1 LAND AND WATER RESOURCES INVENTORY

1.1 INTRODUCTION

The District is in the southwest portion of the Minneapolis-St. Paul (MSP) metropolitan area and covers approximately 80 square miles. The District's boundary generally follows the bluff line along both banks of the Minnesota River for approximately 32 river miles (R.M.) from the City of Carver and Louisville Township in the west, to the Minnesota River's confluence with the Mississippi River in the east. The District's authority covers twelve cities, three townships, and five counties, and spans the north bank of the Minnesota River from the City of Carver in Carver County to the City of Minneapolis in Hennepin County, and the south bank of the Minnesota River from Louisville Township in (Figure 1) and Scott County to the City of Mendota in Dakota County (Figure 1-1 and Figure 1-2).

This section presents the District's land and water resource information in accordance with M.S. 103B.231 and MN Rules 8410.0060. The statutes and rules require this plan to "contain an inventory of water resource and physical factors affecting the water resources based on existing records and publications." The paragraphs below provide general information on climate, watershed characteristics such as geology and soils, surface water resources, groundwater quality, and its susceptibility to contamination, fish and wildlife habitat, the human environment, unique features, and potential pollutant sources.

1.2 CLIMATE AND PRECIPITATION

Minnesota has a continental climate, which means it is not affected by the moderating effects of any ocean. Given its mid-latitude location, the District has four distinct seasons. Winters are generally cold and subject to arctic outbreaks, while summers are often subject to prolonged heat due to an influx of warm air from the southwestern United States, or warm, humid air from the Gulf of Mexico. Spring and fall are the moderate times of year but can have outbreaks of severe thunderstorms due to the interaction of cold and warm air masses, which dominate in winter and summer. The following sections document weather station information, temperature, and precipitation trends for the District from 1971-2000.

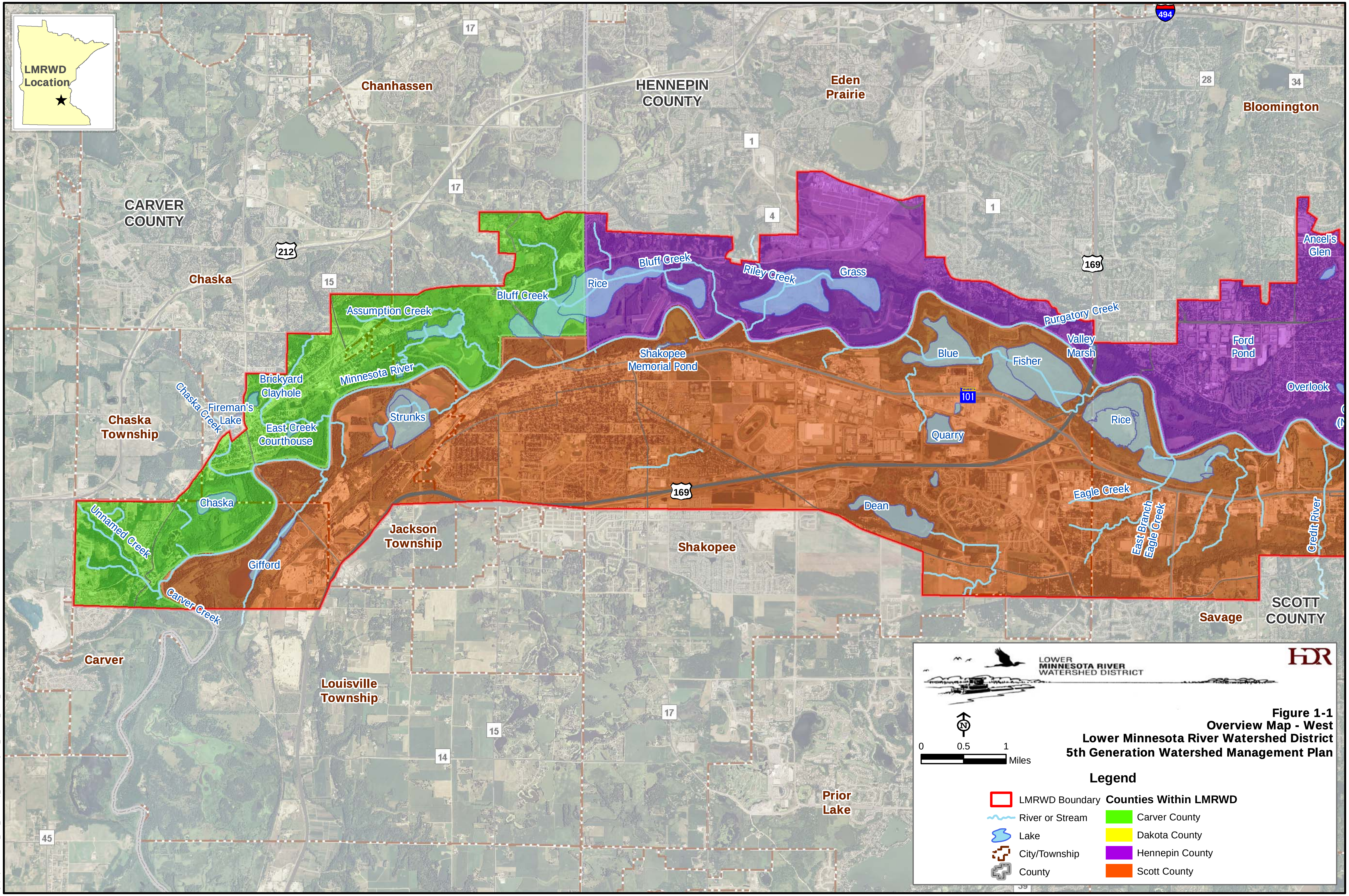


Figure 1-1
Overview Map - West
Lower Minnesota River Watershed District
5th Generation Watershed Management Plan

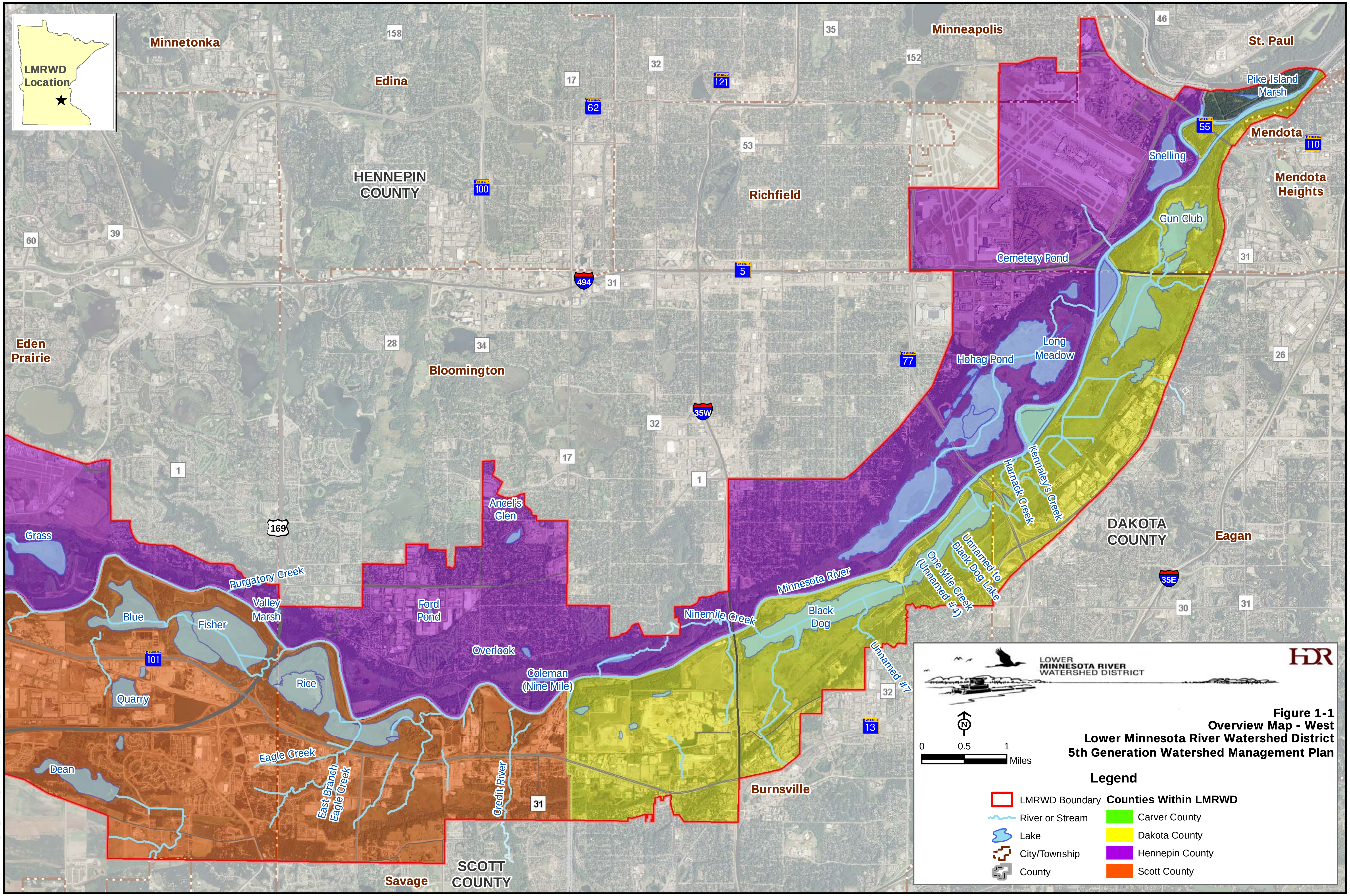


Figure 1-1
Overview Map - West
Lower Minnesota River Watershed District
5th Generation Watershed Management Plan

1.2.1 Weather Station

The MSP Airport Station of the United States National Oceanic and Atmospheric Administration (NOAA) is a "first order" (those maintained by either the National Weather Service or Federal Aviation Administration) weather station located less than two (2) miles from the northern boundary of the District's eastern end. The National Weather Service forecast office for the metropolitan area, located in Chanhassen, also records weather data. There is also a cooperative weather station in Chaska. The Chaska station provides minimum and maximum air temperature readings and precipitation measurements once a day. The Minnesota State Climatology Office manages a network of stations within the District and provides more detailed local weather data.

1.2.2 Temperature

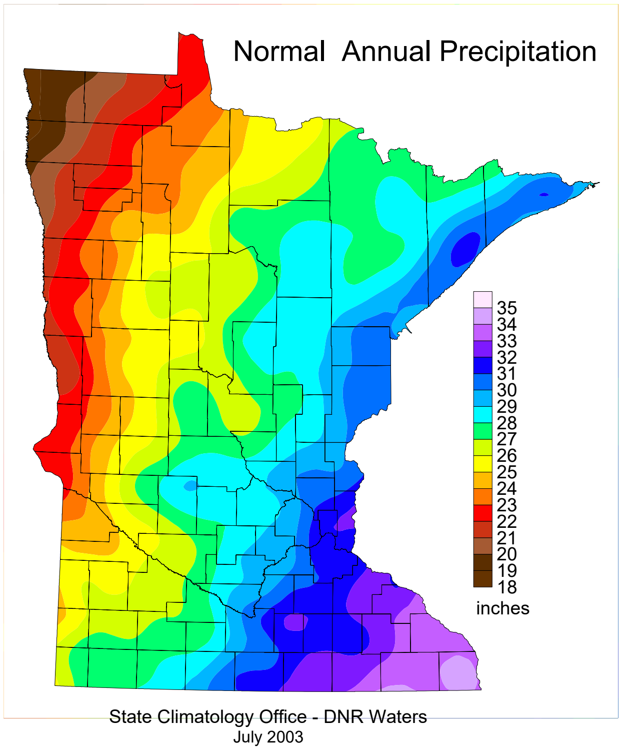
To date, the highest temperature on record at the airport station was 108ºF, set in July 1936, and the lowest temperature was -34ºF, set six (6) months earlier in January 1936. Extreme temperatures tell little except that in one season, temperatures can range from uncomfortably hot to bitterly cold. In general, temperature varies greatly from season to season, or even from day to day. However, a comparison of the MSP Airport station and Chaska station data shows slight temperature differences across the District. The average annual temperatures of the two stations for the current 30-year period are 45.4ºF and 46.4ºF, respectively (MRCC 2000-2010).

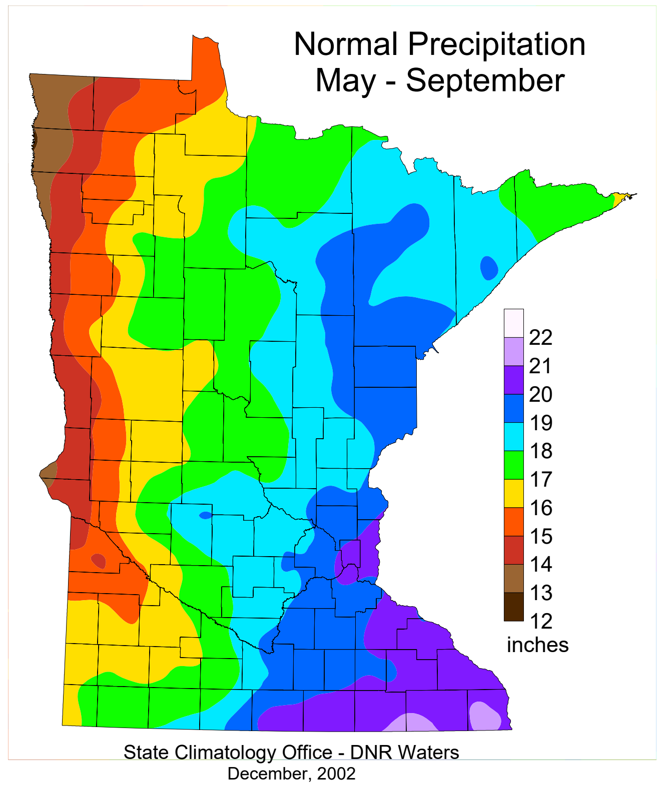
1.2.3 Precipitation

For the current 30-year period, average total annual precipitation at the MSP Airport station and the Chaska Station is 29.4 inches and 30.6 inches, respectively. The difference of one inch of average total annual precipitation does not indicate any significant tendency for any one part of the District to get more precipitation than another. However, in a given event, and especially in the warm season, storm precipitation totals can widely vary between individual stations within a region. Annual precipitation of 17.90 inches in 1987, and 9.82 inches in 1990, is another example of how extremes can occur in the area within a relatively short period of time (MRCC 2000-2010).

Average annual precipitation for the current 30-year period over the state of Minnesota is shown in Figure 1-3, which also shows the current 30-year (1981-2010) average precipitation for May to September, and April through October, respectively. Table 1-1 gives a precipitation summary for the MSP Airport station. Over the entire Minnesota River watershed, annual precipitation ranges from 22 inches in the west to 31 inches in the east.

Figure 1-3: Normal Precipitation





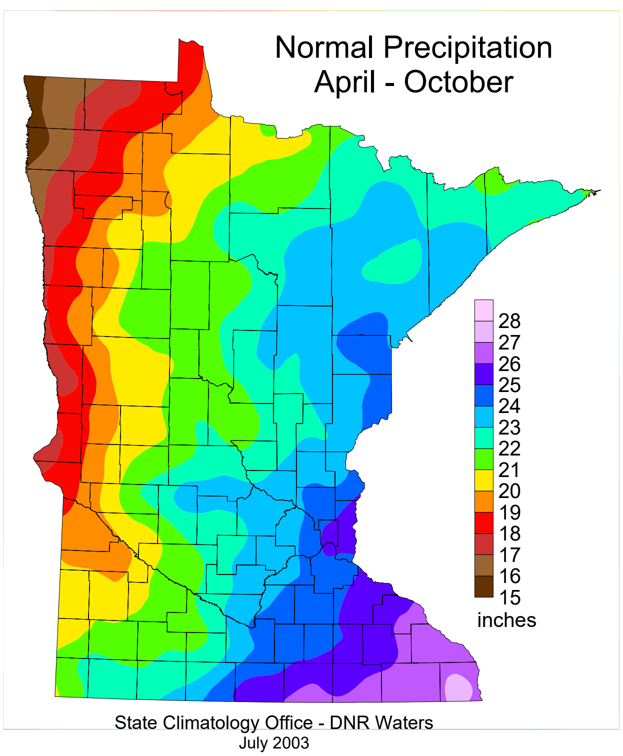


Table 1-1: Precipitation Summary - Minneapolis/St. Paul Airport Station
Averages 1981-2010 Extremes: 1891-2010

Total Precipitation, Inches					Snow inches		# Days with Precipitation	
Month	**Normal**	**Max Yr**	**Min Yr**	**1-Day Max**	**Normal**	**Max Yr**	**≥ .01**	**≥ 1.00**
Jan	0.90	3.63 1967	0.10 1990	1.21 1967	12.2	46.4 1982	8.9	0.0
Feb	0.77	2.14 1981	0.06 1964	1.34 2012	7.7	26.5 1962	7.4	0.0
Mar	1.89	4.75 1965	0.32 1994	1.66 1965	10.3	40.0 1951	9.3	0.2
Apr	2.66	7.00 2001	0.16 1987	2.58 2006	2.4	21.8 1983	10.7	0.4
May	3.36	9.3 2012	0.53 2009	3.39 2012	0.0	2.4 1954	11.5	0.5
Jun	4.25	9.82 1990	0.22 1988	3.28 2003	0.0	0.0 N/A	11.3	1.1
Jul	4.04	17.90 1987	0.58 1975	10.00 1987	0.0	0.0 N/A	10.2	0.9
Aug	4.30	9.3 2007	0.43 1946	7.36 1977	0.0	0.0 N/A	9.7	1.3
Sep	3.08	7.53 1942	0.30 2012	3.55 1942	0.0	1.7 1942	9.8	0.8
Oct	2.43	5.68 1971	0.01 1952	4.83 2005	0.6	8.2 1991	9.2	0.4
Nov	1.77	5.29 1991	0.02 1939	2.91 1940	9.3	46.9 1991	8.7	0.3
Dec	1.16	4.27 1982	0.00 1943	2.47 1982	11.9	33.6 2010	9.8	0.1
Annual	**30.61**	**17.90 1987**	**0.01 1952**	**10.00 1987**	**54.5**	**46.9 1991**	**116.5**	**6.0**
Winter (DJF)	2.83	6.24 – 1967	0.69 – 1958	1.90 02/24/1930	32.0	71.7 – 1967	9.3	0.2
Spring (MAM)	7.41	16.13 – 1965	2.12 – 1910	3.16 05/21/1906	13.7	48.1 – 1965	17.8	1.0
Summer (JJA)	12.43	23.52 – 1987	1.73 – 1894	9.15 07/23/1987	0.0	0.0 – 1949	20.2	3.2
Fall (SON)	6.74	13.50 – 1911	1.71 – 1952	4.96 09/12/1903	10.6	55.1 – 1991	14.5	1.3

Thunderstorms are the main source of precipitation during the warm season and can cause varying degrees of damage due to excessive rain, strong winds, lightning, hail, or any combination. The District's primary interest is heavy or persistent rainfall and runoff, which have the potential to cause flooding. Significant rainfall in June and July of 1993 in the Upper Midwest, combined with wet soil conditions, were the cause of severe flooding in the Upper Mississippi River Basin, including the Minnesota River (Larson, 1996).

Snowfall throughout the entire Minnesota River Basin can be considerable and may cause flooding in the District if the spring thaw occurs rapidly. Rapid melting of snow in the entire watershed was one of the most important contributing factors to the Minnesota River floods in 1951, 1965, 1969, 1997, and 2001. The heaviest monthly snowfall recorded to date at the MSP Airport station was 46.9 inches in November 1991. Annually, snowfall has been recorded in all months except June, July, and August (MRCC-Snow, 2000 - 2010).

Tornadoes and sleet (or freezing rainstorms) occur infrequently. Humidity, another variable in the overall climate picture, is of minor importance, except that the Minnesota River Valley probably experiences higher humidity than the upland areas that border the valley. Fog or low clouds occur, but not with sufficient frequency to warrant management concerns. Generally, the summer precipitation far exceeds that of the winter; summer rainfall usually being sufficient for proper plant growth. From May to September, the growing months, the average rainfall is 18.4 inches, or about 62 percent of the normal annual precipitation. The growing season is approximately 156 to 160 days for the current 30-year period but can be as short as 120 days to as long as 188 days. In a cold year, freezing temperatures may occur until the middle of May and begin again in early September. In a warm year, the spring's last freezing temperature may occur in the first week of April, and not occur again until late October. When adequate precipitation occurs, this growing season is suitable for most crop production (MRCC-Growing, 2000 - 2010).

1.2.4 Climate Variability in Minnesota

The primary source of moisture for warm-season precipitation in Minnesota is the warm, moist air that moves into the state from the Gulf of Mexico. Minnesota is in a unique position relative to dominant, continental air masses. To the west and north, the dominant air mass is semi-arid, while to the south and east, the dominant air mass is semi-humid. As a result, the annual precipitation in the state is highest in the southeast and declines to the northwest.

Seasonal variability occurs as different air masses dominate. During the warm season in Minnesota, moisture from the Gulf of Mexico is often available, and is the reason most of the state's precipitation occurs between May and September. However, when this moisture source is obstructed, or when atmospheric patterns divert storm systems around Minnesota, drought conditions can occur.

When Gulf of Mexico moisture is abundant and numerous storms move through Minnesota, unusually heavy precipitation can lead to flash floods. Weather patterns that tend to persist over seasonal or longer periods are affected by the jet stream position, which is in turn influenced by ocean temperature anomalies. Although Minnesota has a continental climate, the occurrence of extended periods of wetter or drier conditions is often influenced by ocean temperatures and currents. Regardless of whether the temperature increases or decreases in the event of global climate change, the physical distance between the Gulf of Mexico and the District will remain essentially the same, as will the physical distance between the District and the U.S. and Canadian Rocky Mountains. Thus, the battle for dominance between semi-arid and semi-humid air masses will continue.

Given the multiple weather scenarios affecting Minnesota, wide ranges of climatic outcomes are normal. It is important to note that climate extremes should not be considered as aberrations, but rather treated as an inherent characteristic of a continental climate (DNR-Climate, 2010).

1.3 Geology and Topography

1.3.1 Surficial Geology

Minnesota's geological history includes several periods when great sheets of ice (glaciers) covered the upper Midwest region. The last period when the glaciers advanced as far as the Twin Cities was the Mankato sub-stage of the Wisconsin Glacial Age, about 11,000 years ago.

The Mankato glacier retreated in an erratic fashion. At times, the edge, or terminus, of the glacier remained relatively static for many years. At other times, it melted at a great rate and retreated rather quickly across the face of the land, geologically speaking. These two glacier retreat rates determined the District's geology and topography. First, the glacier deposited large quantities of granular material (glacial till) in the form of a terminal moraine (a row of rocks and soil originally pushed up by the glacier's advancing edge) during its stationary period. The hummocky terrain on the uplands south of the District is typical of such deposits. Second, as the glacier retreated along what is now the Minnesota River Valley, the melt water from the glacier was drained by the Glacial River Warren, which cut a channel in the glacial deposits. That channel is now the Minnesota River Valley. While melting, the glacier released tremendous quantities of water. This water cut the channel much deeper than it appears today. At one time, water filled the valley completely, from Richfield on the north to the bluffs on the south side of the valley.

As the flow receded, the valley filled with sediment. Again, the recession was not continuous, so erosion and sedimentation varied. As a result, the lower valley filled irregularly. Vestiges of this irregular sedimentation appear in terraces, most prominently in the area around Shakopee. Alluvium and terrace deposits cover the majority of District. Moraine deposits and lesser amounts of glacial outwash deposits cover the remainder of the District. A map of the District's surficial geology is included as Figure 1 -4 and Figure 1-5 (Meyer, 2007).

1.3.2 Bedrock Geology

The District's bedrock geology information was obtained from the Minnesota Geological Survey's 2000 bedrock geologic and topographic maps of the seven-county MSP metropolitan area (Mossler, J.H. and R. G. Tipping 2000). The District's bedrock geology and structure are shown on Figure 1-6 and Figure 1-7. More detailed information on bedrock geology is found in the Hennepin, Ramsey, Dakota, and Scott county geologic atlases and the hydrologic investigations atlas, which covers Carver County.

From the District's western boundary to the west edge of Shakopee, the Minnesota River floodplain follows a buried bedrock valley. The oldest and deepest bedrock formation in this valley is the St. Lawrence/Franconia formation, made up of dolomite and sandstone. At Shakopee, this bedrock valley veers to the north side of the Minnesota River floodplain. In Shakopee's Fisher Lake, another bedrock valley intersects from the south. The combined valley follows an easterly path north of the District through Bloomington, passing into and across the District at the north end of Long Meadow Lake.

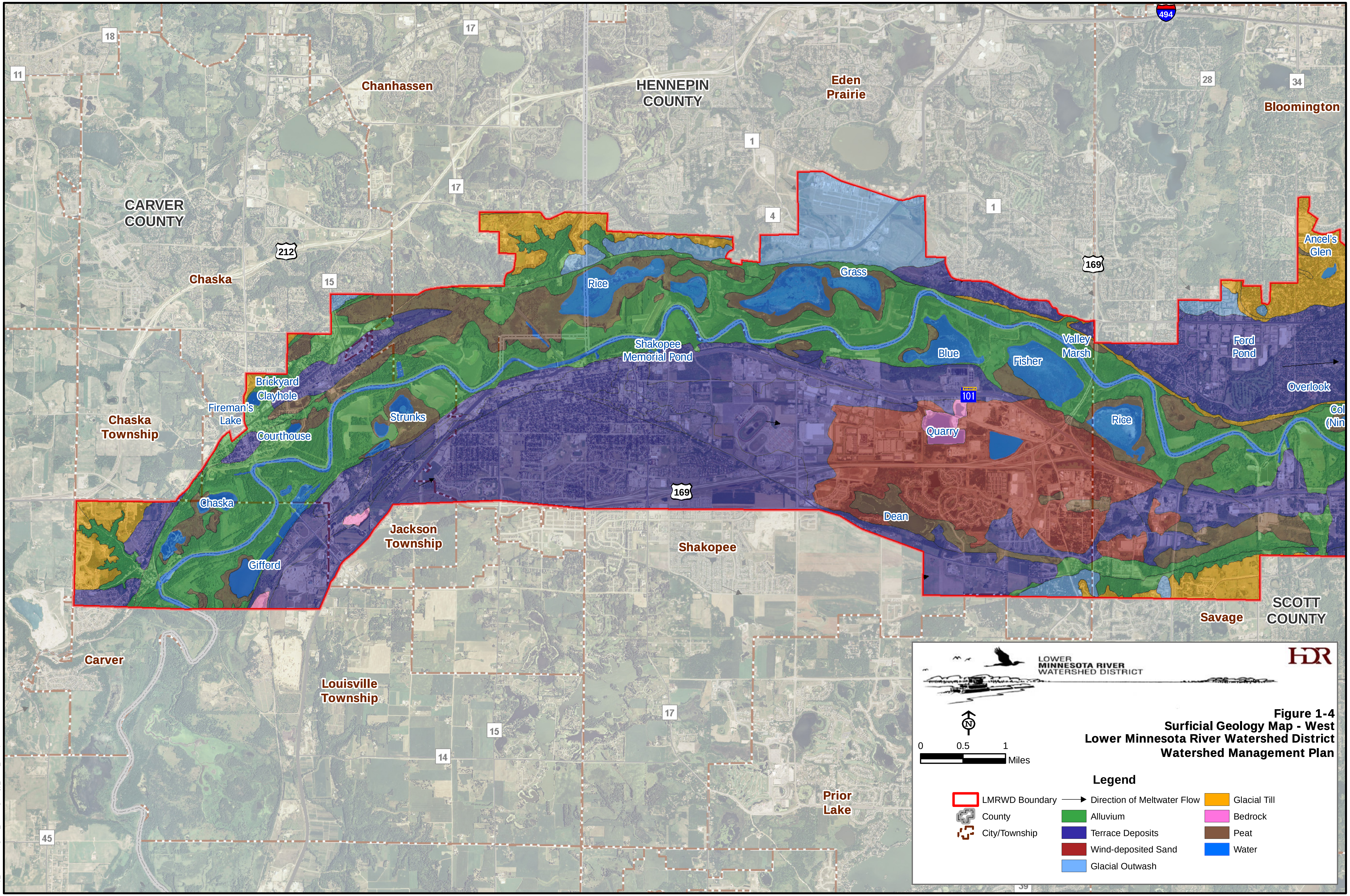
The majority of the District includes the subcropping Prairie du Chien group, composed mainly of dolomite. Outcrops of this bedrock formation can be seen on the bluffs on the the Minnesota River's south side, especially in Scott County and the western edge of Dakota County. Between the deeper St. Lawrence/Franconia formation and the Prairie du Chien formation is the Jordan Sandstone, which usually follows the buried bedrock valley. The Jordan sandstone also subcrops on the north side of the Minnesota River floodplain in Bloomington. On the uplands, at the District's very east end, are shallow St. Peter sandstone and Platteville and Glenwood Formations' subcropping bedrock.

1.3.3 Topography

The District's topography is dominated by the Minnesota River, the broad Minnesota River floodplain, and the steep river bluffs. Figure 1-8 and Figure 1-9 show the topography within the District from east to west. Elevations within the District range from approximately 1,025 feet to 600 feet above mean sea level. The highest elevations occur on the bluffs north of the Minnesota River in the cities of Eden Prairie and Bloomington. The lowest elevations occur throughout the District along the banks of the Minnesota River.

