SEPTEMBER 3, 2019

LAND & WATER RESOURCES NARRATIVE

RUM RIVER ONE WATERSHED ONE PLAN

LAND & WATER RESOURCES NARRATIVE

INTRODUCTION

The purpose of this document is to provide a brief summary of land and water resources information to inform and support the development of a comprehensive watershed management plan for the Rum River Watershed. The Rum River Watershed is situated within the Upper Mississippi River Basin in central Minnesota. The watershed is 1,584 square miles in size, and stretches from Mille Lacs Lake in the north, the headwaters of the Rum River, to the City of Anoka in the south, the location of the confluence of the Rum and Mississippi Rivers. The watershed covers portions of ten (10) counties; Aitkin, Crow Wing, Morrison, Mille Lacs, Kanabec, Benton, Isanti, Chisago, Sherburne, and Anoka.

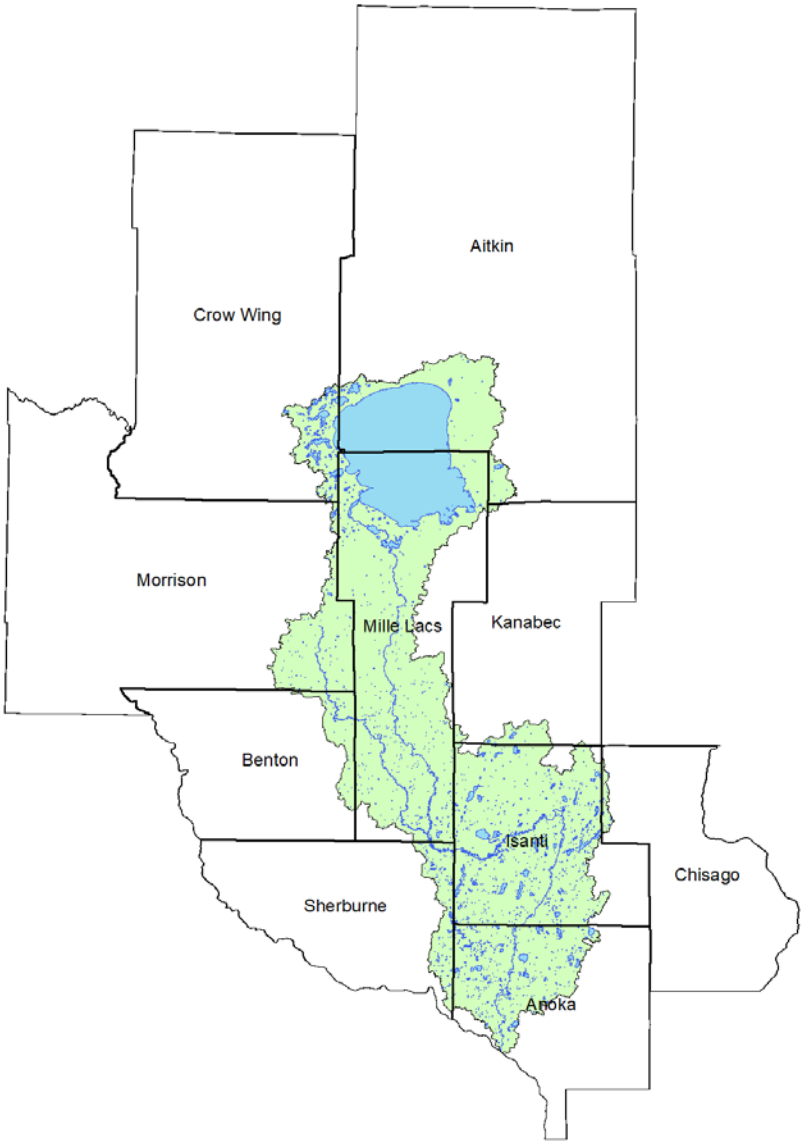

Figure 1: Watershed Map

LAND USE

Land use varies greatly throughout the watershed. The upper third of the watershed is dominated by hardwood forests and large wetland complexes. This area is home to Mille Lacs Lake, a recreation and tourism destination with high-density shoreland development around much of its perimeter. The middle third of the watershed is a transitional area, changing from hardwood forests and wetland complexes in the north, to increasingly-intensive agricultural use in the south. The lower third is the most-densely populated, starting with small-acreage suburban development and trending towards more urbanized development patterns near the Rum River's confluence with the Mississippi in Anoka.

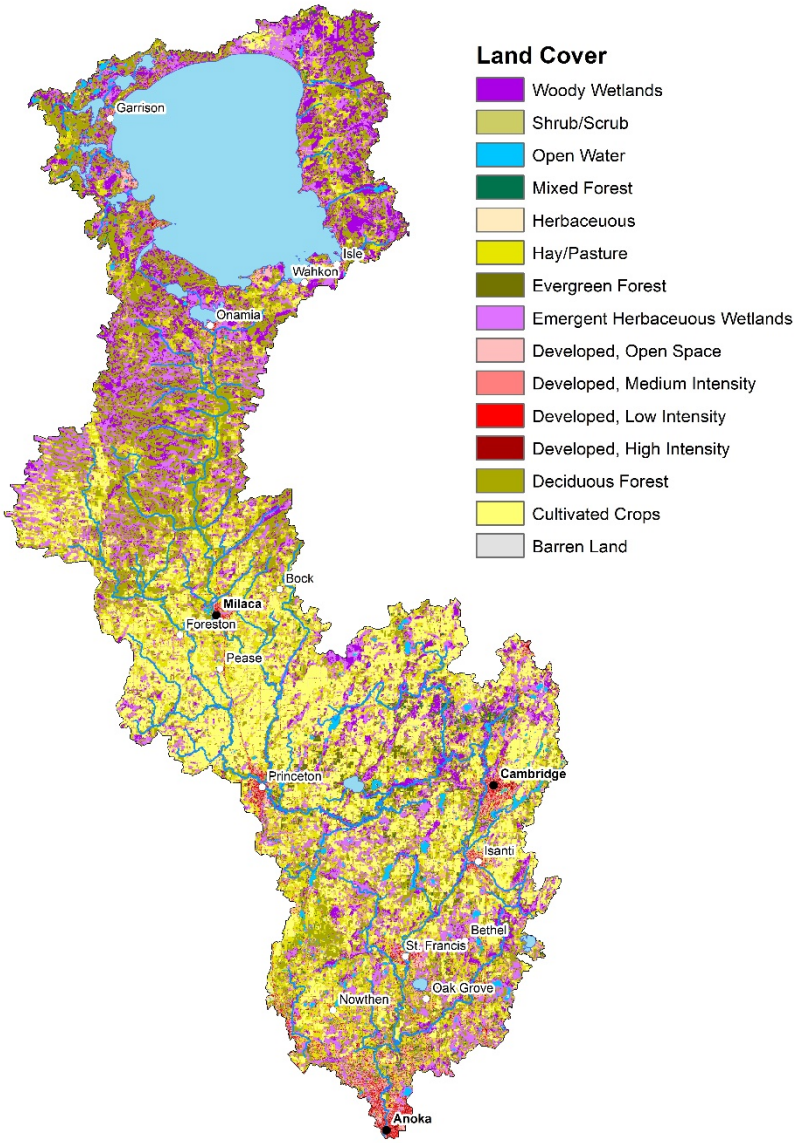

Figure 2: Land Cover (2016 NLCD)

Anticipated land use changes in the watershed include the development of housing in areas within commuting distance of the Twin Cities and regional population centers. This is a re-emerging trend that has resulted in sprawling suburban development of formerly rural areas. The trend is evidenced by population growth in many watershed counties that is well above the State average, and correlating geographically with proximity to the Twin Cities.

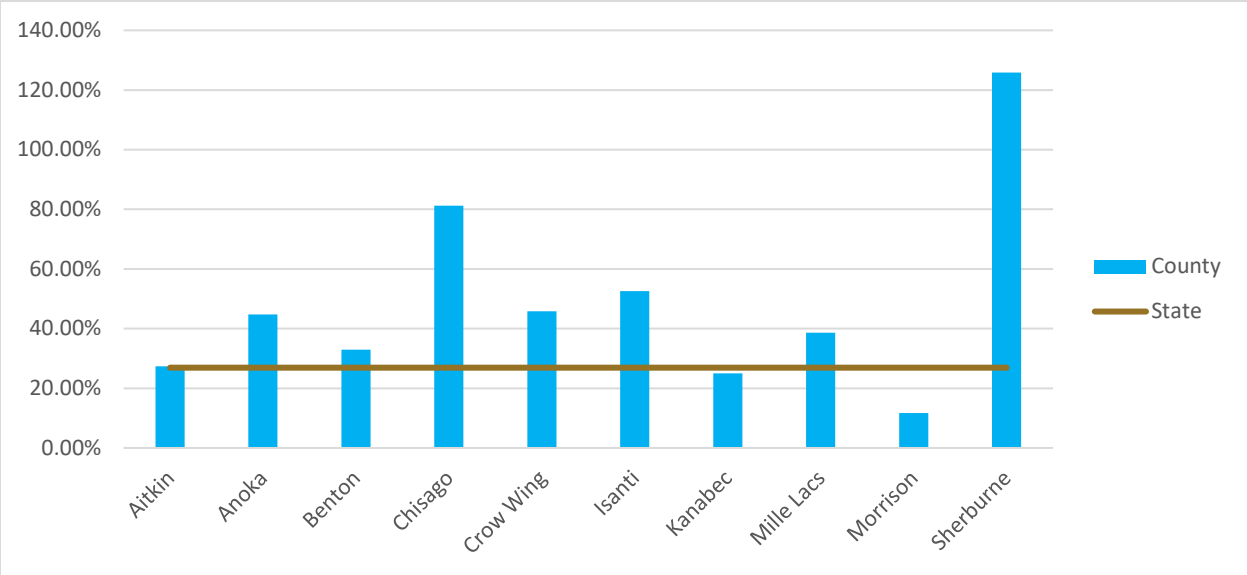

Figure 3: Population Growth 1990 – 2017 (MN State Demographic Center)

However, population projections appear to signify a coming end to this trend. Projections of migration patterns at the county level, covered in more detail in the demographics section of this document, appear to show a net loss in many of those counties previously associated with sprawling suburban development. Instead, these projections appear to show increases in migration to the metropolitan counties. Property values also appear to support this hypothesis with apartment property values increasing by 11.5% in 2018, compared to only 7.1% for residential homesteads according to the Minnesota Department of Revenue.

What is not clear is whether this is indicative of domestic or international migration patterns. Data from the Minnesota State Demographic Center shows that Minnesota has been losing residents as a result of domestic migration. At the same time, Minnesota has been seeing increased migration from international migrants, at a rate much greater than the losses experienced as a result of domestic migration. As a result, it may be that the increases projected in the metropolitan counties are not associated with domestic land use changes, but the settlement patterns and housing preferences of international migrants. As a result, this trend may not have a significant effect on land use changes within the watershed, other than the potential development of additional multi-family housing in the southernmost areas of the watershed.

Another emerging trend that appears to be supported by the migration projections is the redevelopment of lakeshore properties. According to Minnesota Lakes and Rivers, in the last two decades the average age of the lake home and cabin owner in Minnesota has increased ten (10) years, from 58 to 68. A growing number of these owners are retiring and choosing to convert their seasonal property to a full-time residences. This trend appears to be supported by the migratory population increases projected for the northernmost counties in the watershed, those with abundant seasonal recreation resources.

The utilization of these properties, once seasonal retreats, as full-time residences, has resulted in increased redevelopment and new development intensity. The small cabin of yesteryear is being replaced by larger lake homes with all the comfort of the suburbs, including larger footprints and supporting

accessory structures. This is resulting in increased development density and disturbance of natural habitat. The size and scope of these impacts, coupled with their proximity to sensitive and important natural resources, may result in irreparable degradation to the resources that precipitated the development in the first place.

While suburban and lake shore development has accounted for significant land use changes over the past few decades, agricultural land use still accounts for a significant area of the watershed. Agricultural land use occupies approximately 38% of the total watershed acres. The majority of these agricultural lands are utilized for hay or pasture.

The United States Department of Agriculture (USDA) estimates that there are 2,153 farms in the watershed. Many of these are small-acreage operations; 69% of the operations are less than 180 acres in size. In comparison, the average farm size statewide is 371 acres. Approximately half of the 2,134 operators are full time agricultural producers not reliant on off-farm income.

	PUBLIC		PRIVATE		TRIBAL			
LANDCOVER	ACRES	%	ACRES	%	ACRES	%	TOTAL ACRES	%
FOREST	47,793	4.8%	255,930	25.7%	1,257	0.1%	304,981	30.59%
GRASS	4,073	0.4%	198,877	19.9%	76	0.0%	203,026	20.36%
ORCHARDS	0	0.0%	0	0.0%	0	0.0%	0	0.00%
ROW CROPS	1,605	0.2%	179,298	18.0%	29	0.0%	180,933	18.15%
SHRUBS	110	0.0%	2,022	0.2%	0	0.0%	2,133	0.21%
WETLANDS	14,486	1.5%	91,024	9.1%	353	0.0%	105,863	10.62%
RESIDENTIAL/COMMERCIAL	2,103	0.2%	50,344	5.0%	275	0.0%	52,722	5.29%
OPEN WATER[1]	1,861	0.2%	145,427	14.6%	137	0.0%	147,426	14.79%
WATERSHED TOTALS	**72,032**	**7.2%**	**922,924**	**92.6%**	**2,128**	**0.2%**	**997,084**	100%

1. Ownership undetermined.

Figure 4: Ownership/Land Use (USDA, NRCS)

The USDA estimates that approximately 92% of the land in the watershed is privately owned. However, public lands do account for a notable portion of the watershed, approximately 7% of total watershed acres. The majority of these publicly-owned lands are located in the northern third of the watershed, with many large state and federal land holdings in northern Mille Lacs County and southern Aitkin County.

OWNERSHIP TYPE	ACRES	% OF WATERSHED
CONSERVANCY	-	-
COUNTY	1,403	0.1
FEDERAL	283	0
STATE	65,285	6.5
OTHER PUBLIC	5,162	0.5
TRIBAL	2,128	0.2
PRIVATE MAJOR	20	2
PRIVATE	903,089	90.6

Figure 5: Land Ownership (USDA, NRCS)

DEMOGRAPHICS

Demographic characteristics are statistical data relating to a population of people, and the particular groups within it. This data is commonly tabulated based on geopolitical boundaries. As a result, the information that follows is provided for each individual county within the watershed.

The population of the watershed counties varies greatly. The population of the other counties fluctuates accordingly based on proximity to regional population centers and metropolitan areas, with population generally increasing towards the southern end of the watershed. The population of the Rum River Watershed is estimated at 251,686 based on the tabulation of population data from census tracts within the watershed.

