

A **stressor** is something that adversely impacts or causes fish and macroinvertebrate communities in streams to become unhealthy. Biological stressor identification is performed for streams with either fish or macroinvertebrate biota impairments and encompasses both evaluation of pollutants (such as phosphorus, bacteria or sediment) and non-pollutant-related factors as potential stressors (e.g., altered hydrology, fish passage, habitat).

Stressor identification studies have been completed for the Zumbro River watershed (MPCA October 2016) and the Mississippi River Lake Pepin watershed (MPCA June 2013). These studies identify the factors (i.e., stressors) that are causing the biotic (i.e., fish and macroinvertebrate) community impairments within the planning area, including both pollutants and non-pollutants. Table C-C-16 summarizes the primary stressors identified in streams with aquatic life impairments in the planning area. Common stressors were:

- **Elevated Temperature:** warmer water impacts organisms indirectly due to the relationship of warmer water with lower dissolved oxygen (DO) and aquatic toxicity of chemicals, as well as directly through changes in growth and reproduction, egg mortality, disease rates, and direct mortality.
- **Low Dissolved Oxygen (DO)**: when dissolved oxygen drops below optimal levels, desirable aquatic organisms, such as fish, may suffer stress or die off.
- **Elevated Nitrate:** elevated levels of nitrate in streams can be toxic to fish and macroinvertebrates, especially for certain species of caddisflies, amphipods, and salmonid fishes.
- **Sediment/turbidity**: increased turbidity of water harms fish and macroinvertebrates through gill abrasion, loss of visibility, and reduced sunlight penetration needed for plants.
- **Loss of Habitat/Bedded Sediment:** excess fine sediment that deposits on the bottom of stream beds negatively impacts fish and macroinvertebrates that depend on clean, coarse stream bottoms for feeding, shelter, and reproduction.
- **Flow Alteration and Connectivity:** flow alteration is the change of a stream's flow volume and/or flow pattern typically caused by anthropogenic activities, which can include channel alteration, water withdrawals, land cover alteration, wetland drainage, agricultural tile drainage, urban stormwater runoff, and impoundment.
- **Elevated Chloride/Conductivity:** Aquatic organisms can become stressed by an increase in ion concentrations. Calcium, sodium, and magnesium are all necessary for aquatic health, but imbalances can be toxic (SETAC, 2004). Increased use of road salt and de-icing products has putting more streams at risk for this stressor (Kostick, 1993).
- **Elevated nutrients (phosphorus)**: very low or highly fluctuating dissolved oxygen levels due to excess nutrients (phosphorus) fertilizing stream algae growth.

Unionized ammonia and pesticides were identified as potential stressors, but there is insufficient information to determine a causal linkage between these potential stressors and impairments.

The MPCA listed Hay Creek as impaired by turbidity for aquatic life. More turbidity data are currently being collected to determine if this listing is accurate. Aquatic life (fish and invertebrates) is doing well throughout this watershed, and the MPCA does not believe that turbidity related to sediment is a stressor at this time (MPCA 2013).

Table C-16 Stressors for biotic impairments in the Zumbro River and Mississippi River Lake Pepin watersheds

Stream Name	AUID	Biological Impairment	Stressor						
			Temperature	Dissolved Oxygen and Eutrophication	Nitrate	Total Suspended Solids	Lack of Habitat	Flow Alteration/ Connectivity	Chloride/ Conductivity
Spring Creek	07040004-568	Inverts	●	---	o	●	---	---	---
Spring Creek	07040004-570	Fish	---	---	o	●	●	---	---
Cold Creek	07040004-510	Inverts	---	---	o	---	●	---	---
Trout Brook (Mazeppa Creek)	07040004-515	Inverts	---	---	o	---	●	o	---
Trout Brook (Dumfries)	07040004-585	Fish	---	---	---	---	●	o	---
Unnamed creek	07040004-964	Inverts	---	o	●	---	●	o	---
Unnamed creek (Spring Creek Tributary)	07040004-605	Inverts	---	---	●	o		---	---
Spring Creek	07040004-606	Inverts	---	●	●	---	●	---	---
Shingle Creek	07040004-562	Inverts	---	---	●	o		---	---
Unnamed Creek	07040004-579	Inverts	---	---	---	---	●	---	---
North Fork Zumbro	07040004-971	Inverts	---	o	o	●	●	---	---
Unnamed Creek	07040004-578	Inverts	---	---	●	o	●	●	---
Middle Fork	07040004-973	Inverts	---	---	●	o	---	---	---
Dodge Center Creek	07040004-989	Inverts	---	---	o	●	●	o	---
Henslin Creek	07040004-618	Inverts	---	---	●	o	---	---	---
Judicial Ditch 1	07040004-987	Inverts	---	●	●	o	●	●	---
Judicial Ditch 1	07040004-988	Fish and Inverts	---	o	●	o	●	●	---
South Branch Middle Fork	07040004-976	Inverts	---	---	o	●	---	---	---
South Branch Middle Fork	07040004-980	Inverts	---	---	o	●	●	●	---
Salem Creek	07040004-503	Inverts	---	---	●	---	●	---	---
Salem Creek Trib	07040004-597	Fish and Inverts	---	o	●	o	●	●	---
Unnamed Creek (Trib to Willow)	07040004-800	Fish and Inverts	---	---	---	---	●	●	---
Badger Run	07040004-620	Fish	---	---	---	o	●	●	---
Unnamed Creek	07040004-621	Fish	---	---	---	---	●	●	---
South Fork Zumbro	07040004-507	Inverts	---	o	o	●	●	●	o
South Fork Zumbro	07040004-536	Inverts	---	---	---	o	●	---	---
Cascade Creek	07040004-581	Inverts	---	o	---	●	●	●	---
Cascade Creek	07040004-991	Fish	---	---	o	o	●	●	---
Gilbert Creek	07040001-530	Fish	---	---	---	---	●	---	---

Source: Mississippi River Lake Pepin Tributaries Biotic Stress Identification (MPCA 2013); Zumbro River Watershed Stressor Identification Report (MPCA 2016)

C.8.5 Pollutant Sources

The Mississippi Pepin WRAPS, Zumbro WRAPS, and Zumbro TMDL identify pollutant sources to impaired waters. These sources include point sources and non-point sources of pollutants. More detailed discussion of the pollutant sources summarized here is included in Section 2.3 of the WRAPS documents.

Point sources are defined as facilities that discharge stormwater or wastewater to a lake or stream and have a National Pollutant Discharge Elimination System or State Disposal System (NPDES/SDS) permit. Point sources in the planning area include industrial facilities and numerous wastewater treatment facilities. Point sources in the planning area are described in Section 2.3 of the WRAPS documents.

Nonpoint sources of pollution, unlike pollution from industrial and wastewater treatment facilities come from many diffuse sources. Nonpoint source pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves over cropland, forests, developed areas, or other landscapes, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes and streams. Precipitation and runoff infiltrating through the soil can also leach pollutants and convey them to both groundwater and surface waters. Common non-point pollutant sources in the planning area include:

- **Cropland runoff and infiltration:** Cropland can deliver sediment, nitrogen and phosphorus when soil is disturbed or exposed to wind and rain. Nutrient loading can occur via overland runoff as well as leaching of nutrients from cropland soils by infiltrating precipitation collected by tile or conveyed to groundwater. Assessment of the Lower Mississippi River basin identified over 50% of nitrogen loading coming from agricultural groundwater (MPCA, 2013). Analyses of nitrate concentrations in trout streams in southeast Minnesota identify a strong correlation between row crop land use and stream nitrate concentrations (MPCA 2017).
- **Near-stream/ditch erosion:** Near-stream/ditch erosion can deliver excess sediment and nutrients from destabilized banks or transport deposited sediment in the stream during very high flows. While streams naturally transport water and sediment, erosion issues occur when the streams are out of balance /equilibrium.
- **Livestock facilities and manure application:** Fertilizer and manure contain high concentrations of phosphorus, nitrogen, and bacteria that can runoff into lakes and streams when not properly managed. Animal feedlots that are not properly managed may become significant sources of bacteria and nutrients. Feedlots located within the planning area are presented in Figure C-17.
- **Failing subsurface sewage treatment systems (SSTS):** SSTS (septic systems) that are not maintained or failing can contribute excess phosphorus, nitrogen, and bacteria.
- **Internal loading:** Lake sediments contain large amounts of phosphorus that can be released into the lake water through physical mixing or under certain chemical/oxygen conditions.
- **Urban and rural stormwater:** Runoff from impervious surfaces common to developed areas may collect phosphorus, sediment, bacteria, and other pollutants prior to discharging to downstream waters.