1.4 Surface Water Resources

Surface water resources within the District include several lakes, ponds, wetlands, streams, and approximately 32 miles of the Minnesota River. The Minnesota Department of Natural Resources (DNR) has regulatory jurisdiction over the lakes, wetlands, and watercourses defined as public


CARVER COUNTY
HENNEPIN COUNTY
SCOTT COUNTY
Chanhassen
Eden Prairie
Bloomington
Chaska
Chaska Township
Jackson Township
Shakopee
Savage
Carver
Louisville Township
Prior Lake
Rice
Grass
Shakopee Memorial Pond
Blue
Fisher
Valley Marsh
Ford Pond
Overlook
Ancel's Glen
Brickyard Clayhole
Fireman's Lake
Courthouse
Strunks
Quarry
Rice
Chaska
Gifford
Dean
LOWER MINNESOTA RIVER WATERSHED DISTRICT
HDR
Figure 1-4
Surficial Geology Map - West
Lower Minnesota River Watershed District
Watershed Management Plan
0 0.5 1
Miles
Legend
LMRWD Boundary
County
City/Township
Direction of Meltwater Flow
Alluvium
Terrace Deposits
Wind-deposited Sand
Glacial Outwash
Glacial Till
Bedrock
Peat
Water

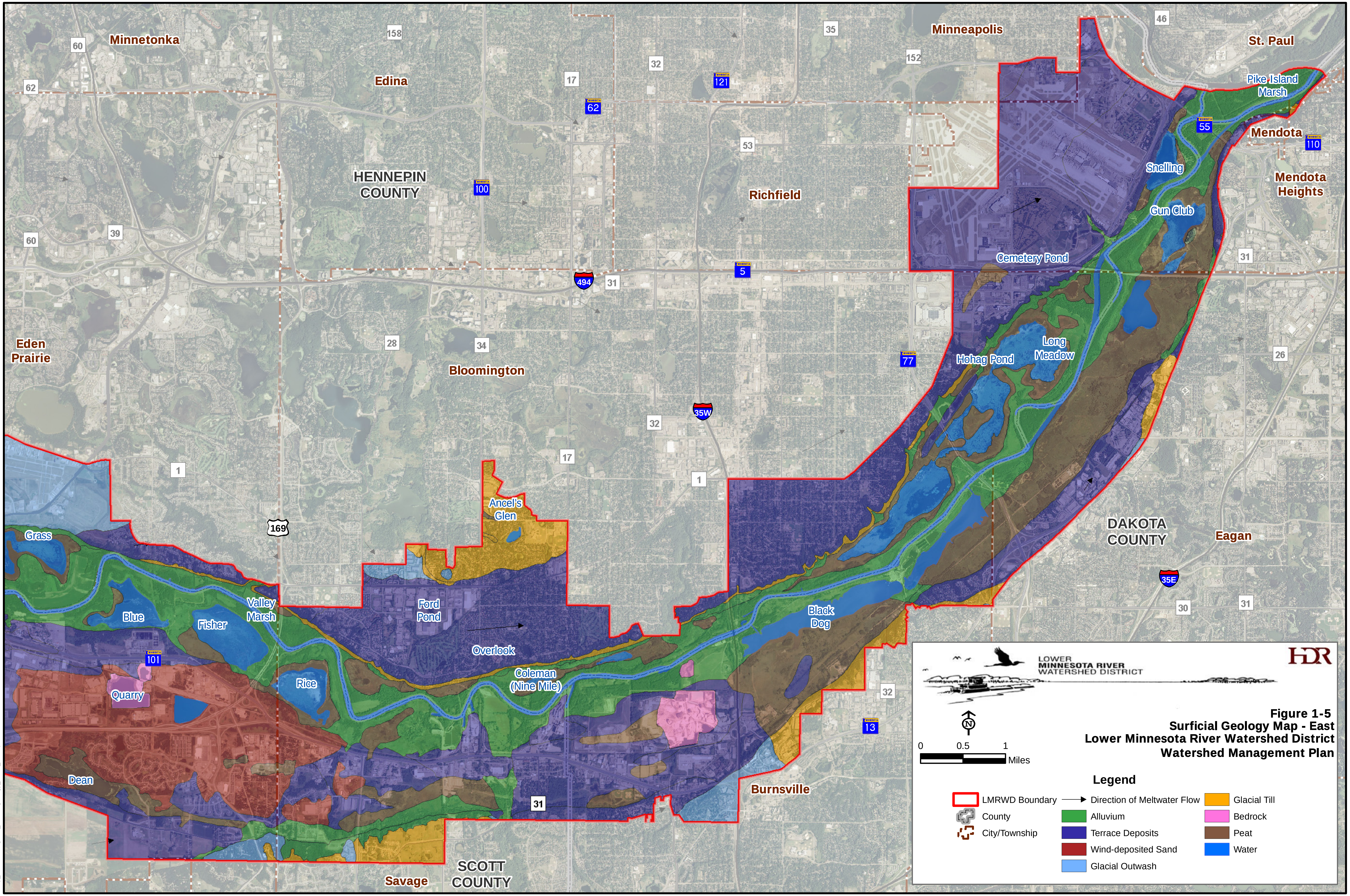


Figure 1-5
Surficial Geology Map - East
Lower Minnesota River Watershed District
Watershed Management Plan

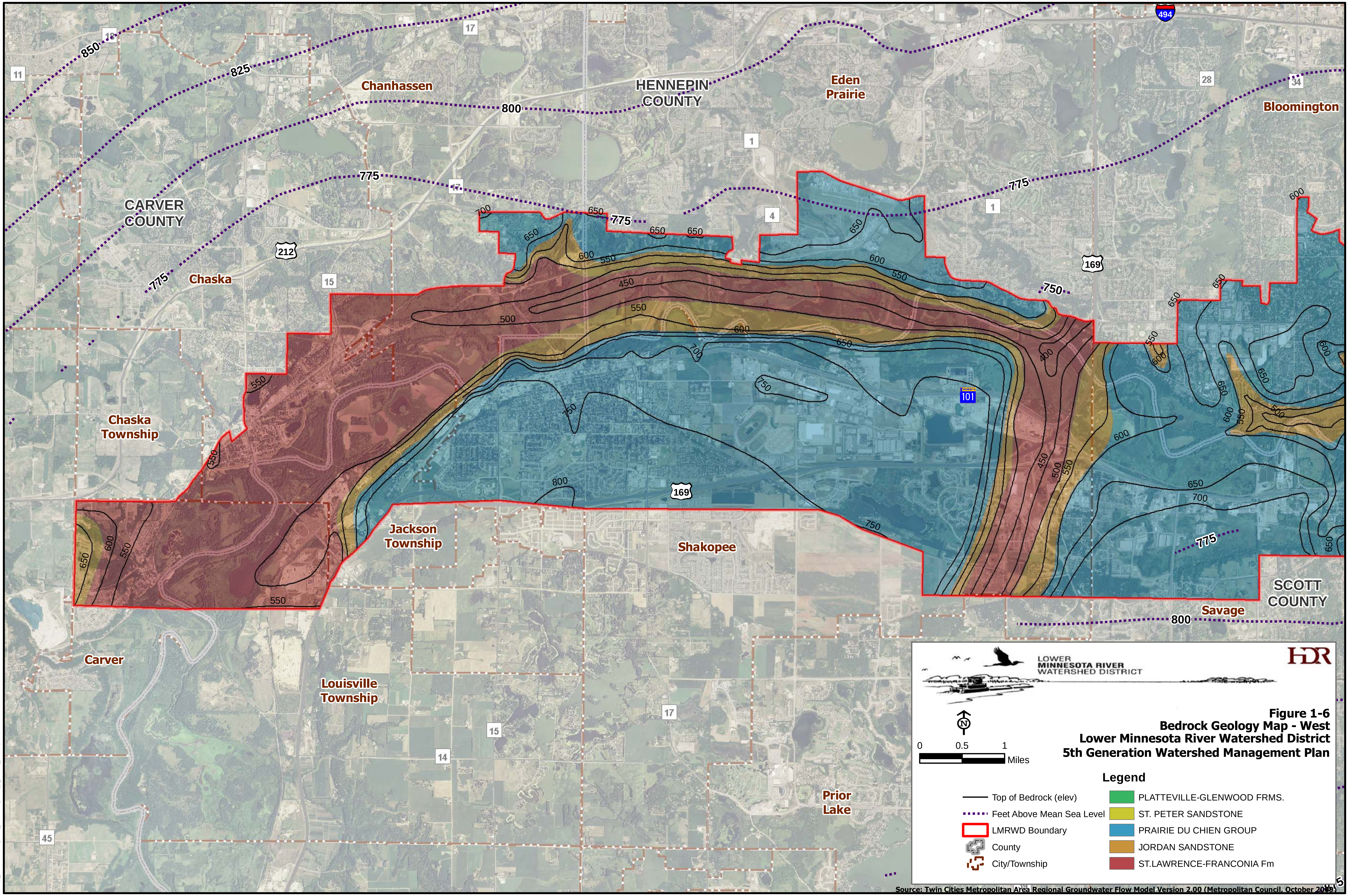
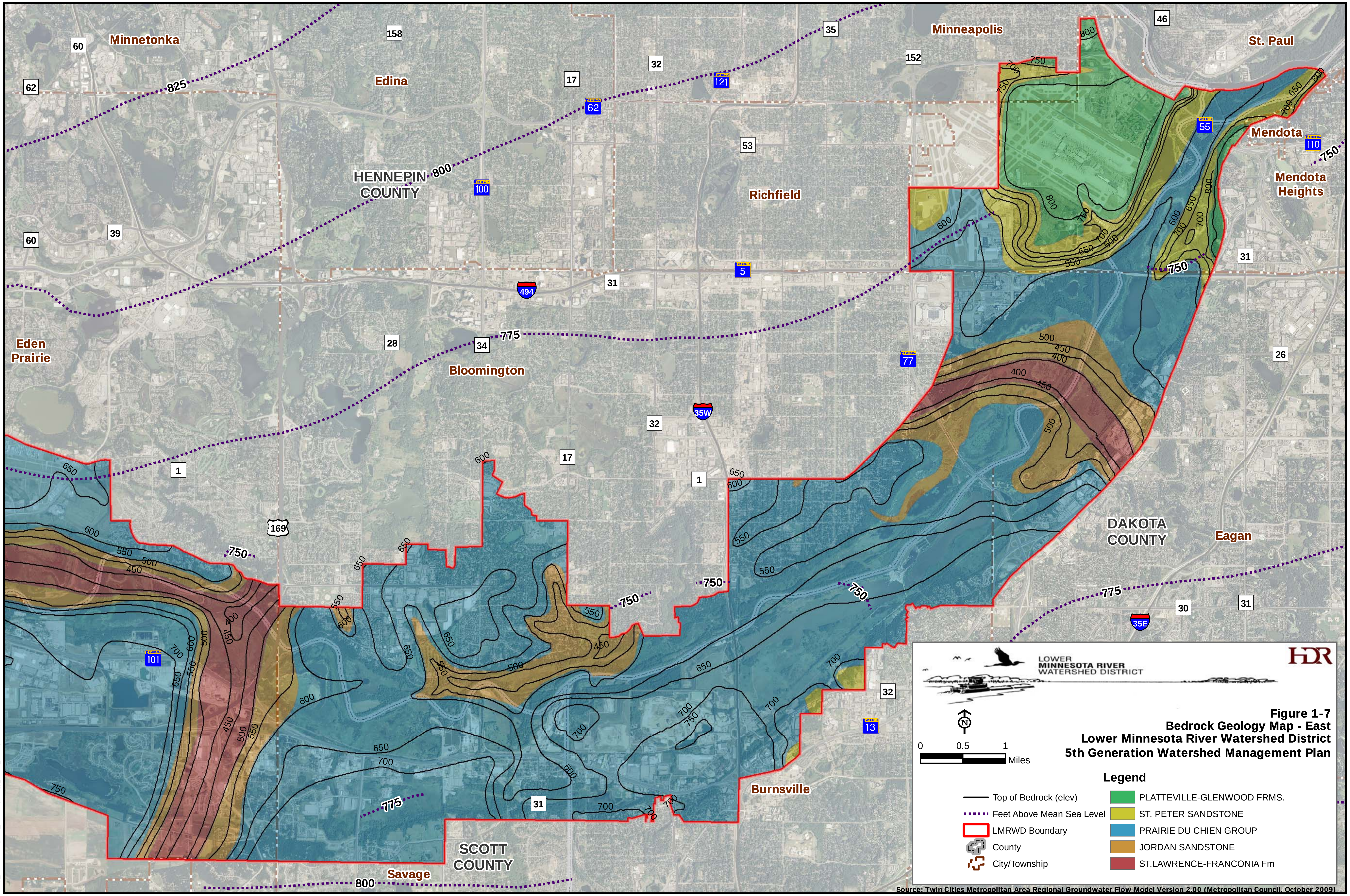


Figure 1-6
Bedrock Geology Map - West
Lower Minnesota River Watershed District
5th Generation Watershed Management Plan
LOWER MINNESOTA RIVER WATERSHED DISTRICT
HDR
Legend
Top of Bedrock (elev)
Feet Above Mean Sea Level
LMRWD Boundary
County
City/Township
PLATTEVILLE-GLENWOOD FRMS.
ST. PETER SANDSTONE
PRAIRIE DU CHIEN GROUP
JORDAN SANDSTONE
ST.LAWRENCE-FRANCONIA Fm
0 0.5 1 Miles
CARVER COUNTY
HENNEPIN COUNTY
SCOTT COUNTY
Chanhassen
Eden Prairie
Bloomington
Chaska
Chaska Township
Jackson Township
Shakopee
Savage
Carver
Louisville Township
Prior Lake
Source: Twin Cities Metropolitan Area Regional Groundwater Flow Model Version 2.00 (Metropolitan Council, October 2009)


Minnetonka
Edina
Minneapolis
St. Paul
Mendota
Mendota Heights
HENNEPIN COUNTY
Richfield
Eden Prairie
Bloomington
DAKOTA COUNTY
Eagan
Burnsville
SCOTT COUNTY
Savage
825
800
775
750
LOWER MINNESOTA RIVER WATERSHED DISTRICT
HDR
Figure 1-7
Bedrock Geology Map - East
Lower Minnesota River Watershed District
5th Generation Watershed Management Plan
0 0.5 1 Miles
Legend
Top of Bedrock (elev)
Feet Above Mean Sea Level
LMRWD Boundary
County
City/Township
PLATTEVILLE-GLENWOOD FRMS.
ST. PETER SANDSTONE
PRAIRIE DU CHIEN GROUP
JORDAN SANDSTONE
ST.LAWRENCE-FRANCONIA Fm
Source: Twin Cities Metropolitan Area Regional Groundwater Flow Model Version 2.00 (Metropolitan Council, October 2009)

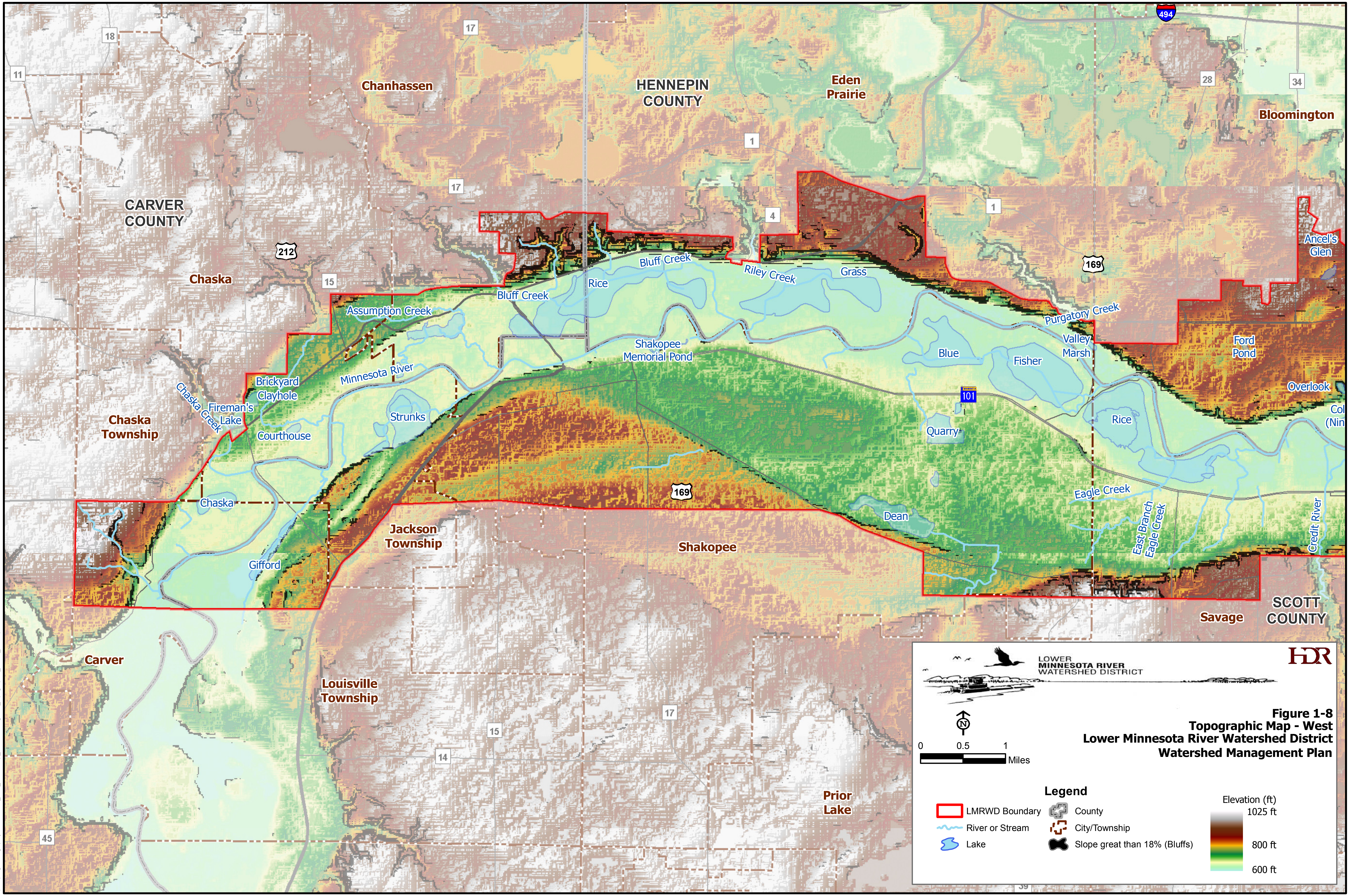
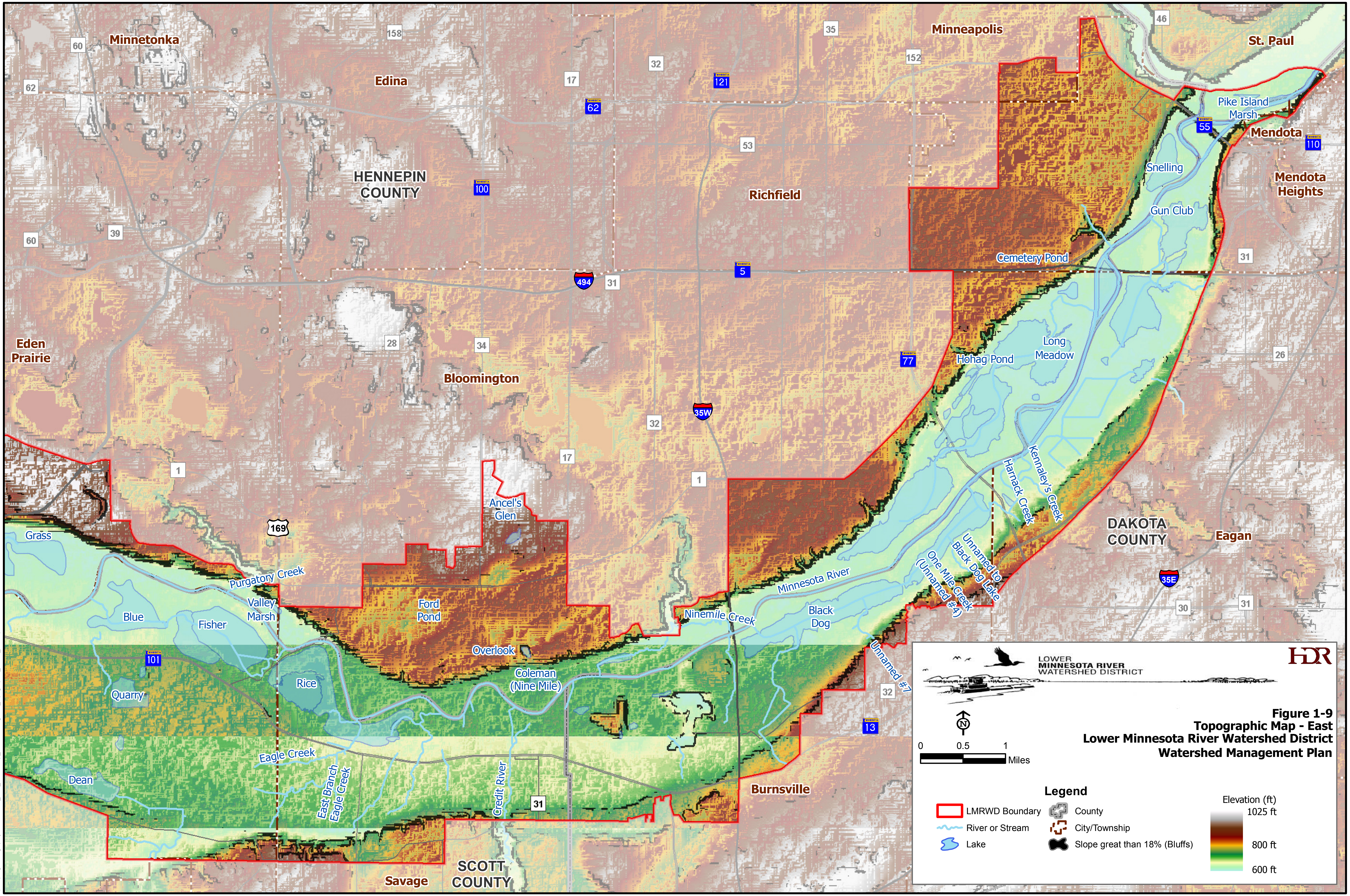


Figure 1-8
Topographic Map - West
Lower Minnesota River Watershed District
Watershed Management Plan



Minnetonka
Edina
Minneapolis
St. Paul
HENNEPIN COUNTY
Richfield
Pike Island Marsh
Mendota
Mendota Heights
Snelling
Gun Club
Cemetery Pond
Eden Prairie
Bloomington
Hohag Pond
Long Meadow
Ancel's Glen
Grass
Purgatory Creek
Valley Marsh
Blue
Fisher
Ford Pond
Overlook
Minnesota River
Ninemile Creek
Black Dog
Harnack Creek
Kennaley's Creek
Unnamed to Black Dog Lake
One Mile Creek (Unnamed #4)
Unnamed #7
DAKOTA COUNTY
Eagan
Quarry
Rice
Coleman (Nine Mile)
Eagle Creek
Dean
East Branch Eagle Creek
Credit River
Burnsville
Savage
SCOTT COUNTY
LOWER MINNESOTA RIVER WATERSHED DISTRICT
HDR
Figure 1-9
Topographic Map - East
Lower Minnesota River Watershed District
Watershed Management Plan
0 0.5 1 Miles
Legend
LMRWD Boundary
River or Stream
Lake
County
City/Township
Slope great than 18% (Bluffs)
Elevation (ft)
1025 ft
800 ft
600 ft

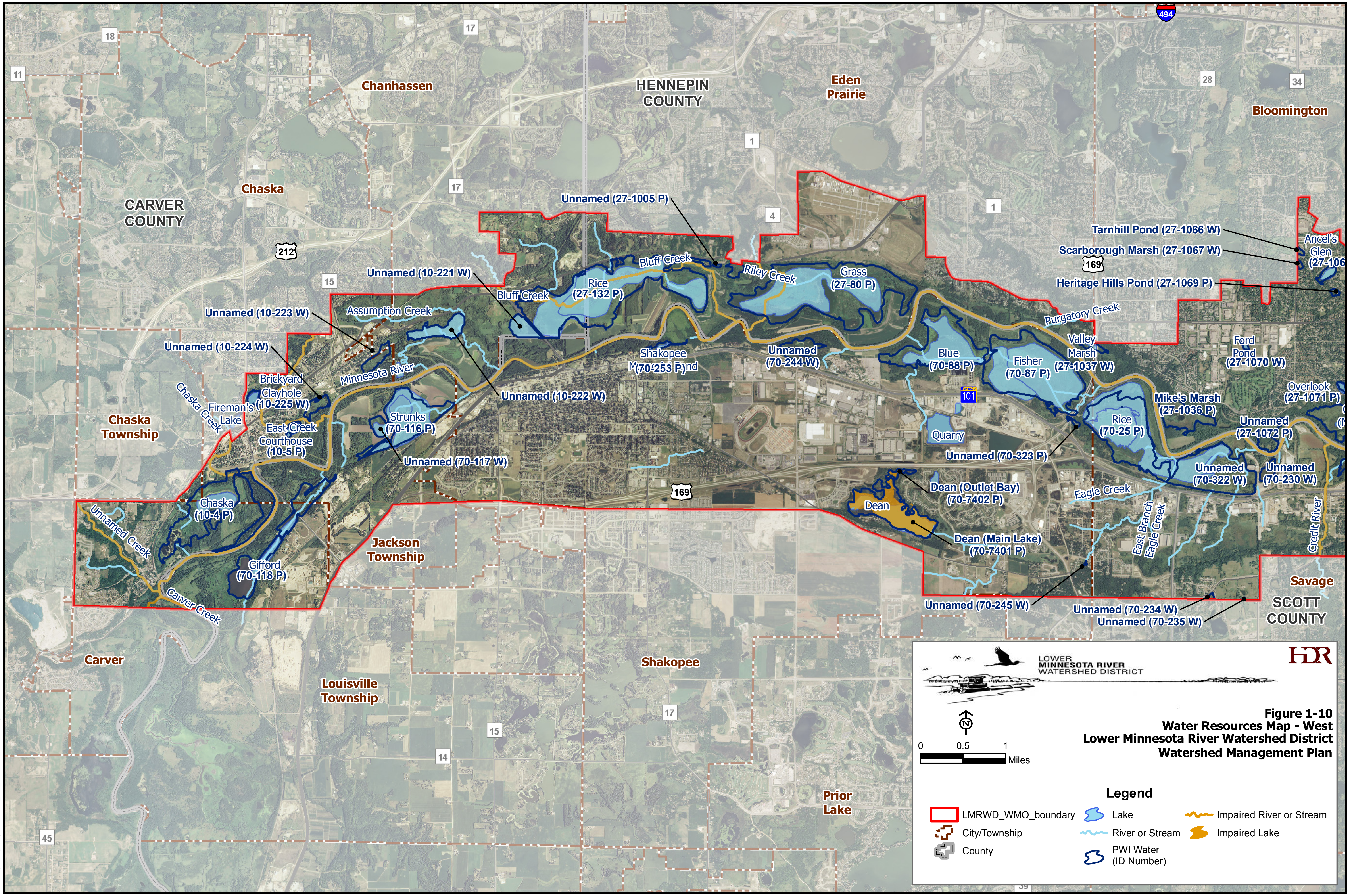
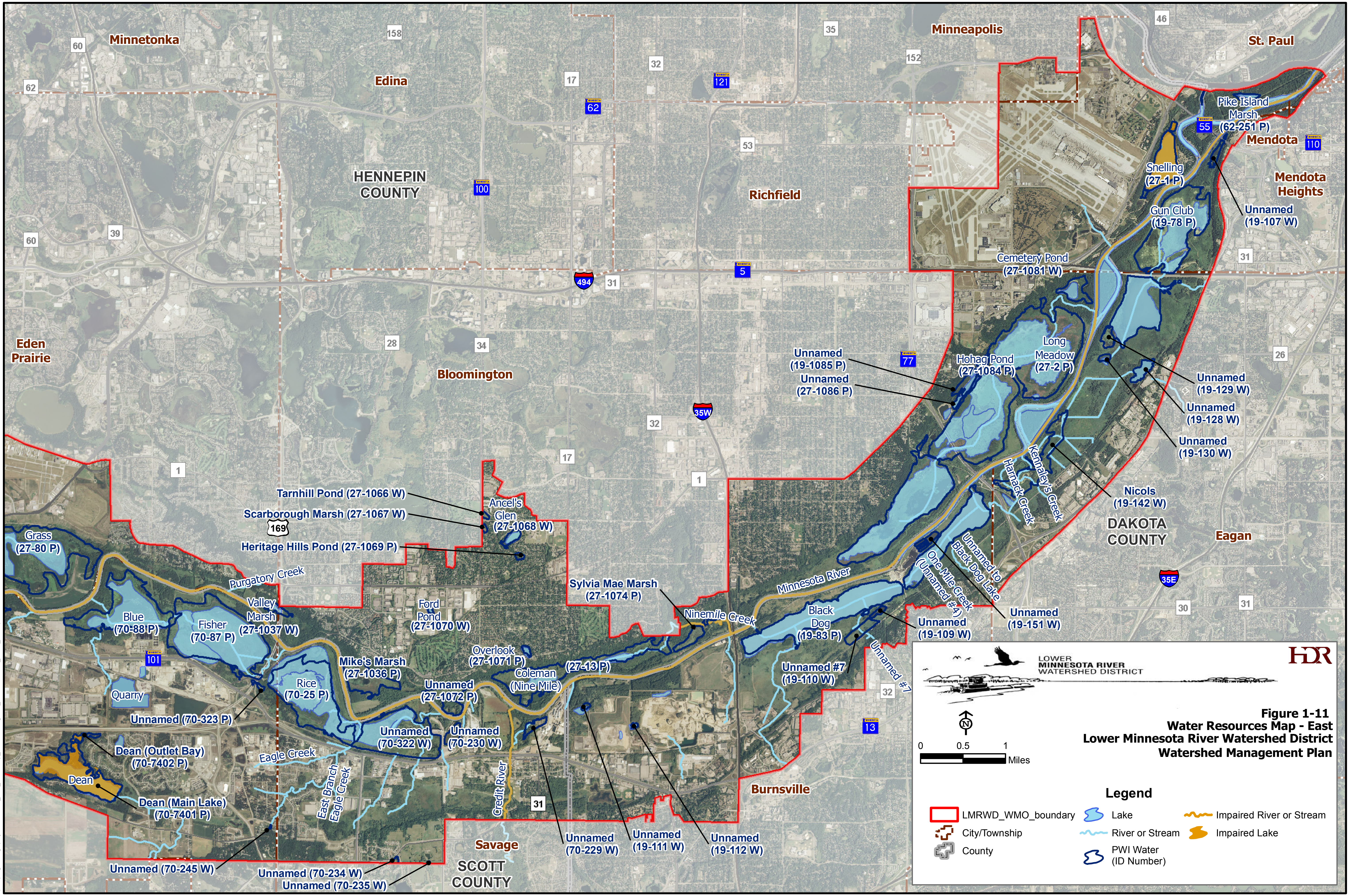


Figure 1-10
Water Resources Map - West
Lower Minnesota River Watershed District
Watershed Management Plan


Minnetonka
Edina
Minneapolis
St. Paul
HENNEPIN COUNTY
Richfield
Mendota
Mendota Heights
Eden Prairie
Bloomington
DAKOTA COUNTY
Eagan
Burnsville
Savage
SCOTT COUNTY
Pike Island Marsh (62-251 P)
Snelling (27-1 P)
Gun Club (19-78 P)
Unnamed (19-107 W)
Cemetery Pond (27-1081 W)
Long Meadow (27-2 P)
Hohag Pond (27-1084 P)
Unnamed (19-1085 P)
Unnamed (27-1086 P)
Unnamed (19-129 W)
Unnamed (19-128 W)
Unnamed (19-130 W)
Nicols (19-142 W)
Hamack Creek
Kennaley's Creek
Unnamed to Black Dog Lake
One Mile Creek (Unnamed #4)
Unnamed (19-151 W)
Unnamed (19-109 W)
Black Dog (19-83 P)
Unnamed #7 (19-110 W)
Unnamed #7
Minnesota River
Ninemile Creek
Sylvia Mae Marsh (27-1074 P)
Tarnhill Pond (27-1066 W)
Scarborough Marsh (27-1067 W)
Heritage Hills Pond (27-1069 P)
Ancel's Glen (27-1068 W)
Grass (27-80 P)
Purgatory Creek
Valley Marsh (27-1037 W)
Blue (70-88 P)
Fisher (70-87 P)
Ford Pond (27-1070 W)
Mike's Marsh (27-1036 P)
Overlook (27-1071 P)
Coleman (Nine Mile)
(27-13 P)
Rice (70-25 P)
Quarry
Unnamed (27-1072 P)
Unnamed (70-323 P)
Unnamed (70-322 W)
Unnamed (70-230 W)
Dean (Outlet Bay) (70-7402 P)
Dean
Dean (Main Lake) (70-7401 P)
Eagle Creek
East Branch Eagle Creek
Credit River
Unnamed (70-229 W)
Unnamed (19-111 W)
Unnamed (19-112 W)
Unnamed (70-245 W)
Unnamed (70-234 W)
Unnamed (70-235 W)
60
62
158
17
32
35
152
46
121
62
53
100
39
494
31
5
55
110
31
28
34
77
26
35W
32
17
1
1
169
101
35E
30
31
32
13
31
HDR
LOWER MINNESOTA RIVER WATERSHED DISTRICT
N
0 0.5 1 Miles
Figure 1-11
Water Resources Map - East
Lower Minnesota River Watershed District
Watershed Management Plan
Legend
LMRWD_WMO_boundary
City/Township
County
Lake
River or Stream
PWI Water (ID Number)
Impaired River or Stream
Impaired Lake

1.4.1 Impaired Waters

The Minnesota River, Chaska Creek, Carver Creek, Unnamed Creek (Carver, MN), East Creek, Dean Lake, Snelling Lake, Credit River, Bluff Creek, Riley Creek, and Nine Mile Creek are currently on the Minnesota Pollution Control Agency's (MPCA) list of impaired waters. Lakes and streams on the list do not meet federal water quality standards for designated uses. For each water body on the list, the MPCA is required to conduct a study to determine the allowable Total Maximum Daily Load (TMDL) for each pollutant that exceeds the standards. Impaired waters within the District are summarized in Table 1-2 below. Figure 1-10 and Figure 1-11 identify the locations of public waters listed as impaired by the MPCA. Of the 21 impairments within the District, there are seven completed TMDL Implementation Plans and six in progress.