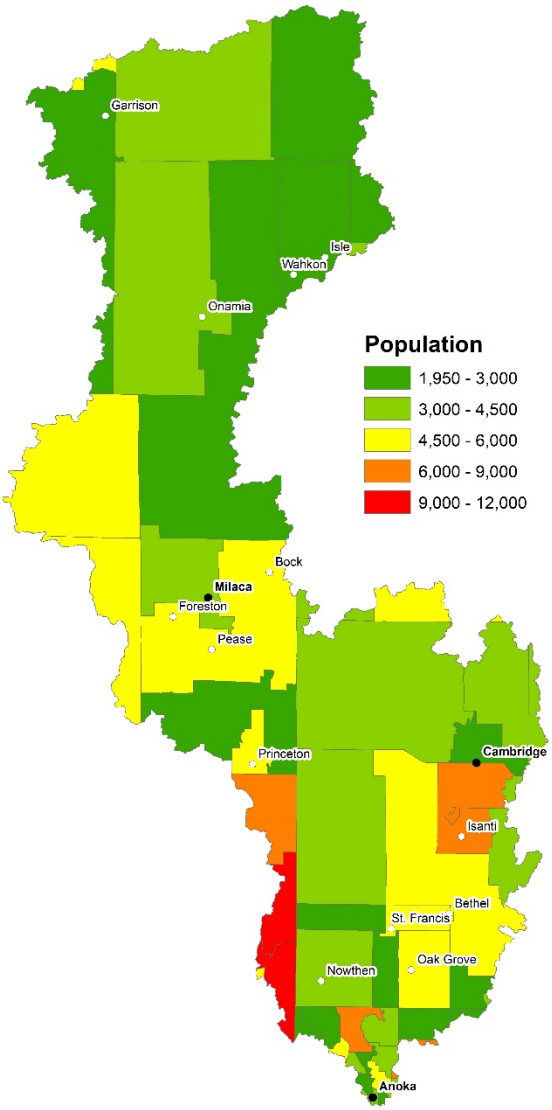

Figure 6: Population by Census Tract (2010 Census)

Statewide, the Minnesota State Demographic Center estimates that total population will continue to grow, exceeding 6 million by 2032. This trend of continued population growth is also evident in the Rum River Watershed counties, which, when aggregated, are projected to increase approximately 12.5% between 2015 and 2050. However, analysis of population projections at the county level reveals distinct differences.

When analyzed collectively, population is projected to increase, but four (4) counties (Aitkin, Kanabec, Mille Lacs, and Morrison) within the watershed are actually expected to experience decreasing population. This change will be most dramatic in Aitkin and Kanabec counties, losing approximately 17.5% and 16%, respectively, of their 2015 population by 2050. The remaining six (6) counties are projected to see population increases, generally increasing in scope with increasing proximity to regional population centers and metropolitan areas.

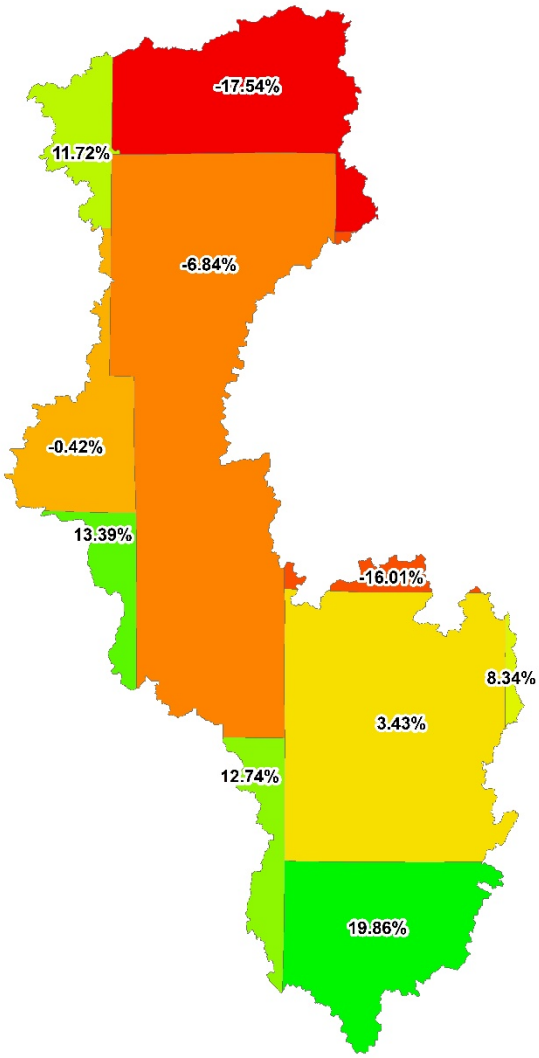

Figure 7: Projected Population Change 2015 – 2050 (2017 MN State Demographic Center)

These projections are a factor of two (2) important measures, natural increase and migration. Natural increase is a factor of births and deaths for a given period of time; a positive value correlates with a greater

number of births than deaths. Migration is a measure of the movement of people from one place to another; a positive value correlates with a net increase in the number of people living in a given area.

Similar to the overall population change projections, four (4) counties have negative values projected for both natural increase and migration. Aitkin (-29.69%) and Kanabec (-9.21%) counties are expected to lose the greatest percentage of their population as a result of natural processes. Mille Lacs (-10.99%) and Kanabec (-6.8%) counties are expected to lose the greatest percentage of their population as a result of migration.

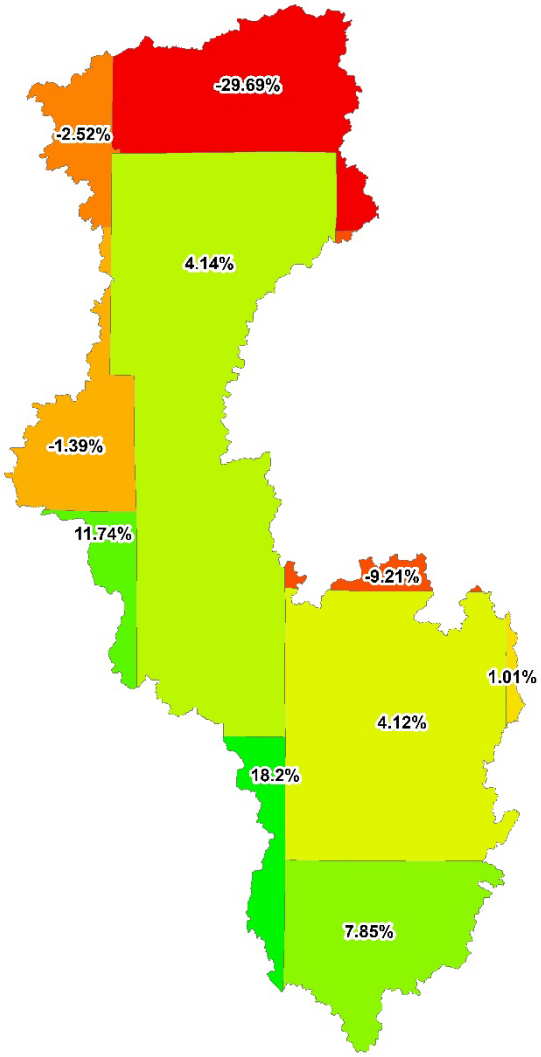

Figure 8: Projected Population Change as a Result of Natural Processes 2015 – 2050 (2017 MN State Demographic Center)

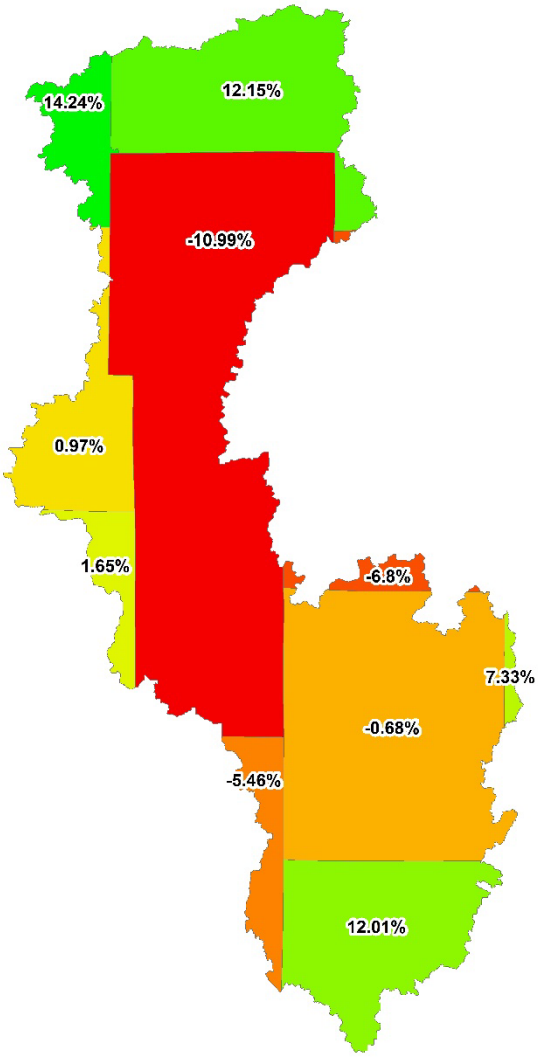

Figure 9: Projected Population Change as a Result of Migration 2015 – 2050 (2017 MN State Demographic Center)

The median age of inhabitants in the watershed counties appears to correlate with projected population changes as a result of natural processes, as the four (4) "oldest" counties are also the four (4) expected to see a net reduction in population as a result of natural processes. Aitkin County has the highest median age (54.5 years of age) and Benton County has the lowest median age (35.6 years of age). However, the average resident in the Rum River Watershed is older than the average Minnesotan, averaging 41.5 years of age in comparison to the Minnesota state-wide average of 37.9 years of age.

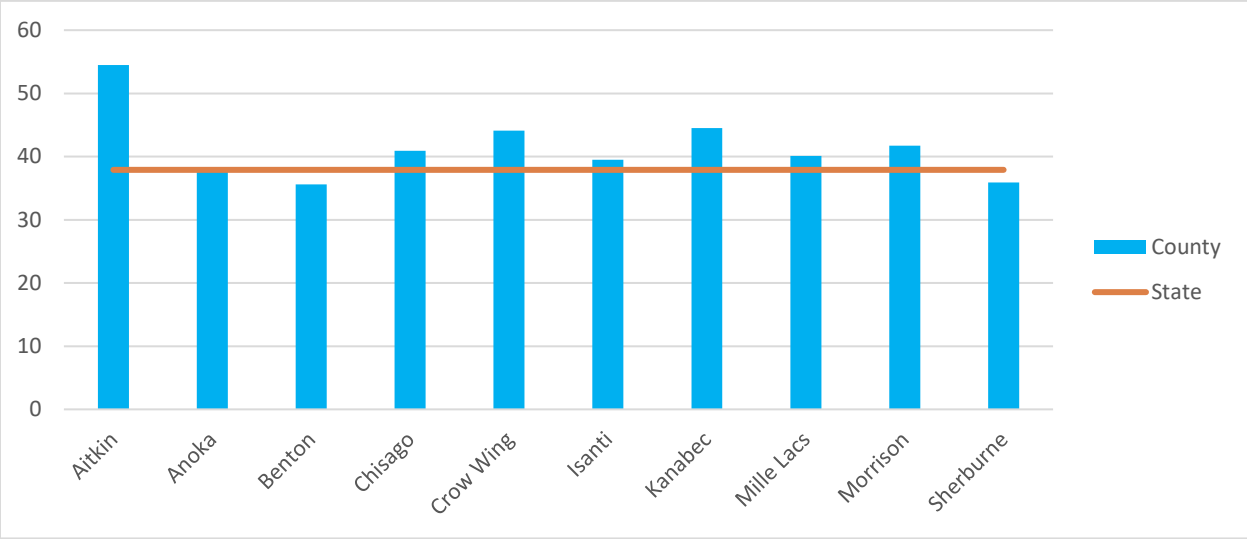

Figure 10: Median Age (2013 – 2017 ACS 5-Year Estimates)

Similar to population, median household income is another area in which the "metro affect" is readily apparent. Average household income in Sherburne County ($83,895) is approximately 83% higher than that of the average Aitkin County household ($45,860). The six (6) counties located furthest from the Twin Cities metro all have median household incomes below the State average.

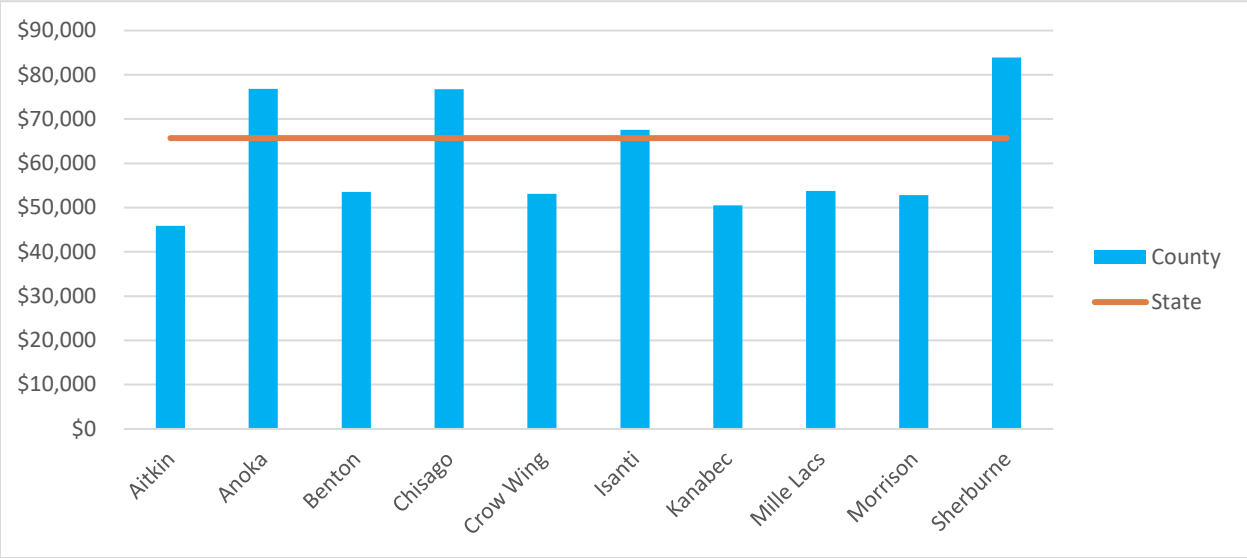

Figure 11: Median Household Income (2013 – 2017 ACS 5-Year Estimates)

A similar trend is apparent in regards to individuals living below the poverty level. The percentage in Benton County (14.10%) is nearly three-times that of the Chisago County (5.40%). The six (6) counties located furthest from the Twin Cities metro have the highest poverty levels.