The MPCA maintains a database which includes the locations of potential pollutant sources (e.g., underground storage tanks). This data is available from the MPCA at: https://www.pca.state.mn.us/data/whats-my-neighborhood

Study Area
Watercourses
Pond or Lake
Municipal Boundary
County Boundary
State Boundary

Feedlots

< 100 animal units
100-999 animal units
1000+ animal units

Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses from Public Water Inventory (PWI). Ponds and lakes from National Hydrography Dataset (NHD). Feedlots from Minnesota Pollution Control Agency (MPCA).

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FEEDLOTS
WAGZ Comprehensive Watershed Management Plan

FIGURE C-17

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Barr Footer: ArcGIS 10.8.1, 2021-04-27 21:58 File: \\barr.com\gis\Projects\23\55\1058\Maps\Reports\1W1P\Figure C-17 - Feedlots.mxd User: cmb

C.8.6 TMDL Analyses

Figure C-16 presents the impaired waters in the planning area. Waterbodies on the impaired waters list are required to have an assessment completed that addresses the causes and sources of the impairment. This process is known as a total maximum daily load (TMDL) analysis. The TMDL analysis includes target goals for water quality improvement. The MPCA recently completed the *Zumbro River Watershed Total Maximum Daily Load Report* (Zumbro TMDL, MPCA 2018) and the *Mississippi River Lake Pepin Tributaries Total Maximum Daily Load Report* (Mississippi Pepin TMDL, MPCA 2015). Information from these TMDL documents is summarized in this document. Additional information may be obtained from the MPCA website at: https://www.pca.state.mn.us/water/watersheds/zumbro-river and https://www.pca.state.mn.us/water/watersheds/mississippi-river-lake-pepin

Generally, the TMDL methodology relies on water quality monitoring data and water quality modeling to estimate a TMDL, defined as the maximum amount of pollutant that a waterbody can receive and still meet water quality standards and/or designated uses. A TMDL is comprised of three components:

- Wasteload Allocation (WLA) – the portion of the TMDL allocated to existing or future point sources of the relevant pollutant.
- Load Allocation (LA) – the portion of the TMDL allocated to existing or future nonpoint sources of the relevant pollutant. The LA may also encompass "natural background" contributions, internal loading and atmospheric deposition.
- Margin of Safety (MOS) – accounting of uncertainty about the relationship between pollutant loads and receiving water quality.

The Zumbro TMDL and Mississippi Pepin TMDLs address the impairments and stressors identified in Table C-C-17; these include impairments for total suspended solids (TSS), bacteria, and eutrophication (phosphorus). Note that there are recently identified impairments that are not addressed by TMDLs already completed.

Table C-17 Zumbro RIver watershed and Mississippi River Lake Pepin watershed 303(d) impairments addressed by Zumbro TMDL and Mississippi Pepin TMDL

HUC10 Watershed	Stream Name	AUID	Impaired Use	Pollutant	Year Listed
Hay Creek 0704000104	Hay Creek	07040001-518	Aquatic Recreation	E. coli	2012
	Bullard Creek	07040001-256	Aquatic Recreation	E. coli	2012
Wells Creek 0704000106	Wells Creek	07040001-708	Aquatic Recreation	E. coli	2012
Lake Pepin 0704000107	Miller Creek	07040001-534	Aquatic Recreation	E. coli	2012
	Gilbert Creek	07040001-530	Aquatic Recreation	E. coli	2012
Middle Fork Zumbro River 0704000403	Milliken Creek	07040004-555	Aquatic Life	TSS	2010
	Zumbro River	07040004-973	Aquatic Recreation	E. coli	2016
	Zumbro River	07040004-992	Aquatic Recreation	E. coli	2016
	Zumbro River	07040004-993	Aquatic Life	TSS	2010
North Fork Zumbro River 0704000404	Trout Brook	07040004-515	Aquatic Recreation	E. coli	2016
	Zumbro River	07040004-971	Aquatic Life	TSS	2016
			Aquatic Recreation	E. Coli	
South Branch Middle Fork Zumbro River 0704000402	Rice Lake	74-0001-00	Aquatic Recreation	Phosphorus	2016
	Zumbro River	07040004-978	Aquatic Recreation	E. coli	2016
	Dodge Center Creek	07040004-989	Aquatic Life	TSS	2016
			Aquatic Recreation	E. coli	
South Fork Zumbro River 0704000401	Bear Creek	07040004-538	Aquatic Recreation	E. coli	2016
	Unnamed Creek	07040004-595	Aquatic Recreation	Fecal coli	2008
	Unnamed Creek	07040004-596	Aquatic Recreation	Fecal coli	2008
Zumbro River 0704000405	Lake Zumbro	55-0004-00	Aquatic Recreation	Phosphorus	2002
	West Indian Creek	07040004-542	Aquatic Recreation	E. coli	2016
	Long Creek	07040004-565	Aquatic Recreation	E. coli	2016
	Middle Creek	07040004-567	Aquatic Recreation	E. coli	2016
	Spring Creek	07040004-568	Aquatic Life	TSS	2016
	Spring Creek	07040004-570	Aquatic Life	TSS	2016
			Aquatic Recreation	E. coli	
	Trout Brook	07040004-571	Aquatic Recreation	E. coli	2016
	Hammond Creek	07040004-575	Aquatic Recreation	E. coli	2016
	Dry Run Creek	07040004-576	Aquatic Recreation	E. coli	2016
	Spring Creek Tributary	07040004-769	Aquatic Life	TSS	2016
			Aquatic Recreation	E. coli	

Source: Zumbro River Watershed TMDL (MPCA 2018); Mississippi River Lake Pepin Tributaries TMDL (MPCA 2013)

C.8.6.1 Total Suspended Solids Impairments

The Zumbro TMDL includes detailed analysis of TSS loading to impaired reaches (see Section 4.4 of the Zumbro TMDL). Considerations and conclusions from that analysis include:

- Permitted point sources in the Zumbro River watershed with regulated TSS limits include dewatering from gravel and quarry pits. Wastewater facilities within the watershed are required to treat TSS to below the water quality standard.
- Modeling estimates that upland sources contribute 42% of the sediment load for the entire watershed, which is consistent with the predominance of highly erodible/unstable soils in the watershed. The next highest sediment source is bed and bank erosion at 39% followed by gully and ravine erosion at 18%.
- Point sources and tile drainage contribute relatively small fractions to the overall sediment delivery.
- The TSS load duration curves document exceedances during higher flows, confirming the nonpoint source contributions and the significant loads delivered during large rain events.

The Mississippi Pepin TMDL does not address TSS loading as the impairments addressed in that TMDL do not include turbidity or TSS impairments (MPCA 2015).

C.8.6.2 Bacteria Impairments

The Zumbro TMDL and Mississippi Pepin TMDL include detailed analysis of bacteria loading to impaired reaches (see Section 4.3 of the Zumbro TMDL and Section 4 of the Mississippi Pepin TMDL). Considerations and conclusions from that analysis include:

- Permitted sources of bacteria include industrial and municipal wastewater treatment facility effluent, municipal stormwater, and livestock feedlots. Wastewater facilities in the watershed are required via permit to treat below the bacteria water quality standard.
- Prior studies suggest the presence of background *E. coli* and a fraction of *E. coli* may be present regardless of the control measures taken by traditional implementation strategies. *E. coli* load allocations in the Zumbro TMDL include natural background.
- Fifteen of the 17 reaches included in the Zumbro TMDL analysis demonstrated bacteria loading exceedances during all flow regimes during which data was collected. For two reaches (North Fork Zumbro River and Middle Creek), bacteria exceedances were skewed towards high flow regimes.
- In the Mississippi River Lake Pepin watershed, bacterial loading exceeded targets during all flow regimes for all reaches included in the Mississippi Pepin TMDL, with the exception of Hay Creek. During very high flows, bacterial loading in Hay Creek was generally below target values, despite exceeding target values in all other flow regimes.