Table 1-2: 2016 Impaired Waters in the Lower Minnesota River Watershed District

Impaired Water	Affected Use	Pollutant or Stressor	TMDL Study		TMDL Implementation Plan Status
			Start	Completion	
Minnesota River	Aquatic recreation	Fecal Coliform	2018	2022	N/A
Minnesota River	Aquatic consumption	Mercury water column	-	2008	Completed
Minnesota River	Aquatic consumption	Mercury in fish tissue	-	2008	Completed
Minnesota River	Aquatic life	Dissolved oxygen	-	2004	Completed
Minnesota River	Aquatic life	Turbidity	2014	2019	In progress
Minnesota River	Aquatic consumption	PCB in fish tissue	1998	2025	In progress
Dean Lake	Aquatic recreation	Nutrients/ Eutrophication	2014	2019	In progress
Snelling Lake	Aquatic consumption	Mercury in fish tissue	-	2007	Completed
Bluff Creek	Aquatic life	Fish and Biological Assessments	2008	2013	Completed
Bluff Creek	Aquatic life	Turbidity	2008	2013	Completed
Nine Mile Creek	Aquatic life	Chloride	2005	2010	Completed
Nine Mile Creek	Fish and Biological Assessments	Fish and Biological Assessments	2014	2019	In progress
Riley Creek	Aquatic life	Turbidity	2014	2019	In progress
Unnamed Creek	Aquatic recreation	Fecal Coliform	2014	2019	In progress
Carver Creek	Aquatic recreation	Fecal Coliform	-	2007	Completed
Carver Creek	Aquatic life	Turbidity	2014	2019	In progress

Chaska Creek	Aquatic recreation	Fecal Coliform	2014	2019	In progress
East Creek	Aquatic life	Turbidity	2014	2019	In progress
East Creek	Aquatic recreation	Fecal Coliform	2014	2019	In progress
East Creek	Aquatic life	Fish and Biological Assessments	2014	2019	In progress
Sand Creek	Aquatic life	Chloride	-	2016	Completed
Sand Creek	Aquatic life	Turbidity	2014	2019	In progress
Sand Creek	Aquatic life	Fish and Biological Assessments	2014	2019	In progress
Sand Creek	Aquatic life	Nutrients/ Eutrophication	2014	2019	In progress

1.4.2 Minnesota River

The Minnesota River originates at Big Stone Lake on the border of Minnesota and South Dakota. From Big Stone Lake, the river flows southeasterly to Mankato before turning northeastward to its confluence with the Mississippi River at St. Paul, a total distance of 330 miles. The river drains an area of approximately 16,900 square miles, including about 1,610 square miles in South Dakota and 323 square miles in Iowa. In Minnesota, the watershed encompasses 37 counties. Approximately 90 percent of the watershed lands are used for agricultural purposes. There are approximately 825 miles of tributary streams and 2,500 lakes in the Minnesota River watershed.

The river bed is relatively flat with an average slope of about 0.8 feet per mile. The width of the river floodplain varies from 0.75 to 3.0 miles. Upstream of the District, the river is relatively shallow and free-flowing. Shortly after the river enters the District, the combined effect of channel dredging and the backwater pool created by the COE Dam No. 2 on the Mississippi River at Hastings, changes the river's character to a deeper, low-velocity channel maintained for commercial and recreational navigation.

Maximum Minnesota River flows tend to occur during March and April, following the spring snowmelt. Spring and early summer rains normally maintain relatively high river flows through mid-summer. Average river flows fall off through late summer and fall; the lowest flows occur in late winter in the absence of significant surface runoff.

The USGS, in cooperation with the COE, monitors the Minnesota River with a continuous water stage recorder located at R.M. 39.4, approximately 6.0 R.M. upstream of the District's western border. Annual mean discharge from 1935 to 2008 was 4,551 cubic feet per second (cfs). Calculated on an area basis, the mean flow represents a direct runoff amount of 3.8 inches per year over the 16,200-square mile watershed above Jordan. The maximum recorded discharge of 117,000 cfs occurred at Jordan during the spring flood of 1965. Recent significant floods include the summer flood of 1993, the spring flood of 1997, and the spring flood of 2001; with maximum discharges of

92,200 cfs, 82,400 cfs, and 87,100 cfs, respectively. The minimum recorded discharge occurred in November 1955 with a flow rate of 79 cfs.

1.4.3 Streams

Tributary streams flowing to the Minnesota River in the District vary in size from a 1.0 square mile watershed area to nearly 45 square miles. The smaller watershed streams, such as Eagle Creek, Assumption Creek, and other unnamed streams, are groundwater-dependent and either totally or mostly within the District's boundaries. The larger streams, such as Nine Mile Creek, Credit River, Chaska Creek, Bluff Creek, Purgatory Creek, Riley Creek, and Carver Creek, all have origins in watersheds that are outside the District, but they all enter the Minnesota River valley from the surrounding uplands and flow across a portion of the valley before entering the river.

Other watershed districts manage some tributary streams/channels such as Nine Mile Creek, Riley-Purgatory-Bluff Creek, and Prior Lake-Spring Lake. Other streams come under the authority of joint power WMOs such as Credit River, Chaska Creek, and Carver Creek.

The DNR identifies the following four streams in the District as "fishable" trout streams:

- Assumption Creek
- Harnack Creek (Unnamed #1)
- Eagle Creek
- Kennaley's Creek

Figure 1-10 and Figure 1-11 include the trout streams' locations.

1.4.4 Lakes

Most of the District's sixteen lakes are located within or adjacent to the Minnesota Valley National Wildlife Refuge, Recreation Area, and State Trail. Figure 1-10 and Figure 1-11 provide the locations of these lakes. Table 1-3 gives details on each of the lakes within the District that can be classified as floodplain/groundwater or quarry lakes.

Floodplain/groundwater lakes are generally shallow, with fish populations that experience frequent winterkills. However, these lakes are naturally restocked from annual flooding by the Minnesota River. In addition to the water supplied by flooding, all lakes are spring-fed, and some have streams that flow through them. These lakes provide essential habitat for migratory birds, fish, and resident wildlife. For example, a cricket frog population, an extremely rare species in Minnesota, has been found near Coleman Lake (Nine Mile Lake), a floodplain lake in the City of Bloomington. The floodplain/groundwater lakes in the refuge are managed by the U.S. Fish and Wildlife Service (USFWS) to promote the growth of natural wildlife food and to provide wildlife-oriented recreation opportunities.

Dean Lake, in Shakopee, is an expression of the groundwater table in the area. It is underlain by a relatively thin layer of porous sand and dammed by a ridge of limestone. Groundwater flows through the lake and the lake's water surface elevation is affected by fluctuations in the groundwater table.

Courthouse Lake, in Chaska, is a DNR-designated trout lake and an example of a quarry lake. Quarry lakes are historical stone or clay quarries filled with relatively good quality groundwater. These lakes occasionally experience flooding from the Minnesota River, which can have a degrading effect on water quality through deposition of pollutants carried in the floodwaters.

Table 1-3: Lower Minnesota River Watershed District Lake Data

Lake	Public Waters Inventory Number	Area (ac)	Depth (ft.)		Lake Type	Water Supply
			Average	**Maximum**		
Black Dog	19-83P	391	1.5	3.0-4.0	Floodplain/ groundwater used by Xcel for cooling water	Springs, seepage, intermittent surface drainage
Blue	70-88P	203	1.5	3.0	Floodplain/ groundwater /marsh	Natural springs, seepage, and intermittent surface drainage
Brickyard Clayhole	10-225W	11	25.0	41.0	Quarry	Springs
Chaska	10-4P	46	1.5	3.5	Floodplain/ groundwater	Springs
Coleman	27-13P	114	<1.0	3.5	Floodplain/ groundwater	Nine Mile Creek, seepage, and springs
Courthouse	10-5P	12	25.0	57.0	Trout/quarry	Underground springs
Dean	70-74P	216	3.0	5.0	Floodplain/ groundwater	Seepage, natural springs and intermittent surface drainage
Fisher	70-87P	284	1.0	3.0	Floodplain/ groundwater / marsh	Blue Lake, natural springs, seepage and minor surface drainage
Gifford	70-118P	116	Unknown	Unknown	Floodplain/ groundwater / marsh and	Springs, intermittent surface drainage

					old quarry or channel bed	
Grass	27-80P	467	1.5	3.5	Floodplain/ groundwater	Riley Creek, seepage and springs
Gun Club	19-78P	1216	1.0	2.5	Floodplain/ groundwater /marsh	Springs, seepage
Long Meadow	27-2P	1,188	1.0	3.5	Floodplain/ groundwater / marsh	Natural springs, some surface drainage from north and south
Rice (Hennepin Cty)	27-132P	517	1.0	3.0	Floodplain/ groundwater / marsh	Bluff Creek, springs and intermittent surface drainage
Rice (Scott Cty)	70-25P	259	1.0	3.0	Floodplain/ groundwater / marsh	Natural springs, seepage and some local drainage
Snelling	27-1P	119	6.0	12.0	Floodplain/ groundwater	Mainly natural springs, little surface drainage
Strunks and Unnamed	70-116P and 70-117P	185	1.0	4.0	Floodplain/ groundwater / marsh and southern lake is old quarry or gravel pit	Spring, seepage, and small amount of local drainage

1.4.5 Wetlands

The District also has large areas of wetlands, which are an important part of the natural environment and provide several valuable functions. Wetlands are a critical part of the natural storm drainage system. Wetlands help maintain water quality; reduce flooding and erosion; provide food and habitat for wildlife; and open spaces and natural landscapes for residents. Thus, wetlands are important physical, educational, ecological, aesthetic, recreational, and economic assets to the District.

Some of the District wetlands are adjacent to floodplain lakes, while others result from springs and low wet areas. Springs arising from limestone aquifers produce a special wetland called a calcareous fen. This rare wetland is identified by the specific vegetative community, which is found only in a calcareous fen. MN Rules 7050 identify the following calcareous fens in the District and classify them as “outstanding resource waters.”

- Snelling Fen – Dakota County
- Nicols Meadow Fen – Dakota County
- Quarry Island Fen – Dakota County
- Savage Fen – Scott County
- Seminary Fen – Carver County

Locations of fens within the District are shown Figure 1-12 and Figure 1 - 13. The DNR is responsible for protecting these calcareous fens with assistance from the District. This partnership has yielded the acquisition of portions of Savage Fen and Black Dog Preserve Fen for management under the Scientific and Natural Area designation.

Figure 1-12 and Figure 1-13 show the National Wetlands Inventory (NWI) wetlands within the District and include information on wetland type and association with other types of water bodies. Detailed information about wetlands and wetland types can be found by contacting the USFWS and the DNR. Other agencies and entities delineate wetlands within the District, including USFWS, the COE, the Minnesota Department of Transportation (DOT) and municipalities and counties that administer the Wetland Conservation Act (WCA). (The WCA is discussed in a later section.)

1.4.6 Stormwater System and Floodplain Information

Communities within the District have local water management plans that include maps showing areas served by each existing stormwater system, including stormwater ponds and outfalls. For specific details about storm drainage systems, a reference to the respective communities’ local surface water management plans is provided. The following communities have such plans: Bloomington, Burnsville, Carver, Chanhassen, Chaska, Eden Prairie, Lilydale, Mendota, Mendota Heights, Minneapolis, Savage, Shakopee, and Scott County. Local water management plans provide information about peak flood elevations and flow rates for existing and proposed ponds. All communities within the District have adopted DNR-approved floodplain ordinances. DNR-approved county floodplain ordinances cover unincorporated areas.

The District, in partnership with USGS and the COE, published the Lower Minnesota Floodplain Study in 2004. Upon appropriate review, the information contained in this report may be used as “Best Available Data” until the Federal Emergency Management Agency (FEMA) produces new Flood Insurance Study (FIS) maps of the affected communities.

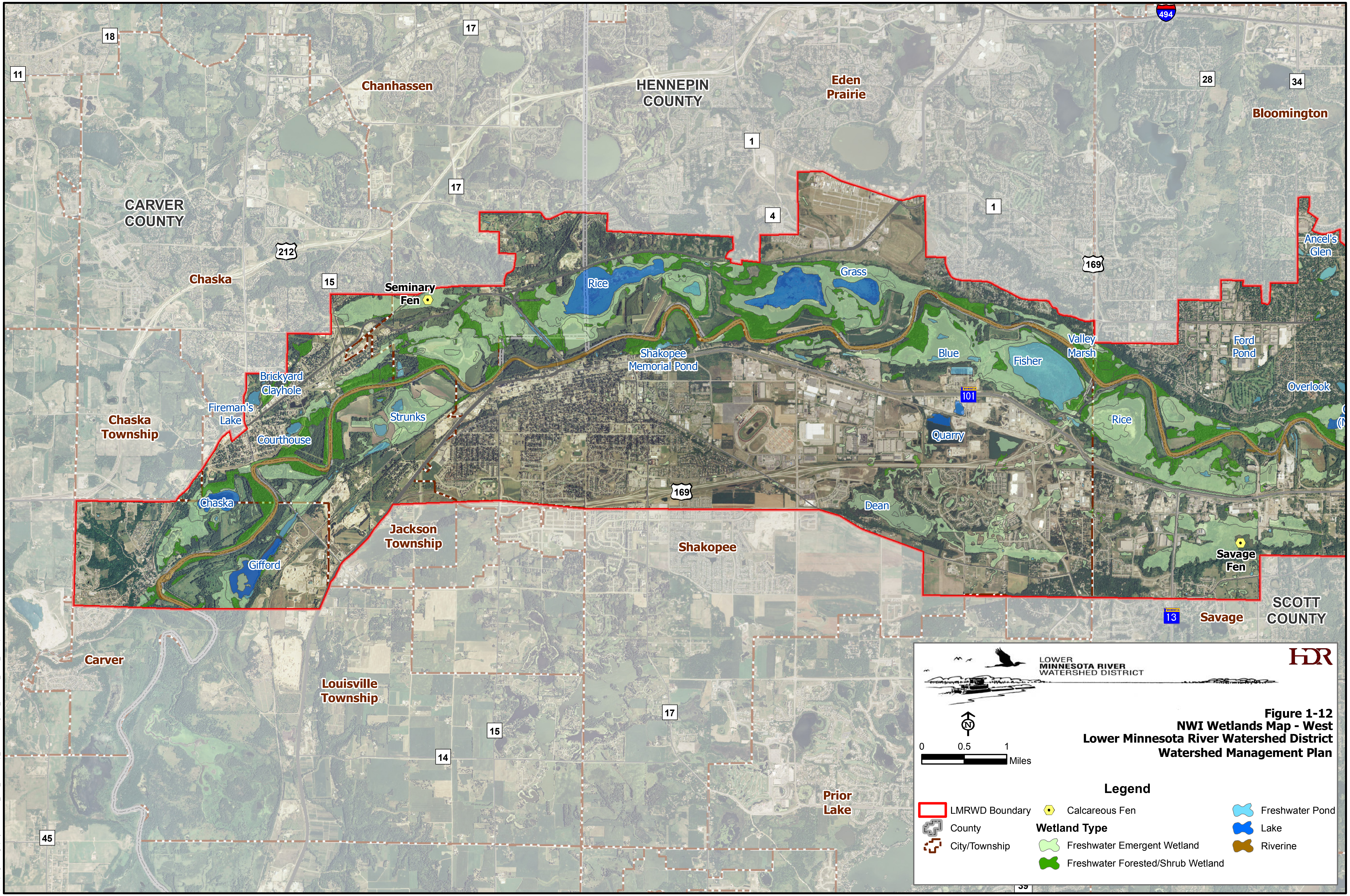
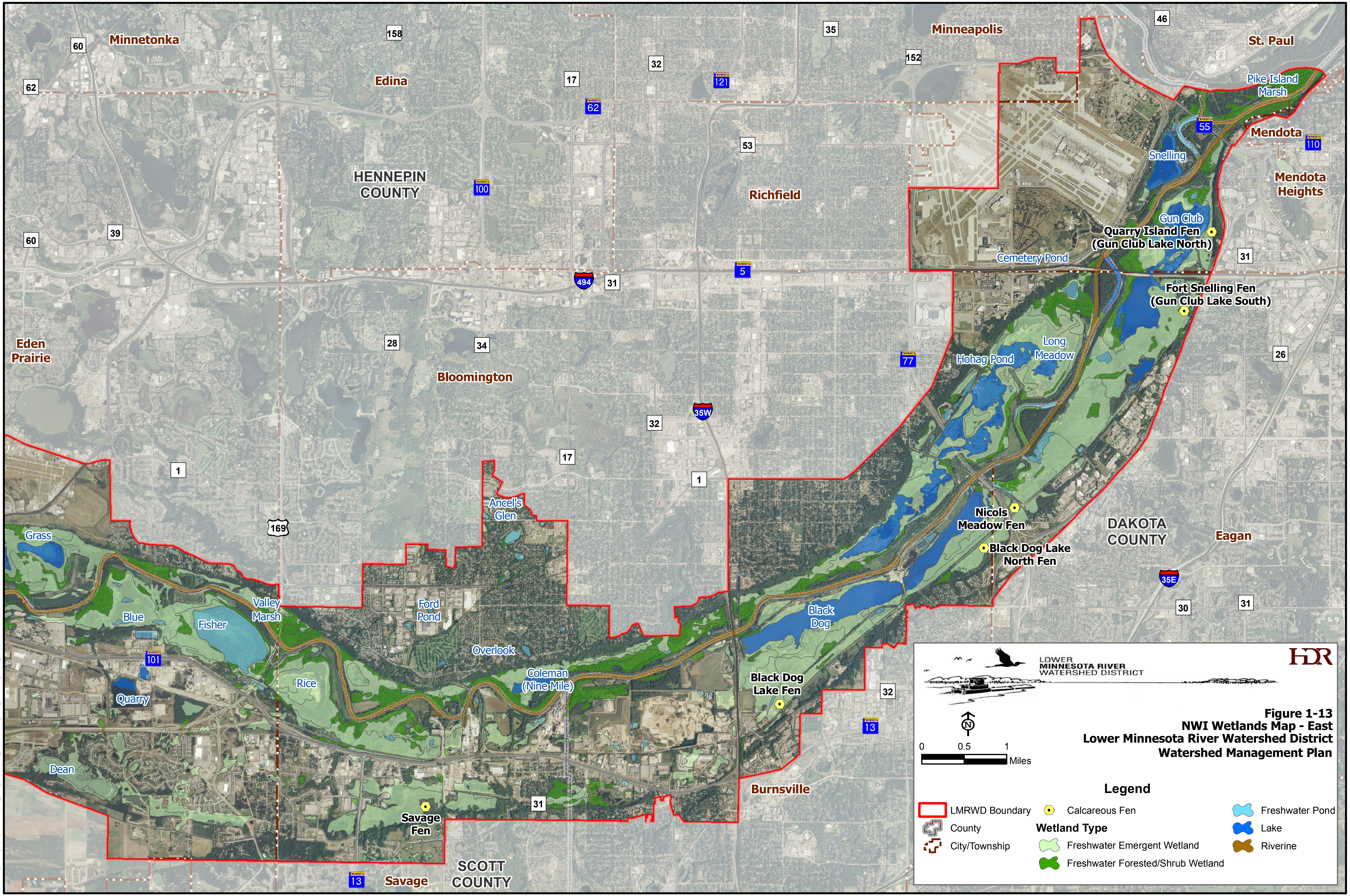


Figure 1-12
NWI Wetlands Map - West
Lower Minnesota River Watershed District
Watershed Management Plan



Minnetonka
Edina
Minneapolis
St. Paul
Pike Island Marsh
Mendota
Mendota Heights
HENNEPIN COUNTY
Richfield
Snelling
Gun Club
Quarry Island Fen (Gun Club Lake North)
Cemetery Pond
Fort Snelling Fen (Gun Club Lake South)
Eden Prairie
Bloomington
Hohag Pond
Long Meadow
Ancel's Glen
Grass
Nicols Meadow Fen
Black Dog Lake North Fen
DAKOTA COUNTY
Eagan
Valley Marsh
Ford Pond
Blue
Fisher
Black Dog
Overlook
Coleman (Nine Mile)
Rice
Quarry
Black Dog Lake Fen
Dean
Burnsville
Savage Fen
SCOTT COUNTY
Savage
LOWER MINNESOTA RIVER WATERSHED DISTRICT
HDR
0 0.5 1 Miles
Figure 1-13
NWI Wetlands Map - East
Lower Minnesota River Watershed District
Watershed Management Plan
Legend
LMRWD Boundary
County
City/Township
Calcareous Fen
Wetland Type
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Lake
Riverine

1.5 HYDROLOGIC AND HYDRAULIC MODELING

Several cities within the District have constructed hydrologic and hydraulic models in conjunction with their local surface water management plans. These entities should be contacted for additional information. In addition, the DNR maintains hydraulic and hydrologic model data files for those water bodies situated in National Flood Insurance Program (NFIP) participant communities. Specific model information can be found in the appropriate FIS for a water body. Model data files are available from the Floodplain Management Program within the DNR Division of Waters.

1.6 SURFACE WATER QUALITY AND QUANTITY MONITORING

Monitoring in the District is carried out by the Metropolitan Council Environmental Services (MCES) and the District in cooperation with other entities and is available on the MPCA website. The MPCA serves as a central clearinghouse for much of the data. Figure 1-4 and Figure 1-15 show water quality and quantity monitoring sites within the District. (The location of the District's Willow Creek station on these figures is inaccurate; it is in the process of being relocated, and the new location has not been determined). The following sections describe water quality data collection efforts and long-term trend analyses, where available, for the Minnesota River and the District's lakes, streams, and fens.

1.6.1 Lakes

The MCES collects water quality data from Brickyard Clayhole, Courthouse Lake, and Fireman's Lake in cooperation with the City of Chaska and Carver County Environmental Services Departments; and from Dean Lake in cooperation with the City of Shakopee, as part of the Citizen Assisted Monitoring Program (CAMP). Data is available for Brickyard Clayhole and Courthouse Lake from 2005-2015, Dean Lake from 2002-2011, and Fireman's Lake from 2005-2014. Lakes are visited biweekly from April through October and the data is published on the CAMP website.

Surface water samples are collected and analyzed for total phosphorus (TP; typically, the most limiting nutrient in Minnesota lakes), total Kjeldahl nitrogen (TKN), and chlorophyll-a (Chl-a; an estimate of phytoplankton biomass). Secchi transparency (a measurement of water clarity) is also monitored, as well as the lake's perceived physical condition and recreational suitability. In many Minnesota lakes as TP increases, so will phytoplankton biomass (i.e. Chl-a). Also, as phytoplankton biomass increases, water transparency (i.e. Secchi depth) decreases. Volunteers also measure each lake's surface water temperature and fill out a lake sampling form to describe the lake and the weather conditions at the time of sampling. Each lake is sampled at the deepest location.

Table 1-4 shows annual average TP, TKN, Chl-a and Secchi depth for Brickyard Clayhole from 2005-2015. Table 1-4 also shows State of Minnesota eutrophication standards for Chl-a, TP, and Secchi depth found in Minnesota Administrative Rule 7050.0222. Annual average values for all four parameters remained relatively steady over the course of the monitoring period. Relatively slight increases were observed in TP and TKN concentrations in 2008. and concentrations. In 2013 Chl-a concentrations are the highest within the sampling period while TKN concentrations are the lowest. In 2009, annual average TKN concentration returned to pre-2007 values. Annual average values for Chl-a, TP and Secchi depth all met State of Minnesota eutrophication standards each year.

Table 1-4: Brickyard Clayhole Annual Average Water Quality Parameters

	MN Eutrophication Standard	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Chl-a (mg/L)	<0.014	0.002	0.002	0.003	0.003	0.004	0.003	0.004	0.003	0.013	0.003	0.004
TKN (mg/L)	N/A	0.55	0.53	0.83	1.00	0.57	0.56	0.60	0.52	0.49	0.58	0.52
TP (mg/L)	<0.40	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01
SD (m)	>2.5	4.5	4.8	3.5	3.9	3.8	3.9	3.6	3.5	3.9	3.7	4.1

Chart 1-1 shows the relationship between annual average Chl-a and Secchi depth for Brickyard Clayhole, which is statistically-significant at the alpha 0.05 level. As Chl-a concentrations increase the Secchi depth, or water transparency, should decrease; this inverse relationship is consistent with Chart 1-1.

Chart 1-1: Brickyard Clayhole Annual Average Secchi depth versus Chl-a

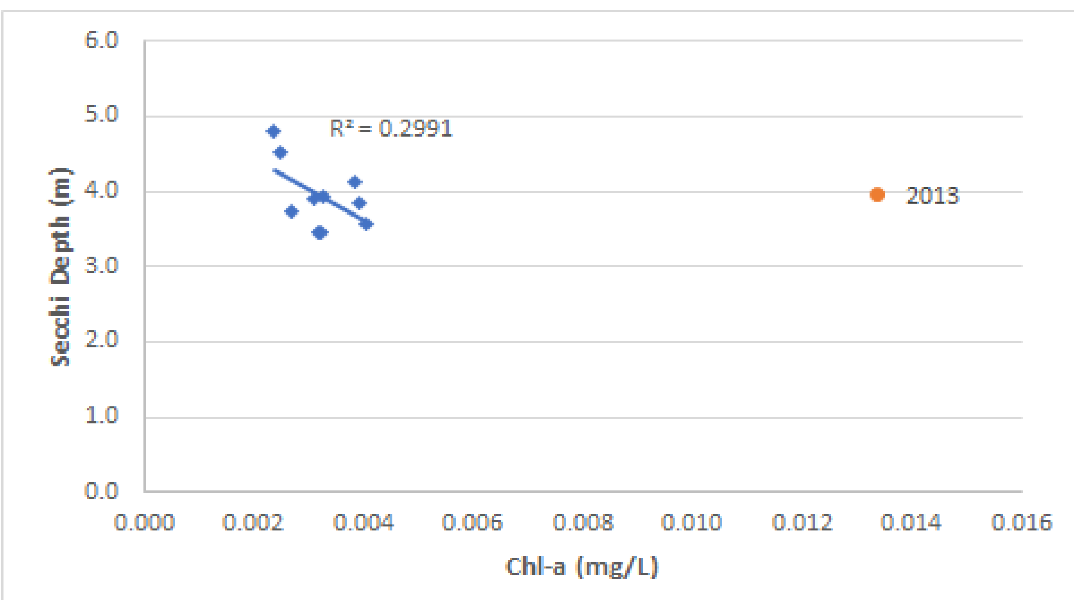


Chart 1-2 shows the relationship between annual average TP and Chl-a measurements for Brickyard Clayhole, which is not statistically-significant at the alpha less than 0.05 level. The relatively narrow range and small values of both TP and Chl-a for Brickyard Clayhole are likely reasons for the poor indistinct relationship.