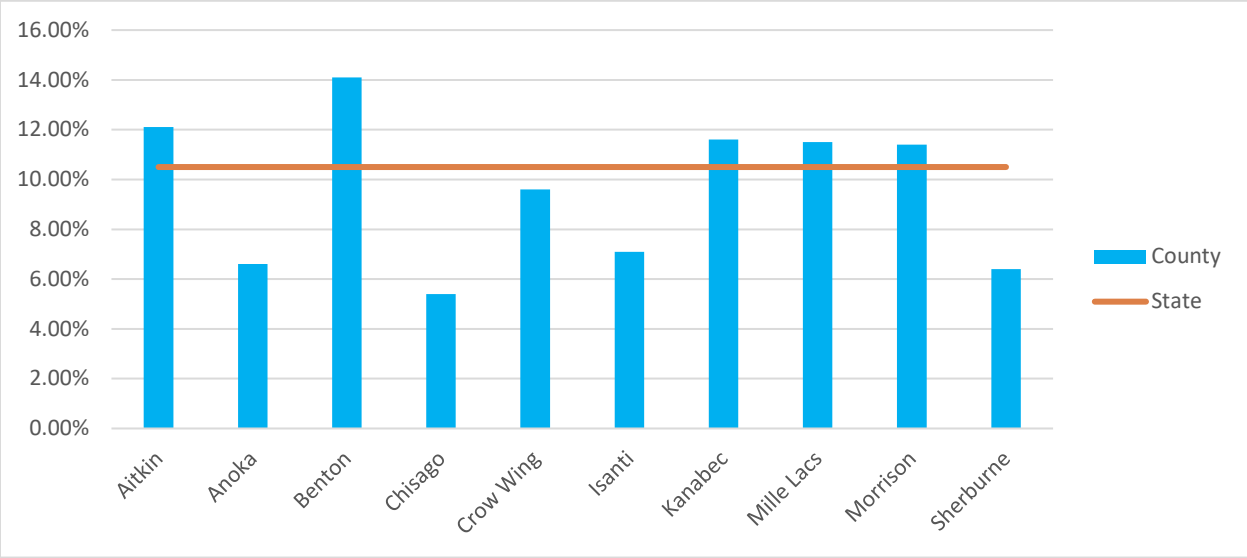

Figure 12: Individuals below Poverty Level (2013 – 2017 ACS 5-Year Estimates)

Demographic and socioeconomic factors impact, and are often impacted by, a host of public sector organizations such as public schools and local units of government. The operation and effectiveness of these organizations is affected by their jurisdiction's net tax capacity, the summation of a jurisdictions total taxable market value multiplied by the corresponding tax rates. The counties in the watershed with a higher net tax capacity generally have a better socioeconomic condition, and vice versa.

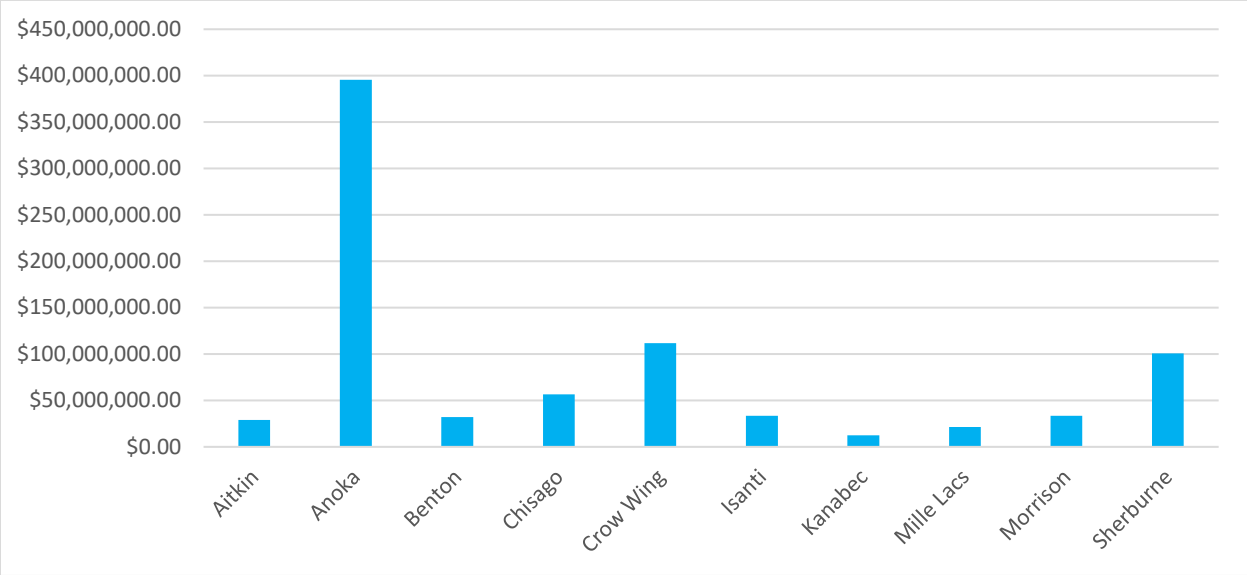

Figure 13: Net Tax Capacity 2018 (MN Department of Revenue)

ECOREGION & SOILS

The Minnesota Department of Natural Resources (DNR) utilizes the Ecological Classification System (ECS) to define distinct areas with uniform ecological characteristics. These characteristics include a number of factors, such as climate, geology, topography, soils, hydrology, and vegetation. Within the ECS there are different units utilized to describe progressively smaller areas of land, starting with provinces, and decreasing in size with sections and subsections.

According to the DNR, approximately one-half of the Rum River Watershed is in the Mille Lacs Uplands subsection, Western Superior Uplands section and Laurentian Mixed Forest province. This area includes a large area of glacial till that was deposited by ice moving out of the Lake Superior basin, taking the form of ground moraines and drumlins. This area includes a large end-moraine that formed the dam that created Mille Lacs Lake, as well as the Pierz Drumlin field. The area has a dense brown and red glacial till, often stony and course in nature, with sandy loams, silt loams, and loamy sands.

The other half of the Rum River Watershed is in the Anoka Sand Plain subsection, Northeast Iowa Morainal section, and Eastern Broadleaf Forest province. This is a transitional area between the prairie to the southwest and mixed conifer-deciduous forests to the northeast. This area was formed by the retreat of the Des Moines ice lobe. This is a sandy lake plain, with gently rolling topography. Soils are often well-drained fine sands.

The ECS provinces, sections, and subsections are based on areas of land with uniform ecological features, including factors such as climate, geology, topography, soils, hydrology, and vegetation. Another classification system, agroecoregions, further refines these areas based on land use, land cover, and soil and water resource concerns. Examples of the factors that differ across agroecoregions include runoff, drainage, erosion, wetland restoration potential, drainage and tiling, agricultural production patterns, and the importance of urban verses agricultural impacts on water quality.

These agroecoregions continue to illustrate the divide between the Mille Lacs Uplands and the Anoka Sandplain, but include additional detail within these areas. The Mille Lacs Uplands in the northern half of the watershed includes areas of drumlins along with steep poorly drained moraine and glacial till. The Anoka Sand Plan in the southern half of the watershed also includes areas of alluvium and outwash steep wetter moraine.

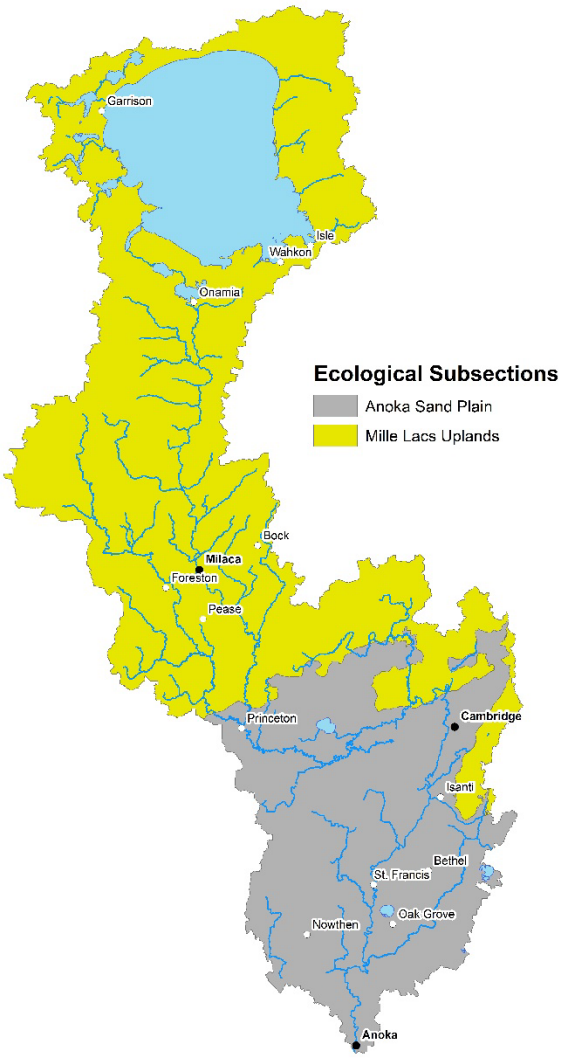

Figure 14: Ecological Subsections (DNR)

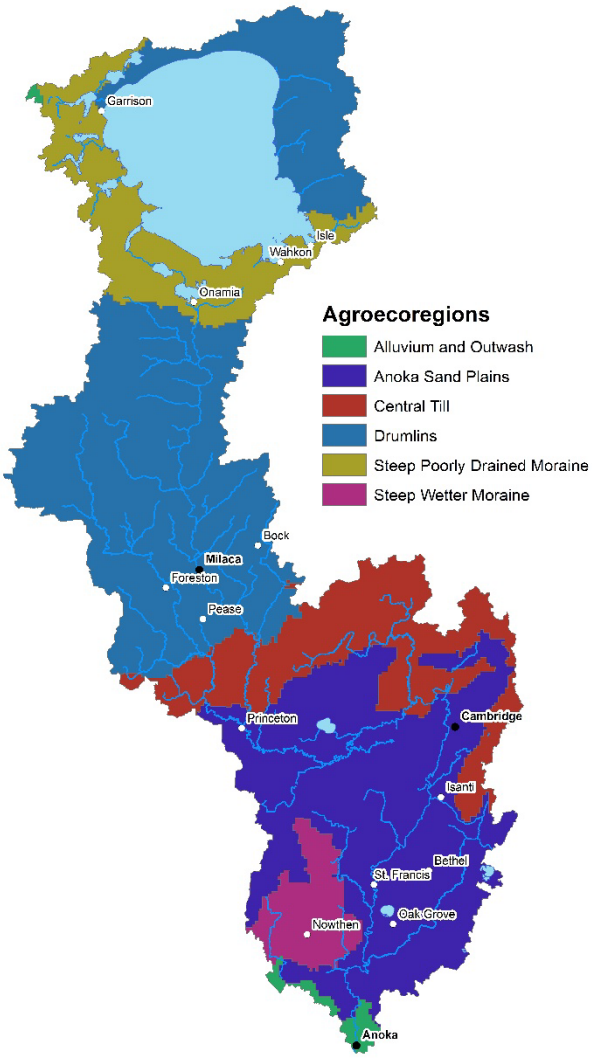

Figure 15: Agroecoregions (MDA)

CLIMATE

Climate is the prevailing long-term weather conditions that persist in a specific area or region. Minnesota has a continental-type climate with warm summers and cold winters. Watershed-wide, average summer temperatures are near 65°F while average winter temperatures are just over 12°F. Average annual temperatures in the watershed range from approximately 43° F in the southern end of the watershed to 40°F in the northern end of the watershed. However, Minnesota is warming, with temperatures increasing 1° to 3° F statewide, with the greatest changes being felt in northern Minnesota.

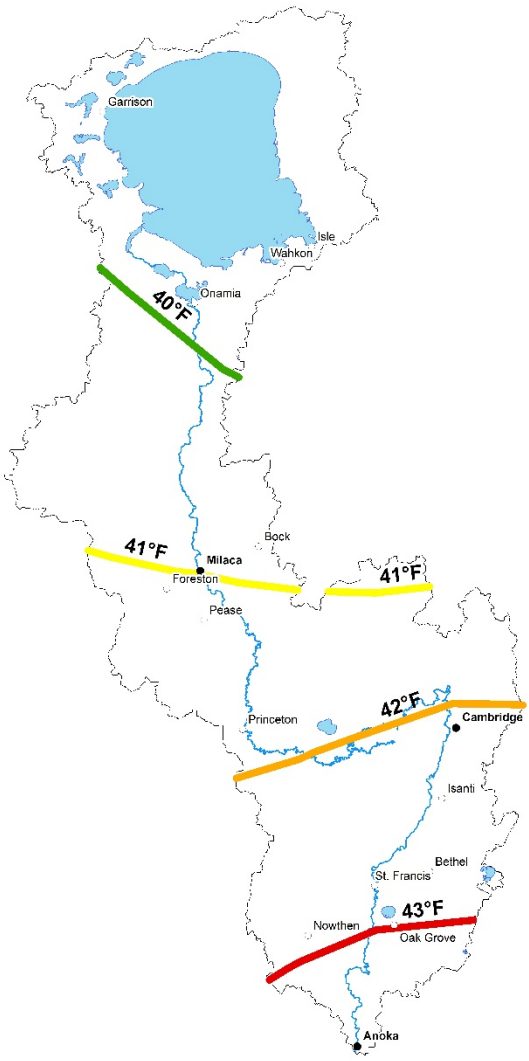

Figure 16: Average Annual Temperature (DNR)

Average annual precipitation in the watershed varies in a similar fashion, with lower annual totals in the northern end of the watershed, increasing towards the southern end of the watershed. Annual average totals, computed over the period from 1971 to 2000, range from approximately 50 inches at the southern end of the watershed, to 35 inches in the north.

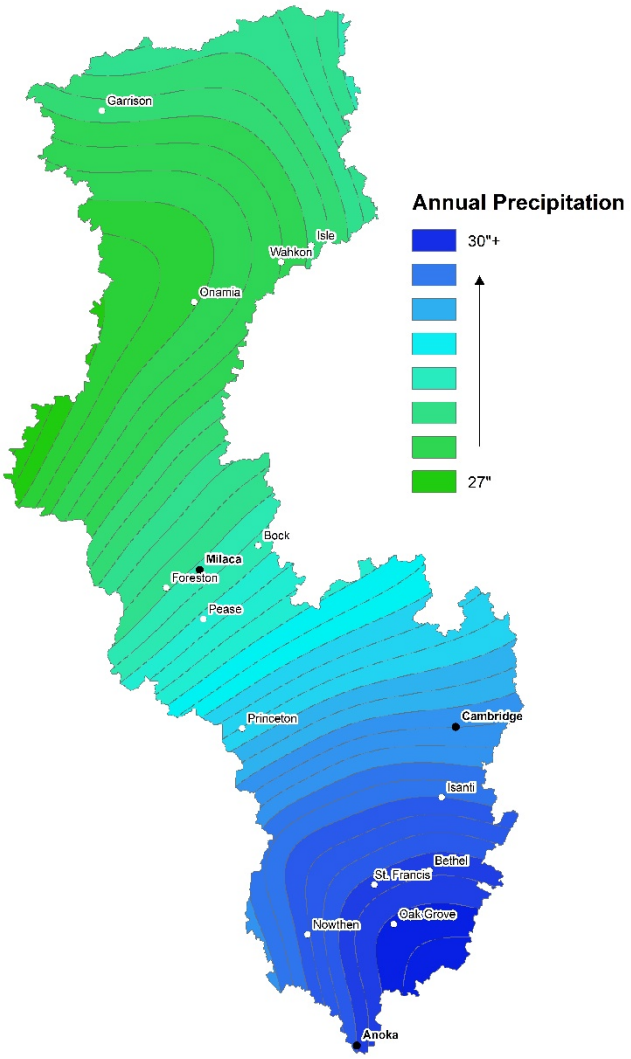

Figure 12: Average Annual Precipitation 1971 – 2000 (NWS & DNR)

However, similar to average annual temperatures, increases in annual precipitation are being observed watershed-wide. These changes appear to be more dramatic in the northern end of the watershed. As a result, the historical difference in precipitation totals is eroding.