C.8.6.3 Eutrophication Impairment – Rice Lake

The Zumbro TMDL includes detailed analysis of nutrient loading to Rice Lake (see Section 4.2 of the Zumbro TMDL). A Hydrologic Simulation Program-Fortran (HSPF) watershed simulation model was used to estimate phosphorus loading to Rice Lake from the surrounding watershed (MPCA, 2018). A BATHTUB (Walker, 1999) in-lake model was used to estimate in-lake phosphorus concentrations. Considerations and conclusions from the TMDL analysis of Rice Lake include:

- Initial comparison between model-predicted and observed in-lake phosphorus concentrations showed model predictions (84 ug/L) significantly less than observed values (290 ug/L). These results suggest significant internal phosphorus loading from lake sediments may be present.
- Background sources of phosphorus include atmospheric deposition and low levels of soil erosion from stream channels and upland areas occurring under natural conditions. Given the estimated water quality improvement in Rice Lake resulting from internal load management, it is unlikely that natural background sources are a major component of phosphorus loading.
- An estimated 89% load reduction is necessary to achieve the total phosphorus water quality standard in Rice Lake.

Three other nutrient impairments in the Zumbro River watershed (including two stream reaches and Lake Zumbro) will be addressed by future TMDLs.

C.8.7 Water Quality Modeling

Water quality modeling has been used to estimate pollutant loading within the planning area. The type, extent, and level of detail vary among different modeling efforts. Past modeling efforts are summarized in this section.

C.8.7.1 HSPF Modeling – Nitrogen, Phosphorus, and TSS Loading

In support of the Zumbro WRAPS and Zumbro TMDL studies, HSPF modeling was performed for the entire Zumbro River watershed. HSPF modeling is also available in a separate model for the Mississippi River Lake Pepin tributary area (developed to support the MRLP WRAPS). HSPF is a large-basin, watershed model that simulates runoff and water quality in urban and rural landscapes. HSPF focuses on a generalized, larger scale perspective of watershed processes. The HSPF model provides estimation of river flows and water quality in areas where limited or no observed data has been collected. The HSPF model also provides estimations of the locations and proportions of watershed sources -- specific combinations of land use, slopes and soils -- comprising pollutant loading at downstream locations where more substantial observed data are available.

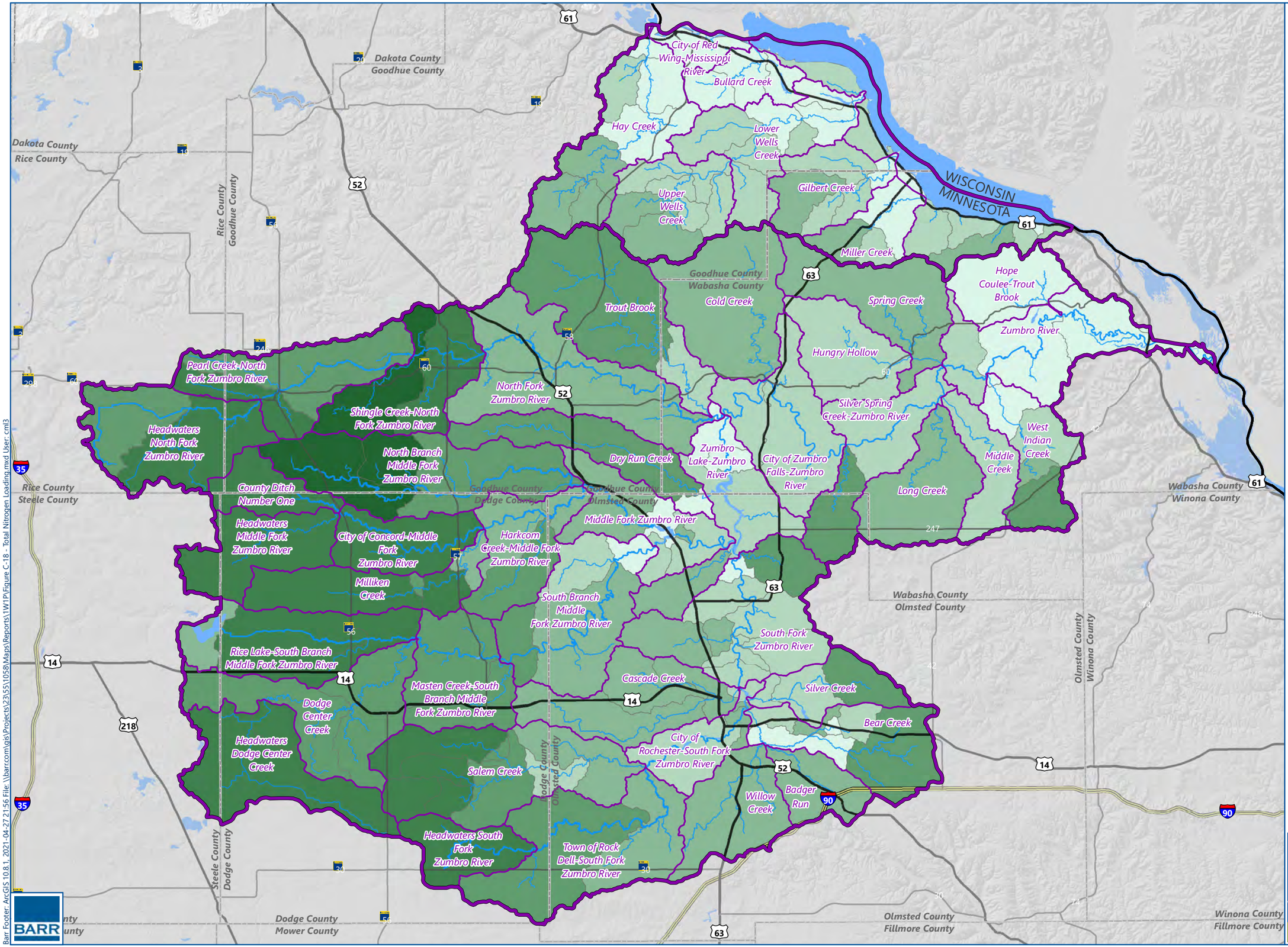
Estimated total nitrogen (TN) loading, TP loading, and TSS loading using HSPF are presented in Figure C-18, Figure C-19, and Figure C-20, respectively. ~~HSPF modeling has not been performed for the Mississippi River Lake Pepin watershed.~~

C.8.7.2 Urban Water Quality Modeling – P8

The City of Red Wing and City of Rochester developed water quality models for portions of their cities connected to storm sewer networks. The City of Red Wing and City of Rochester water quality models are built using the P8 Urban Catchment Model, or Program for Predicting Polluting Particle Passage thru Pits, Puddles, and Ponds, (P8) which is commonly used for predicting the generation and transport of stormwater runoff and pollutants in urban watersheds.

The P8 model tracks the movement of particulate matter (fine sand, dust, soil particles, etc.) as it is carried along by stormwater runoff traveling over land and pavement. Particle deposition in ponds along the way is also tracked, so that the model can estimate the amount of pollutants carried by the particles that eventually reach a water body.

The P8 model for the City of Red Wing was developed for existing land use and watershed conditions. The P8 model inputs were developed based on the information compiled for the development of the hydrologic and hydraulic model (XP-SWMM), where available. Model results are documented in the City's Local Surface Water Management Plan (City of Red Wing, 2014). The City of Rochester P8 water quality model was incorporated into the City's 1999 Stormwater Management Plan and updated in 2004 to include portions of the Bear Creek watershed.



TOTAL NITROGEN LOADING

WAGZ Comprehensive Watershed Management Plan

FIGURE C-18

BARR

Study Area
Subwatersheds (HUC12)
Watercourses
Pond or Lake
County Boundary
State Boundary

Total Phosphorus Loading

lbs/acre/yr

- <0.4
- 0.4 to 0.6
- 0.6 to 0.8
- 0.8 to 1.0
- 1.0 to 1.2
- >1.2

Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses from Public Water Inventory (PWI). Ponds and lakes from National Hydrography Dataset (NHD). Phosphorus Loading from HSPF modeling from MPCA WRAPS study.