Chart 1-2: Brickyard Clayhole Annual Average Chl-a versus TP

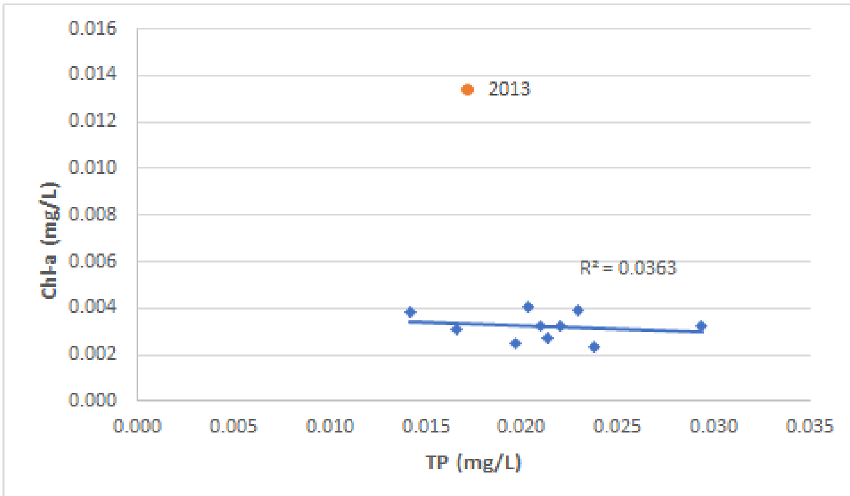


Chart 1-3 shows Brickyard Clayhole annual average Chl-a concentrations for 2005-2015. Chl-a concentrations trended upwards slightly over the course of the measurement period but are still relatively low compared to other lakes except for 2013. The 2013 concentrations, although higher than all recorded years, met the Minnesota eutrophication standard.

Chart 1-3: Brickyard Clayhole Annual Average Chl-a Concentrations

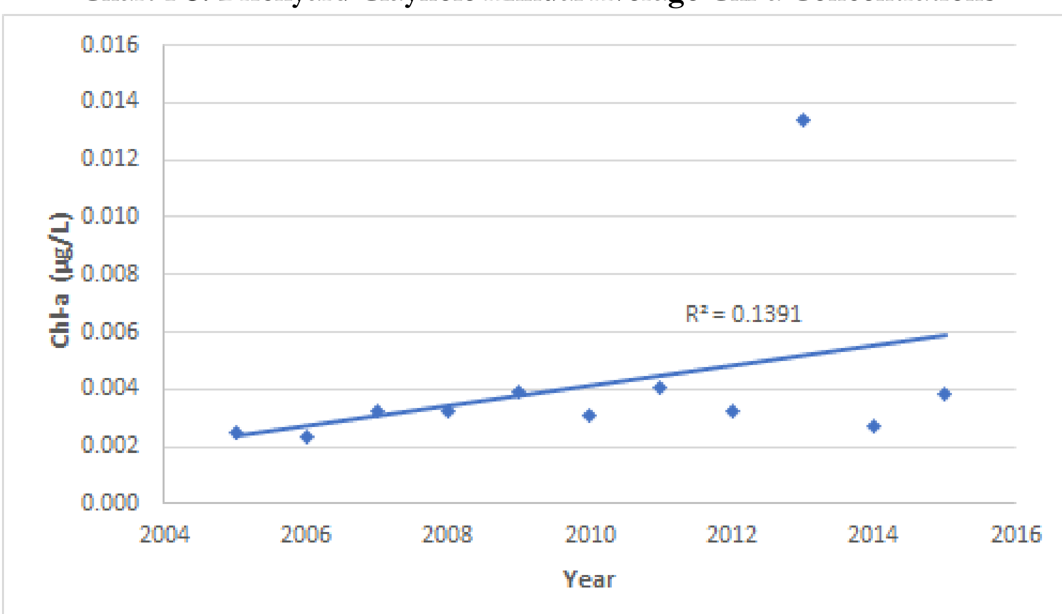


Table 1-5 shows annual average TP, TKN, Chl-a and Secchi depth for Fireman's Lake from 2005 to 2014. Table 1-5 also shows State of Minnesota eutrophication standards for Chl-a, TP, and Secchi depth found in Minnesota Administrative Rule 7050.0222. Annual average values for TKN and Secchi depth remained steady over the course of the monitoring period. The exception was Chl-a, which almost doubles in value from 2009-2010 and from 2011 to 2012.decreased significantly. TP values remained steady except for except for 2012. Annual average values for Chl-a, TP and Secchi depth all met State of Minnesota eutrophication standards each year. The average annual Secchi depth did not meet State of Minnesota Eutrophication standards in 2012 and 2013.

Table 1-5: Fireman's Lake Annual Average Water Quality Parameters

	MN Eutrophication Standard	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Chl-a (mg/L)	<0.014	0.003	0.005	0.002	0.003	0.003	0.006	0.004	0.007	0.007	0.003
TKN (mg/L)	N/A	0.39	0.49	0.37	0.67	0.64	0.52	0.58	0.60	0.52	0.50
TP (mg/L)	<0.40	0.02	0.03	0.02	0.02	0.03	0.03	0.02	0.10	0.03	0.02
SD (m)	>2.5	3.0	2.8	2.9	3.2	3.3	2.8	2.5	2.3	2.2	2.8

Chart 1-4 shows the relationship between annual average Chl-A versus Secchi depth for Fireman's Lake. As Chl-a concentrations increase the Secchi depth should be inversely affected decrease; this inverse relationship is consistent with Chart 1-4 below.

Chart 1-4: Fireman's Lake Annual Average Secchi depth versus Chl-a

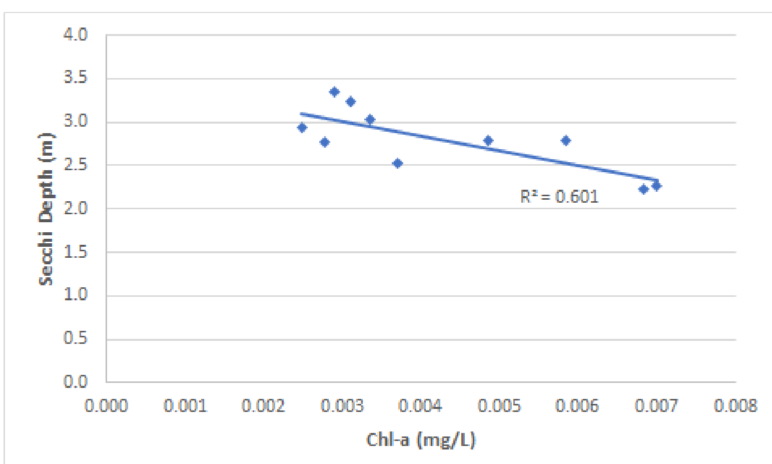


Chart 1-5 shows the relationship between annual average TP and Chl-a for Fireman's Lake, which is not statistically-significant at the alpha = 0.05 level. In many Minnesota lakes, it is expected that as TP increases, so should Chl-a. The relatively narrow range and small values of Chl-a for Fireman's Lake are likely reasons for the indistinct poor relationship.

Chart 1-5: Fireman's Lake Annual Average Chl-a versus TP

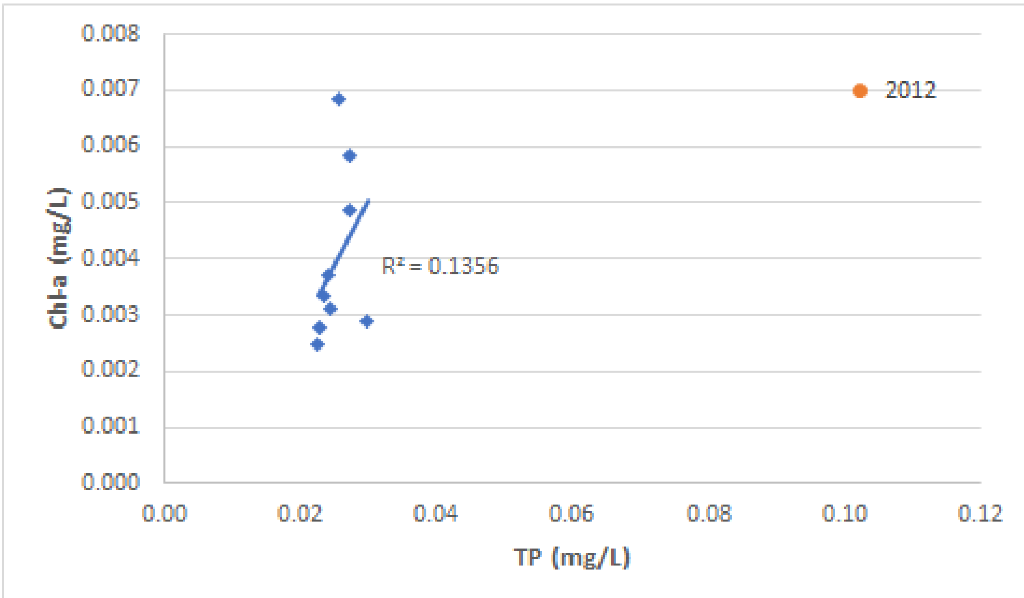


Chart 1-6 shows Fireman's Lake annual average Chl-a concentrations for 2002-2015. Annual average Chl-a for Fireman's Lake have trended upward over the course of the monitoring period.

Chart 1-6: Fireman's Lake Annual Average Chl-a Concentrations

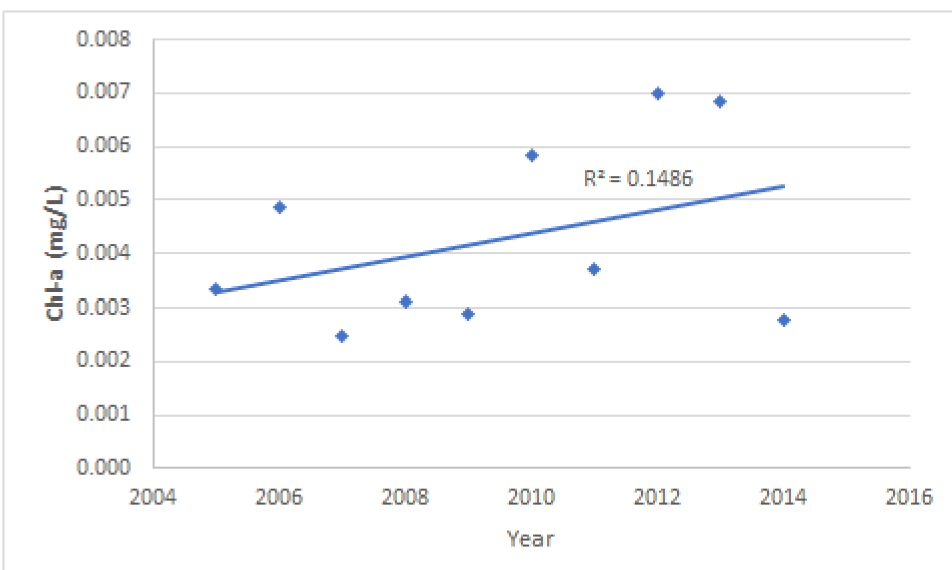


Table 1-6 shows annual average TP, TKN, Chl-a, and Secchi depth for Courthouse Lake from 2005 to 2015. Table 1-6 also shows State of Minnesota eutrophication standards for Chl-a, TP, and Secchi depth found in Minnesota Administrative rule 7050.0222. Annual average values for all four parameters remained steady over the course of the monitoring period except for 2003 to 2006. During this period, TP, Chl-a, and TKN values increased to a relative peak in 2010 and then begin to decrease. and Chl-a decreased before returning to pre-2003 levels.

Table 1-6: Courthouse Lake Annual Average Water Quality Parameters

	MN Eutrophication Standard	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Chl-a (mg/L)	<0.014	0.002	0.002	0.006	0.007	0.005	0.007	0.006	0.003	0.021	0.003	0.002
TKN (mg/L)	N/A	0.58	0.57	0.72	0.98	0.70	0.83	0.74	0.72	0.77	0.69	0.64
TP (mg/L)	<0.40	0.02	0.02	0.02	0.02	0.02	0.04	0.03	0.04	0.03	0.03	0.02
SD (m)	>2.5	4.6	4.7	2.4	3.6	4.1	3.2	3.3	4.2	3.5	4.3	4.0

Chart 1-7 shows the inverse relationship between annual average Chl-a and Secchi depth for Courthouse Lake from 20051-201509, which is not statistically-significant at the alpha = 0.05 level. The relatively narrow range and small values of Chl-a for Courthouse Lake are likely reasons for the poor relationship. Annual average values did not meet State of Minnesota eutrophication standards for Chl-a in 201308, TP in 1997, 1999-2001, and 2004-2005 and Secchi depth in 1997, 1999, and 2007. As Chl-a concentrations increase the Secchi depth should decrease, this relationship is consistent with Chart 1-7 below.

Chart 1-7: Courthouse Lake Annual Average Secchi depth versus Chl-a

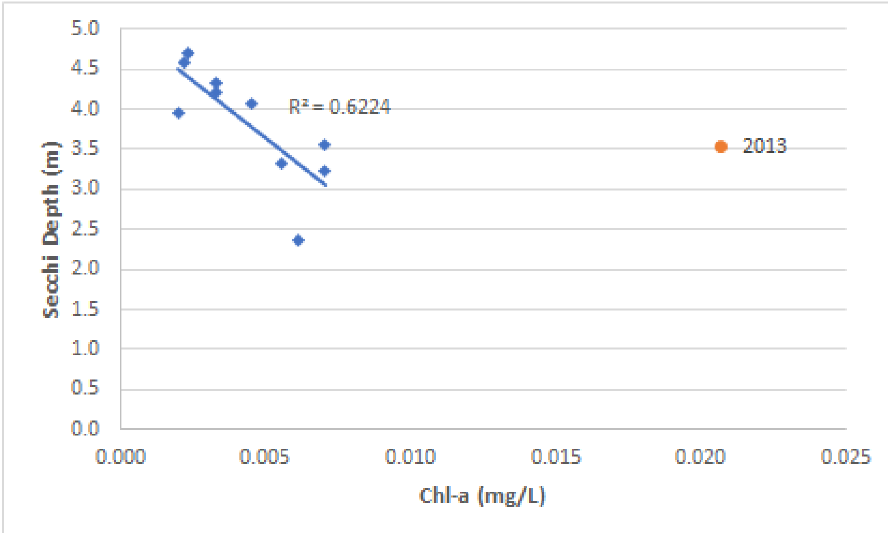


Chart 1-8 shows the relationship between annual average TP and Chl-a for Courthouse Lake. Many Minnesota lakes, it is expected that as TP increases., so should Chl-a; this relationship is observed in Chart 1-8 below. The relatively narrow range and small values of both TP and Chl-a for Courthouse Lake are likely reasons for the indistinct poor relationship. In many Minnesota lakes, it is expected that as TP increases, so should Chl-a; this relationship is observed in Chart 1-8 below.

Chart 1-8: Courthouse Lake Annual Average Chl-a versus TP

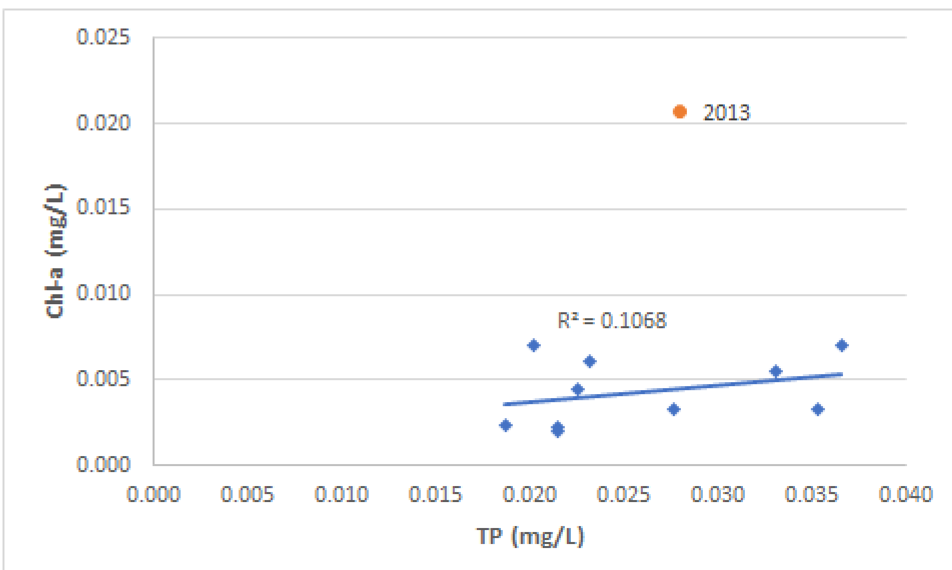


Chart 1-9 shows Courthouse Lake annual average Chl-a concentrations for 20051-2015. Annual average Chl-a concentrations for Courthouse Lake remained relatively steady over the monitoring period except for 2013.

Chart 1-9: Courthouse Lake Annual Average Chl-a Concentrations

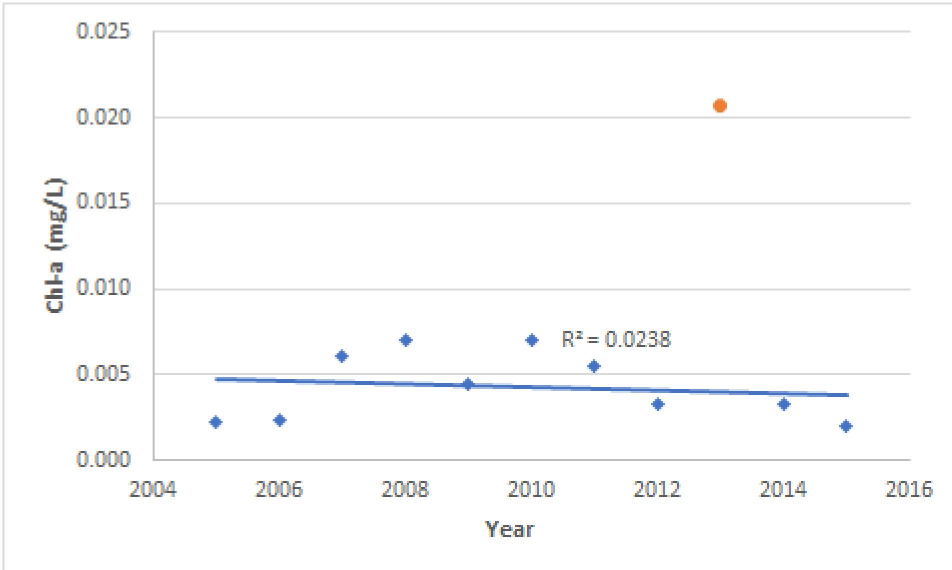


Table 1-7 shows annual average TP, TKN, and Secchi depth for Dean Lake from 2002 to 2011. Table 1-7 also shows State of Minnesota eutrophication standards for Chl-a, TP, and Secchi depth found in Minnesota Administrative rule 7050.0222. Annual average values for TKN and Secchi depth remained steady over the course of the monitoring period. Annual average Chl-a values fluctuated significantly over the monitoring period while TP values trended upwards, however all four parameters achieved relatively low numbers in 2011. Dean Lake only met State of Minnesota eutrophication standard for Chl-a in 2004 and 2011. Dean Lake met the State of Minnesota eutrophication standard for TP in all years except 2009 and did not meet the standard for Secchi depth in any years.

Table 1-7: Dean Lake Annual Average Water Quality Parameters

	MN Eutrophication Standard	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Chl-a (mg/L)	<0.014	0.043	0.024	0.007	0.039	0.067	0.042	0.015	0.047	0.024	0.002
TKN (mg/L)	N/A	2.31	1.74	1.48	2.84	3.36	2.30	3.07	4.45	1.45	0.89
TP (mg/L)	<0.40	0.15	0.21	0.11	0.19	0.28	0.23	0.19	0.44	0.16	0.07
SD (m)	>2.5	0.5	0.6	0.4	0.3	0.7	0.5	1.9	-	0.7	1.6

Chart 1-10 shows the relationship between annual average Chl-a and Secchi depth for Dean Lake. As Chl-a concentrations increase the Secchi depth should decrease. This indirect relationship is consistent with Chart 1-10 below. The relatively narrow range and small values of Chl-a for Dean Lake are likely reasons for the relatively indistinct poor relationship.

Chart 1-10: Dean Lake Annual Average Secchi depth versus Chl-a

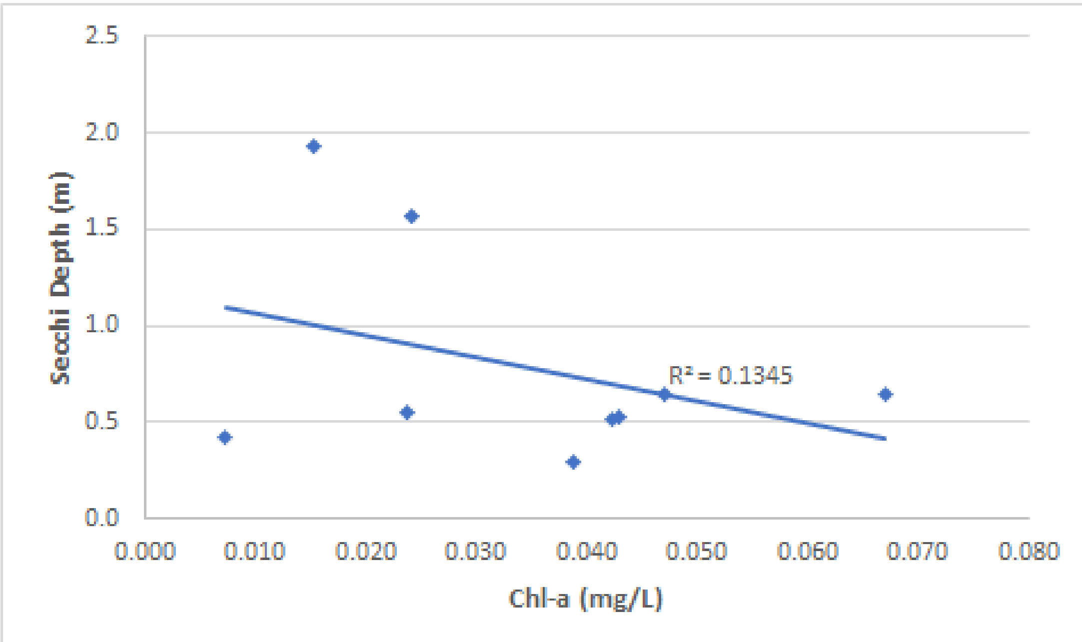


Chart 1-11 shows the direct relationship between annual average Chl-a and TP measurements for Dean Lake. In many Minnesota lakes, it is expected that as TP increases, so should Chl-a; this relationship is observed in Chart 1-11 below.

Chart 1-11: Average Annual Dean Lake Chl-a versus TP

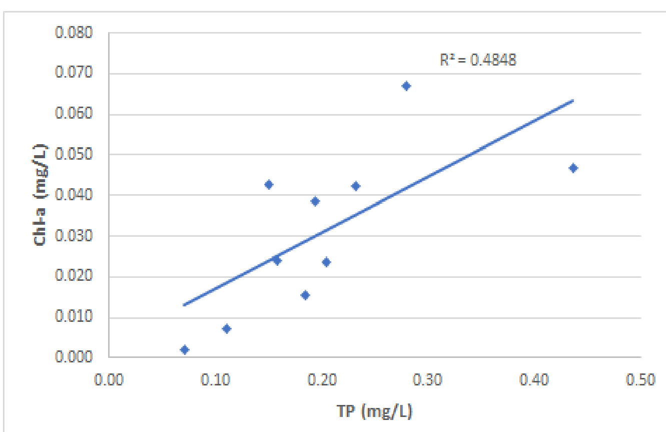
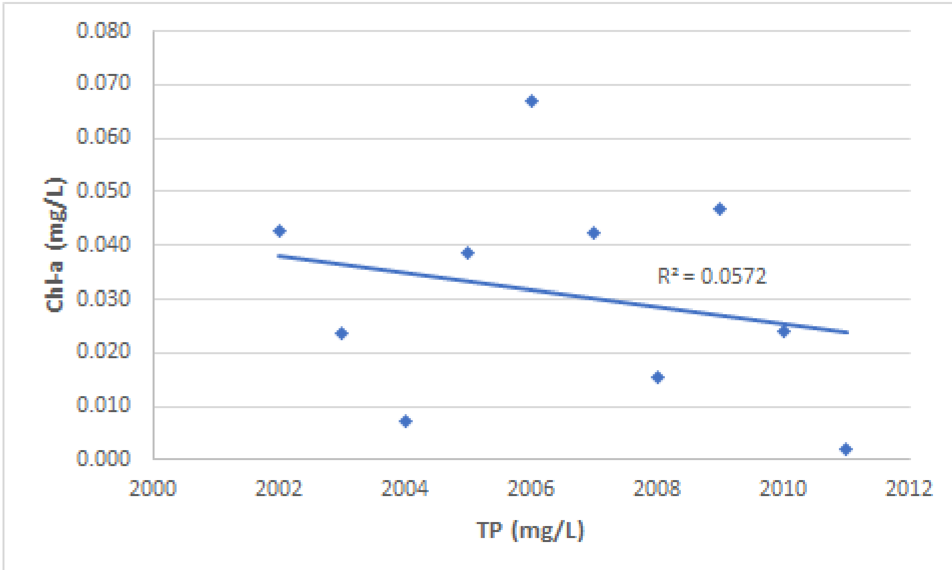


Chart 1-12 shows Dean Lake annual average Chl-a concentrations for 2002-2009. No significant trend exists over the course of the monitoring period.

Chart 1-12: Dean Lake Annual Average Chl-a Concentrations



MCES grades lake water quality relative to other lakes throughout the state based on the data presented in Table 1-8. Table 1-8 below summarizes the lake grade for each of the lakes monitored within the District given by the MCES in the yearly CAMP reports for each lake. Lake grades are based on analysis of water quality monitoring data for the year.

Table 1-8: Metropolitan Council Environmental Service Lake Grade

Lake	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Brickyard	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Courthouse	B	A	A	A	A	A	A	A	A	A	A	B	A	A
Firemen's	A	A	A	A	B	A	A	B	B	A	B	B	A	
Dean	F	D	D	D	F	F	D		C					

Brickyard Clayhole and Courthouse and Fireman's Lake all have had excellent overall water quality over the course of the monitoring period. None of these lakes show any water quality trends, either upwards or downwards. In contrast, Dean Lake has had poor overall water quality over the course of the monitoring period without any upward or downward trends. Floodplain lakes with the District do not have enough water quality data to report. These lakes are significantly influenced by backwater from the Minnesota River, so monitoring data may not provide much information on water quality in these lakes.

1.6.2 Minnesota River

In an effort to understand historical runoff and pollutant loads entering the District from the greater Minnesota River Basin, a trend analysis was performed for annual runoff, total phosphorus (TP), and total suspended solids (TSS). This trend analysis includes monitoring data collected by the Metropolitan Council and the USGS, at the USGS gauge at Jordan (#05330000). Chart 1-13 shows total annual runoff in millions of acre-feet at the USGS gauge at Jordan from 1935 to 2007 (USGS-Water Info, 2009). This data represents the watershed runoff yield from the Minnesota River Basin upstream of the District. A trend analysis of the data indicates that annual yield has increased over the 72 years. The 20-year average annual yield has more than doubled in the latter 57 years, increasing from nearly 2 million acre-feet in 1950 to over 5 million acre-feet in 2007. Chart shows the annual TSS load in tons at the Jordan gauge from 1976 to 2009 (MCES 2009). Chart 1-14 shows the annual TP load in tons at the Jordan gauge from 1979 to 2008 (MCES 2009).

Results of the analysis show that the watershed yield has doubled since the 1940s, the total TSS load has doubled since the 1980s, and the TP load has increased by about 15 percent since the 1980s. This is significant because, unless these trends are reversed, the District will experience more bank scour issues like those in Eden Prairie. These bank scour issues are due to the increased runoff volumes and will suffer more sediment deposition in the navigation channel. In the floodplain lakes, bank scour issues are due to the significant increase in TSS loads. The increases in the TP loads will likely result in increased algae growth and more instances of low dissolved oxygen in the river, which will reduce fisheries habitat.

USGS operates an automatic monitoring network that continuously measures dissolved oxygen, temperature, pH, and specific conductance of the Minnesota River near Fort Snelling at R.M. 3.5. (Specific conductance, a measure of the ability of water to conduct an electrical current, gives a good idea of the amount of dissolved material in the water.) Biological monitoring, which assesses the integrated effects of water pollution on aquatic organisms, is also carried out at this site by the USGS.

Extensive conventional pollutant monitoring is also conducted to complement automatic monitoring. The monitoring results are used to characterize water quality and determine specific sources of pollution. Monitoring results also address the extent and nature of problems that may exist. Conventional pollutant monitoring is carried out at the following sites on the Minnesota River within the District:

- Near Shakopee (R.M. 25.1)
- Near Savage (R.M. 14.3)
- Near the Black Dog Power Plant (R.M. 8.5)
- Near Fort Snelling (R.M. 3.5)

More information regarding USGS monitoring on the Minnesota River is available by contacting the USGS or visiting the program website.