Data from the Minnesota State Climatology Office was utilized to review annual precipitation data for locations in Anoka, Milaca, and Garrison. These locations represent, respectively, the southern, central, and northern regions of the watershed. While all three (3) locations appear to be showing an increase, this increase is happening at a higher rate in the northern end of the watershed. The increasing frequency of high-yield precipitation events appears to be a likely culprit for these increases in annual precipitation.

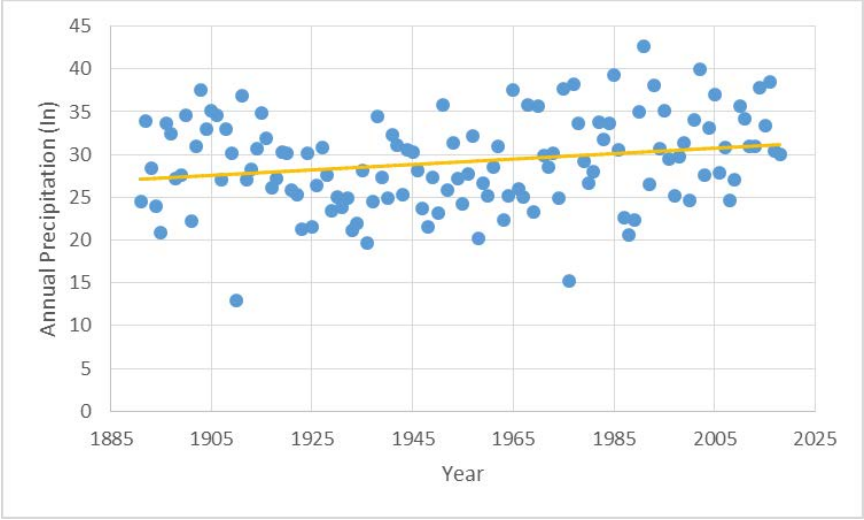

Figure 13: Changes in Annual Precipitation – Anoka (Minnesota State Climatology Office)

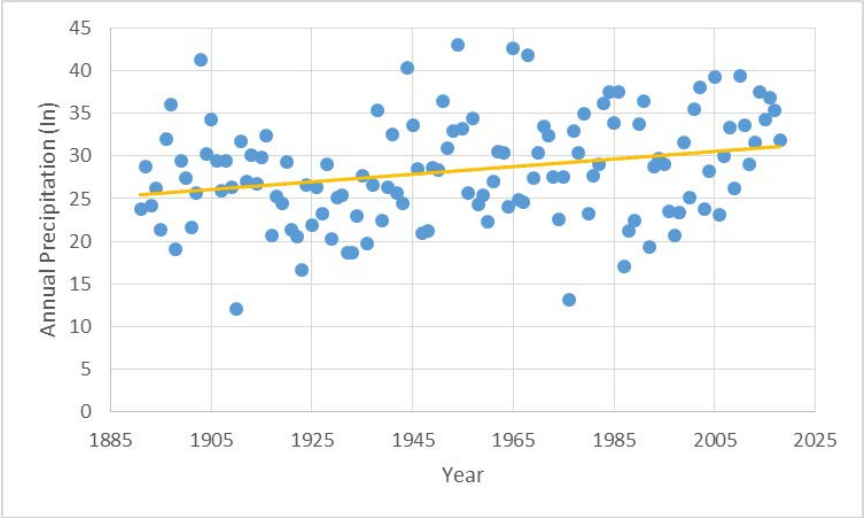

Figure 14: Changes in Annual Precipitation – Milaca (Minnesota State Climatology Office)

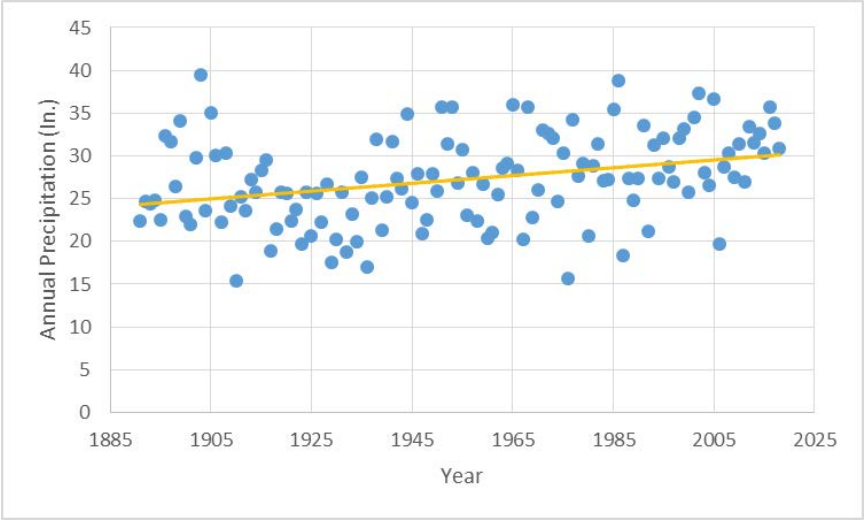

Figure 15: Changes in Annual Precipitation – Garrison (Minnesota State Climatology Office)

GEOLOGY

Geology is the science of the earth's physical structure and substance, including the processes that act on it. A region's geology has a strong impact on groundwater quantity and quality. It also has an impact on land use and development patterns.

Quaternary geology is the study of the most recent geologic period, covering the last 2.6 million years. This period includes the deposition of glacial sediments, currently located above bedrock and below topsoil. In the Rum River Watershed these deposits are commonly the result of either the Superior or Des Moines Lobes.

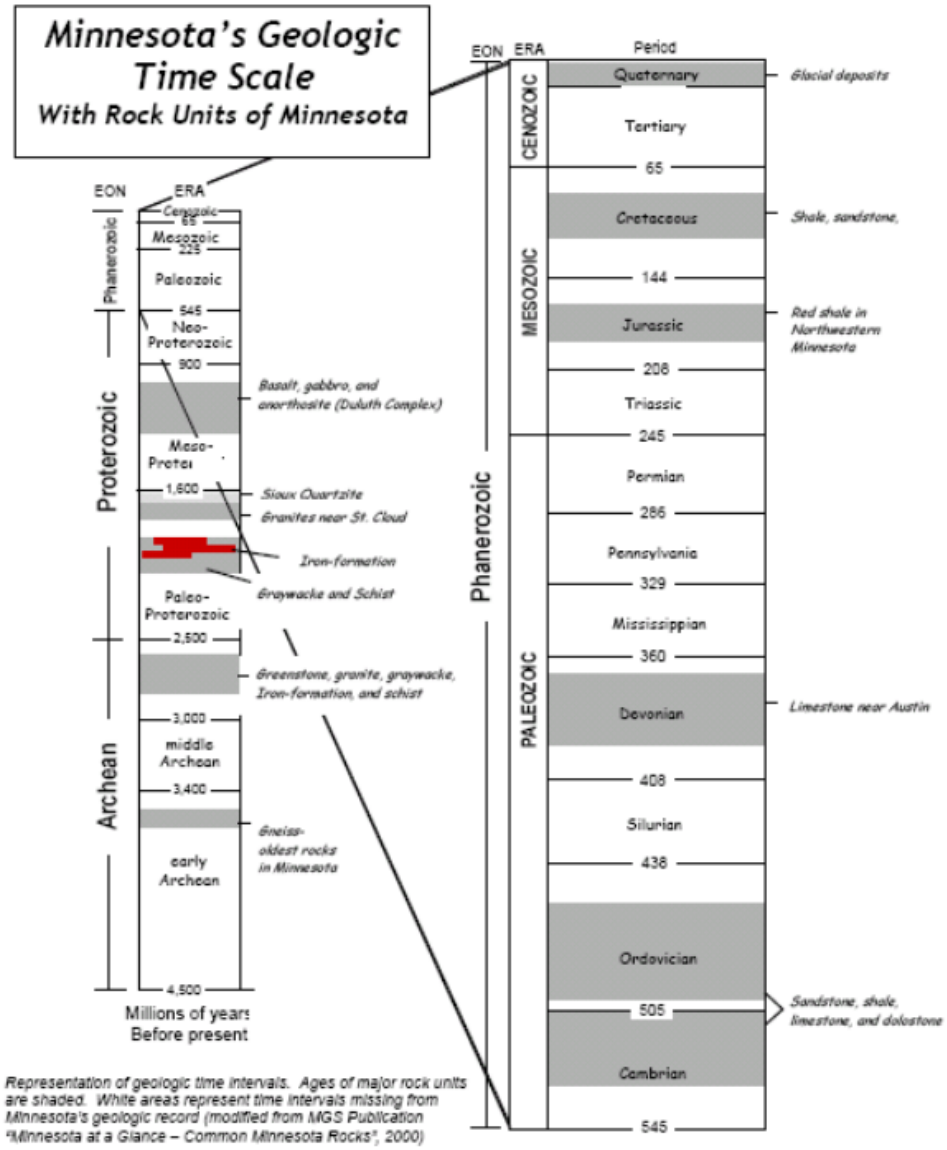

Figure 16: Geologic Time Scale (MNDOT)

These glacial sediments include an area of non-calcareous till in the northern end of the watershed that was left by the Superior Lobe, part of the Mille Lacs-Highland Moraine Association. This is a sandy and stony glacial till. North of Mille Lacs Lake there is a small area of calcareous till, a reddish-brown clayey till left by the Culver Moraine Association, the southeastern edge of the Des Moines Lobe.

In the northern half of the watershed there are intermittent peat deposits. These are large deposits of organic material located in wetlands. The northern half of the watershed also includes areas of sand and gravel deposits. South of Mille Lacs Lake, following larger river channels, these are the result of outwash and scoured bedrock surfaces in meltwater channels from the Superior Lobe. North of Mille Lacs Lake these are the result of glacial lake outwash associated with the Des Moines Lobe.

Similarly, the large sand deposits widespread in the southern half of the watershed are the result of the same glacial outwash associated with the Des Moines Lobe. Deposits at the extreme southern end of the watershed near Anoka are terraced remnants of former channels and floodplains. The calcareous till identified with the Pine City Moraine includes areas of interbedded red and gray drift associated with the incorporation of the underlying Superior-lobe drift. The calcareous till identified with the Culver Moraine is generally a reddish brown clay, with red sediment incorporated from earlier glacial lakes.

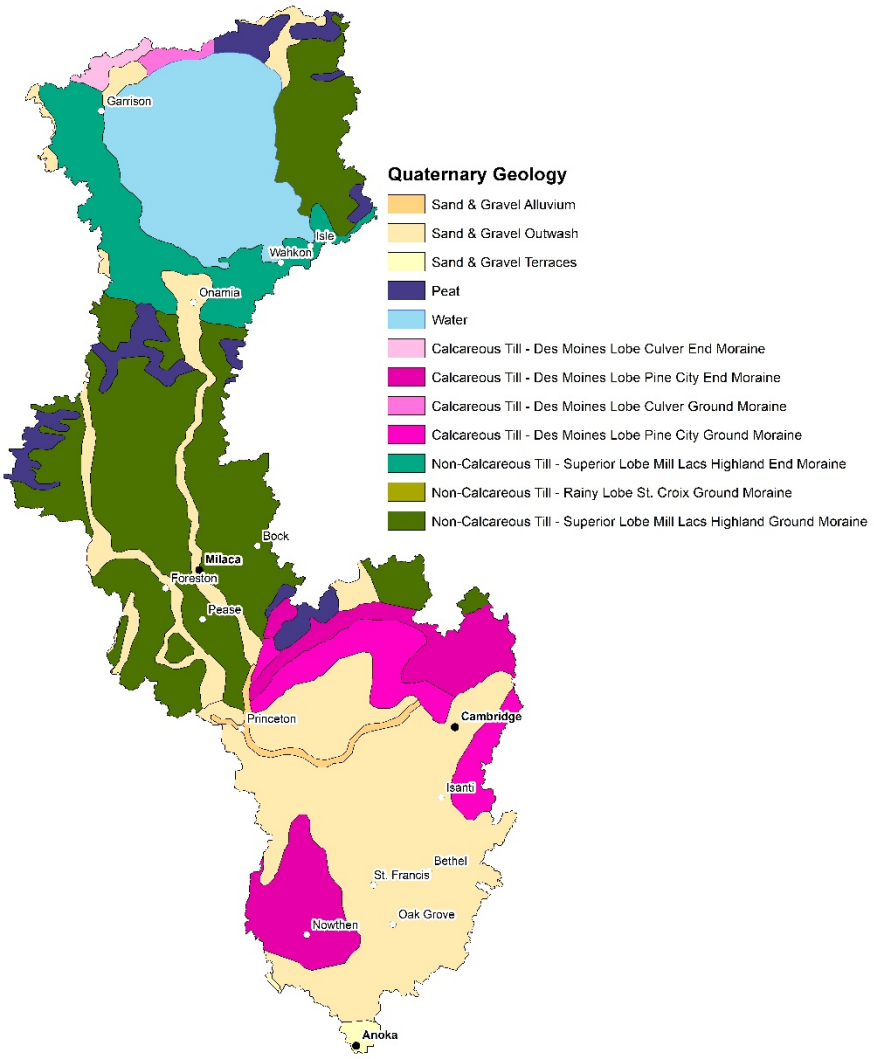

Figure 17: Quaternary Geology (USGS)

Located underneath these glacial sediments is bedrock. Bedrock is the large mass of rocks that form the Earth's surface. In the Rum River Watershed bedrock depth varies, with some areas exhibiting exposed bedrock while others have bedrock that is 400 feet deep or more. According to the Minnesota Geological Survey (MGS) the bedrock geology of the watershed includes Precambrian crystalline rocks in the north and Precambrian and Paleozoic sedimentary rocks in the south.