N

0 2.5 5
Miles

TOTAL PHOSPHORUS LOADING
WAGZ Comprehensive Watershed Management Plan
FIGURE C-19

BARR

Barr Footer: ArcGIS 10.8.1, 2021-04-27 21:49 File: \\barrcom\gis\Projects\23\55\1058\Maps\Reports\1W1P\Figure C-19a - Total Phosphorus Loading.mxd User: cml3

Study Area
Subwatersheds (HUC12)
Watercourses
Pond or Lake
County Boundary
State Boundary

Sediment Loading (MRLP)

tons/acre/yr

- 0.007 - 0.01
- 0.01 - 0.02
- 0.02 - 0.03
- 0.03 - 0.04
- 0.04 - 0.06

Sediment Loading (Zumbro)

tons/acre/yr

- <0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4

Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses from Public Water Inventory (PWI). Ponds and lakes from National Hydrography Dataset (NHD). Sediment Loading from HSPF modeling from MPCA WRAPS study.

N

0 2.5 5
Miles

SEDIMENT LOADING
WAGZ Comprehensive Watershed Management Plan

FIGURE C-20

BARR

Barr Footer: ArcGIS 10.8.1, 2021-04-27 22:05 File: \\barrcom\gis\Projects\23\55\1058\Maps\Reports\1W1P\Figure C-20 - Sediment Loading.mxd User: cml3

C.9 Water Quantity and Flooding

The Zumbro River is the defining surface water feature within the Zumbro River watershed. The Zumbro River drains approximately 1,420 square miles before discharging to the Mississippi River. The MDNR, in partnership with the USGS, maintains flow gages at several locations within the watershed (see Section C.7.1 and Table C-C-12). Gages with the longest period of record include the Zumbro River at Kellogg (operated since 1975), South Fork Zumbro River near Rochester (operated since 1975) and the Zumbro River at Zumbro Falls (operated since 1909).

Flow data for the above gages (as well as USGS 05457000) is available from the MDNR cooperative stream gaging website at: https://www.dnr.state.mn.us/waters/csg/index.html

Flow measured at the South Fork Zumbro River at Rochester gage (MDNR 41063001) provides the most complete record over the past 40 years (other, longer records include recent gaps). Average annual flow measured at this gage is presented in Figure C-21 in cubic feet per second (cfs) and as average annual runoff (in inches) over the 303 square mile tributary area. During the 1981-2010 climate normal period, the average annual flow was 218 cfs (or about 0.7 cfs per square mile); this corresponds to approximately 10 inches of runoff/groundwater inflow. These values increase to 254 cfs (or about 0.8 cfs per square mile) and 11.4 inches of runoff/groundwater inflow when measured over the 1991-2020 climate normal period.

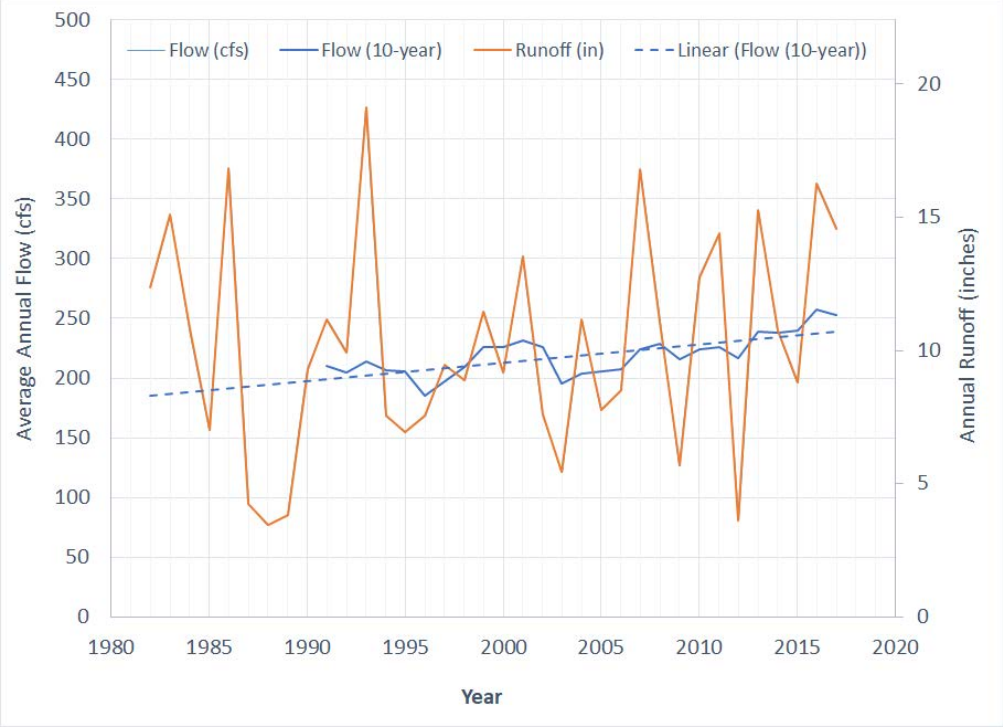


Figure C-21 Average annual flow in South Fork Zumbro River at Rochester (MDNR 41063001)

For comparison, flow measured at the Zumbro River at Kellogg gage (MDNR 41043001) dating back to 1975 corresponds to approximately 10 inches of runoff near the watershed outlet. Flow measured at the Zumbro River at Zumbro Falls gage (MDNR 41031002) from 1909-1980 corresponds to approximately 6 inches of runoff over the 1,150 square mile tributary watershed. The flow data suggests runoff in the planning area is increasing, although there is limited concurrent data. Annual flow at Rochester, averaged over a 10-year period, shows an increasing trend over the 1981-2019 period of record (see Figure C-21).

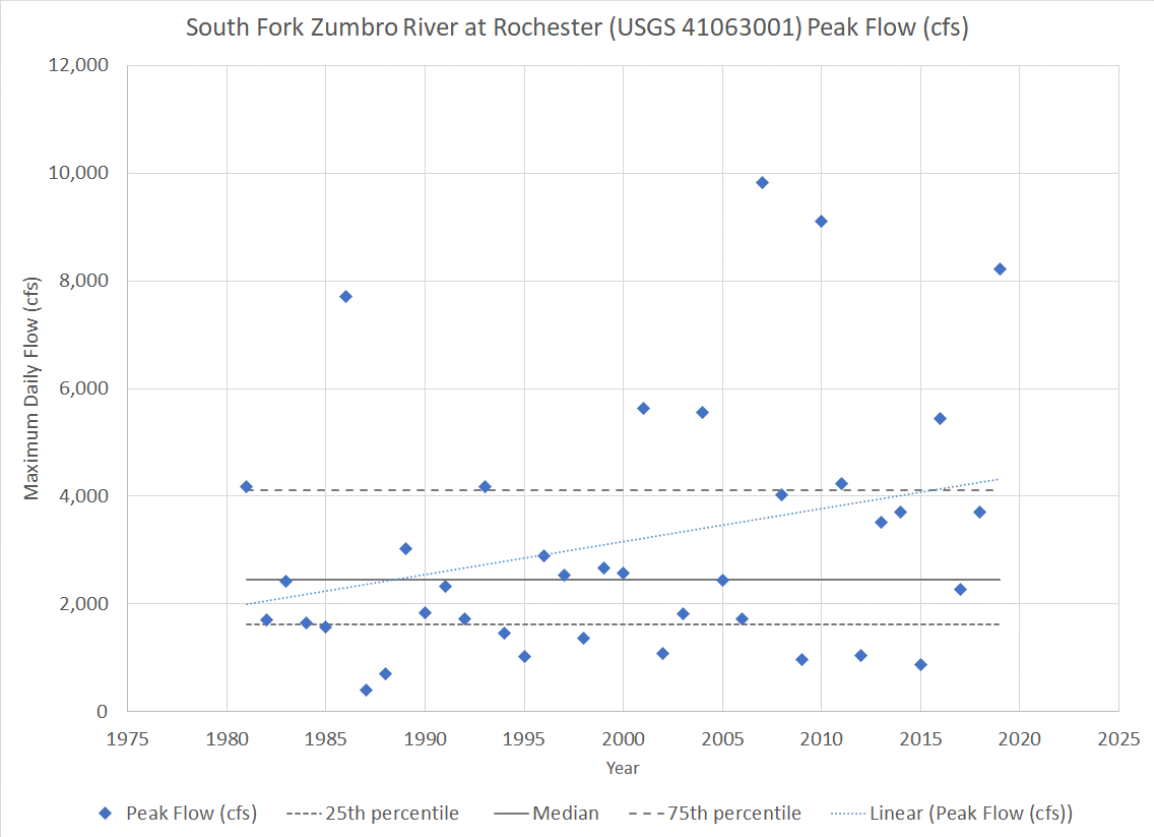


Figure C-22 Peak daily flow in South Fork Zumbro River at Rochester (MDNR 41063001)

Annual maximum daily flow data shows more frequent occurrence of peak flows since the flow record began in 1981 (see Figure C-22). Seven of the ten highest peak flows have occurred since 2000, including five of the top six peak flows. Comparison of annual peak flows to the 25th percentile, median, and 75th percentile of peak annual flows suggests this trend occurs for higher frequency (lower-return interval) events. Although the period of record is limited, estimation of the 5-year and 10-year flood events based on pre-2000 and post-2000 data show significant increases in peak flow for events of the same frequency.