MCES is responsible for collecting and treating wastewater in the MSP metropolitan area. Performance monitoring of the two MCES wastewater treatment plant (WWTP) discharges, at the Seneca WWTP in the City of Eagan and the Blue Lake WWTP in the City of Shakopee, is conducted regularly to meet National Pollutant Discharge Elimination System (NPDES) permit requirements.

Chart 1-1: Annual Mean Discharge at the USGS Jordan Station – Minnesota River

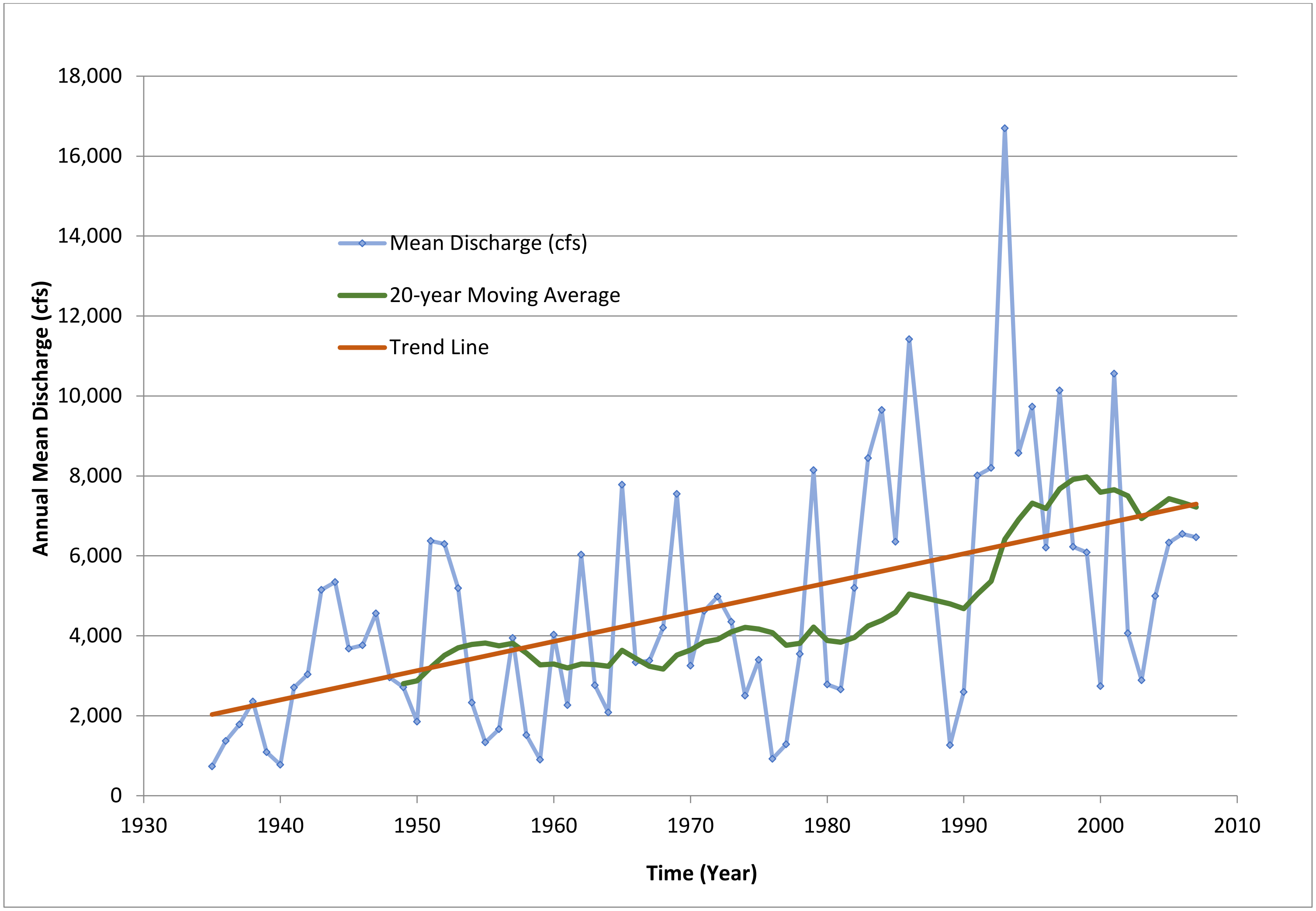


Chart 1-2: Annual Total Suspended Solids Load at the USGS Jordan Station – Minnesota River

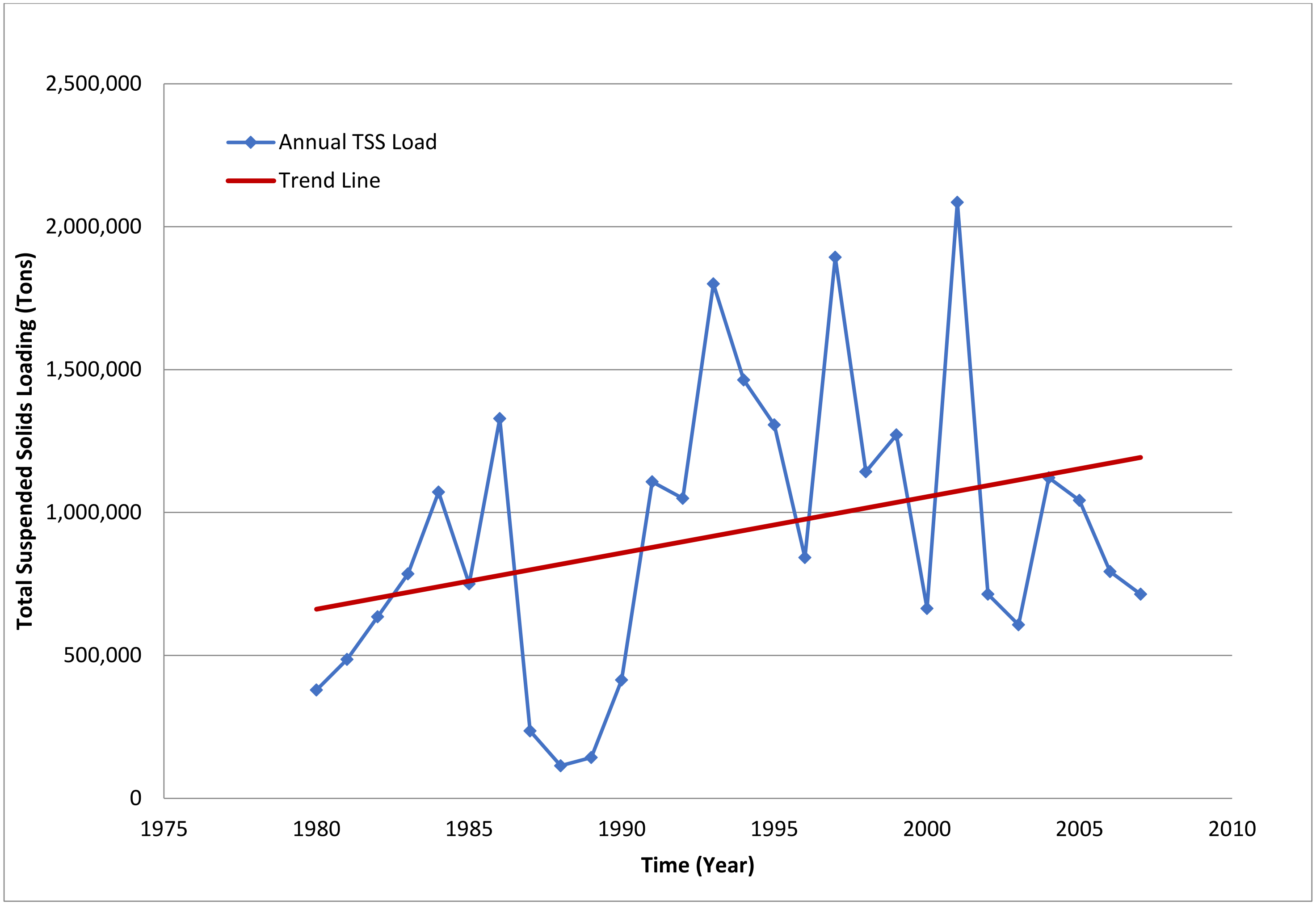
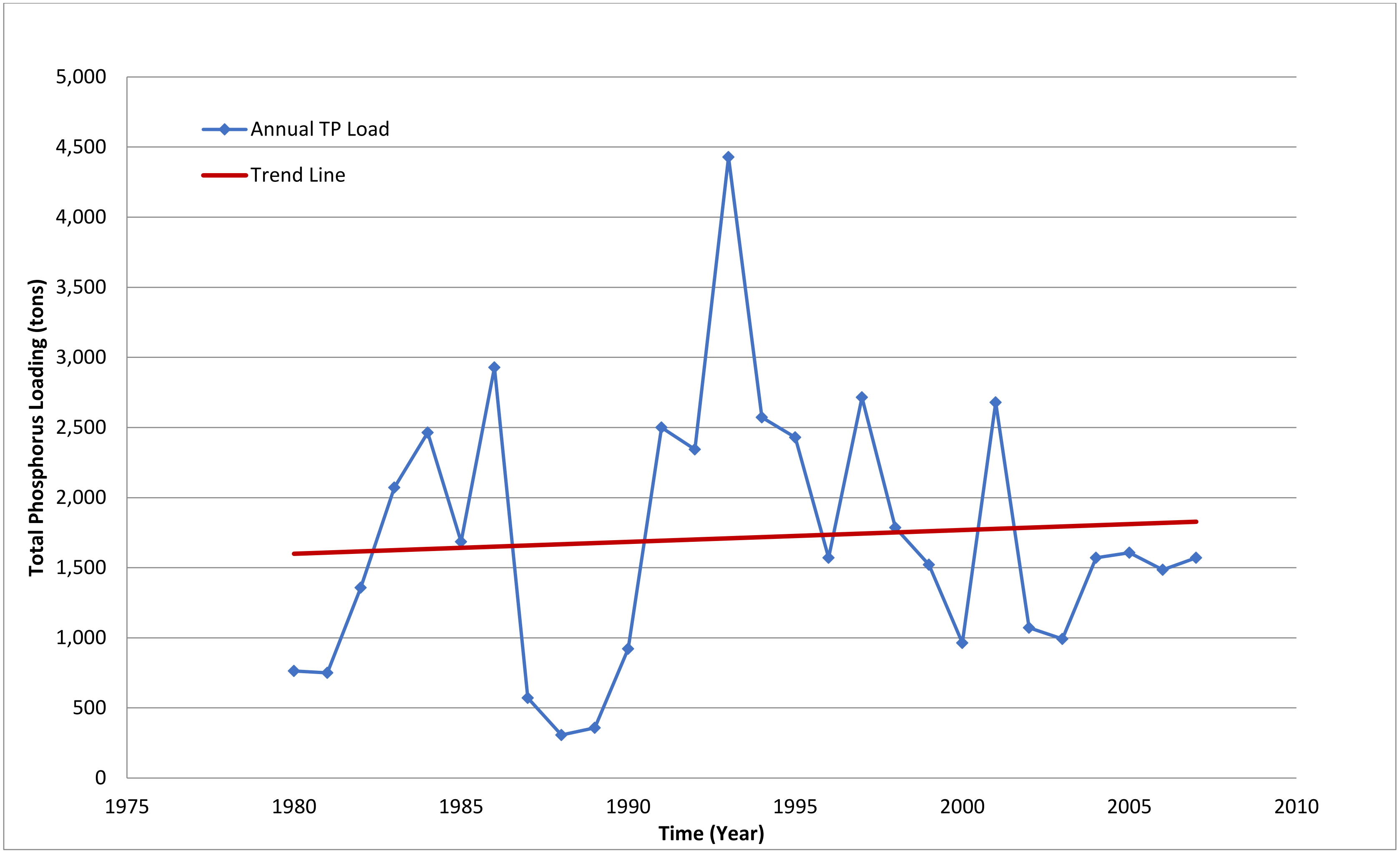


Chart 1-3: Annual Total Phosphorus Load at the USGS Jordan Station – Minnesota River



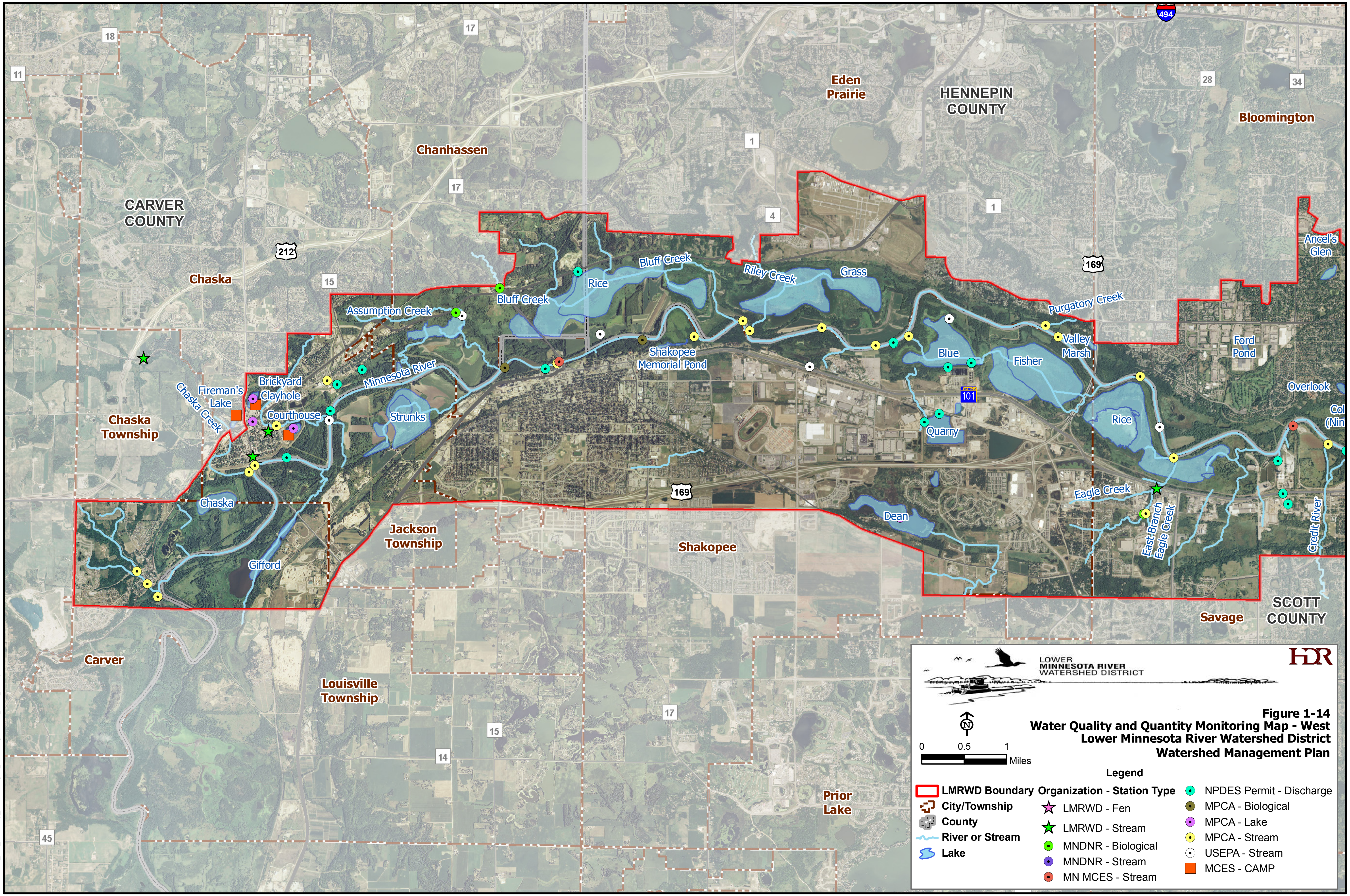


Figure 1-14
Water Quality and Quantity Monitoring Map - West
Lower Minnesota River Watershed District
Watershed Management Plan

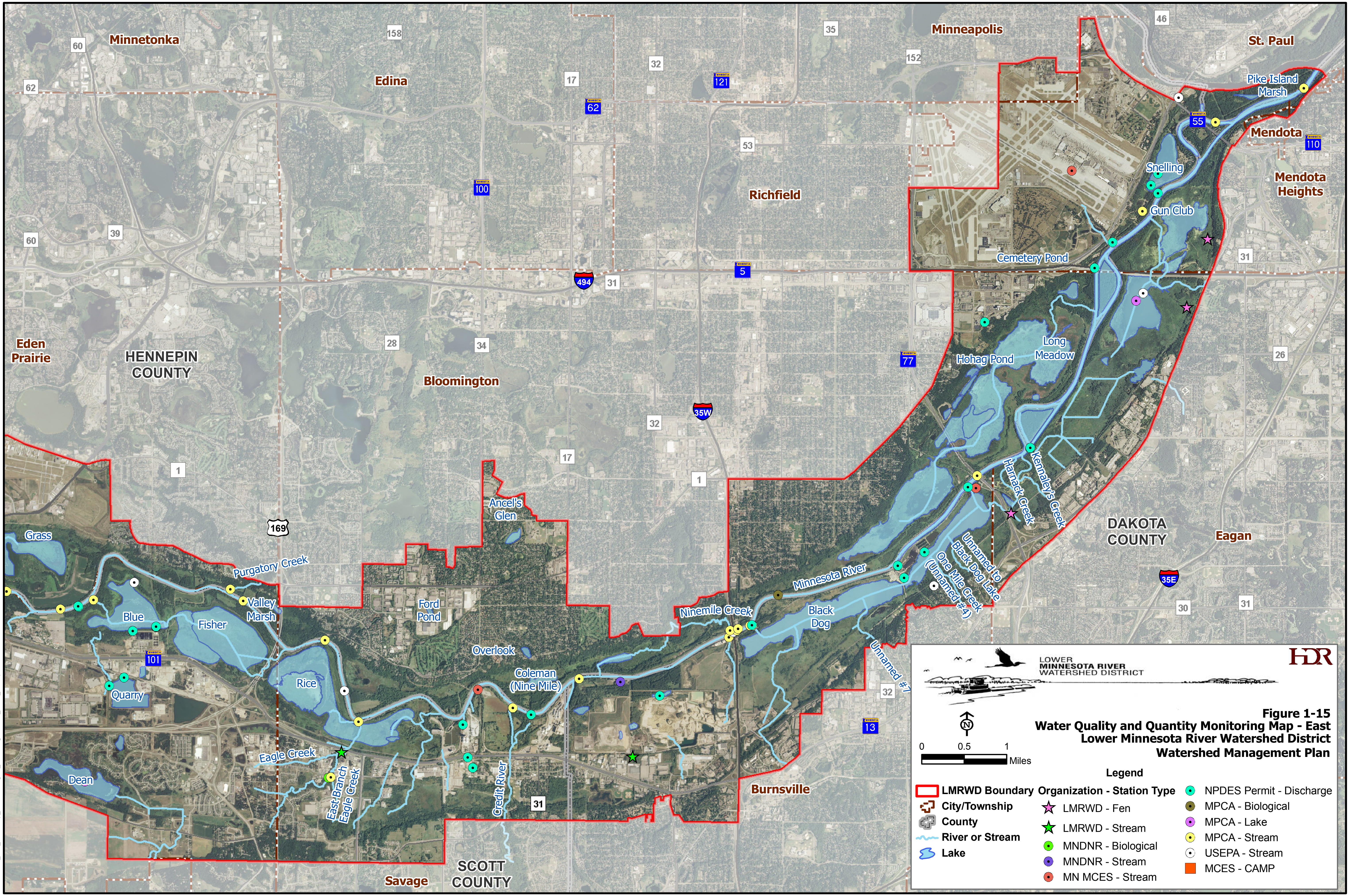


Figure 1-15
Water Quality and Quantity Monitoring Map - East
Lower Minnesota River Watershed District
Watershed Management Plan

1.6.3 Streams

Since 1999, the District, in cooperation with MCES and Scott SWCD, has operated a stream monitoring station on Eagle Creek in the City of Savage and on Willow Creek in the City of Burnsville, in cooperation with MCES and Dakota SWCD. The purpose of these stations is to measure the mass, or nonpoint source pollutant "load," that tributary streams transport to major rivers. Eagle Creek is sampled during significant runoff events and during base-flow conditions to help determine the sources and extent of nonpoint pollution. Since Eagle Creek supports a trout population, temperature monitoring at additional locations have also been sponsored by the District.

MCES also operates monitoring stations on streams tributary to the District but outside its jurisdiction at Bluff Creek (since 1990), Carver Creek (since 1989), Credit River (since 1989), Nine Mile Creek (since 1989), and Riley Creek (since 1999).

In 2005, MCES published the "2004 Stream Monitoring and Assessment" that, among other analyses, 1) contains the results of a trend analysis performed on annual loads and flow-weighted mean pollutant concentrations using the Kendall Tau test, and 2) compared historic to 2004 mean watershed yields and flow-weighted mean concentrations for several pollutants. The "2004 Stream Monitoring and Assessment" contained analyses for Eagle Creek, Bluff Creek, Carver Creek, Credit River, Nine Mile Creek, Riley Creek, and Willow Creek in addition to 20 other Twin Cities metropolitan area streams.

The MCES' "2004 Stream Monitoring and Assessment" identified potential decreasing trends in Nine Mile Creek for nitrate (NO3), total dissolved phosphorus (TDP), total phosphorus (TP), total suspended solids (TSS), and Bluff Creek for NO3 and TP (MCES, 2004). The report also identified decreasing trends in Sand Creek for TDP and TP, as well as an increasing trend in Sand Creek for TSS.

The MCES' "2004 Stream Monitoring and Assessment" includes watershed yields and flow-weighted mean concentrations. This assessment concluded the following regarding streams within or tributary to the District: 1) Sand Creek delivered the highest flow-weighted mean concentrations of TSS to the Minnesota River, 2) Bluff, Sand, and Riley Creeks had the highest pollutant yields of TSS and 3) in general, the streams tributary to the Minnesota River had the greatest TSS, TP, and NO3 yields of the 27 sites assessed.

In 2012, the MCES completed its annual stream water quality assessment report. The report 1) presents a trend analysis of pollutant concentrations and 2) calculates annual pollutant loads and flow-weighted mean pollutant concentrations of the streams mentioned above, over the record period. The District, to avoid duplication of effort, will use the results of these analyses to prioritize monitoring efforts and implementation activities.

The District, in cooperation with Scott SWCD, has published quarterly or annual reports on Eagle Creek for pollutant monitoring since 2007 and temperature monitoring since 2006. In general, these reports show that Eagle Creek is within eco-region means for pollutants and within trout supporting temperature ranges. The notable exception is winter time concentrations of bacteria, turbidity, and sediment. Because the creek is spring fed, it does not freeze in the winter. The open water attracts many waterfowl to the creek which elevates these pollutants.

The District, in cooperation with Dakota SWCD, has published quarterly reports on Willow Creek Pollutant monitoring since the fourth quarter of 2004. The October – December 2009 Quarterly Report compares 2009 quarterly pollutant concentrations to historical (1999-2008) pollutant concentrations. When 2009 monitoring results are compared against historical mean concentrations, most parameters were near, or below 10-year averages and water quality has remained relatively stable over the historical monitoring period. However, during the first quarter of 2009, concentrations for several endpoints (BOD, chloride, conductivity, hardness, lead, nickel, ammonia, and nitrate/nitrite) were substantially higher than 10-year averages. This is a consequence of early season runoff event samples, which typically carry larger pollutant loads in excess of events sampled later in the year. This pattern of higher pollutant concentrations during the first quarter has routinely been observed for this station and appears to be the norm for this watershed.

In cooperation with Carver County Environmental Services and the City of Chaska, the District has operated three monitoring stations on East Chaska Creek since 2003. The purpose of these sites is to monitor the entire East Chaska Creek watershed for flow and nutrients. This data is used to analyze land use effects within the watershed on the creek.

The District, in cooperation with the Minnesota Department of Agriculture (MDA), Carver County Environmental Services, and the City of Chaska, operates a monitoring site on West Chaska Creek. The purpose of this site is to gauge the output from the entire Chaska Creek watershed into the Minnesota River. The District has published reports for monitoring at this site in 1997 and for the period from 1999 to 2005.

The District has monitored stream flows at three locations and, in cooperation with Chaska High School, monitored invertebrates in Assumption Creek. The District has published reports for stream flow monitoring in Assumption Creek in 2006 and for invertebrate monitoring since 2001. Stream flow monitoring in Assumption Creek indicates presence of year-round baseflow, and invertebrate monitoring indicates that water quality is generally good. The District has monitored invertebrates in Spring Creek in cooperation with Chaska High School. The District has published reports for invertebrate monitoring in Spring Creek since 2001. Invertebrate monitoring in Spring Creek indicate good to very good water quality. In addition, the District monitored temperatures in Unnamed Creek #7 during 2006. Temperature monitoring at Unnamed Creek #7 in 2006 indicates that mean summer temperature was below the optimal limit for Brown trout for all of 2006. There is little evidence of significant urban stormwater inputs based on temperature data collected in 2006.

Overland runoff and discharge from storm sewers has formed small intermittent streams that have created numerous gullies along the steep slopes of the Minnesota River bluffs. Many of these gullies have experienced excessive erosion, which threatens slope stability and serves as source of sediment in the Minnesota River. In 2007, the District collaborated with the Minnesota Conservation Corps (MCC) to take an inventory of these gullies and detect those with the most severe erosion. The District has used the gully inventory results to identify slope stabilization projects since implementation (and continues to implement with partnering cities).

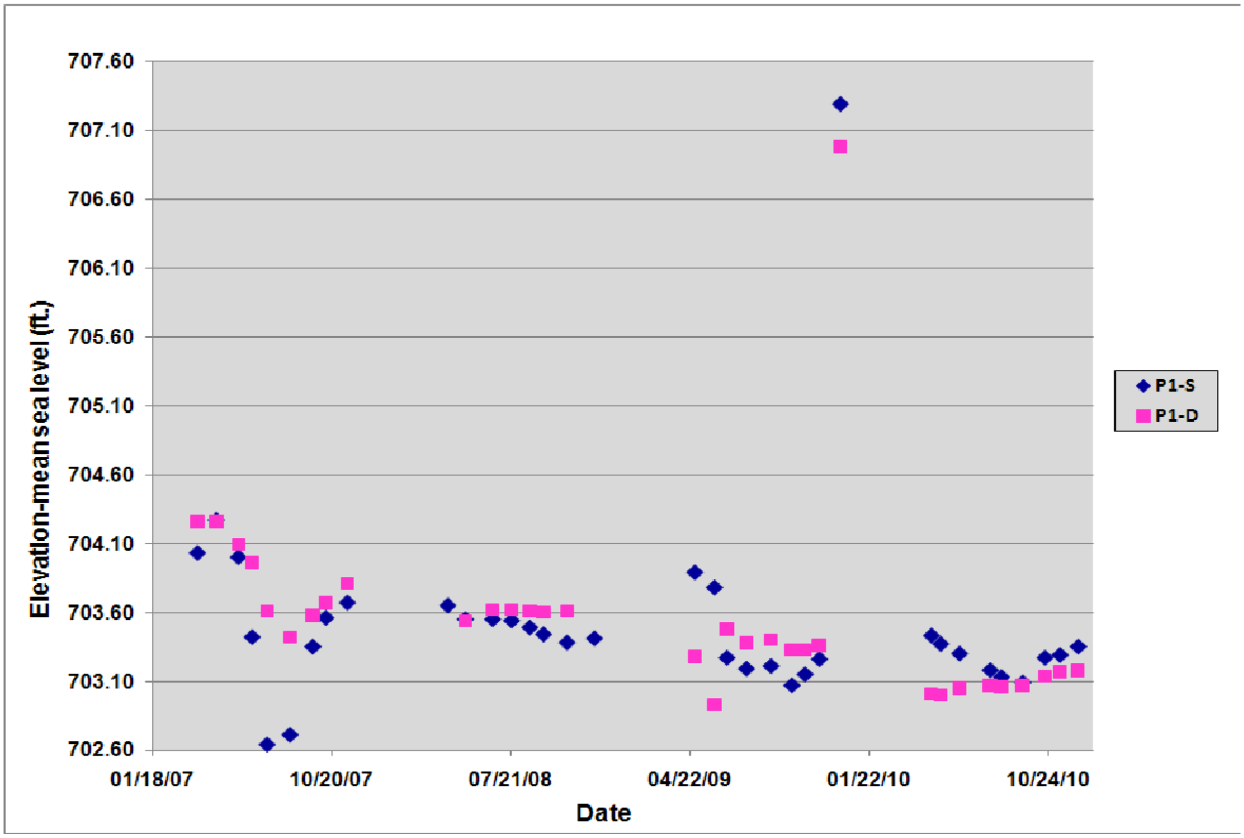
1.6.4 Fens

In 2007, the District began contracting with the Dakota County SWCD to collect monthly "depth to water" measurements for a network of 28 fen wells. Water levels are monitored at the following fens:

- Quarry Island
- Snelling Fen
- Nicols Fen

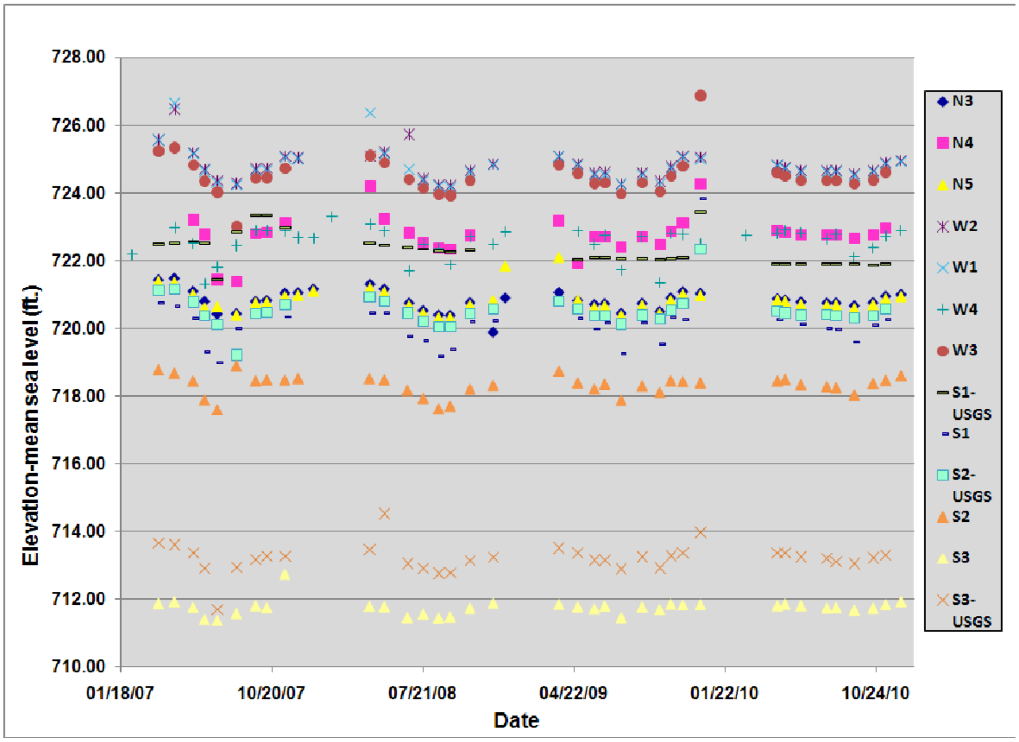
Chart 1-16, Chart 1-17 and Chart 1-18 shows fen well monitoring results for Quarry Island, Snelling and Nicols fens, respectively, from 2007 – 2010.