Paleozoic bedrock formed more recently, approximately 545 to 245 million years ago. This geologic era saw the development of the first land plants and animals. The Precambrian era, immediately preceding the Paleozoic era, began with the formation of earth approximately 4,500 million years ago. This geologic era saw the development of the first multicellular organisms, bacteria, algae, and some invertebrates.

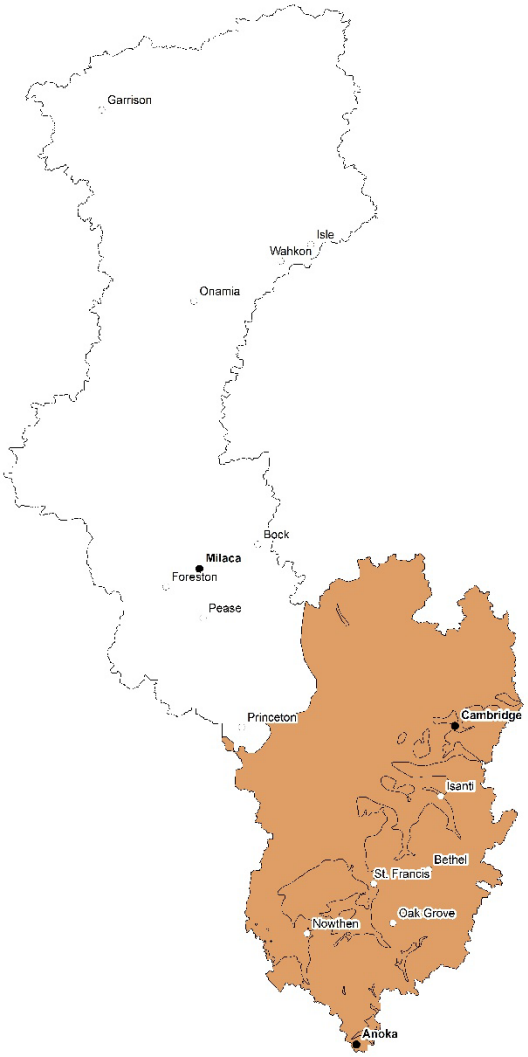

Figure 18: Paleozoic Bedrock (MGS)

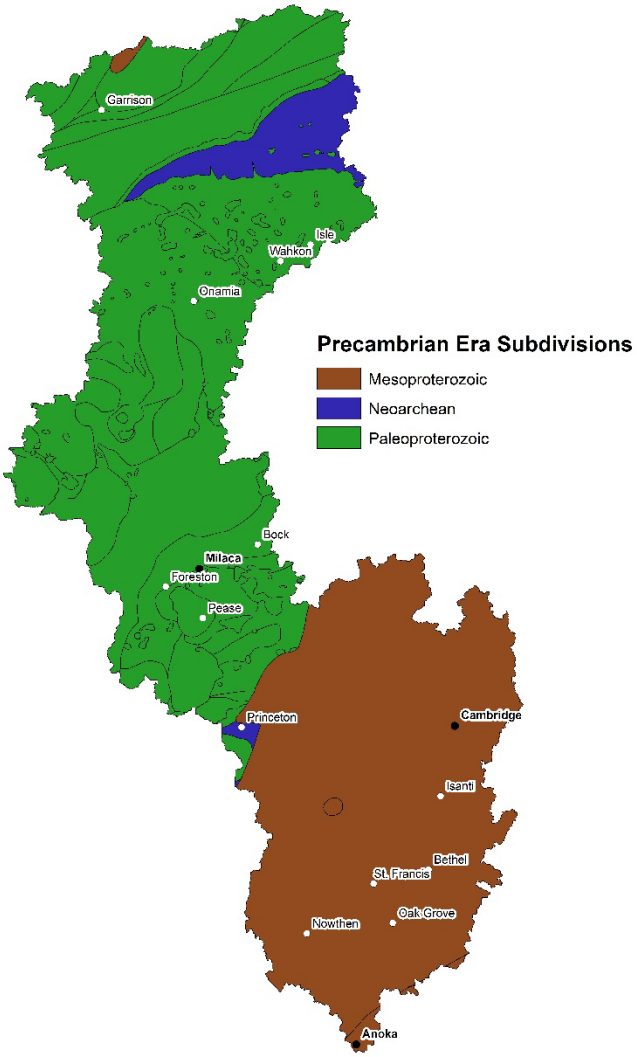

Figure 19: Precambrian Bedrock (MGS)

Moving back to the earth's surface, the elevation of land in the watershed generally decreases from north to south, ranging from approximately 1400 to 800 feet above sea level. The northern end of the watershed has little local relief, nearly level or gently sloping throughout much of the area; drumlins are evident in much of the area. The southern end of the watershed includes nearly level to moderately steep outwash plains and stream terraces.

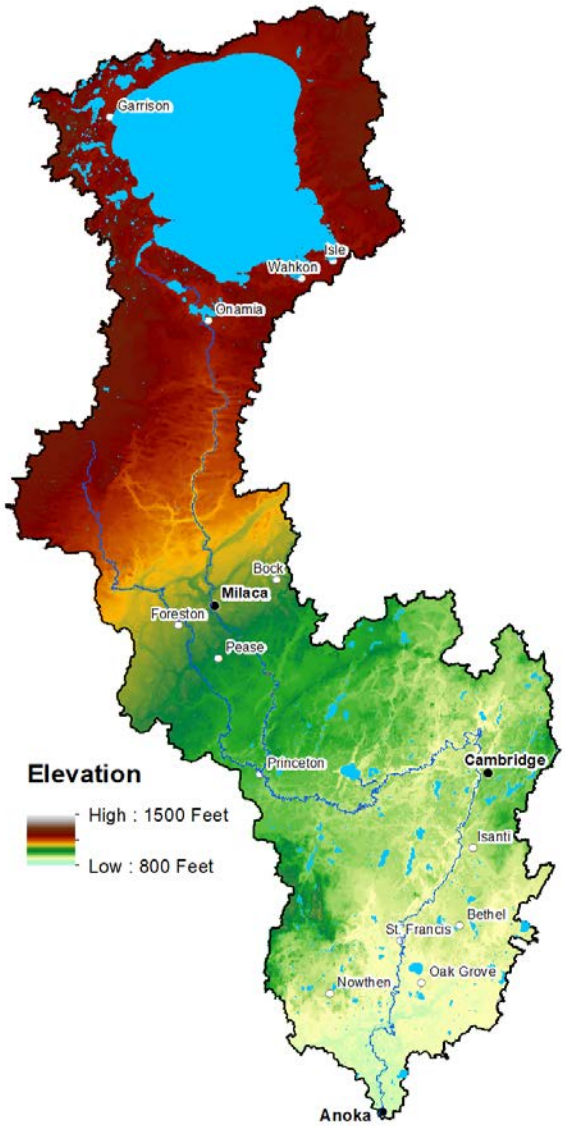

Figure 20: Elevation (USGS)

SURFACE WATER

The Rum River Watershed has many outstanding surface water resources, including 212 lakes and 158 stream segments. The watershed's namesake, the Rum River, works its way through the watershed starting at Mille Lacs Lake and ending in the Mississippi River, traveling 151 stream miles. The Rum River is a great recreational resource; it has been designated as a State Water Trail and State Wild, Scenic and Recreational river, offering excellent canoeing, tubing, and kayaking opportunities. Fishing is another recreational opportunity on the River, with anglers catching smallmouth bass, northern pike, and walleye.

Other major rivers and streams in the watershed include the West Branch of the Rum River, Stanchfield Creek, Cedar Creek, Estes Brook, and Bogus Brook. In total, the 158 public water stream segments in the watershed exceed 680 stream miles. The watershed has an abundance of high-quality lakes, three (3) of which, Mille Lacs, Onamia, and Borden, are over 1,000 acres in size. Mille Lacs Lake in particular is the fifth-largest lake in Minnesota, and offers an ever-expanding list of recreational opportunities.

Figure 21: Public Waters (DNR)

Wetlands are another prevalent surface water resource in the Rum River Watershed, accounting for approximately 24% of the total land area. Nearly one-half of these wetlands are classified as emergent wetlands, dominated by herbaceous perennial plants (e.g. grasses, sedges, etc.). The remainder are scrub shrub or forested wetlands, with a small percentage of deepwater habitats.

Figure 22: National Wetland Inventory (DNR)

DRAINAGE SYSTEMS & WASTE WATER TREATMENT

The Rum River Watershed has many drainage systems and waste water treatment facilities. Reflecting the diverse nature of the watershed, drainage systems in the watershed include both urban stormwater management and agricultural drainage systems. Wastewater treatment facilities include municipal sewer systems, subsurface sewage treatment systems (SSTS), and feedlots.

Urban municipal separate storm sewer systems (MS4s) are publicly-owned stormwater conveyance systems that do not include sewage, and are not part of a publicly-owned treatment system. MS4 systems in urbanized areas are permitted by the MPCA. There are 16 of these systems in the watershed, and all of them are in the southern one-third of the watershed, correlating with areas of high-density development.

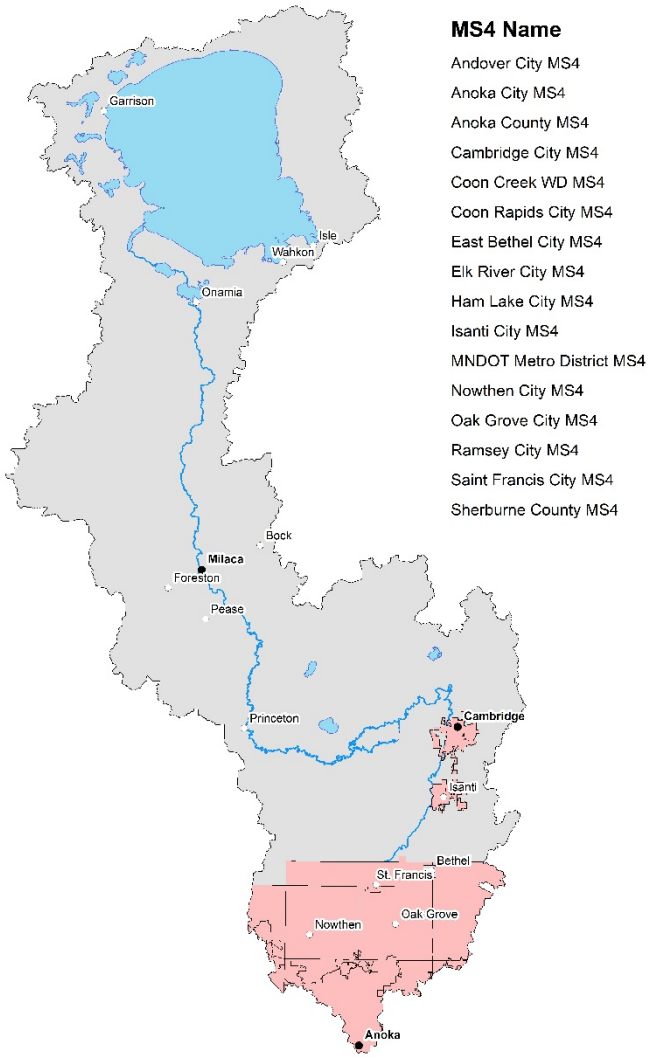

Figure 23: MS4 Boundaries (MPCA)

Urban stormwater conveyance systems are not found in rural areas, but many rural areas still require drainage systems to facilitate effective agricultural production. This drainage is often provided by private and public drainage systems; approximately 27% of the watercourses in the Rum River Watershed are drainage ditches. Many of these are county ditch systems, not roadside ditches, established pursuant to Minnesota Statute 103E and antecedent statutes.

County ditches are managed by drainage authorities, which are generally county boards, watershed district boards, or joint boards thereof in the area served by the drainage system. Funding for these systems is derived from assessments levied against the property owners determined to receive a benefit from the drainage associated with the system's construction, in amounts proportional to the amount of benefit received. There are 236 public ditch segments within the watershed, the majority of which are located in the southern half of the watershed.

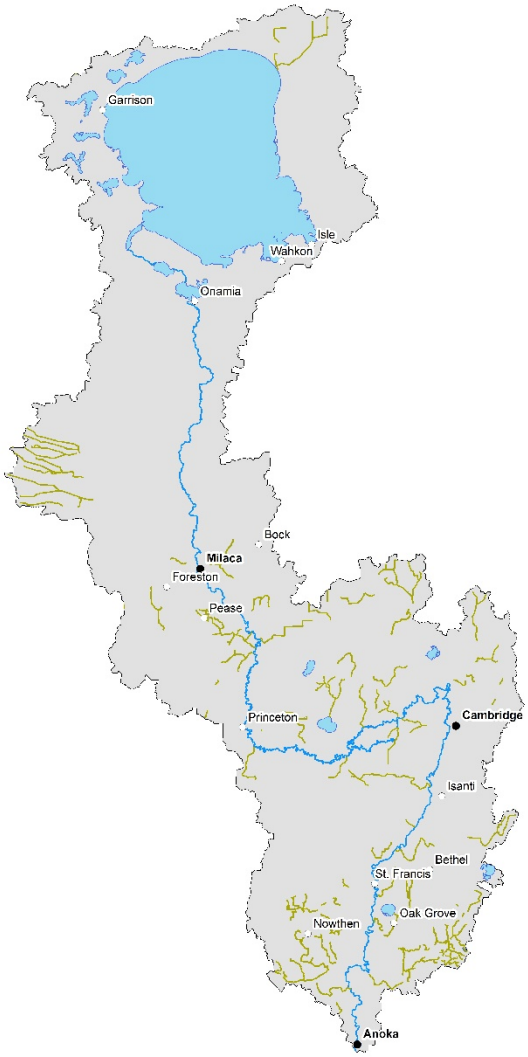

Figure 24: County Ditch Systems (DNR)

Outside of county ditch systems there are many other watercourses that have been altered to provide for additional drainage, including those in both urban and rural areas of the watershed. Altered watercourses were identified and inventoried at a statewide level in 2008 as part of a joint project between the MPCA and the Minnesota Geospatial Information Office (MnGeo). The project categorized streams by category, grouping them as natural, altered, impounded, or no definable channel.

In the Rum River Watershed 51.9% of watercourses were found to be altered. Altered watercourses include those that have been ditched, straightened, or modified. Only 35.8% of watercourses were determined to be in an unaltered natural condition.