In addition to increasing trends in average annual flow, the portion of precipitation that becomes flow (from runoff or groundwater discharge) appears to be increasing. Figure C-23 presents cumulative precipitation and cumulative flow at the Zumbro River at Kellogg gage (MDNR 41031002). Similar data

from the South Fork Zumbro River at Rochester gage (MDNR 41063001) is presented in

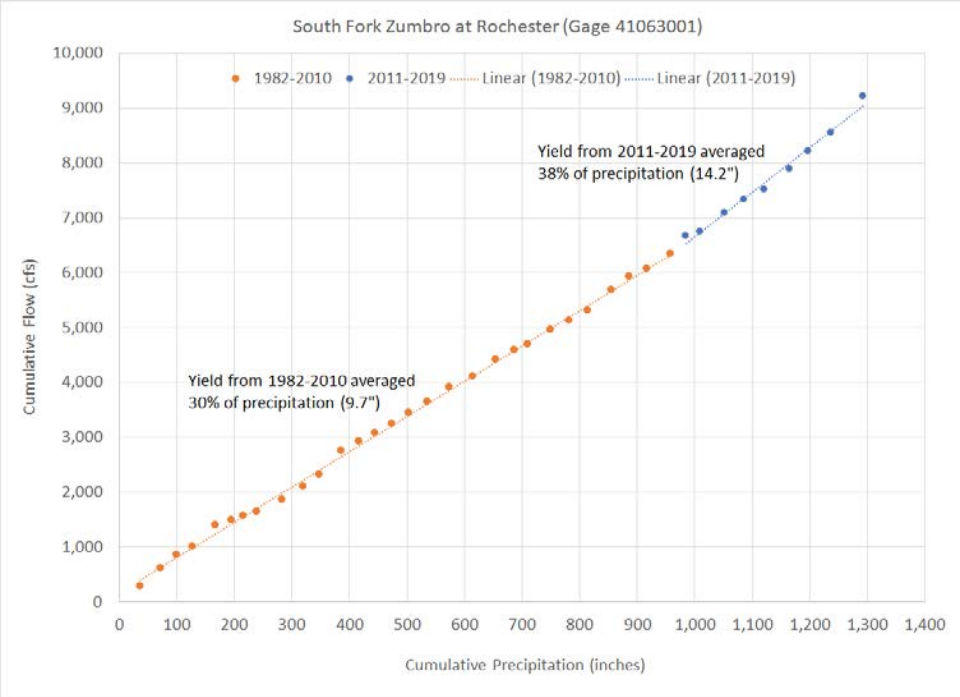


Figure C-24. These figures, sometimes referred to as "double-mass curves" show an increase increased flow in relation to precipitation (i.e., steeper slopes) later in the period of record.

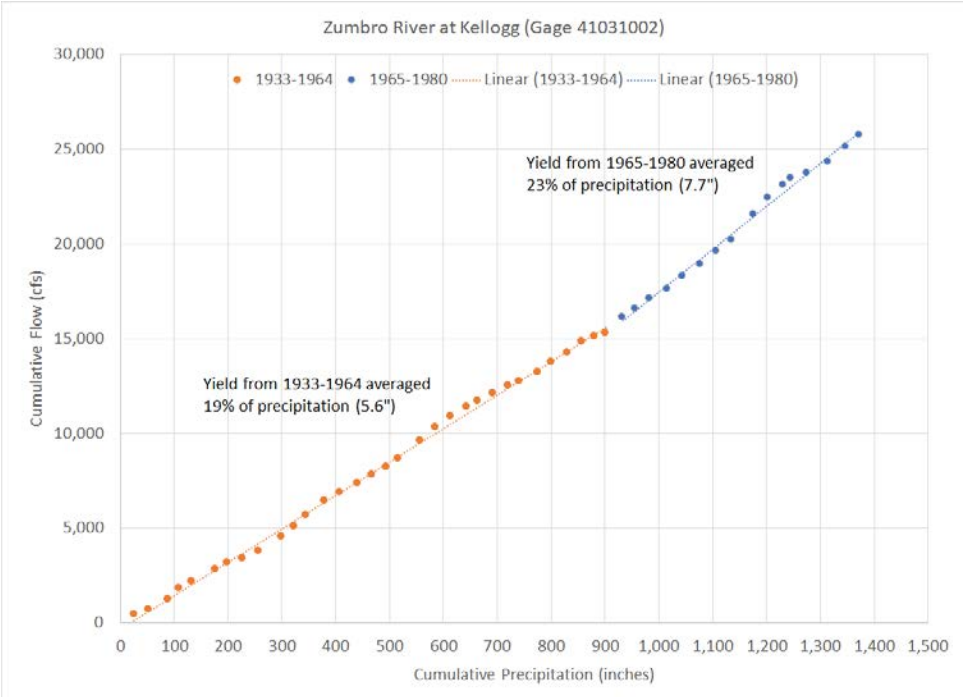


Figure C-23 Cumulative precipitation and flow at Zumbro River at Kellogg (MDNR 41031002)

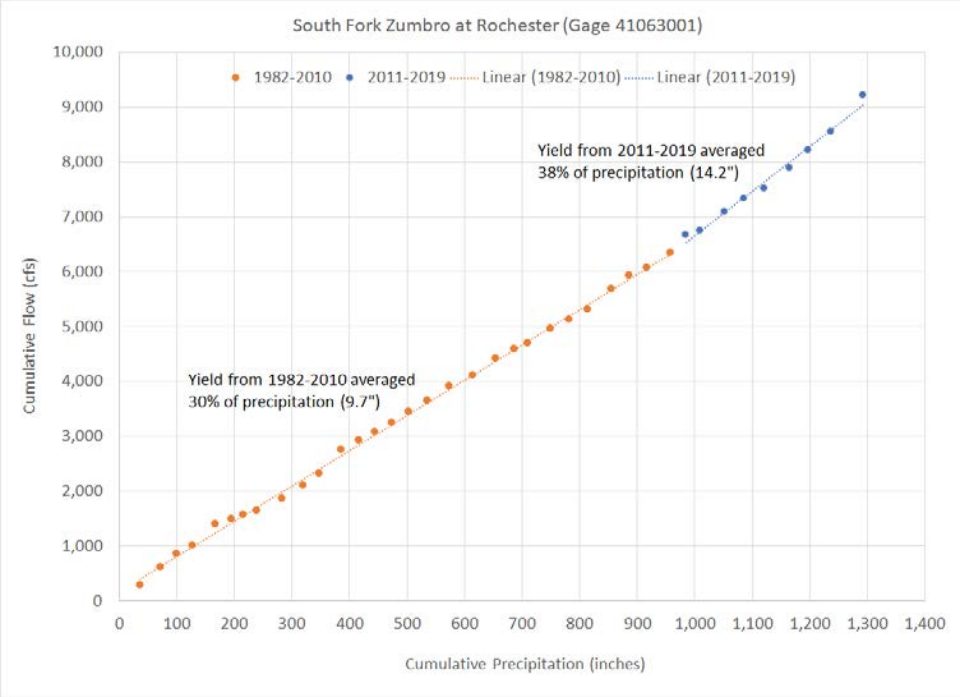


Figure C-24 Cumulative precipitation and flow at South Fork Zumbro River at Rochester (MDNR 41063001)

C.9.1 Floodplains and Historic Flooding

High flows (or flood flows) are typically of greater concern than average flow conditions due to the potential risk to public safety and infrastructure. The Bear Valley Watershed District (BVWD) was formed in part to address flooding issues within its jurisdiction. Several Flood Insurance Studies (FIS) have been performed for areas located within the planning area. An FIS contains information regarding flooding in a community, including flood history of the community and information on engineering methods used to develop Flood Insurance Rate Maps (FIRM) for a community. Homeowners within Federal Emergency Management Agency (FEMA) designated floodplains are required to purchase flood insurance. Homeowner and renters outside of the official floodplain can also qualify for flood insurance.