Chart 1-16: 2007-2010 Quarry Island Fen Well Monitoring Results



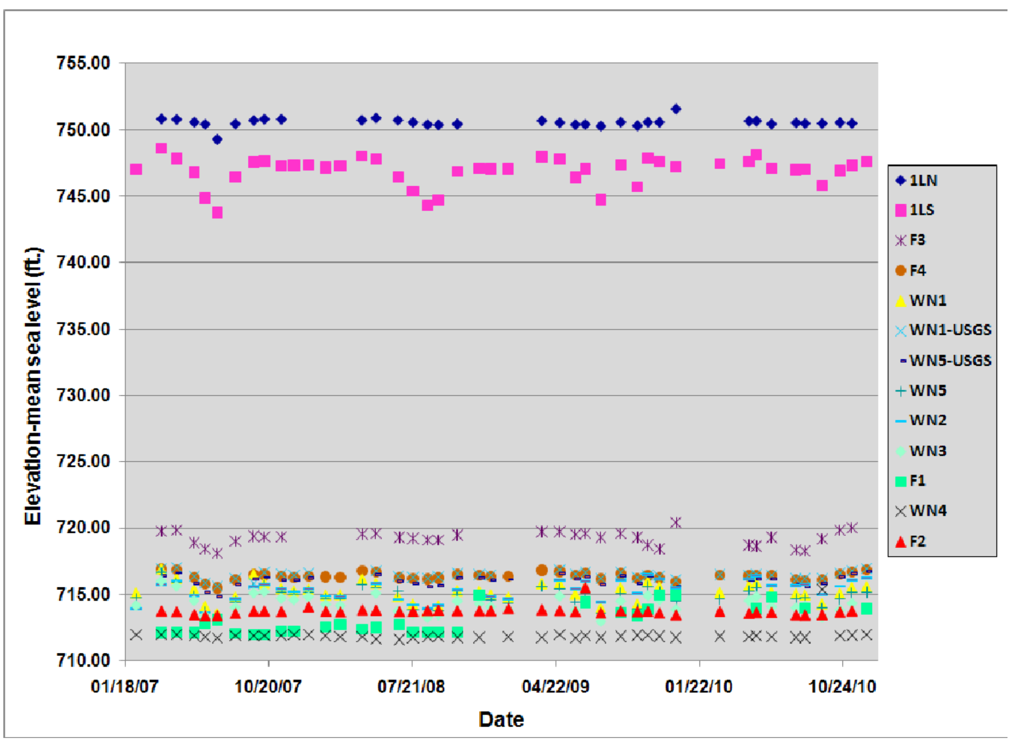
Source: 2010 Lower Minnesota River Watershed District Fen Well Monitoring Report

Chart 1-17: 2007-2010 Snelling Fen Well Monitoring Results



Source: 2010 Lower Minnesota River Watershed District Fen Well Monitoring Report

Chart 1-18: 2007-2010 Nichols Fen Well Monitoring Results



Source: 2010 Lower Minnesota River Watershed District Fen Well Monitoring Report

Water elevations among the 2007-2010 monitoring years have been relatively consistent and follow similar annual patterns in the Snelling and Nichols fens. Water elevations in the shallow wells of the Quarry Island Fen appear to be less consistent and slightly decreasing. In general, water elevations have decreased during dry summer months, and rebounded as precipitation increased in the fall. Although monthly fen well measurements do not closely mirror recent precipitation patterns, measurements do reflect general precipitation trends, especially during summertime periods of low rainfall.

Due to the brief record period for this monitoring effort, a limited regression analysis was performed on the datasets for each well. A trend line was fitted to monthly data from each well to determine if water levels are increasing or decreasing (Table 1-9). A "goodness of fit" test was completed for all trend lines, with R2 values ranging from 0 to 0.6054. Due to these low R2 values, all trends should be considered weak.

Based on this analysis, water elevations in fen wells are mixed and do not demonstrate any obvious trends (low R2 values). However, one of the Nichols fen wells (F1) is beginning to exhibit a slight increasing trend (R2=-.6145). This trend may be due to increased precipitation amounts observed in recent years, reflecting higher groundwater levels. Additional monthly measurements are needed to expand on existing baseline data to provide for a stronger trend analysis.

Table 1-9: Quarry Island, Fort Snelling, and Nichols Fens 2007-2010 Regression Analysis

Quarry Island Fen Trends		
Well	*2007-2010 Trend*	*R2 (Trend Fit)*
P1-S	Negative	0.0034
P1-D	Positive	0.1067
Fort Snelling Fen Trends		
Well	*2007-2010 Trend*	*R2 (Trend Fit)*
N3	Negative	0.0287
N4	Positive	0.0251
N5	Negative	0.0209
W2	Negative	0.0782
W1	Negative	0.0768
W4	Positive	0.0122
W3	Positive	0.0002
S1-USGS	Negative	0.3038
S1	Positive	0.0068
S2-USGS	Positive	0.0001
S2	Negative	0.0006
S3	Negative	0.0056
S3-USGS	Positive	0.0088
Nichols Fen Trends		
Well	2007-2010 Trend	R2 (Trend Fit)
1LN	Positive	0.0017
1LS	Positive	0.0113
F3	N/A	0
F4	Positive	0.0144
WN1	Negative	0.0035
WN1-USGS	Positive	0.0144
WN5-USGS	Positive	0.0428
WN5	Negative	0.0056
WN2	Positive	0.2498
WN3	Negative	0.0654
F1	Positive	0.6054
WN4	Positive	0.0428
F2	Negative	0.0005

Source: 2010 Lower Minnesota River Watershed District Fen Well Monitoring Report

Since 1987, the District installed a series of groundwater observation wells in Savage Fen to monitor groundwater levels in Savage Fen. Chart 1-19 and Chart 1-20 show groundwater level monitoring results for Wells #10 and #12, respectively. These two wells were selected for analysis because they have the longest record period. A trend line was fitted to monthly data for each well to determine if water levels are increasing or decreasing. Groundwater levels for Well #10 and Well #12 trend downwards over time. A "goodness of fit" test was completed for both trend lines, with R^2 values of 0.0134 for Well #10 and 0.0642 for Well #12. Due to these low R^2 values, trends for Wells #10 and #12 should be considered weak.

Chart 1-19: Savage Fen Groundwater Monitoring Results – Well #10

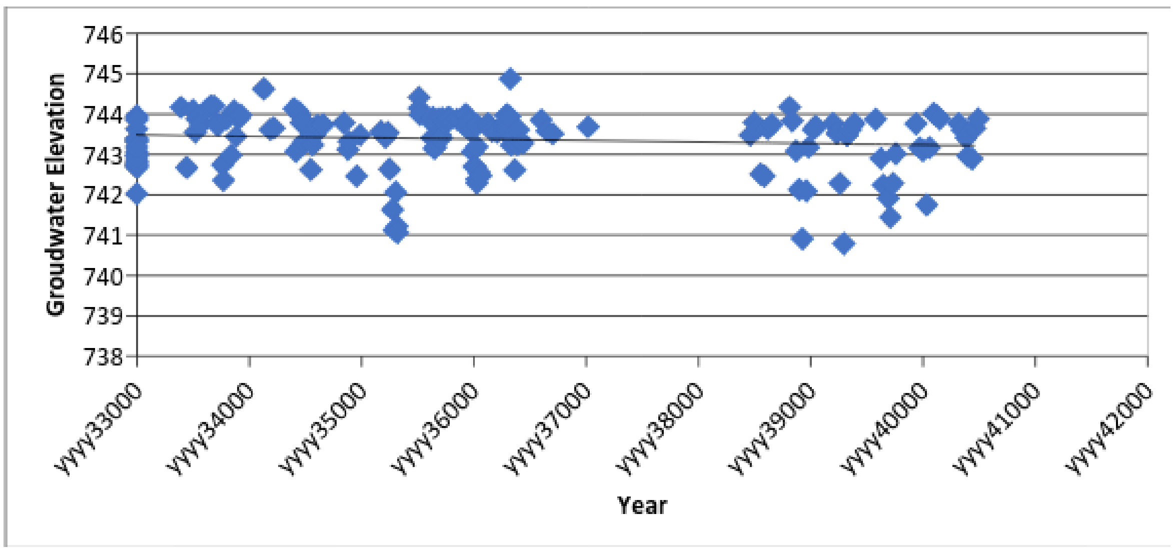
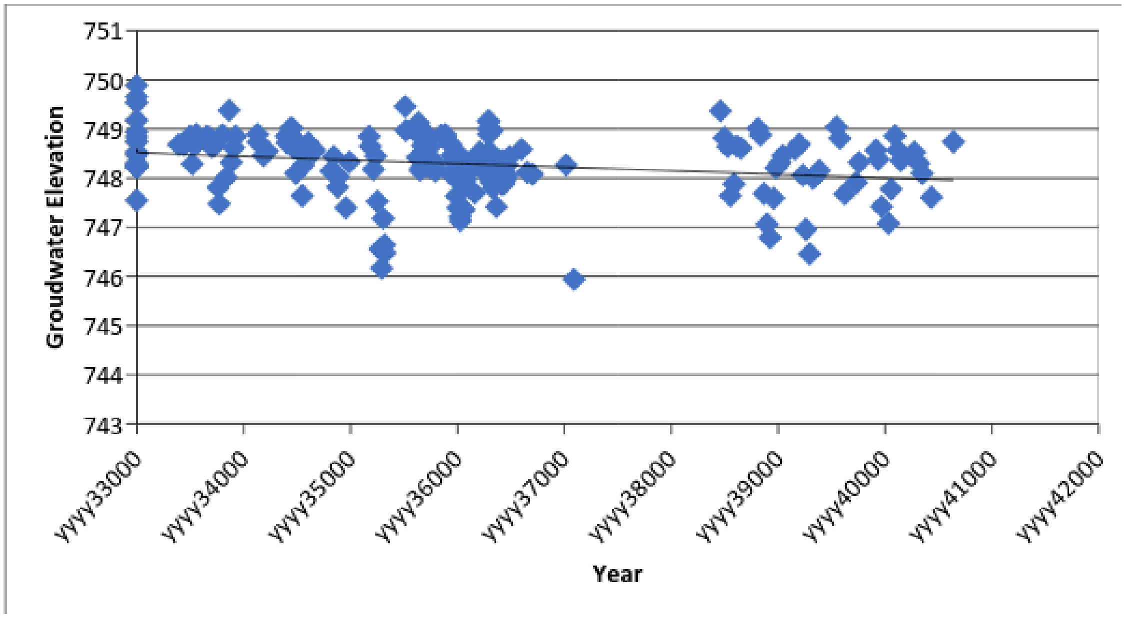


Chart 1-20: Savage Fen Groundwater Monitoring Results – Well #12



The District has also independently monitored water levels at Snelling Fen. Data from the fen monitoring is available at the District office or on the District's website. At Seminary Fen, the District has worked cooperatively with DOT and Carver County to monitor water levels from 2006 to 2007. As part of this Plan, this data was not presented. Longer-term data is needed to determine any trends in water levels at Seminary Fen.

1.7 Surface Water Appropriations

Several DNR-permitted surface water appropriations occur with the District. These include appropriations for irrigation, power generation, quarry dewatering, and other mining operations. Table 1-10 shows the 2007 surface water usage volumes for the DNR-permitted surface water appropriations.

Table 1-10: 2007 DNR Permitted Surface Water Appropriations

Permittee	Water Use	Water Body	Permitted Surface Water Use Volume (millions of gallons per year)
Xcel Energy - Black Dog Plan	Steam Power Cooling	Minnesota River	149,305
Kraemer Mining and Materials, Inc.	Quarry Dewatering	Quarry/Gravel Pit	4,000
Edward Kraemer and Sons, Inc.	Sand and Gravel Washing	Dug Pit	50
Minnesota Valley Country Club	Golf Course Irrigation	Dug Pit	60
Mueller & Sons, Inc.	Sand/Gravel Pit Dewatering	Quarry/Gravel Pit	70
Sever Peterson	Crop Irrigation	Minnesota River	13
US Fish and Wildlife Service	Lake Level Maintenance	Chaska Lake	8
US Fish and Wildlife Service	Fisheries/Hatcheries	Fisher Lake	8

1.7.1 Shoreland Ordinances

Shoreland ordinances vary according to a water body's shoreland classification. The DNR's classifications are natural environment, recreational development, and general development. The DNR's shoreland regulations (i.e., setbacks) are most strict for natural environment water bodies and least strict for general development water bodies. Local government units (LGU) are responsible for the implementation, administration, and enforcement of shoreland management standards through their planning and zoning controls.

All municipalities within the District, except for Mendota Heights, Lilydale, Mendota, and Carver, have DNR-approved shoreland management ordinances. Unincorporated areas come under the counties' authority, all having DNR-approved shoreland ordinances.

1.8 GROUNDWATER RESOURCES

District groundwater protection and management are important issues as counties in the MSP metropolitan area rely highly on groundwater for domestic, municipal, industrial, and agricultural water supplies.

Counties within the District were given authority by the state to adopt groundwater management plans, which provide a mechanism to set priorities, address issues, and build local capacity for groundwater protection and management. Table 1-11 shows the status of the groundwater management plans for each of the District's counties.

Table 1-11: County Groundwater Management Status

County	Groundwater Management Plan Status
Carver	First plan approved in August 1992. The new plan approved in 2016.
Dakota	First plan approved in 1992. Updated plan approved in July 2000. New plan approved in October 2006. The revised plan is scheduled to be submitted in 2018.
Hennepin	Approved in March 1994. No plan to update it.
Scott	First plan drafted in 1996, revised extensively in 1998, and approved in 1999. No update since then.
Ramsey	Approved in September 1995. An updated plan was prepared in 2009 but, it was not submitted for approval. Since 2016, the county is planning to update the 1995 plan. However, this has little impact on the District since Pike Island is the only portion of Ramsey County located within its boundary.

1.8.1 General Groundwater Information

The lower Minnesota River lies within an artesian basin containing glacial sediment and bedrock aquifers with large groundwater reserves. The DNR requires a permit for surface or groundwater appropriation, which is more than 10,000 gallons of water per day or 1.0 million gallons per year. There are certain exemptions to this requirement related to domestic consumption, reuse of permitted water appropriations, test pumping, and agricultural purposes. The DNR Waters Division provides more detailed information on groundwater usage for specific areas and DNR-permitted appropriations within the District.

County geologic atlases and groundwater plans present detailed information about the water table and bedrock aquifers within the District, including the potentiometric surface (a measurement of water pressure) and potential aquifer yield. Figure 1-10 shows water table contours for the area around the District. The potentiometric surface indicates the direction of groundwater flow. Groundwater will flow from the areas of higher potentiometric elevation toward the lower potentiometric elevation. The cut of the Minnesota River valley has a predominant effect on the potentiometric levels in and near the valley.

1.8.2 Groundwater Quality

The District's general quality of deeper groundwater aquifers meets good drinking water standards. Since most District's residents receive their drinking water from these deeper groundwater supplies, groundwater quality protection is of great concern.

As lands within the District continue to develop, the areas with impervious ground cover will increase. This, in turn, restricts the recharge of the aquifers by infiltration. This potential threat can be mitigated by development design practices that condense impervious areas and provide landscape features that promote infiltration.

Within the District, there are various potential sources of groundwater contamination. Septic tanks, spreading of chemicals and wastes, and commercial/industrial sites are all examples of pollution sources that could impair groundwater quality if improperly located or designed. Additional information on pollution sources within the District is provided in future sections.

Areas with sandy soils and a shallow depth to bedrock are particularly susceptible to groundwater contamination due to the soils' rapid infiltration rate. An example of such an area would be the land around the City of Shakopee and Blue Lake. At this location, there is less than 50 feet of sand and gravel outwash over the Prairie du Chien aquifer. More information about areas susceptible to groundwater pollution can be obtained from county geologic atlases and groundwater plans.

1.8.3 Groundwater Availability and Use

Groundwater is available from multiple aquifers, including:

- Surficial aquifer (terrace deposits, alluvium, and glacial outwash)
- St. Peter
- Prairie du Chien-Jordan
- Franconia-Ironton-Galesville
- Mt. Simon

The Minnesota River is a regional groundwater discharge area. Groundwater moves toward the Minnesota River and discharges into the river, floodplain lakes, wetlands, springs, and flowing wells, thus providing a high-quality water source for the District's surface water resources. Flow directions in the surficial aquifers can be locally influenced by nearby surface water bodies or by pumping in deeper aquifers.

Table 1-12 summarizes groundwater use within the District. Surficial aquifer appropriations are included under 'Quaternary' aquifers in the table. The majority of surficial aquifer pumping is for temporary dewatering, which is typically performed for construction purposes and does not result in long-term impacts to the regional water table. As shown in Table 1-12, the primary categories of groundwater use from other aquifers include municipal water supply, agricultural processing, and sewage treatment. The principal source of groundwater for most of these uses, however, is the Prairie du Chien-Jordan aquifer.

Table 1-12: 2007 Groundwater Appropriation

Use Type	Aquifer Use 2007 (Millions of Gallons)				
	Franconia-Ironton-Galesville	Mt. Simon	Multi-Aquifer Wells	Prairie du Chien-Jordan	Quaternary
Agricultural Processing	59		762	136	
Dewatering					473
Fire Protection					14
Golf Course				148	
Landscaping/ Athletic Fields			26	34	
Metal Processing				321	
Municipal Waterworks	214	640	35	2,036	
Non-Metallic Processing				151	
Heating / Air Conditioning				253	
Private Waterworks	6		3	6	
Sewage Treatment				638	
Steam Power Cooling				38	
Total	**279**	**640**	**826**	**3,762**	**487**

Pumping lowers the potentiometric surface in the aquifer, diverting flow toward the well. This diversion can occur vertically as well as horizontally, so that pumping in one aquifer can affect water levels and flow directions in another aquifer. As a result, pumping in a bedrock aquifer can eventually lower the water table in surficial aquifers. Some bedrock aquifers provide recharge to surface water bodies such as fens. As mentioned, the five calcareous fens within the District are recharged from groundwater. The hydraulics of these fens may be affected by pumping. Because of these relationships, all requests for new groundwater appropriations and amendments to existing permits must be reviewed and approved by the DNR. During the review process, and prior to making judgments on the sustainability of an appropriation application (new or existing), the DNR reviews potentiometric surface levels, effects of seasonal pumping, proximity to existing appropriations, and total aquifer appropriations.

1.8.4 Groundwater Sustainability

Groundwater sustainability has been defined as the development and use of groundwater in a manner that can be maintained for an infinite time without causing unacceptable environmental, economic, or social consequences. Sustainability has traditionally been viewed mostly as water quality protection and the absence of well interference (i.e., one well affecting the production of another).

Water quality protection has focused on aquifer susceptibility to contamination and protection of water supplies from contamination sources. Aquifer susceptibility maps for the District are available in the county geologic atlases for Dakota, Hennepin, Ramsey, and Scott counties, and in the Carver County Surface Water Management Plan. The Minnesota Department of Health (DOH) administers the wellhead protection program, which focuses on preventing contamination of groundwater that may be captured by a public water supply well.

Traditional sources of contamination addressed in county groundwater plans include:

- Underground storage tanks
- Septic tanks
- Abandoned wells
- Use of pesticides and fertilizers
- Landfills and dumps

Future groundwater management for sustainability will include increased focus on coordinated groundwater management, surface water, and water-dependent ecosystems. Examples of this new emphasis include groundwater management to protect discharges to sensitive wetlands. Other examples involve rethinking the quantity and quality of groundwater discharges needed to protect fish and other biologic communities and understanding the amount of water use that can be sustained indefinitely.

1.9 SOILS

Figure 1-16 and Figure 1-17 identify major soil associations within the District. More detailed soils information, such as development limitations, infiltration characteristics, and erosion characteristics of soil groups at specific sites, can be found in the United States Department of Agriculture (USDA) Soil Survey for the District's counties. Information is also available at the SWCD office for each county and on the USDA Natural Resources Conservation Service (NRCS) Website.

1.9.1 General Description

The Minnesota River valley includes, at its lowest elevations, floodplain soils such as alluvium, peat, and muck identified as the Chaska-Minneiska-Colo soil complex. Alluvial soils are usually flood deposits. The particulate sizes range from gravelly sand to silt and clay, with silt and very fine sands being predominant. Peat and muck are soils with high organic content. In peat, partially decayed vegetative (organic) matter such as reeds, grasses, mosses, and leaves can be identified. In muck, the advanced decomposition makes the materials unidentifiable.

At the District's edge of the floodplain, just below the bluffs that border the Minnesota River valley, lie well-drained silt loams and more poorly drained silty clay loams. These soils result from erosion on the higher levels of the bluffs.

In Dakota County, the break between floodplain and upland is very sharp. Above the bluff are soils that formed on glacial drift called the Mankato till, which were deposited as the Grantsburg Sublobe of the Des Moines lobe. These soils are part of the Mankato ice sheet retreated up as the present-day Minnesota River Valley. These gray-brown Podzolic soils developed for the most part under forest conditions that covered most of the District. Today, only remnants of that forest remain.

In Carver County, soils outside the floodplain are fine-textured (sandy to loamy), level to gently sloping, and are the result of the Glacial River Warren deposits. Above these soils, on the steeper slopes, are coarse textured soils. Soils associated with glacial moraine are found on top of the bluffs.

In Hennepin County, the soil associations are like those in Carver County, extending over the same moraine deposits of the north bluff. Above the bluffs near Interstate Highway 35W, there is a small amount of sandy loam. These soils likely developed on stream-deposited material, with the bluff representing an old river terrace. This is further proof of the Glacial River Warren's extent and the existence of river terraces in and near the Minnesota River valley.

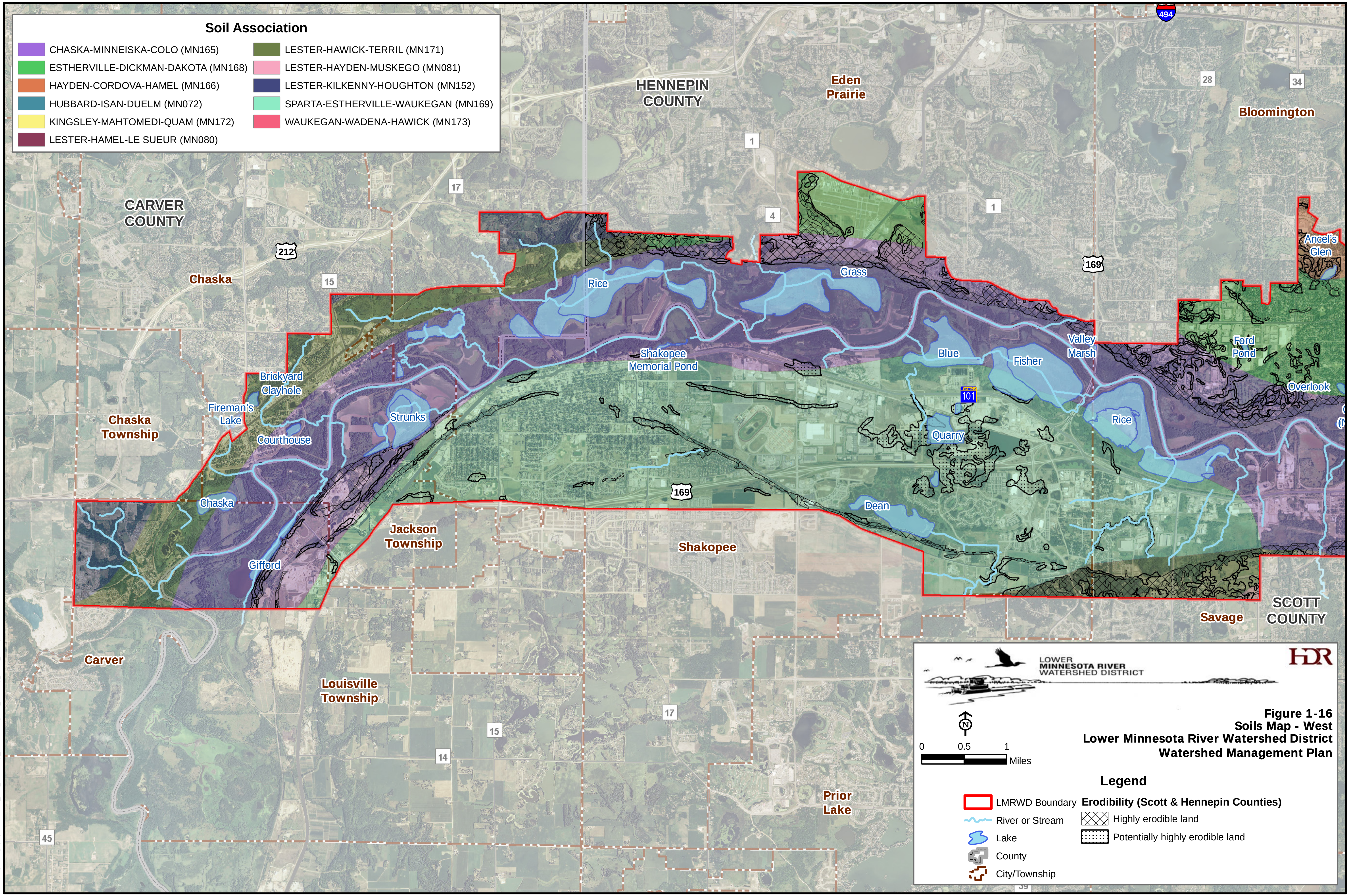
In Scott County, about two miles west of Savage and between the floodplain and the higher upland regions, larger terraces appear and become evident to the western end of the District. Several related soils are found on these terraces: silt and silty clay loams on the lower terraces, and sandy loams on the upper terraces. District soils are shown on Figure 1-16 and Figure 1-17.

1.9.2 Soil Erosion and Sedimentation

Erosion and its resulting sedimentation are the primary causes of nonpoint source water quality problems on the Minnesota River. The sediments create navigation problems by forming sandbars which require monitoring for the channel.

Cropland erosion (most of which is located outside of the District) is a major source of the District's sediment problems. Gully, streambank, roadside, and development-related erosion are also sources of sediment problems. Gully erosion can occur because of over-grazing, poor management, or intensive land use above steeply-sloped lands such as the Minnesota River valley bluffs. These bluffs are composed almost entirely of highly erodible, sandy soils that are difficult to control, stabilize, and re-vegetate once disturbed. When development occurs without regard for slope, soil type, or loss of vegetation, soil erosion and sedimentation are accelerated.

Figure 1-16 and Figure 1-17 show highly erodible land and potentially highly erodible land within the District for Scott and Hennepin counties. The topographic information on Figure 1-8 and Figure 1-9 identifies locations of steeply sloped lands (greater than 18 percent) such as the blufflands. Slope is a main factor in determining critical erosion areas; other factors include slope length, land cover, and erodibility.