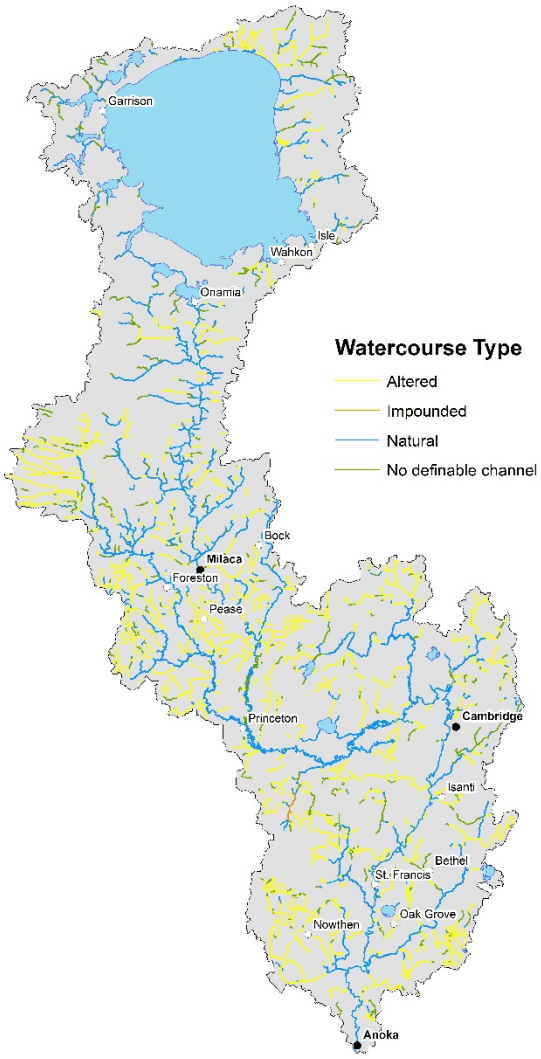

Figure 25: Altered Watercourses (MPCA)

Areas with high-density development often rely on municipal sewer systems to collect and treat wastewater. These systems are often associated with cities, but some have been constructed to serve other areas of high-density development, such as those associated with high-density recreational shoreland development. These systems, along with others that generate and discharge high volumes of wastewater, are permitted by the MPCA through the National Pollution Discharge Elimination System (NPDES) and/or the State Disposal System (SDS). There are 36 of these facilities with current NPDES and/or SDS permits in the watershed; they are generally located in or near regional population centers.

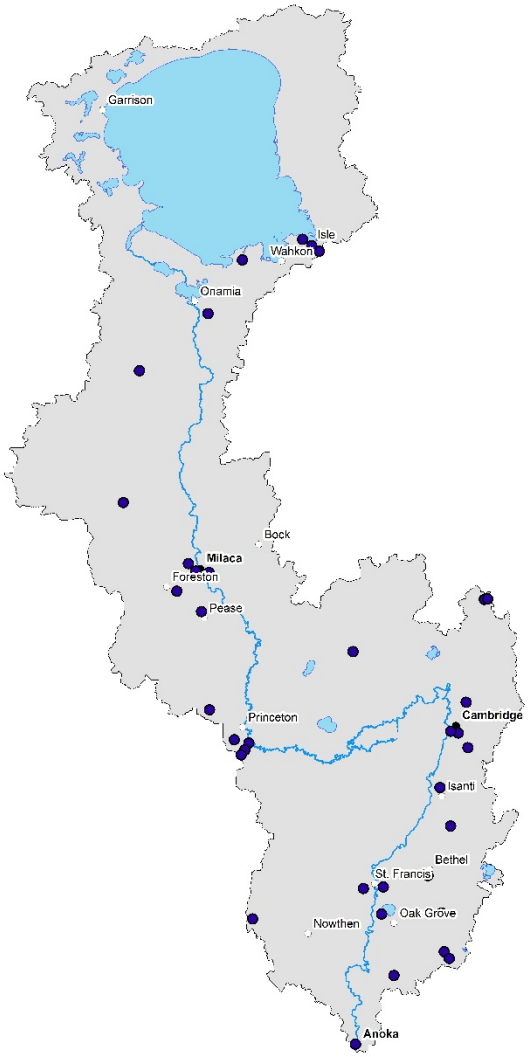

Figure 26: Wastewater Facilities (MPCA)

Instead of large organized collection systems the rural areas of the watershed rely on individual SSTS for wastewater treatment. SSTS are designed and operated in accordance with rules and recommendations from the MPCA and the University of Minnesota. SSTS are permitted locally, typically by counties or townships, although some cities without organized collection and treatment systems do operate their own SSTS programs.

These systems typically rely on treatment and disposal below grade, utilizing aerobic treatment processes in the soil to treat wastewater before discharge to the water table. The Rum River has a shallow water table and dense soils; as a result, many new SSTS are elevated "mound" systems, instead of conventional "trench" systems. As an example, in Mille Lacs County, approximately 76% of all systems are mounds. However, while exact figures are unavailable, it is estimated that there are still many outdated systems that have yet to be replaced with those that are in compliance with current rules and regulations.

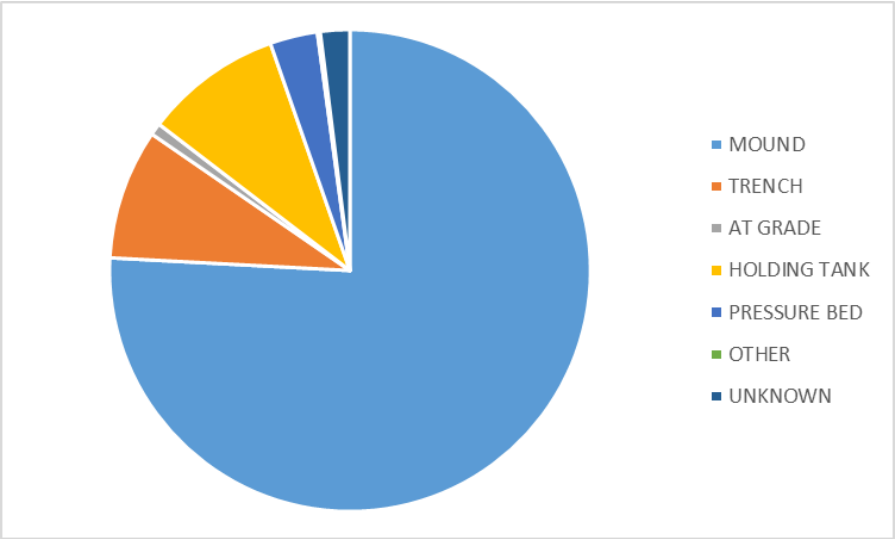

Figure 27: SSTS by System Type – Mille Lacs County (Mille Lacs County Environmental Resources)

Another consideration in regards to waste treatment in rural areas of the watershed is feedlots. The MPCA regulates the collection, transportation, storage, processing, and disposal of animal manure and other livestock wastes. State rules require the registration of all feedlots capable of holding 50 or more animal units (10 in shoreland areas). Animal units are a method of quantifying the waste generated by different animals; one (1) animal unit is equivalent to the amount of waste produced by a typical 1,000 pound steer.

ANIMAL	ANIMAL UNITS
Mature Dairy Cow > 1,000 Lbs.	1.4
Cow/Calf Pair	1.2
Stock Cow/Steer	1.0
Horse	1.0
Diary Heifer	0.7
Swine 55 - 300 Lbs.	0.3
Sheep	0.1
Chicken Broiler (> 5 Lbs., dry manure)	0.005
Turkey > 5 Lbs.	0.018

Figure 28: Animal Units (MPCA)

Manure storage and management requirements associated with feedlot registration and permitting are based on the number of animal units in a feedlot. The enforcement of more restrictive requirements correlates with increased animal units. At 1,000 animal units the feedlot is deemed to be a concentrated animal feeding operation (CAFO). At this threshold additional state and federal permits are required.

There are 275 feedlots in the Rum River Watershed. Approximately 95% the feedlots have 300 animal units or less, and there is only one CAFO. While the total number of feedlots appears to be decreasing, the size of those that remain is growing. This correlates with larger trends in agriculture, in which smaller family farms are being replaced by larger corporate operations. Mille Lacs County is home to nearly half (48%) of all feedlots in the watershed; however, the one CAFO in the watershed is located in Isanti County.

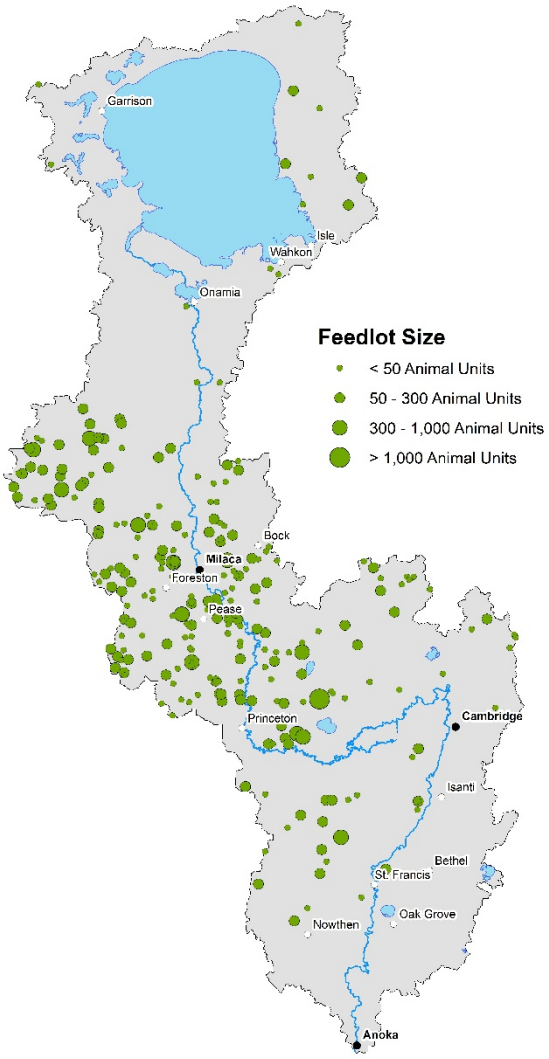

Figure 29: Feedlots (MPCA)

SURFACE WATER QUANTITY

Stream flow data on the Rum River can be utilized as an indicator to assess surface water quantity watershed-wide. The United State Geological Survey (USGS) maintains a streamflow gaging station on the Rum River in St. Francis. Stream flow data is available from 1934 to 2017. This data appears to show that annual mean discharge, a product of water velocity and volume, is increasing over time.

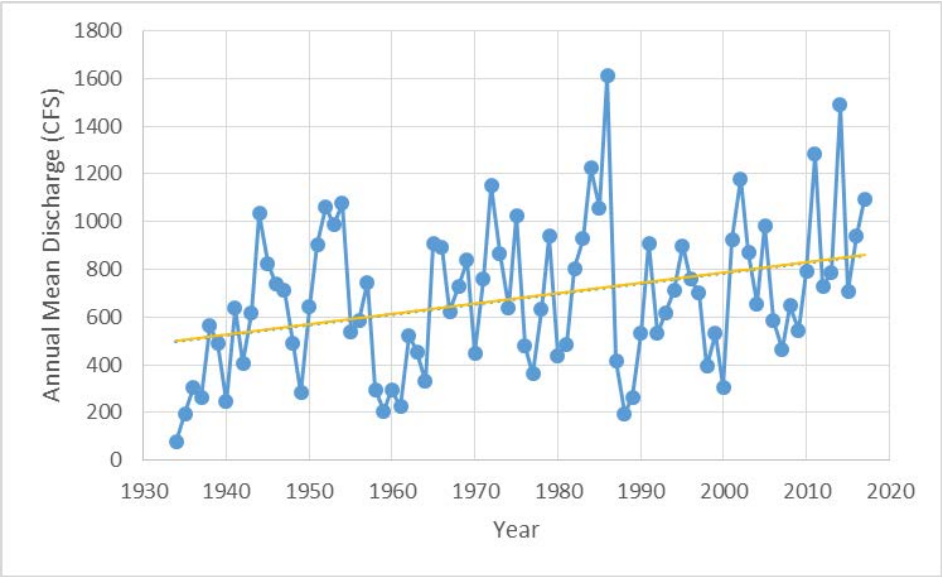

Figure 30: Rum River near St. Francis Annual Mean Discharge (USGS)

Similarly, lake water levels are another useful indicator to assess water quantity. Mille Lacs Lake is the largest lake in the watershed, and the USGS maintains a gage at Cove Bay near Onamia. Lake level data is available from 1992 to 2018. Similar to the Rum River, water levels appear to be increasing, albeit not as dramatically as is exhibited on the river.

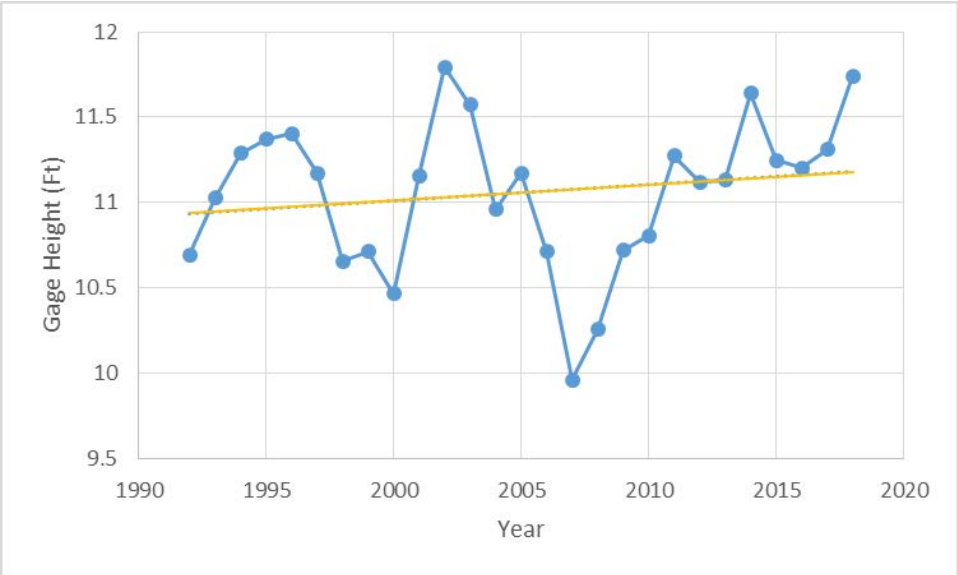

Figure 31: Mille Lacs Lake Water Level (USGS)

Stream discharge and lake levels are directly related to flooding concerns in many areas of the watershed. As a result, many communities participate in the National Flood Insurance Program (NFIP). This program aims to reduce the impact of flooding by providing flood insurance and promoting sound floodplain management. The Federal Emergency Management Agency (FEMA) is responsible for oversight of the NFIP program, and has created Flood Insurance Rate Maps (FIRM) to identify areas that are susceptible to flooding.

The FIRM maps include multiple flood zones, based on the probability of a flood event occurring in a single year. The most common category, known as the base flood, is the 1% annual chance flood zone, otherwise known as the "100-year" flood. FIRM data accuracy and availability varies by location, as the maps are completed on a county basis. Data is unavailable for Kanabec County.