The FIS identifies areas that are expected to be inundated in a flood event having a 1 percent chance of occurring in a given year (also commonly referred to as the 100-year event). In some areas, the estimated water level is identified (e.g., FEMA zones AE, AH, AO). In some cases, no estimated flood depths or flood elevations are shown because detailed analysis has not been performed (e.g., FEMA zone A). Figure C-25 presents the mapped 100-year (1 percent) floodplain within the planning area watershed.

Within the planning area, each county has adopted a floodplain ordinance that regulates land disturbing activity within the floodplain. Additionally, the Cities of Lake City, Red Wing, Rochester maintain floodplain zoning regulations as part of the city code of ordinances. The Partners have also performed capital projects throughout the planning area to minimize the risk and consequence of flooding.

Many of the flood mitigation projects constructed within the planning area were designed prior to the increases in estimated precipitation published in Atlas 14 (see Section C.2.1) and more recent analysis of climate trends (see Section C.2.2). The City of Rochester and other LGUs within the planning area continue to evaluate flood risk and develop strategies to mitigate flood damages.

C.9.1.1 Rochester Flood Control Project

From July 5 to July 6, 1978, intense rainfall around Rochester resulted in flooding of 2,000 homes and business, evacuation of 5,000 residents, and approximately $58 million in damages (in 1978 dollars) (City of Rochester, 2013). Following the 1978 flood event, the City of Rochester, Olmsted County, and the Olmsted SWCD, with assistance of the US Army Corps of Engineers and the Natural Resource Conservation Service (NRCS), constructed a flood protection project. The Rochester flood control project was constructed from 1984 to 1995 and included a river component and reservoir component. The flood control project incorporates a combination of upstream reservoir storage, streambank stabilization, channel improvements, and approximately 1.3 miles of levees.

The City's flood control project includes seven reservoirs specifically designed to store rainfall in headwater areas of the South Fork Zumbro River watershed and reduce peak flows. These reservoirs include:

- WR-4 (Willow Creek by Gamehaven)
- WR-6A (Willow Creek west of Trunk Highway 63)
- BR-1 (Chester Lake)
- SR-2 (Silver Lake)
- KR-3 (Kalmar Township, south of landfill)
- KR-6 (Kalmar Township, dry basin)
- KR-7 (Kalmar Township, east of landfill)

These reservoirs limit the peak outflow to between 2% and 10% of the peak inflow rate as estimated for a 500-year event (pre-Atlas 14) (City of Rochester, 2013). Although the reservoirs are designed primarily for flood risk reduction, they provide recreational and habitat benefits as well (see also Section C.6.4). The South Zumbro Joint Powers Board manages the reservoirs, provides necessary maintenance, and identifies sources or sediment and nutrients impacting the reservoirs.

Study Area
Watercourses
Pond or Lake
County Boundary
State Boundary
Floodplain

Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses, Public Water Basins, and Public Water Wetland from Public Water Inventory (PWI). Ponds and lakes from National Hydrography Dataset (NHD). Floodplain data from MN DNR Zonation Analysis and FEMA. Digital floodplain data for Wabasha County only available through Zonation Analysis.

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Miles

FLOODPLAIN
WAGZ Comprehensive Watershed Management Plan

FIGURE C-25

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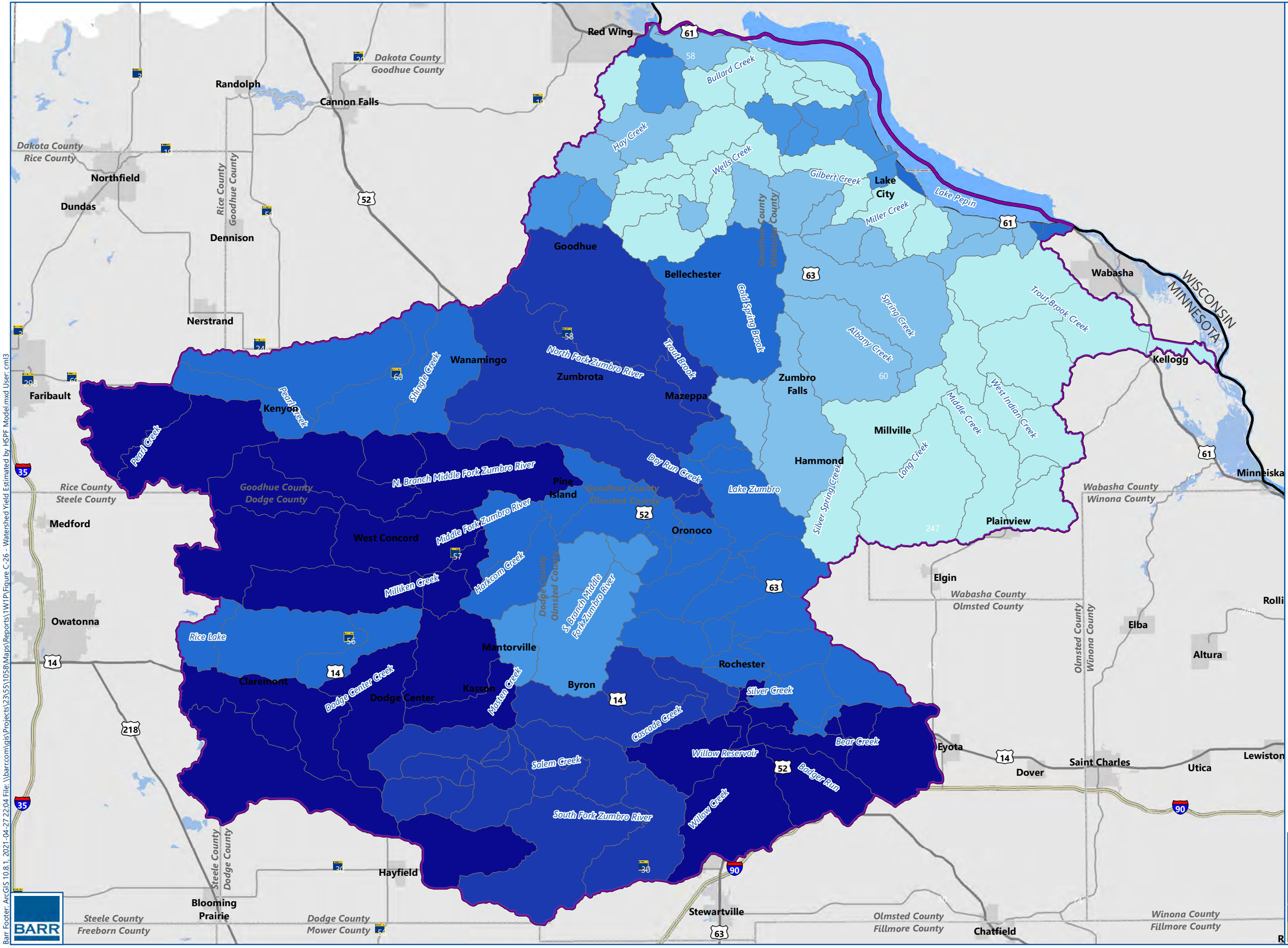
C.9.2 Hydrologic and Hydraulic Modeling

Hydrologic and hydraulic models have been developed for portions of the planning area; these models vary in extent and level of detail. The City of Red Wing developed an XP-SWMM hydrologic and hydraulic model for the city as part of the development of its 1999 Surface Water Management Plan; the model is periodically updated. The City of Rochester developed an XP-SWMM model as part of its 1999 Surface Water Management Plan. Portions of the City of Rochester and the surrounding watershed have also been modeled HEC-RAS. Much of the XP-SWMM and HEC-RAS modeling covering the City of Rochester and surrounding watersheds has been updated to reflect Atlas 14 precipitation estimates (see Section C.2.1). The City of Rochester has used the updated analyses to update its floodplain ordinance and develop additional flood risk mitigation strategies.