Soil Association
CHASKA-MINNEISKA-COLO (MN165)
ESTHERVILLE-DICKMAN-DAKOTA (MN168)
HAYDEN-CORDOVA-HAMEL (MN166)
HUBBARD-ISAN-DUELM (MN072)
KINGSLEY-MAHTOMEDI-QUAM (MN172)
LESTER-HAMEL-LE SUEUR (MN080)
LESTER-HAWICK-TERRIL (MN171)
LESTER-HAYDEN-MUSKEGO (MN081)
LESTER-KILKENNY-HOUGHTON (MN152)
SPARTA-ESTHERVILLE-WAUKEGAN (MN169)
WAUKEGAN-WADENA-HAWICK (MN173)
HENNEPIN COUNTY
Eden Prairie
Bloomington
CARVER COUNTY
Chaska
Chaska Township
Carver
Louisville Township
Jackson Township
Shakopee
Prior Lake
Savage
SCOTT COUNTY
Rice
Grass
Blue
Fisher
Valley Marsh
Shakopee Memorial Pond
Brickyard Clayhole
Fireman's Lake
Strunks
Courthouse
Chaska
Gifford
Quarry
Dean
Ancel's Glen
Ford Pond
Overlook
494
28
34
1
4
17
212
15
169
101
14
45
LOWER MINNESOTA RIVER WATERSHED DISTRICT
HDR
Figure 1-16
Soils Map - West
Lower Minnesota River Watershed District
Watershed Management Plan
0 0.5 1
Miles
Legend
LMRWD Boundary
River or Stream
Lake
County
City/Township
Erodibility (Scott & Hennepin Counties)
Highly erodible land
Potentially highly erodible land

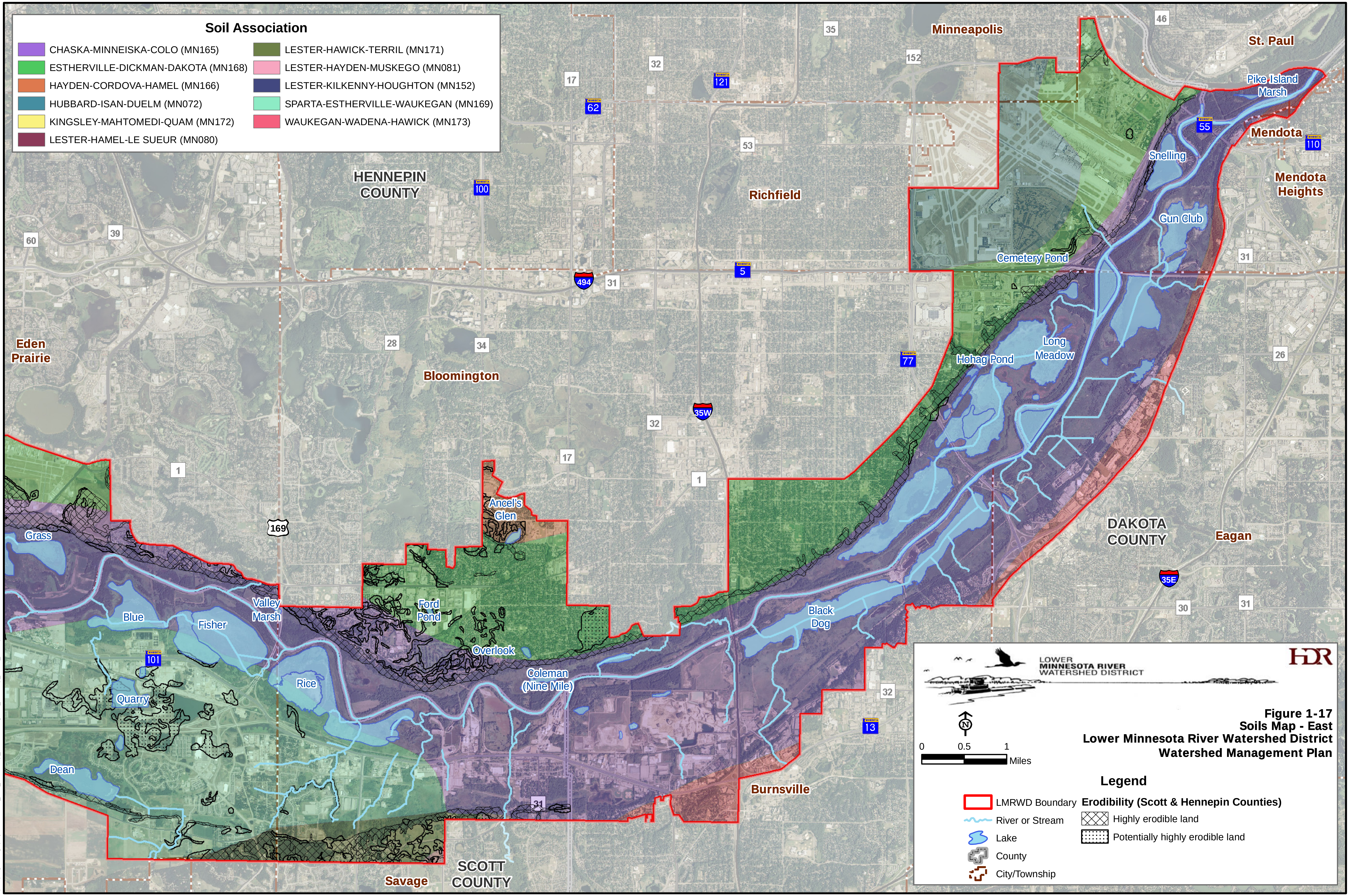


Figure 1-17
Soils Map - East
Lower Minnesota River Watershed District
Watershed Management Plan

1.10 LAND USE AND PUBLIC UTILITY SERVICE

The District is located in the midst of the growing MSP metropolitan area. This location, coupled with commercial and recreational opportunities provided by the Minnesota River, make the District lands highly desirable for residential, commercial, and industrial development. In addition, the District contains some agricultural lands and large areas of open space. Open space is mostly located in and along the Minnesota River's floodplain and consist almost entirely of public lands, which are administered federally by the USFWS in the Minnesota Valley National Wildlife Refuge. At the state level, the Minnesota DNR manages the parks and opens spaces in the Minnesota Valley State Recreation Area and Fort Snelling State Park and scientific and natural areas (SNAs). Locally, counties and municipalities manage the remaining parks and open spaces.

Figure 1-18 and Figure 1-19 show delineated land use in the District (as of 2005) by the Metropolitan Council. Figure 1-20 and Figure 1-21 show Regional Planned Land Use in the District up to the year 2030, as defined by Metropolitan Council. Land use remains relatively static between publication of this Plan and proposed changes for year 2030. Most land use changes will occur on the Minnesota River's south side in the cities of Shakopee and Savage, where agricultural and forested lands are anticipated to transition to single family residences. Further development of District lands could have serious adverse effects on wildlife, water resources, and other sensitive resources. However, if projects are sited properly and the resources are adequately protected, these concerns may be alleviated.

Figure 1-20 and Figure 1-21 show the Metropolitan Urban Services Area (MUSA) boundaries. Areas within the MUSA currently have municipal sanitary sewer facilities or are planned to have municipal sanitary sewer facilities in the future. Lands outside the MUSA boundary are served by individual waste disposal systems. Lands located within the MUSA boundary are more likely to develop quickly and at a greater density than lands located outside the MUSA boundary.

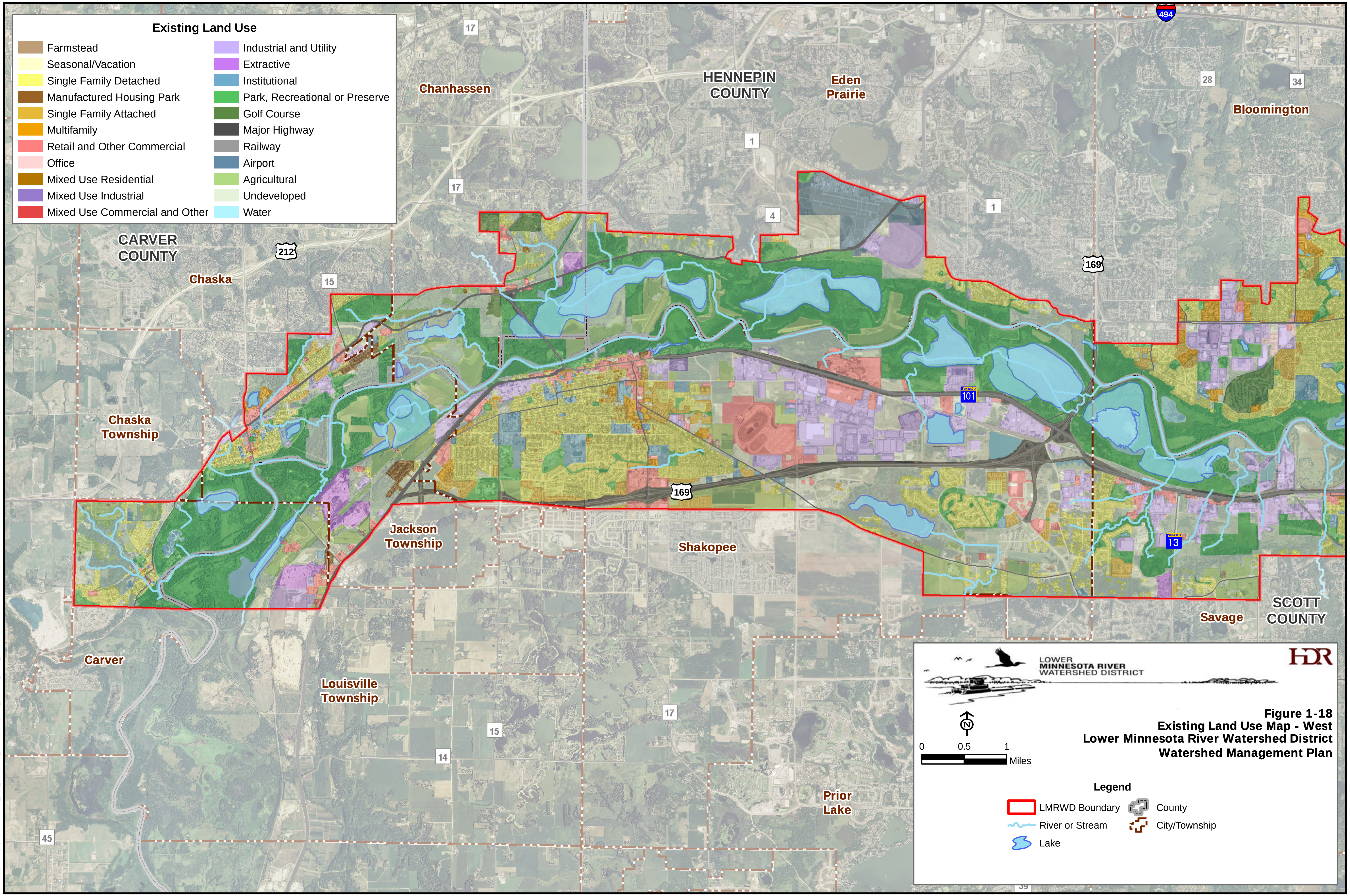


Figure 1-18
Existing Land Use Map - West
Lower Minnesota River Watershed District
Watershed Management Plan

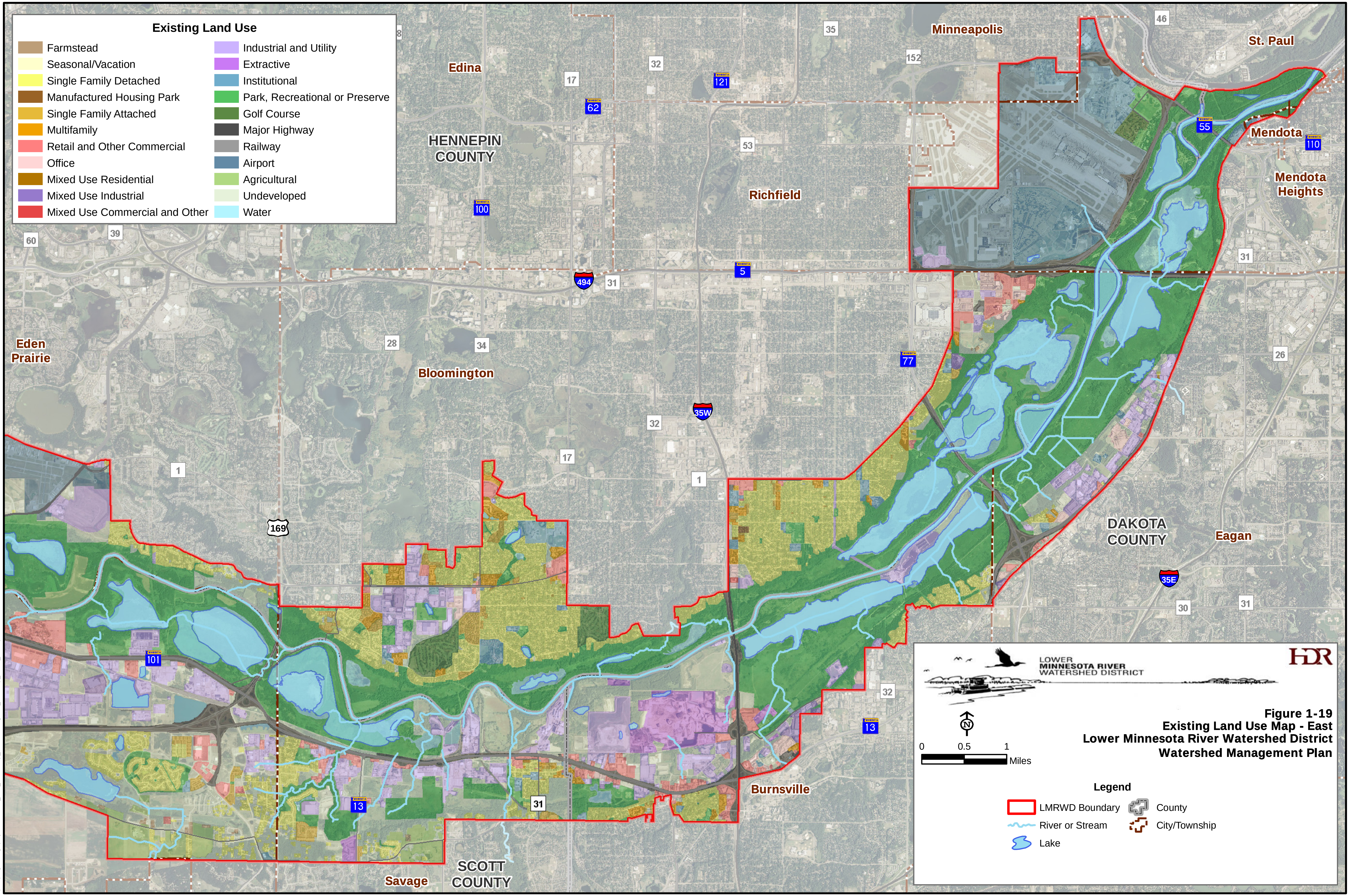


Figure 1-19
Existing Land Use Map - East
Lower Minnesota River Watershed District
Watershed Management Plan

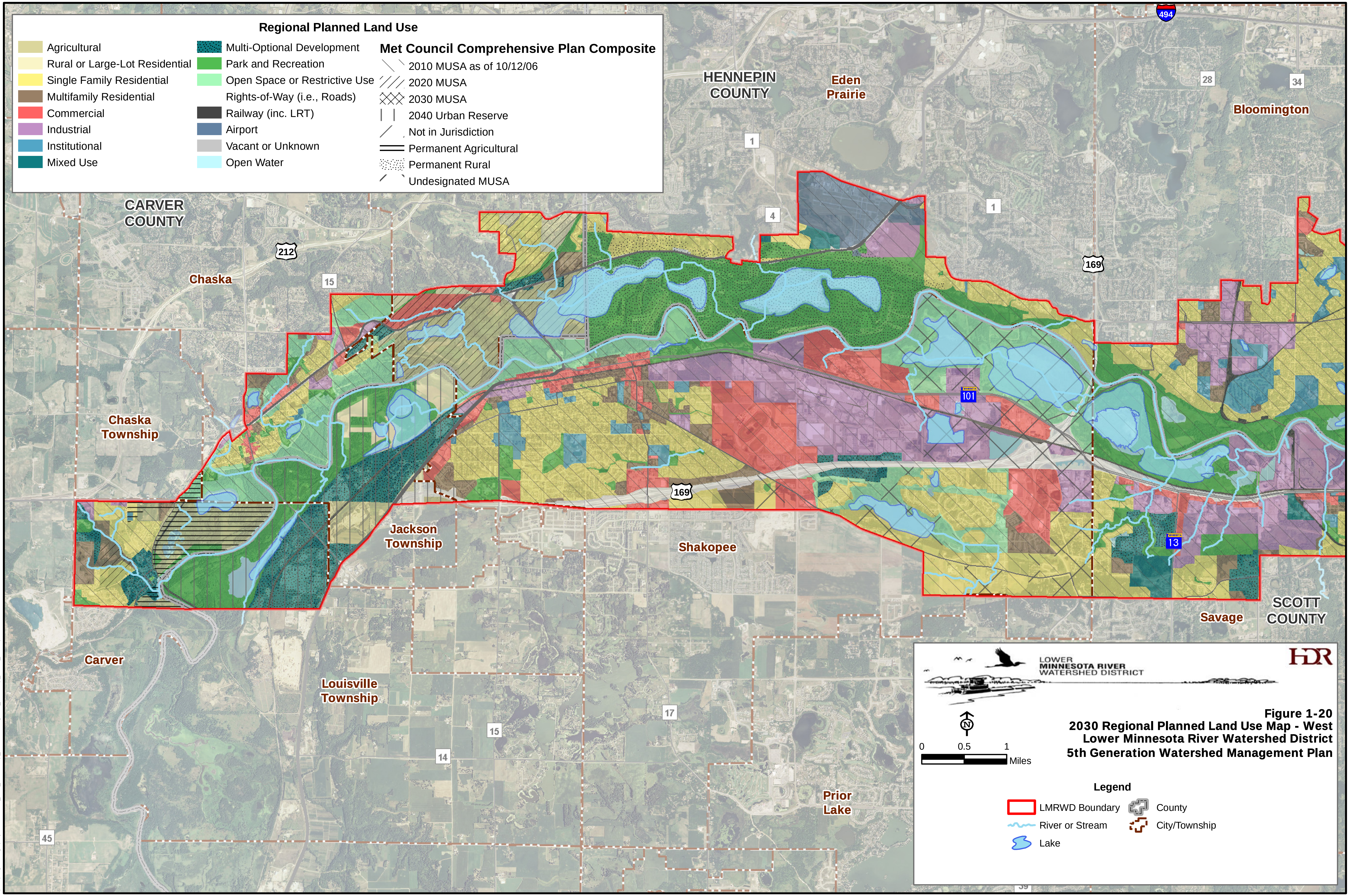


Figure 1-20
2030 Regional Planned Land Use Map - West
Lower Minnesota River Watershed District
5th Generation Watershed Management Plan

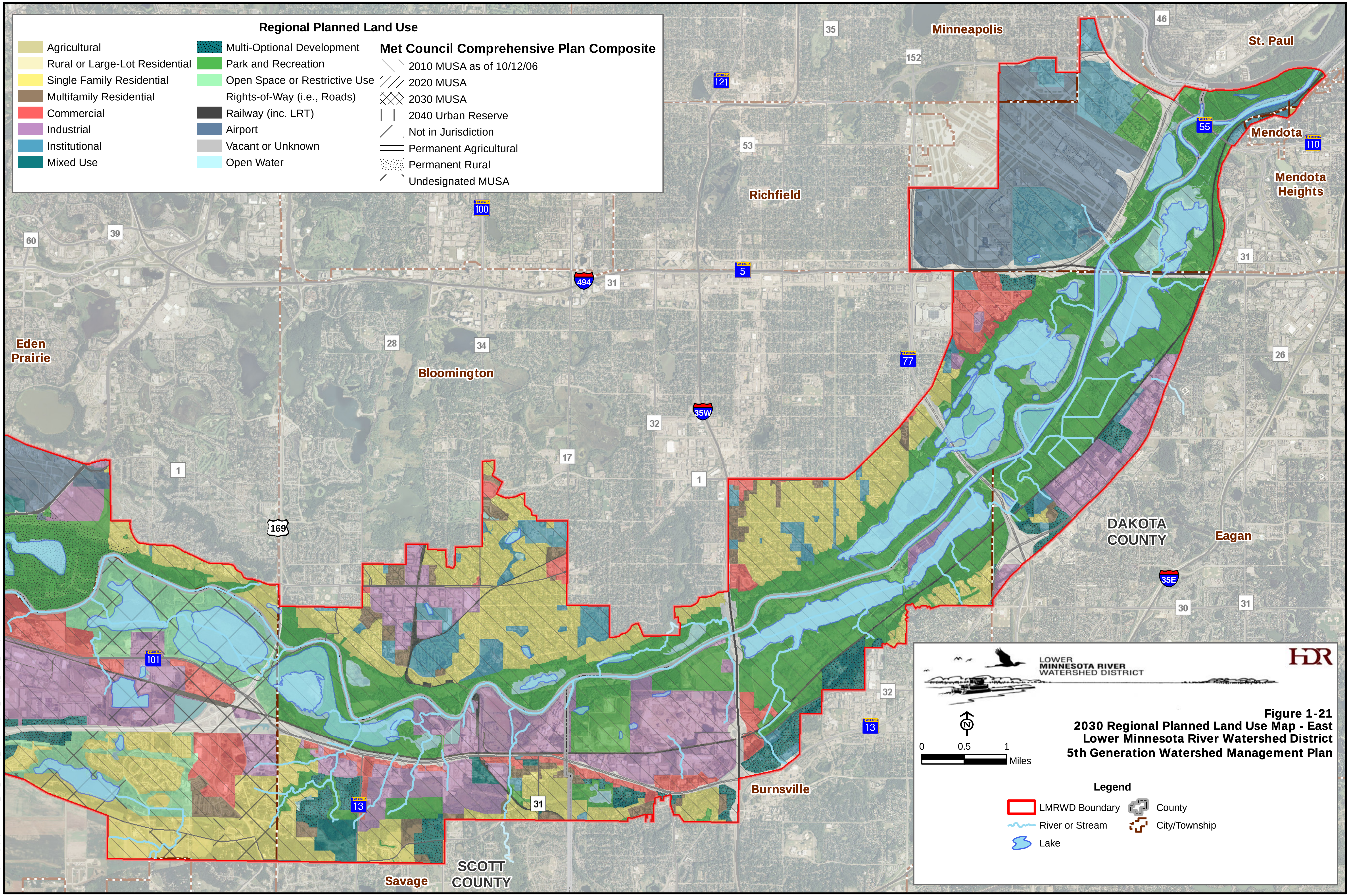
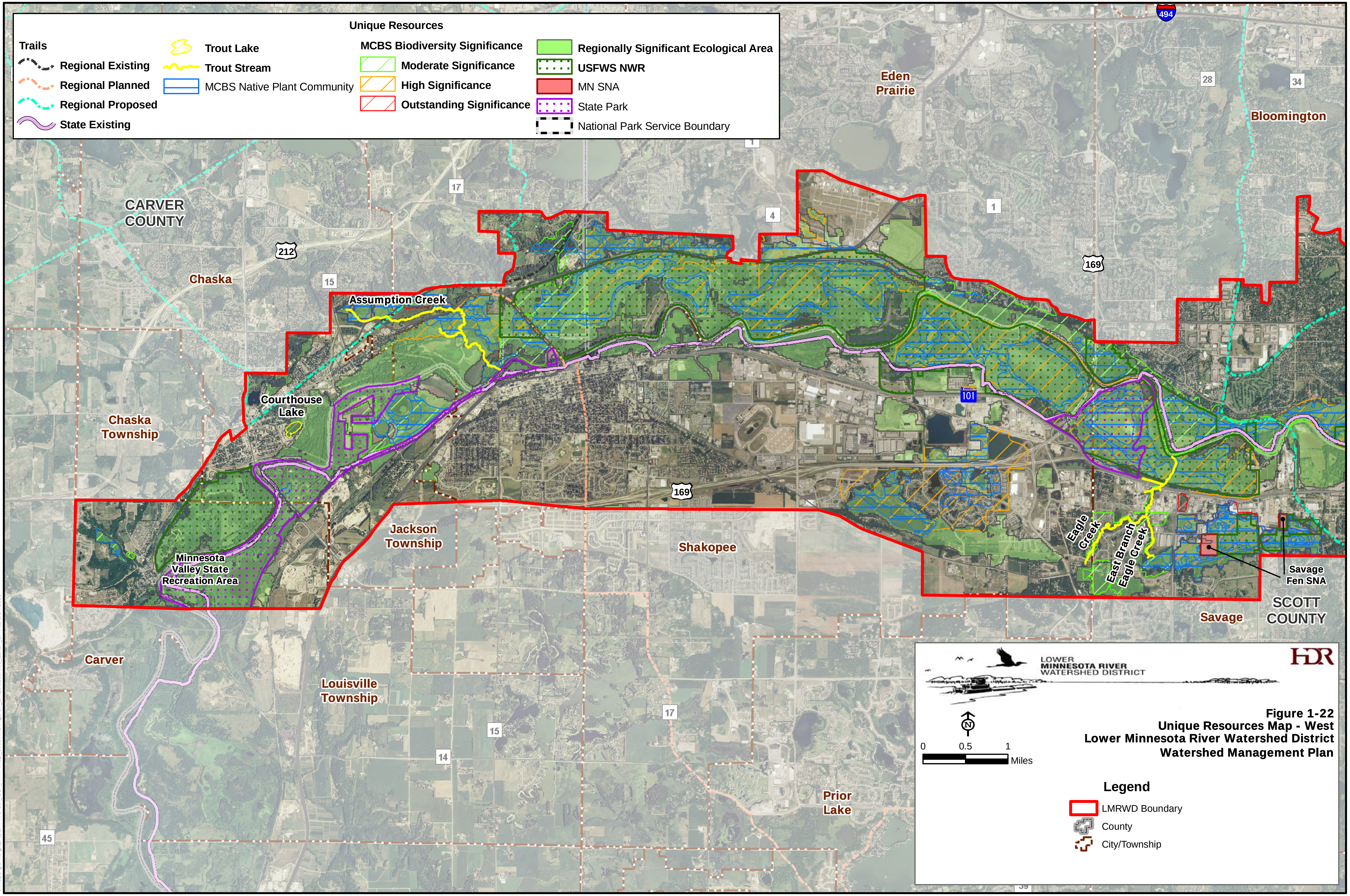


Figure 1-21
2030 Regional Planned Land Use Map - East
Lower Minnesota River Watershed District
5th Generation Watershed Management Plan

1.11 Water Based Recreational Areas

There are approximately 24,000 acres of existing wildlife refuges, parks, trails, and open space along the Minnesota River corridor and managed by the Minnesota Valley National Wildlife Refuge. The Minnesota Valley National Wildlife Refuge was established through the efforts of local citizen groups to protect the Lower Minnesota River valley. The Minnesota Valley Trail was authorized by the state legislature in 1969. Federal legislation entitled "The Minnesota Valley National Wildlife Refuge Act of 1976" declared that the policy of the Congress would preserve the Minnesota River valley and, as a federal action, establish the 9,500-acre Minnesota Valley National Wildlife Refuge and an adjacent 8,000-acre wildlife recreation area. Most of this area is within the District's boundary.

The refuge portion of the area is managed by the USFWS with two main objectives: 1) to provide habitat for a diversity of plants and animals, and 2) to provide opportunities for people to observe and learn about the valley's wildlife. The recreation area is managed by local governments and the DNR. These agencies are developing recreational and educational opportunities that are compatible with Minnesota River valley natural resources. The DNR Division of Parks and Recreation manages the state trail. Management objectives are to develop an accessible, scenic, and recreational travel route between Fort Snelling State Park and Le Sueur. This trail links with other metro area trails to provide hiking, bicycling, horseback riding, snowmobiling, and cross-country skiing opportunities for metropolitan area residents. Figure 1- 22 and Figure 1-23 show the District's existing and proposed regional and state trails, state and federal parks, recreational areas, and the National Wildlife Refuge.



Unique Resources
Trails
Regional Existing
Regional Planned
Regional Proposed
State Existing
Trout Lake
Trout Stream
MCBS Native Plant Community
MCBS Biodiversity Significance
Moderate Significance
High Significance
Outstanding Significance
Regionally Significant Ecological Area
USFWS NWR
MN SNA
State Park
National Park Service Boundary
Eden Prairie
Bloomington
CARVER COUNTY
Chaska
Assumption Creek
Courthouse Lake
Chaska Township
Minnesota Valley State Recreation Area
Jackson Township
Shakopee
Eagle Creek
East Branch Eagle Creek
Savage Fen SNA
Savage
SCOTT COUNTY
Carver
Louisville Township
Prior Lake
494
28
34
17
4
1
212
15
169
101
14
45
LOWER MINNESOTA RIVER WATERSHED DISTRICT
HDR
Figure 1-22
Unique Resources Map - West
Lower Minnesota River Watershed District
Watershed Management Plan
0
0.5
1
Miles
Legend
LMRWD Boundary
County
City/Township

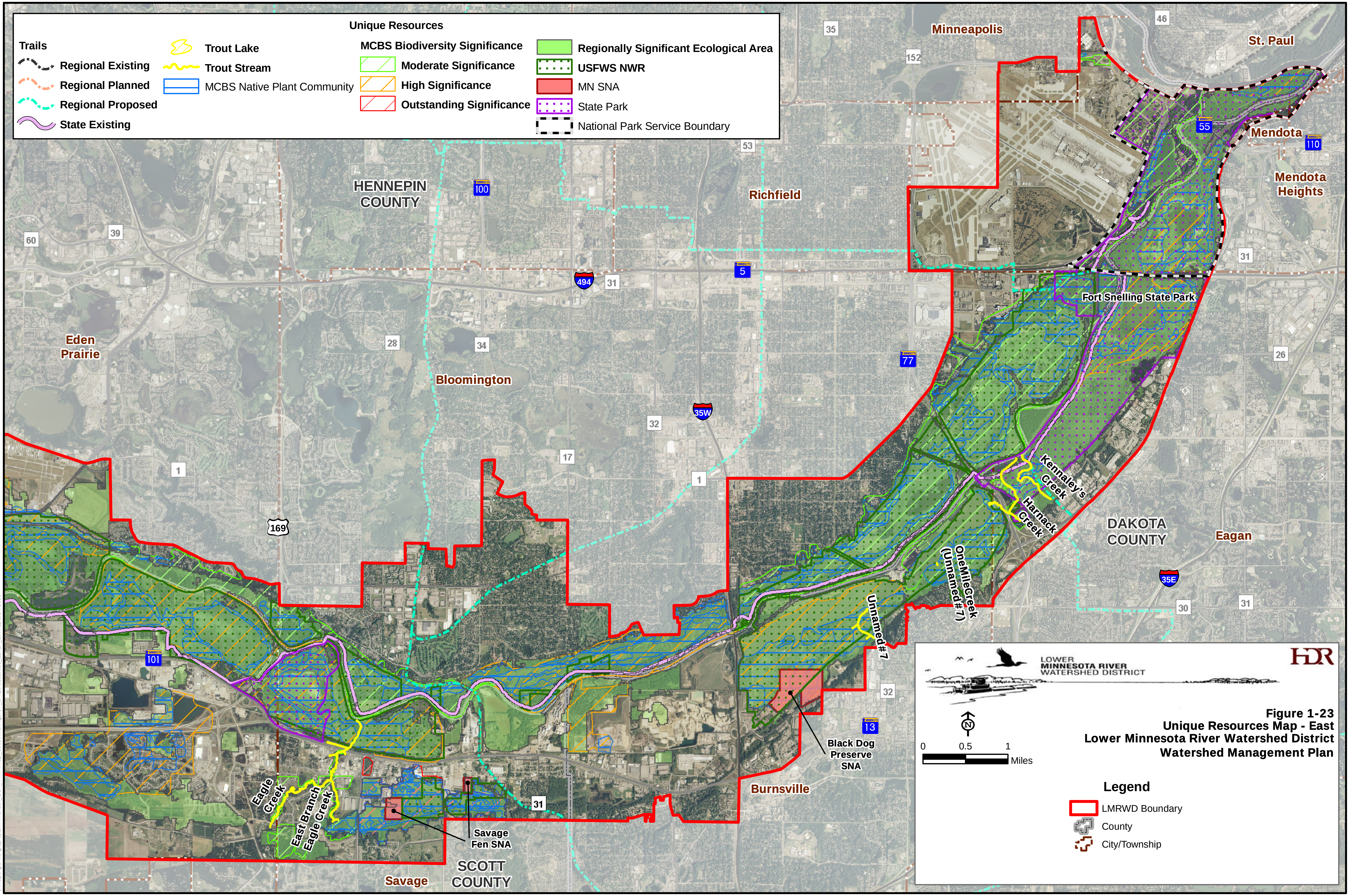


Figure 1-23
Unique Resources Map - East
Lower Minnesota River Watershed District
Watershed Management Plan

1.12 COMMERCIAL AND RECREATIONAL NAVIGATION

Navigation was one the primary initiatives driving the District's establishment. The District was principally established as a legal entity for providing local participation to the COE to construct a navigation channel. Water-borne freight traffic is one of the District's greatest commercial assets and is of great importance to the local and state economy. The Minnesota River is navigable from its confluence with the Mississippi River to the Carver Rapids, just above the City of Carver. The Hastings Dam, located on the Mississippi River in Hastings, Minnesota, controls the Minnesota River's surface water, which extends as far as the Carver Rapids, just upstream of the District's most westerly boundary.