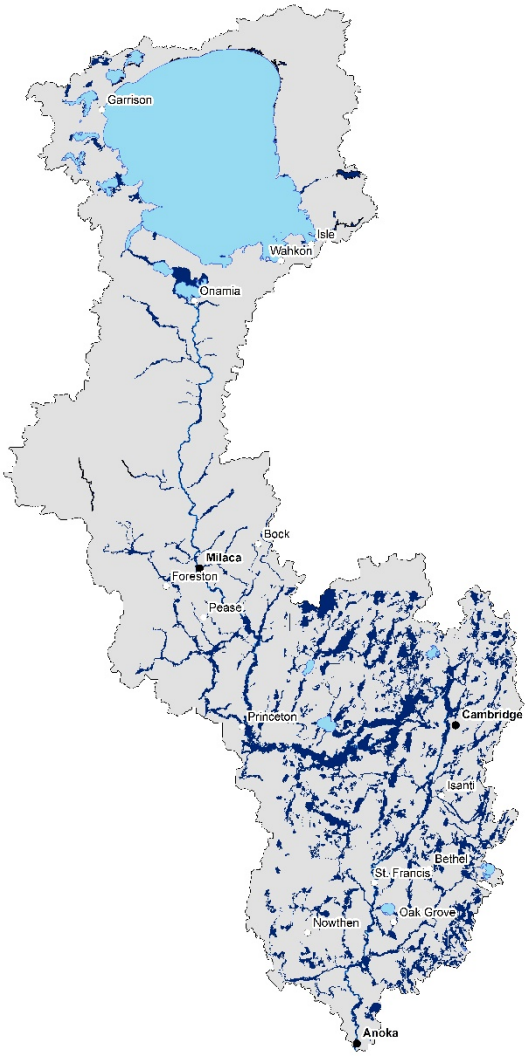

Figure 32: 1% Annual Chance Flood Zones (FEMA/DNR)

SURFACE WATER QUALITY

Surface waters in the Rum River Watershed are generally of high quality, especially in the northern end of the watershed. It is estimated that approximately 40% of Minnesota's lakes and streams are impaired; in the Rum River watershed that figure is less than 10%. However, there are some water bodies that do not meet federal water quality standards for aquatic life, aquatic consumption, or aquatic recreation, with quality generally declining from north to south. It is also important to note that not all water bodies have been assessed for impairments. Mercury in fish tissue and excess phosphorus, causing eutrophication, are the main pollutants.

WATER BODY	YEAR ADDED	COUNTY	AFFECTED USE	POLLUTANT OR STRESSOR
Lake Baxter	2016	Isanti	Aquatic Recreation	Nutrient/eutrophication biological indicators
Bogus Brook	2016	Mille Lacs	Aquatic Recreation	Escherichia coli
Lake Borden	2006	Crow Wing	Aquatic Consumption	Mercury in fish tissue
Borden Creek	2010	Aitkin	Aquatic Life	Dissolved oxygen
Cedar Creek	2016	Anoka	Aquatic Recreation	Escherichia coli
Cedar Creek (Little River)	2010	Mille Lacs	Aquatic Life	Dissolved oxygen
Crooked Brook	2006	Anoka	Aquatic Life	Dissolved oxygen
East Hunter Lake	2016	Sherburne	Aquatic Recreation	Nutrient/eutrophication biological indicators
East Twin Lake	2008	Anoka	Aquatic Consumption	Mercury in fish tissue
Estes Brook	2016	Mille Lacs	Aquatic Life	Aquatic macroinvertebrate bioassessments
Estes Brook	2016	Mille Lacs	Aquatic Recreation	Escherichia coli
Lake Fannie	2008	Isanti	Aquatic Recreation	Nutrient/eutrophication biological indicators
Lake Francis	2016	Isanti	Aquatic Life	Fishes bioassessments
Lake Francis	2002	Isanti	Aquatic Recreation	Nutrient/eutrophication biological indicators
Lake George	1998	Anoka	Aquatic Consumption	Mercury in fish tissue
Green Lake	1998	Isanti	Aquatic Consumption	Mercury in fish tissue
Green Lake	1998	Isanti	Aquatic Consumption	PCB in fish tissue
Green Lake	2016	Isanti	Aquatic Life	Fishes bioassessments
Green Lake	2008	Isanti	Aquatic Recreation	Nutrient/eutrophication biological indicators
Isanti Brook	2016	Isanti	Aquatic Life	Aquatic macroinvertebrate bioassessments
Isanti Brook	2016	Isanti	Aquatic Life	Fishes bioassessments
Lewis Lake	1998	Kanabec	Aquatic Consumption	Mercury in fish tissue
Little Stanchfield Lake	2016	Isanti	Aquatic Recreation	Nutrient/eutrophication biological indicators
Long Lake	2016	Isanti	Aquatic Recreation	Nutrient/eutrophication biological indicators
Mahoney Brook	2016	Anoka	Aquatic Life	Fishes bioassessments
Malone Creek (Thains Creek)	2012	Mille Lacs	Aquatic Life	Dissolved oxygen
Mille Lacs Lake	1998	Aitkin	Aquatic Consumption	Mercury in fish tissue
North Stanchfield Lake	2016	Isanti	Aquatic Recreation	Nutrient/eutrophication biological indicators
Round Lake	1998	Aitkin	Aquatic Consumption	Mercury in fish tissue
Rum River	1998	Multiple	Aquatic Consumption	Mercury in fish tissue
Rum River, West Branch	2016	Mille Lacs	Aquatic Life	Aquatic macroinvertebrate bioassessments
Rum River, West Branch	2016	Mille Lacs	Aquatic Recreation	Escherichia coli
Seelye Brook	2016	Anoka	Aquatic Recreation	Escherichia coli
Lake Shakopee	1998	Mille Lacs	Aquatic Consumption	Mercury in fish tissue
Lake Skogman	2008	Chisago	Aquatic Recreation	Nutrient/eutrophication biological indicators
South Stanchfield Lake	2016	Isanti	Aquatic Recreation	Nutrient/eutrophication biological indicators
Stanchfield Creek	2016	Isanti	Aquatic Life	Fishes bioassessments
Tennyson Lake	2016	Isanti	Aquatic Recreation	Nutrient/eutrophication biological indicators
Tibbetts Brook	2016	Morrison	Aquatic Life	Fishes bioassessments
Trott Brook	2016	Anoka	Aquatic Life	Aquatic macroinvertebrate bioassessments
Trott Brook	2016	Anoka	Aquatic Life	Dissolved oxygen
Trott Brook	2016	Anoka	Aquatic Life	Fishes bioassessments
Twelve Lake	2016	Morrison	Aquatic Recreation	Nutrient/eutrophication biological indicators
Unnamed creek	2016	Morrison	Aquatic Life	Aquatic macroinvertebrate bioassessments
Vondell Brook (County Ditch 11)	2016	Mille Lacs	Aquatic Life	Fishes bioassessments
Washburn Brook (Judicial Ditch 3)	2016	Mille Lacs	Aquatic Life	Fishes bioassessments
West Hunter Lake	2016	Sherburne	Aquatic Recreation	Nutrient/eutrophication biological indicators

Figure 33: Impaired Waters – 2018 (MPCA)

In 2013 the Minnesota Pollution Control Agency (MPCA) initiated a water quality assessment of the Rum River Watershed, conducting biological, chemistry, and flow monitoring on key stream segments. A full Watershed Restoration and Protection Strategy Report (WRAPS) was released in July, 2017. The report identified, on a sub-watershed basis, restoration and protection strategies. These strategies were developed through a combination of public input and analysis of existing data on the quality of waterbodies to identify the strategies and future actions that make sense to address water quality issues. These range from protecting existing high-quality areas to prioritizing restoration of areas that have already experienced impacts.

Figure 34: Impaired Waters (MPCA)

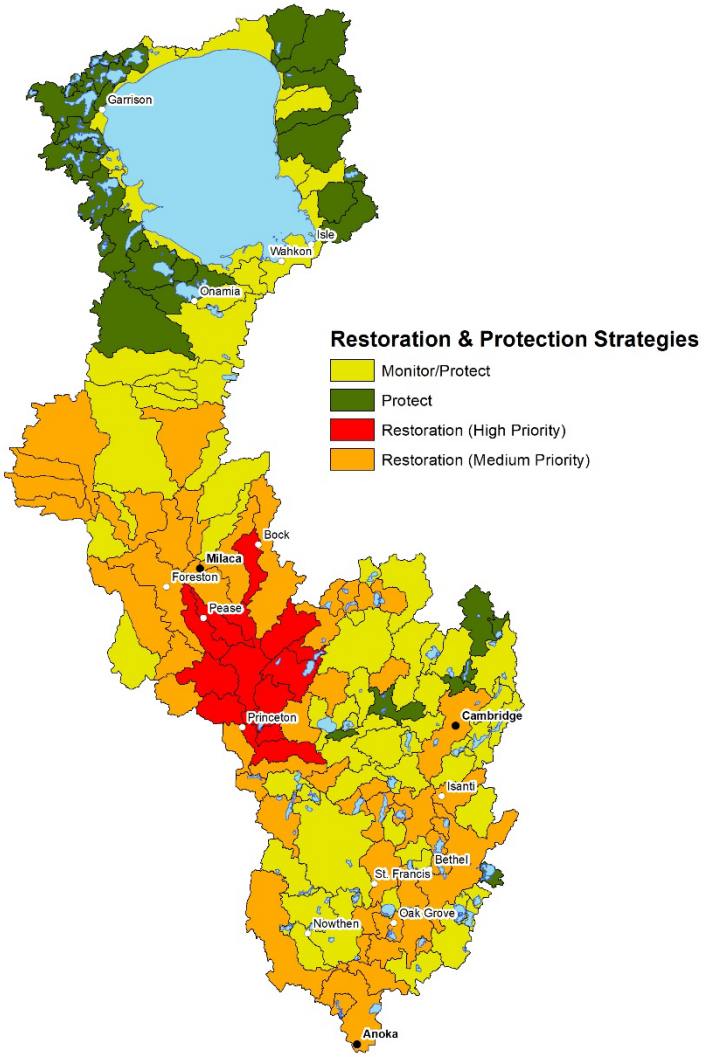

Figure 35: WRAPS Prioritization (MPCA)

The WRAPS report identifies a number of management priorities in addition to impaired waters. For example, the watershed has one lake with declining water quality, Lake George in Anoka County. There are also a number of waters that are close to impairment thresholds including lakes and the Rum River.

GROUNDWATER

Groundwater is one of our most valuable resources. This is the water held underneath the earth's surface in soil pore spaces and fractures in rock formations. Approximately 75% of all Minnesotans rely on groundwater for drinking water.

Wells are located in groundwater aquifers. These are areas in which sufficient quantities of water are readily available, based on the capacity, porosity, and permeability of the applicable sub-surface rock formations. Above the deeper aquifers is the water table, sometimes referred to as the surficial aquifer. This is the upper surface of the saturated area in the ground, in which soils are saturated with groundwater. The surficial aquifer exchanges water with lakes, rivers, and streams.

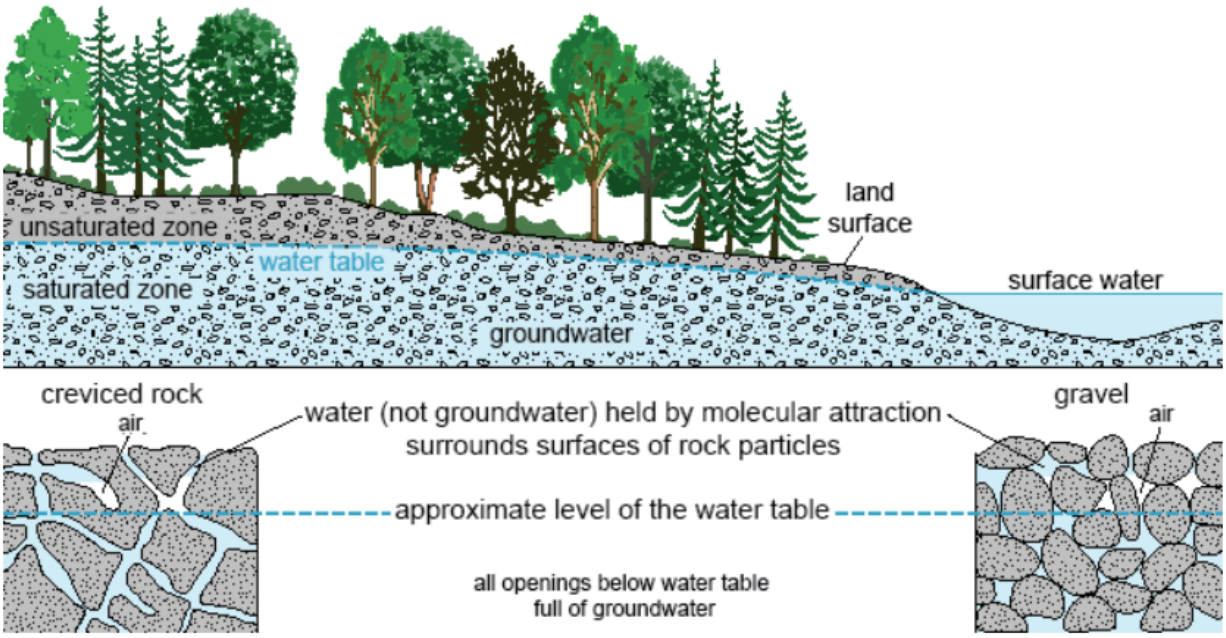

Figure 36: Visualizing Groundwater (USGS)

The availability of groundwater is related to local geologic conditions that determine the type and properties of groundwater aquifers. Based on statewide bedrock and glacial geology Minnesota has been mapped in six (6) groundwater provinces. Within each province, the source and availability of groundwater is similar.

The Rum River Watershed crosses three (3) of Minnesota's six (6) groundwater provinces. Traveling north to south these are the Arrowhead, Central, and Metro provinces. The Arrowhead province has exposed or thinly-covered Precambrian rocks. Groundwater is typically found in faults and fractures.

PROVINCE	SURFICIAL SANDS	BURIED SANDS	BEDROCK
METRO	Moderate	Moderate	Good
CENTRAL	Good	Moderate	Limited
ARROWHEAD	Limited	Limited	Limited

Figure 37: Groundwater Availability by Province & Source (DNR)

Similar characteristics are found in the Central province, which has thick sandy and clayey glacial drift over Precambrian and Cretaceous bedrock. The Metro province has sand aquifers in thick sandy and clayey glacial drift. This is over Precambrian sandstone and Paleozoic sandstone, limestone, and dolostone aquifers.