Throughout the Zumbro River watershed, average runoff has been estimated at the subwatershed scale using the HSPF model for the watershed (see Section C.8.7.1). Runoff estimates from HSPF are presented in Figure C-26.


Red Wing
Randolph
Cannon Falls
Dakota County
Goodhue County
Dakota County
Rice County
Northfield
Dundas
Rice County
Goodhue County
Dennison
Nerstrand
Faribault
Kenyon
Wanamingo
Goodhue
Zumbrota
Bellechester
Mazeppa
Zumbro Falls
Millville
Hammond
Lake City
Wabasha
Kellogg
Minneiska
WISCONSIN
MINNESOTA
Lake Pepin
Bullard Creek
Hay Creek
Wells Creek
Gilbert Creek
Miller Creek
Goodhue County
Wabasha County
Gold Spring Brook
Spring Creek
Albany Creek
Trout Brook Creek
West Indian Creek
Middle Creek
Long Creek
Silver Spring Creek
Trout Brook
North Fork Zumbro River
Pearl Creek
Pearl Creek
Stringle Creek
Doy Run Creek
Lake Zumbro
Pine Island
Goodhue County
Olmsted County
Rice County
Steele County
Goodhue County
Dodge County
N. Branch Middle Fork Zumbro River
Middle Fork Zumbro River
Medford
West Concord
Oronoco
Plainview
Wabasha County
Winona County
Elgin
Wabasha County
Olmsted County
Olmsted County
Winona County
Elba
Altura
Rolli
Owatonna
Rice Lake
Milliken Creek
Harkcom Creek
Dodge County
Olmsted County
S. Branch Middle Fork Zumbro River
Mantorville
Rochester
Claremont
Dodge Center Creek
Dodge Center
Kasson
Byron
Mason Creek
Silver Creek
Cascade Creek
Willow Reservoir
Bear Creek
Badger Run
Salem Creek
South Fork Zumbro River
Willow Creek
Eyota
Dover
Saint Charles
Utica
Lewiston
Hayfield
Blooming Prairie
Steele County
Freeborn County
Dodge County
Mower County
Stewartville
Olmsted County
Fillmore County
Chatfield
Winona County
Fillmore County
Study Area
Pond or Lake
Municipal Boundary
County Boundary
State Boundary
Watershed Yield
inches/year
< 7
7 to 8
8 to 9
9 to 10
10 to 11
> 11
N
0
2.5
5
Miles
WATERSHED YIELD ESTIMATED BY HSPF MODEL
WAGZ Comprehensive Watershed Management Plan
FIGURE C-26
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Barr Footer: ArcGIS 10.8.1, 2021-04-27 22:04 File: \\barrcom\gis\Projects\23\55\1058\Maps\Reports\1W1P\Figure C-26 - Watershed Yield Estimated by HSPF Model.mxd User: cml3

C.10 Wildlife Habitat and Rare Features

The planning area includes significant amounts of natural wildlife habitat and ecological features of significance. The MDNR maintains a database of rare plants, animals, native plant communities and other rare features in its Natural Heritage Information System (NHIS). The NHIS database contains historical records from museum collections, published information, and field work observations, especially from the MDNR Minnesota Biological Survey (MBS). More information about the NHIS can be found on the MDNR website at: https://www.dnr.state.mn.us/nhnrp/nhis.html

C.10.1 Native Plant Communities

There are approximately 50 native plant communities recognized within the planning area (MPCA 2017). These communities provide a variety of functions including filtration, flood attenuation, carbon storage, erosion control, and habitat for thousands wildlife and plant species (MDNR 2016). Native plant communities are assigned a conservation status (S-rank) by the MDNR that reflects its risk of elimination (MDNR 2009). Approximately half of the native plant community types in the planning area are identified as "Critically Imperiled" (S1), "Critically Imperiled to Imperiled" (S1S2), "Imperiled" (S2), or "Vulnerable to Extirpation" (S3).

Of the native plant communities in the planning area, calcareous fens are one of the rarest. Thirteen calcareous fens occur in the Zumbro River watershed. Most are only a few acres in area. Calcareous fens are characterized by non-acidic peat and depend on a continuous supply of cold, oxygen-poor groundwater rich in calcium and magnesium bicarbonates (MDNR 2015). Eight state-listed, rare plant species are known from calcareous fens, including four that occur in the Zumbro River watershed. These communities are highly vulnerable to disturbances, including reductions in the groundwater supply and increased in nutrient loading from surface waters (MDNR 2015).

In 1961, the Richard J Dorer Memorial Hardwood State Forest, which includes the Zumbro Bottoms State Forest, was created to promote conservation and responsible land use and restore a landscape damaged by flooding, a result of the land's overuse. A significant acreage of the forest lies within the watershed's eastern boundaries and serves as a valuable resource for wildlife and recreation in southeastern Minnesota (MDNR).

C.10.2 Sites of Biodiversity Significance

The MBS has identified some areas as having "outstanding," "high," "moderate," or "below" biodiversity significance according to the assemblage of rare species and natural features. Figure C-27 presents areas of biodiversity significance within the planning area. With the planning area there are a significant number of such sites.

In the Mississippi River Lake Pepin watershed, much of the river bluff area is classified as having moderate to high biodiversity significance. Areas surrounding Hay Creek (a trout stream) are classified as outstanding sites of biodiversity significance, as are some areas adjacent to the Mississippi River near the City of Red Wing, including Sorin's Bluff and Wacouta Bay.

The Zumbro River watershed also contains significant acreage of biodiversity sites. Some of the larger sites of high or outstanding biodiversity significance include:

- **Concord 13** – a 740-acre site of outstanding biodiversity significance on the Middle Fork Zumbro River. This site contains large blocks of sugar maple and basswood forest native plant communities and dolomite cliffs. Several rate plant and animal species are present in this area (MBS 2010).