Construction of a navigation channel on the Minnesota River was first authorized in 1892. In 1892, Congress authorized the Minnesota River navigation project, which provided a 4-foot channel construction from the Minnesota River mouth at its confluence with the Mississippi River, upstream for 25.6 river miles to Shakopee. The COE is authorized to provide channel maintenance if appropriations and environmental concerns are addressed in advance.

In 1942, the COE dredged a 9-foot deep, 100-foot wide channel from the mouth of the Minnesota River to Savage (13.2 river miles), paid for by local interests. The 1958 River and Harbor Act authorized improvements on the Minnesota River from its mouth upstream to R.M. 14.7, a point one-half mile above the railroad bridge near Savage. Under this authorization, a channel 9-feet deep and 100-feet wide was provided. Three cutoffs to eliminate wide passage or turnouts to aid navigation were provided to permit tows to pass safely. The COE, with the District as the local sponsor, finished installation of the 100-foot wide, 9-foot deep channel in August 1968. The navigation channel cost roughly $2 million, or about $136,000 per mile. The dredged materials were placed at temporary disposal sites.

Periodic dredging is required to maintain the navigation channel. The required maintenance is accomplished through a cooperative agreement between the District and the COE. Sites most frequently dredged by the COE are located between R.M. 12 and R.M. 14.7. Sites between river mile 1.0 and 2.0, near Pike Island, and between river mile 4.0 and 5.0 are occasionally dredged. Figure 1-24 and Figure 1-25 show the most frequently dredged locations on the Minnesota River. In the past, private interests extended the navigation channel upstream to R.M. 21.8 near Port Peavey in Shakopee, but this channel has been abandoned.

In 1978, the City of Savage petitioned the District to acquire and develop permanent sites for the disposal of dredged materials resulting from the 9-Foot channel maintenance The Managers accepted the petition and ordered preparation of an engineer's report. The engineer's report recommended acquisition and development of six permanent disposal sites. In 2007, the COE - St. Paul District published a Channel Maintenance Management Plan (CMMP), which reviewed the feasibility of potential material placement sites along the Minnesota River, including the six sites originally investigated. The CMMP is available on the COE – St. Paul District website.

In 2007, the District acquired a site from Cargill on the Minnesota River's south bank at mile 14.2 for dredge material placement. This acquisition is documented in the COE CMMP. The site was used in 2008, 2009 and 2010 and is estimated to have capacity for 185,000 cubic yards or 7to 9 years of dredge material placement without removal. The District is investigating acquisition of an additional site from the U.S. Air Force (USAF), on the north side of the Minnesota River at R.M. 3.5. This site would provide material placement for the less frequently dredged reaches of the river between R.M. 1.0 and 2.0, near Pike Island, and R.M. 4.0 and 5.0.

Several private dredge material placement sites are also in use within the District. These sites are primarily used for placement of dredge material from barge slip maintenance and include the following sites on the south bank of the river:

- Cargill-Westfield (R.M. 14.8)
- Kraemer (R.M. 12.1)
- Waste Management (R.M. 12.4)

Both private pleasure craft and commercial traffic navigate the Minnesota River within the District. Commercial barge traffic dominates, traveling the entire 14.7 miles upstream from the river mouth to the head of the 9-Foot navigation channel. Generally, tows on the Minnesota River consist of one power unit and two to four barges.

The main commodity transported on the river is bulk grain or grain products. All commercial terminals in the District are in the City of Savage. Cargill handles grain products, corn products, and fertilizer. Bunge and CHS, Inc., both handle grain products. Other commercial terminals include U.S. Salt and Superior Minerals Company. U.S. Salt handles salt, lightweight aggregate, and cotton seed, and Superior Minerals Company handles aggregates. These shippers draw from an approximately 200,000 square-mile area, which includes eastern South Dakota, southeastern North Dakota, all of Minnesota, the western two-thirds of Wisconsin, and the northern two-thirds of Iowa.

According to the DOT Ports and Waterways Section, annual tonnages from the City of Savage commercial terminals decreased from 3,427,182 tons in 2004 to 1,705,650 in 2008. Annual tonnages vary due to seasonal flooding, freight rates, and foreign grain demands. DOT figures further show that the average barge movement via the Minnesota River since 1991 has been over four million tons per year. Ten years of that period had more than five million tons. As for the most recent six-year period, a drop-in barge movement is explained by several events: First, according to DOT, the Minnesota ethanol industry removes roughly 100 million bushels of corn from the river market each year; that's the equivalent of 1,900 barges annually. As a sidenote, dried grains, a byproduct of corn ethanol, has a potential to move via barge when production stabilizes to justify the capital investment required to handle such movements. Second, periodically, abnormally high ocean shipping rates from New Orleans to Japan, for instance, diverted additional grain from Savage to west coast ports via rail. Without high ocean rates, these grains would have moved from Savage via the river. As a matter of reference, the spread of ocean rates to Japan from Gulf ports versus from Pacific Northwest states increased by a factor of 8 times against the Gulf, meaning grain destined to Japan via the Gulf was simply too expensive. However, the Panama Canal expansion scheduled for completion in 2014 will enable the larger west coast vessels to serve Gulf ports, thus removing the current Gulf penalty. Figure 1-24 and Figure 1-25 show public and private dredge material disposal sites within the District.

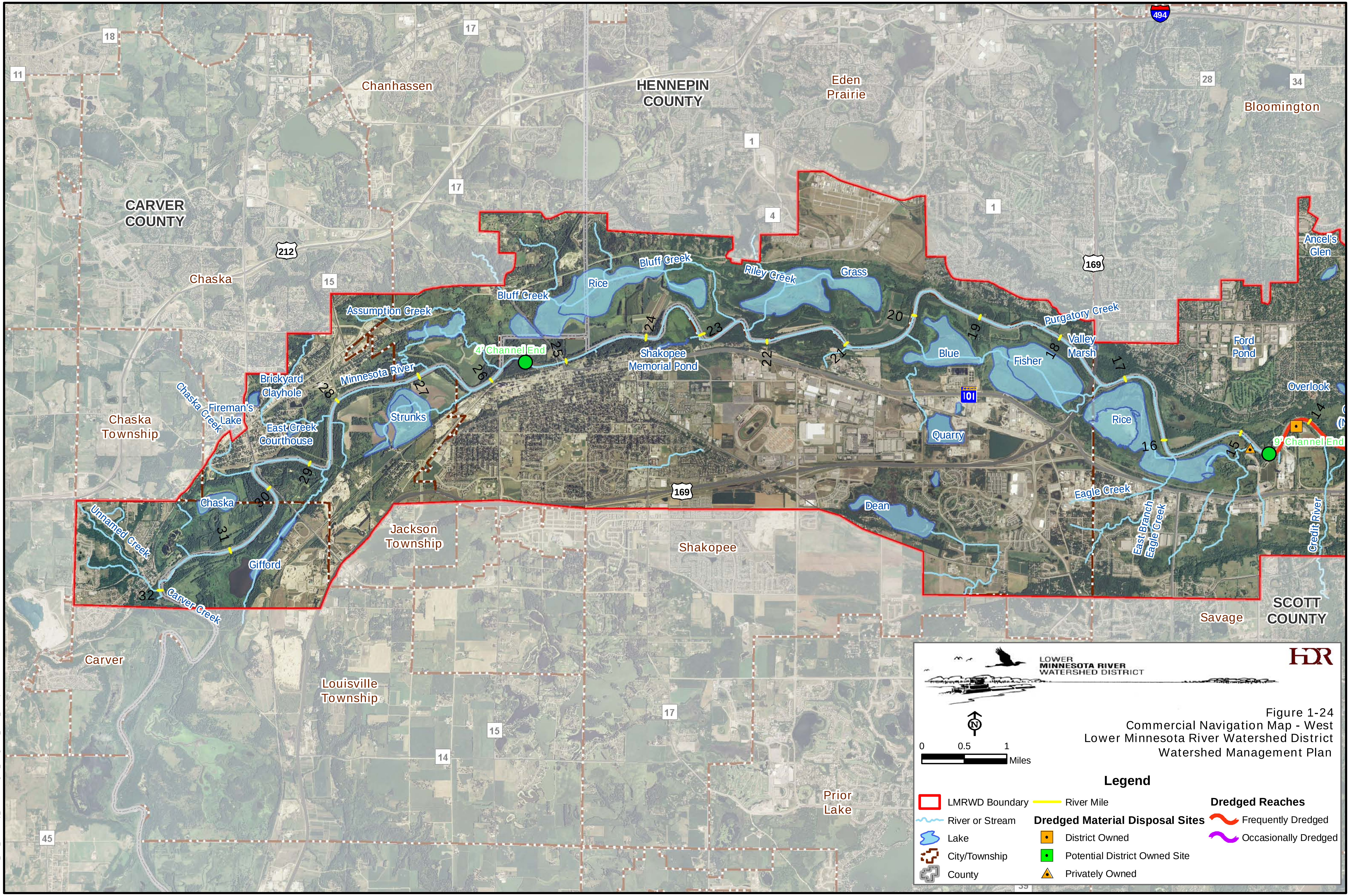


Figure 1-24
Commercial Navigation Map - West
Lower Minnesota River Watershed District
Watershed Management Plan

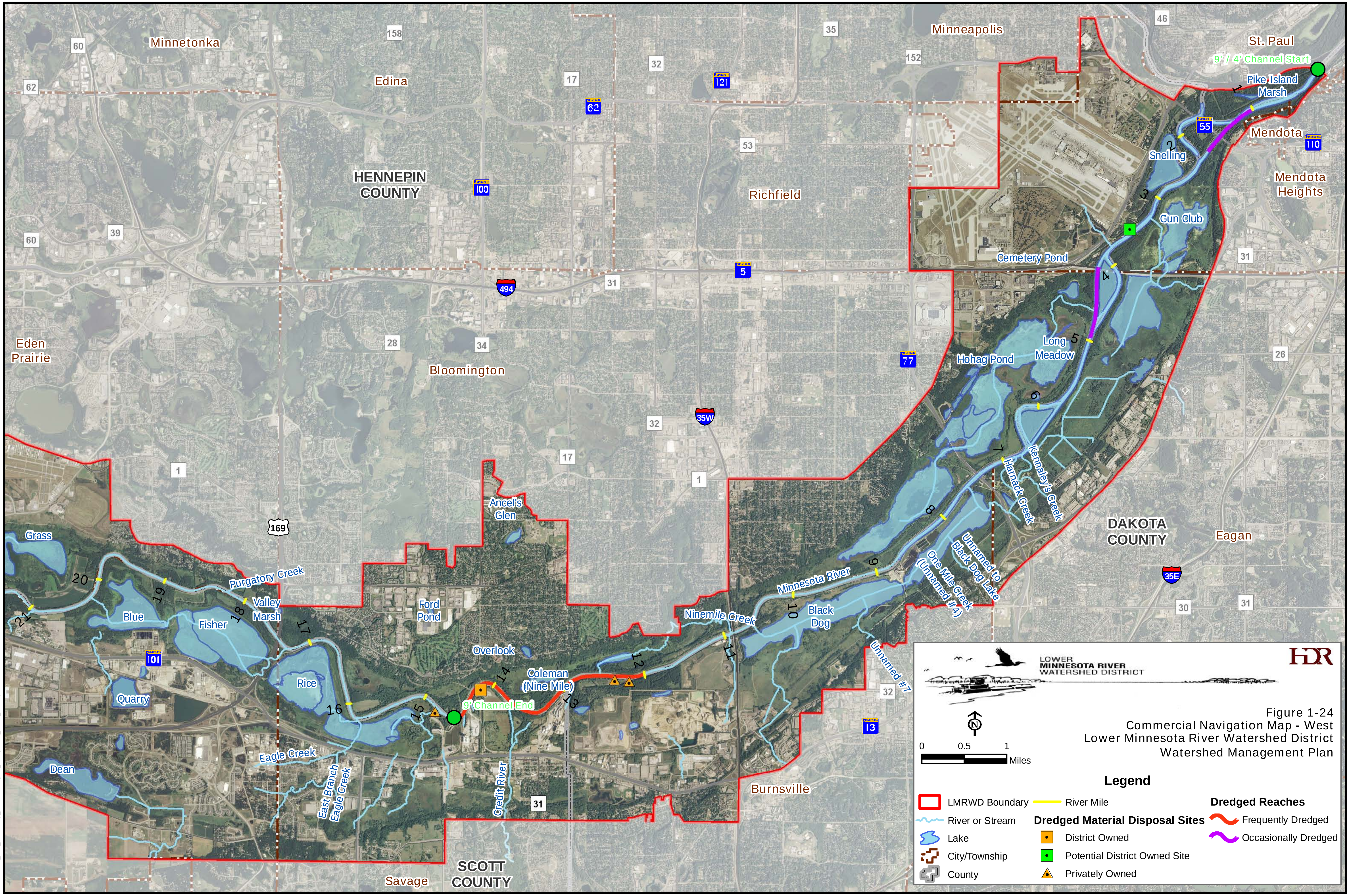


Figure 1-24
Commercial Navigation Map - West
Lower Minnesota River Watershed District
Watershed Management Plan

1.13 Fish and Wildlife Habitat

The District supports critical needs of many wildlife species. Bird watching clubs have recorded hundreds of bird species in the area during migration. There are also several mammal, amphibian, and reptile species. The District's lakes, streams, and rivers are inhabited by carp, buffalo head, bullhead, shad drum, catfish, dogfish, gar, shiner, northern pike, walleye, trout, and sunfish. Many of these fish are available in abundance and provide excellent fishing opportunities. However, before eating fish taken from the Lower Minnesota River, health warnings from the DOH should be consulted.

Appendix E of the Minnesota Valley National Wildlife Refuge Comprehensive Conservation Plan (CCP), completed in 2004, contains a detailed wildlife inventory. In addition, Appendix A of the CCP contains an environmental assessment that evaluates the effect of various management alternatives on fish and wildlife habitat in the Refuge. This assessment applies to all fish and wildlife located in the District. For additional information, the Conservation Plan is located on the USFWS Website.

1.14 Unique Features and Scenic Areas

The District is home to several areas with moderate to high biodiversity significance. The combination of the Minnesota River, the floodplain, and the river bluffs result in a high occurrence of rare and endangered species, unique features, and scenic areas. Unique features include the fens and trout streams discussed in later sections. Scenic areas include the parks, trails, and refuges previously described.

In addition to unique water resources and scenic areas, there are several rare species and natural communities within the District that are important areas for conservation. Numerous native plant communities found in the District are shown on Figure 1-22 and Figure 1-23. The plant communities, delineated by the Minnesota County Biological Survey, interact with each other and their surrounding environment. These interactions have not been altered by human activity, or by introduction of non-native plant or animal species.

According to the Natural Heritage Information System, maintained by the DNR Natural Heritage and Non-Game Research Program, there are hundreds of known occurrences of rare species and natural communities within the District. The Higgins eye pearly mussel is currently listed as a federally endangered species. The peregrine falcon, previously listed as a federally endangered species and since removed from the list, is still considered a threatened species in Minnesota. Endangered state species located in the District include the western prairie fringed orchid, Henslow's sparrow, the cricket frog, and eared false foxglove.

Rare natural communities include mesic prairies and Boiling Springs in Savage. Mesic prairies are found on sites that have relatively good drainage and contain some of the most diverse prairie wildflower displays. Mesic prairies are the most threatened prairie because most were converted for agricultural use. Eagle Creek is the home of Boiling Springs, a location where the water bubbles up, creating the illusion that it is boiling. It is considered a sacred site by the local Native American community.

1.15 Pollutant Sources

1.15.1 Feedlots

Currently, there are no registered feedlots within the District. However, county groundwater plans propose to inventory currently unregistered feedlots.

1.15.2 Abandoned Wells

Abandoned and sealed wells, inactive wells, and wells of unknown status within the District, are identified on Figure 1-26 and Figure 1-27.

1.15.3 Storage Tanks

The MPCA maintains a database of all leak sites, including those from above- and below-ground storage tanks and leaking underground storage tanks (LUST). Many of these leak sites have been closed by the MPCA. The intent of the database is to protect human health and the environment by evaluating, minimizing, or correcting petroleum contamination impacts to soil and water caused by leaking storage tank systems.

Figure1-26 and Figure 1-27 identify LUST site locations.

1.15.4 Industrial Discharges

MCES is delegated as the Control Authority to regulate the use of public sanitary sewer systems within the MCES seven county service area. Companies are issued an Industrial Discharge Permit if it is determined they will have a significant impact on the public sewer system.

Figure 1-26 and Figure 1-27 identify the locations of sites that have been issued an Industrial Discharge Permit by the Industrial Waste and Pollution Prevention Section of MCES.

1.15.5 Wastewater Treatment Plants

Two wastewater treatment plants are located within the District: Seneca in the City of Eagan, and Blue Lake in the City of Shakopee.

Figure 1-26 and Figure 1-27 identify their locations. Discharge from these treatment plants, along with the associated sanitary sewer lines, urban storm water discharges, and various utility lines, present potential environmental hazards within the District.

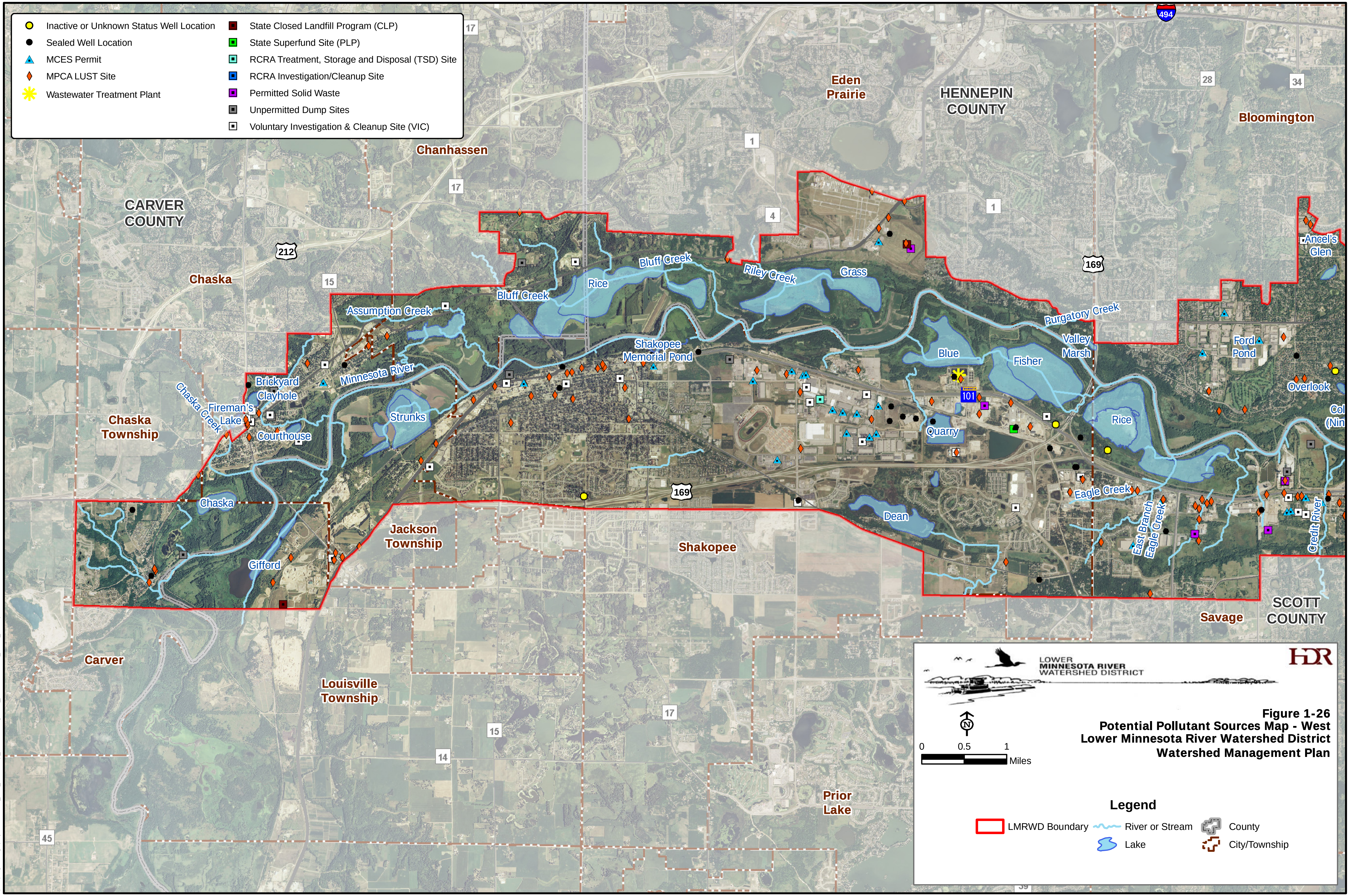


Figure 1-26
Potential Pollutant Sources Map - West
Lower Minnesota River Watershed District
Watershed Management Plan

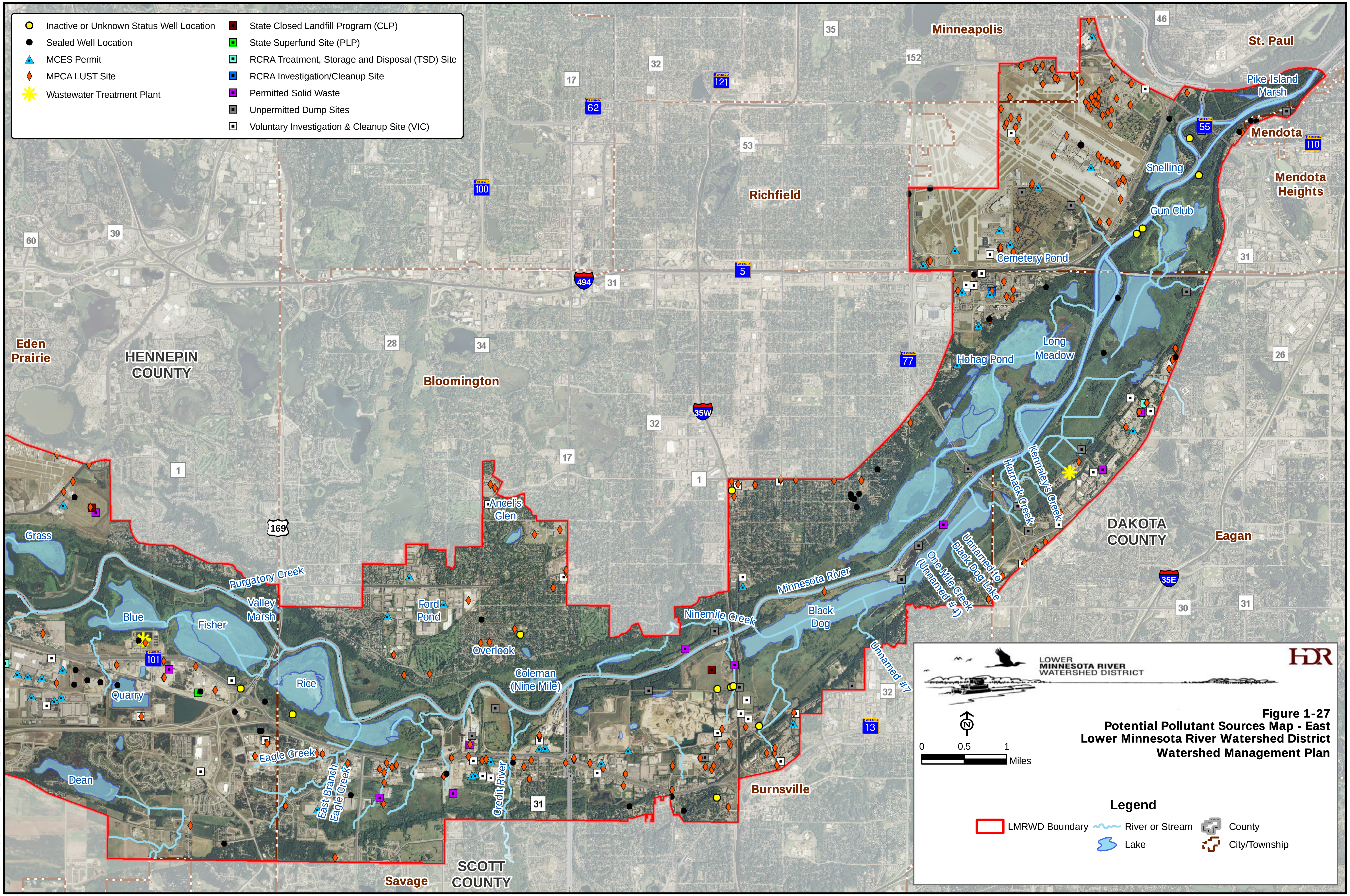


Figure 1-27
Potential Pollutant Sources Map - East
Lower Minnesota River Watershed District
Watershed Management Plan

1.15.6 Landfills and Solid Waste

The MPCA Closed Landfill Program (CLP) is a voluntary program established by the legislature in 1994 to properly close, monitor, and maintain Minnesota's closed municipal sanitary landfills. Three closed sanitary landfills in the CLP program are located within the District in Hennepin (Flying Cloud Sanitary Landfill), Scott (Louisville Landfill), and Dakota (Freeway Sanitary Landfill) counties. Figure 1-26 and Figure 1-27 show their locations.

Figure 1-26 and Figure 1-27 also show the locations of permitted solid waste sites within the District. These facilities manage household and commercial garbage and include landfills, transfer stations, demolition landfills, composting facilities, and solid-waste incinerators.

In the 1980s, MPCA created a list of unpermitted dumpsites that included abandoned dumps, demolition sites, tree disposal sites, industrial dumps, and other dumps. Most of these sites existed prior to the creation of the MPCA in 1967, and detailed information about them is not generally available. If, when these sites are investigated, they are found to present a risk to human health or the environment, they are moved into the appropriate cleanup program.

Figure 1-26 and Figure 1-27 also show locations of unpermitted dump sites within the District.

1.15.7 Hazardous Waste

MPCA, in conjunction with the Environmental Protection Agency (EPA), maintains information on sites with past, present, or potential for future hazardous waste contamination. These sites are regulated and administered under the various programs described below.

State of Minnesota superfund sites, also referred to as Permanent List of Priorities (PLP) sites, are those with known or suspected environmental contamination that has the potential to threaten public health, welfare, or the environment. These sites are investigated and cleaned up under the Minnesota Superfund Program. The PLP sites include those addressed by MPCA, as well as sites with agricultural chemical contamination, which are addressed by the Minnesota Department of Agriculture. PCI, Inc., located in Shakopee, is the only PLP site located within the District. PCI, Inc., shown on Figure 1-26 and Figure 1-27, was an ash disposal site.

Resource Conservation and Recovery Act (RCRA) Treatment, Storage, and Disposal (TSD) facilities are those permitted to treat, store, and dispose of hazardous wastes. These facilities typically collect hazardous wastes from other businesses and treat or dispose of them properly. Safety-Kleen Eagan, located in Eagan, is the only RCRA TSD site within the District (Figure 1-27) RCRA Investigation/Cleanup sites are those where RCRA hazardous waste generators had an actual or potential release requiring investigation and/or cleanup. These generators fall into the very small, small, and large quantity generator classes. There is one RCRA Investigation/Cleanup site located within the District, General Dynamics, at 3101 East 80th Street in Bloomington (Figure 1-27).

The Voluntary Investigation and Cleanup (VIC) Program allows buyers, sellers, developers, or local governments to voluntarily investigate and, if necessary, clean up contaminated land to facilitate its sale, financing, or redevelopment. Those who complete investigation and/or cleanup activities under MPCA oversight can receive liability assurances that protect them from future superfund liability. Locations of sites in the VIC Program within the District are shown on Figure 1-26 and Figure 1-27.

1.15.8 Pesticide and Fertilizer

The Minnesota Department of Agriculture (MDA) is statutorily responsible for the management of pesticides and fertilizer other than manure to protect water resources. The MDA implements a wide range of protection and regulatory activities to ensure that pesticides and fertilizer are stored, handled, applied, and disposed of in a manner that will protect human health, water resources and the environment. The MDA works with the University of Minnesota to develop pesticide and fertilizer Best Management Practices (BMPs) to protect water resources, and with farmers, crop advisors, farm organizations, other agencies, and many other groups to educate, promote, demonstrate, and evaluate BMPs, to test and license applicators, and to enforce rules and statues. The MDA has broad regulatory authority for pesticides and has authority to regulate the use of fertilizer to protect groundwater.