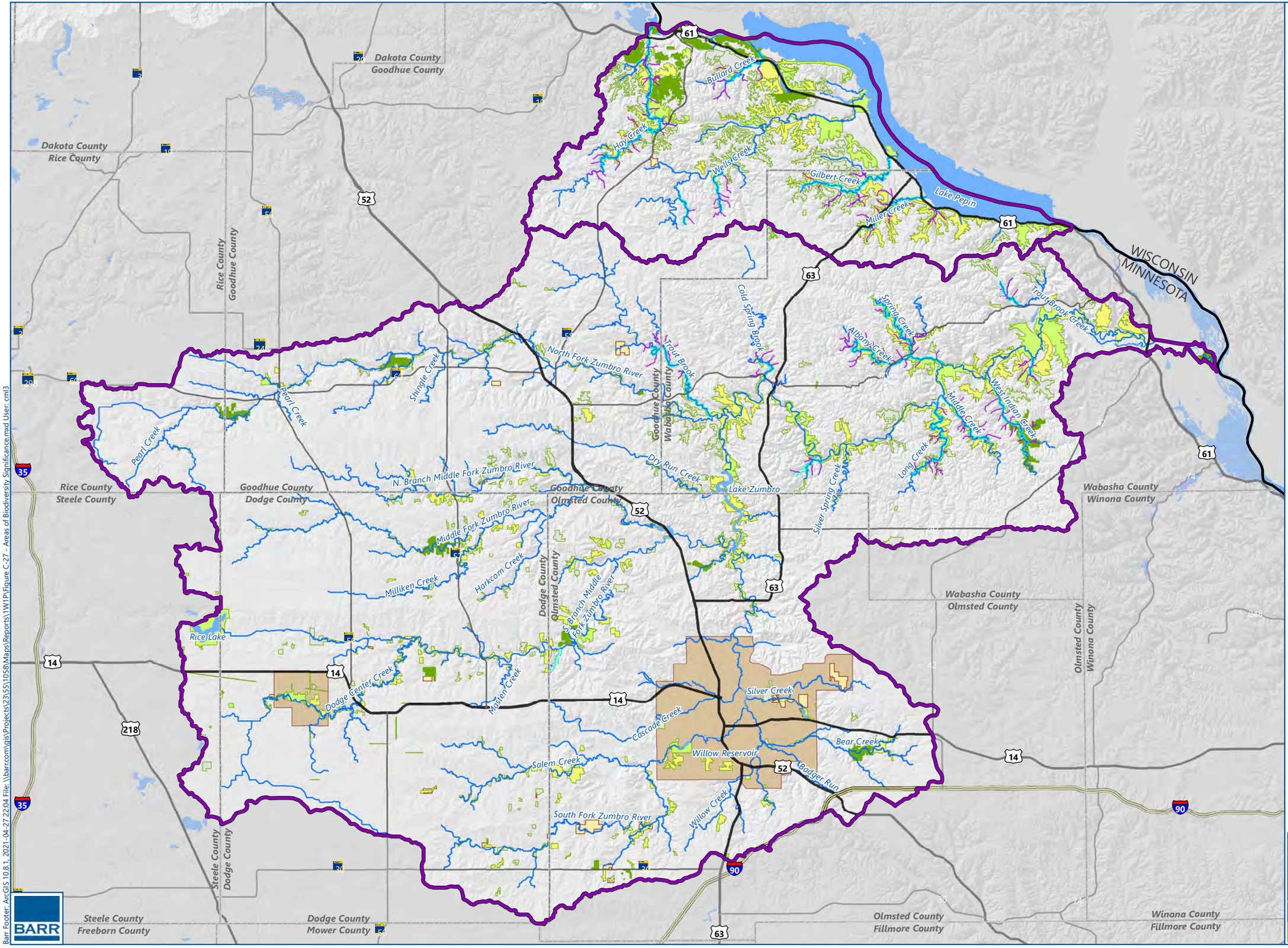
- **West Albany 35** – a 900-acre site of outstanding biodiversity significance located in the Zumbro River floodplain in Wabasha County. This site includes elm, ash, and basswood forest and several rare plant species.

- **Rice Lake State Park** – an approximately 1500-acre site of high biodiversity significance surrounding Rice Lake in Steele County.

- **West Indian Creek** – a 1200-acre site of outstanding biodiversity significance adjacent to the head waters of West Indian Creek, a trout stream. This area is also classified as a high conservation value forest and contains over 120 acres of old-growth forest.

Rice Lake is also classified as a lake of biological significance based on the presence of an outstanding bird community. Rice Lake hosts populations of wild rice, which has cultural significance and provides feed for local wildlife. Rice Lake is the only lake classified as a wild rice lake in the planning area.

Additional information about the MBS sites of biodiversity significance is available from the MDNR website at: https://www.dnr.state.mn.us/eco/mcbs/biodiversity_guidelines.html


Dakota County
Goodhue County
Dakota County
Rice County
Rice County
Goodhue County
Rice County
Steele County
Goodhue County
Dodge County
Goodhue County
Olmsted County
Wabasha County
Winona County
Wabasha County
Olmsted County
Olmsted County
Winona County
Steele County
Freeborn County
Dodge County
Mower County
Olmsted County
Fillmore County
Winona County
Fillmore County
Steele County
Dodge County
Goodhue County
Wabasha County
Olmsted County
Bullard Creek
Hay Creek
Wells Creek
Gilbert Creek
Miller Creek
Lake Pepin
WISCONSIN
MINNESOTA
Cold Spring Brook
Trout Brook
Spring Creek
Trout Brook Creek
Albany Creek
North Fork Zumbro River
Shingle Creek
Pearl Creek
Pearl Creek
Middle Creek
West Indian Creek
Long Creek
Dry Run Creek
N. Branch Middle Fork Zumbro River
Lake Zumbro
Silver Spring Creek
Middle Fork Zumbro River
Milliken Creek
Harkcom Creek
S. Branch Middle Fork Zumbro River
Rice Lake
Dodge Center Creek
Masten Creek
Silver Creek
Cascade Creek
Willow Reservoir
Bear Creek
Badger Run
Salem Creek
South Fork Zumbro River
Willow Creek
52
61
63
14
218
35
90
42
74
243
30
Study Area
Watercourses
Pond or Lake
County Boundary
State Boundary
State Wildlife Management Area
State Game Refuge
Designated Trout Stream
Protected Tributary to Designated Trout Stream
Sites of Biodiversity Significance (MBS)
Outstanding
High
Moderate
Below
Data sources:
Watersheds from MDNR Level 04 Major Watersheds. Watercourses, Public Water Basins, and Public Water Wetland from Public Water Inventory (PWI). Ponds and lakes from National Hydrography Dataset (NHD). Sites of Biodiversity Significance from Minnesota Biological Survey (MBS). Trout Stream Designations from MDNR.
N
0
2.5
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Miles
AREAS OF BIODIVERSITY SIGNIFICANCE
WAGZ Comprehensive Watershed Management Plan
FIGURE C-27
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Barr Footer: ArcGIS 10.8.1, 2021-04-27 22:04 File: \\barr.com\gis\Projects\23\55\1058\Maps\Reports\1W1P\Figure C-27 - Areas of Biodiversity Significance.mxd User: cml3

C.10.3 Rare Species

There are many rare plant, animal, and native plant communities (see Section C.10.1) present within the planning area. The location of specific species is not presented in this Plan for conservation purposes. Data about rare species is maintained in the NHIS database. More information about the NHIS can be found on the MDNR website at: https://www.dnr.state.mn.us/nhnrp/nhis.html

Rare species/communities in the planning area include:

- 59 plant species (7 endangered, 21 threatened, and 27 of special concern)
- 49 wildlife species (4 endangered, 8 threatened, and 26 of special concern)
- Bat colony in Wabasha County blufflands
- Native mussels at 12 sampled locations
- Waterbird colonies in multiple locations

A complete list of the rare species and communities present within the Zumbro River watershed is included as an appendix to the Zumbro WRAPS (MPCA 2017). More information regarding threatened or endangered plant species in the region is available from the USFWS at: https://www.fws.gov/midwest/endangered/plants/

C.10.4 Fisheries and Trout Streams

The rivers, streams, and lakes within the planning area are home to many species of fish, including 10 rare or protected species. The MDNR has performed fish surveys on several lakes and reservoirs within the planning area; this information is available from the MDNR LakeFinder website at: https://www.dnr.state.mn.us/lakefind/index.html

Additional fish surveys have been performed in support of establishing indices of biological integrity (IBI) as part of the Zumbro WRAPS and Mississippi Pepin WRAPS. Fish species identified during biological monitoring in the Zumbro River watershed is included in Appendix 6 of the *Zumbro River Watershed Monitoring and Assessment Report* (MPCA 2016). Fish IBI scores for Zumbro River watershed trout streams are discussed in Section 2.5 and summarized in Figure 36 of the *Zumbro River Watershed WRAPS* (MPCA, 2017).

Many of the streams in the planning area are classified as warm water streams. However, geologic conditions in the Driftless area have resulted in several groundwater-fed cold-water streams. Many of these cold-water streams have been classified as "trout streams" by the MDNR and are subject to additional fishing restrictions and management activities designed to protect and foster the propagation of trout. Trout streams in the planning area are presented in Figure C-27. The Zumbro River watershed contains twelve designated trout streams and 140 designated trout stream tributaries accounting for approximately 320 miles of stream. The Mississippi River Lake Pepin watershed contains 12 designated trout streams covering about 45 miles of stream and another 113 stream reaches (covering 60 miles) designated as trout stream tributaries. Trout streams have stricter water quality standards (e.g., minimum Fish IBI) and may be subject to additional project permitting considerations.

More information about trout streams present in southeaster Minnesota (including the planning area) is available from the MDNR at: https://www.dnr.state.mn.us/fishing/trout_streams/southeastern.html

The MDNR periodically stocks game fish in several lakes, reservoirs, and streams (including trout streams) within the planning area. Additional detail regarding the status of the fishery and stocking activities in each lake is available from the MDNR LakeFinder website at: https://www.dnr.state.mn.us/lakefind/index.html