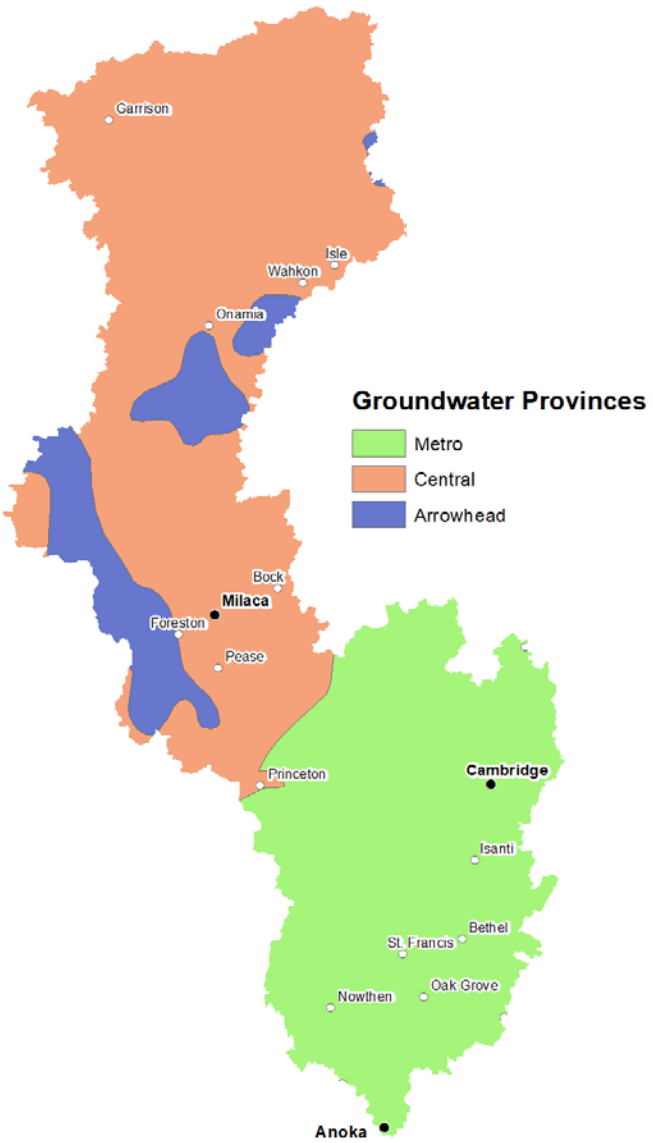

Figure 38: Groundwater Provinces (DNR)

The same geologic factors that influence the availability of groundwater also influence groundwater susceptibility to pollution and contamination. Aquifers that draw from bedrock, covered by thick glacial till, are generally less susceptible to contamination. Those that draw from surficial aquifers covered by sand and gravel have a higher risk.

Based on statewide geomorphology and Quaternary geology the Minnesota Department of Agriculture (MDA) has developed a statewide map illustrating water table aquifer vulnerability. Aquifers in the Rum River Watershed are generally at a medium risk level. However, there are areas of both high and low risk scattered throughout the watershed.

A related factor is water table elevation. The water table is generally within ten (10) feet of the ground surface across the state; however, variations can exist based on local topography and other factors. Within the Rum River Watershed water table depth is generally ten (10) feet deep or less, but deeper water tables are found in some river valleys and floodplain areas.

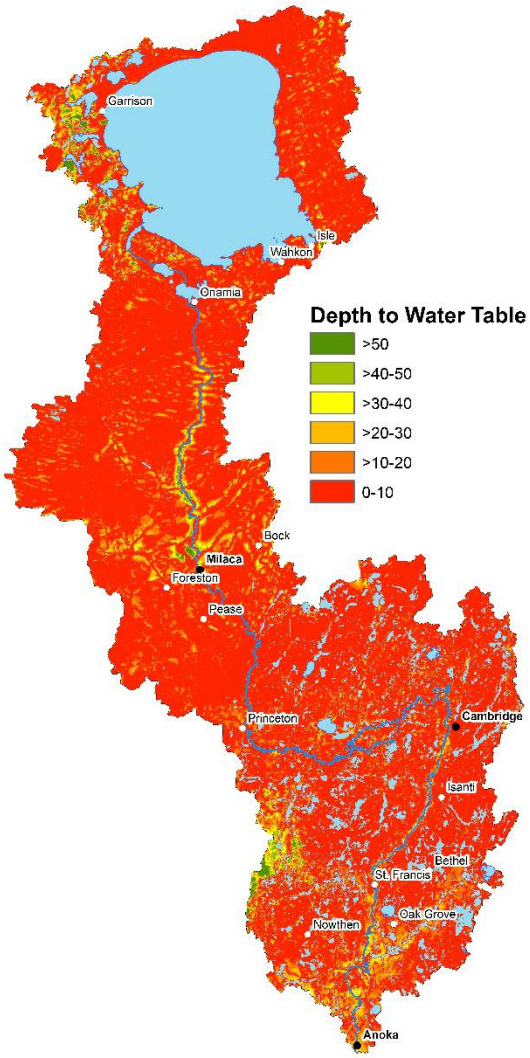

Figure 39: Depth to Water Table (DNR)

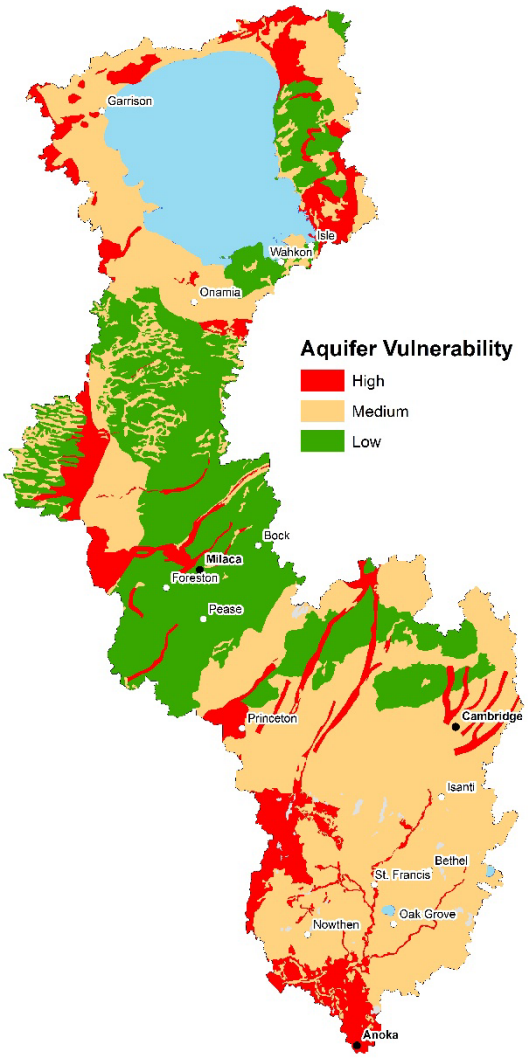

Figure 40: Aquifer Vulnerability (MDA)

While various studies of the geology and aquifers of the region are available, the most recent and comprehensive are County Geologic Atlas'. These are complete or in progress for all counties in the watershed except Mille Lacs. Data is available from the MN Geologic Survey and MN Department of Natural Resources.

GROUNDWATER QUALITY

As a result of our reliance on groundwater as a drinking water resource, quality is of utmost importance. The MPCA's Ambient Groundwater Monitoring Program monitors trends in groundwater quality statewide, including 18 monitoring wells within the Rum River Watershed. The Minnesota Department of Health (MDH) also monitors groundwater quality, analyzing test data from the construction of new wells. Finally, public water suppliers monitor quality of their wells.

The majority of the MPCA's monitoring wells (15) are located in areas served by subsurface sewage treatment systems (SSTS). All but one (1) of the monitoring wells are located in Anoka County. The areas served by SSTS were identified to have higher percentages of contaminants of emerging concern (CECs) than those in urbanized areas CECs demonstrate effects at very low levels of exposure, as such there is no standard "limit" for contamination.

CECs are often manmade chemicals, including pharmaceuticals, pesticides, and detergents. The most common in the Rum River Watershed were sulfadimethoxine, isophorone, and 2-methylanaphthalene. Sulfadimethoxine is an antibiotic. Isophorone is a solvent. 2-methylanaphthalene is a used to make dyes and resins.

Other chemicals of concern include chloride and sodium. Chloride was detected in 93.9% of all samples, with 10 occurrences exceeding the secondary maximum limit, a point at which the contaminant is noticeable for aesthetic considerations, but not presenting a risk to human health. Similarly, sodium was found in wells 98.7% percent of the time; there is no drinking water standard for sodium.

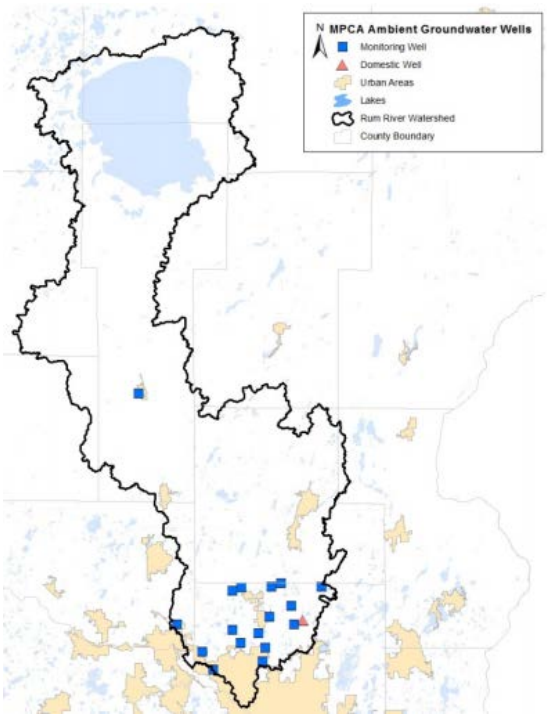

Figure 41: MPCA Ambient Groundwater Monitoring Well Locations (MPCA)

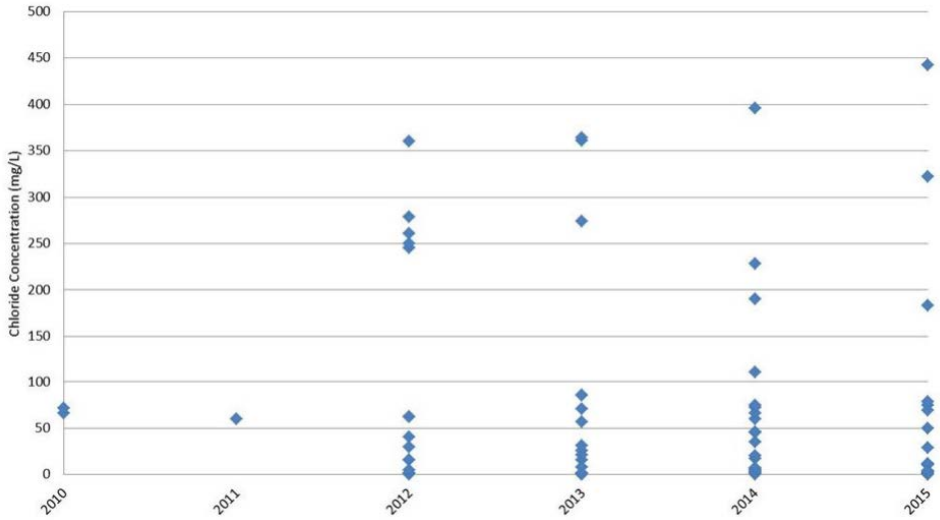

Figure 42: Chloride Detections in Ambient Groundwater Samples 2010 - 2015 (MPCA)

Another chemical of concern is nitrate, a form of nitrogen. Nitrate was detected in 95.2% of the samples, but only three (3) samples were found to exceed the maximum contaminant level of 10 milligrams per liter. This contaminant level was set for the concern of methemoglobinemia (blue-baby syndrome) in infants under the age of six (6) months.

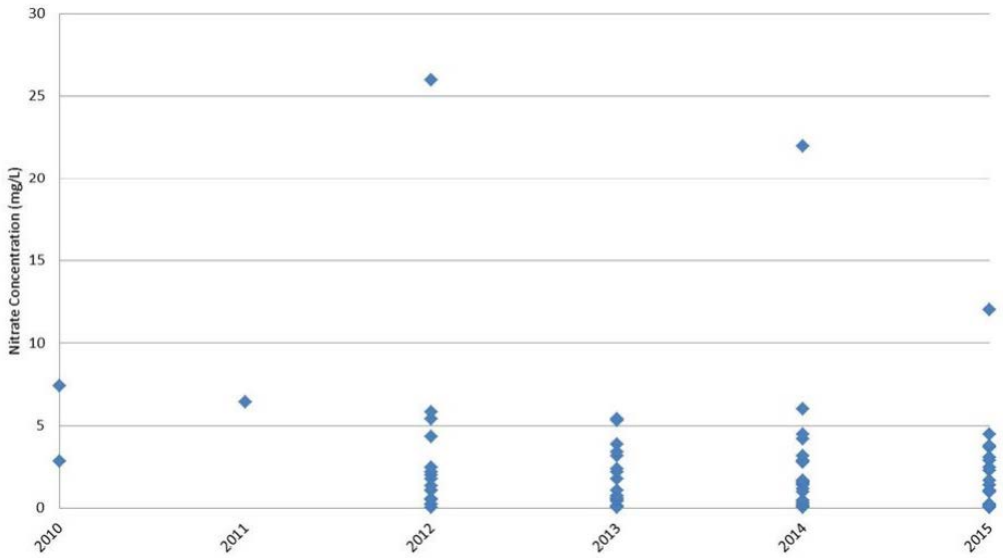

Figure 43: Nitrate Detections in Ambient Groundwater Samples 2010 - 2015 (MPCA)

A naturally-occurring chemical of concern for human consumption is arsenic, which has been found in drinking water wells. Data compiled by MDH from the construction of new wells shows that 10.7% of all wells installed between 2008 and 2015 contains arsenic that is above the maximum contaminant level of 10 micrograms per liter. In the Rum River Watershed individual county information was found to range from 0 to 10%, low in comparison to statewide data.

COUNTY	PERCENTAGE OF WELLS EXCEEDING 10 MICROGRAMS/LITER
Aitkin	5.80%
Anoka	8.80%
Benton	0.80%
Crow Wing	4.30%
Chisago	3.50%
Isanti	2.60%
Kanabec	2.60%
Mille Lacs	0.60%
Morrison	4.10%
Sherburne	2.50%

Figure 44: Percentage of New Wells Exceeding Maximum Arsenic Contamination Levels (MDH)

A contaminant with recently established human health and testing requirements is manganese. Public water suppliers have begun to test for manganese. It does occur at levels exceeding health standards in some areas of the watershed.

GROUNDWATER QUANTITY

Groundwater is not an infinite resource. Groundwater aquifers can be "pumped dry" as a result of human activity when recharge doesn't meet or exceed discharge. As a result, it is important that groundwater volume, recharge, and usage are considered.

As a result, groundwater usage is regulated and monitored statewide. The DNR permits high-capacity ground and surface water withdrawals when pumped volume exceeds 10,000 gallons per day or one million gallons per year. The largest permitted withdrawals in the Rum River Watershed are public and private water supply wells and agricultural irrigation wells.

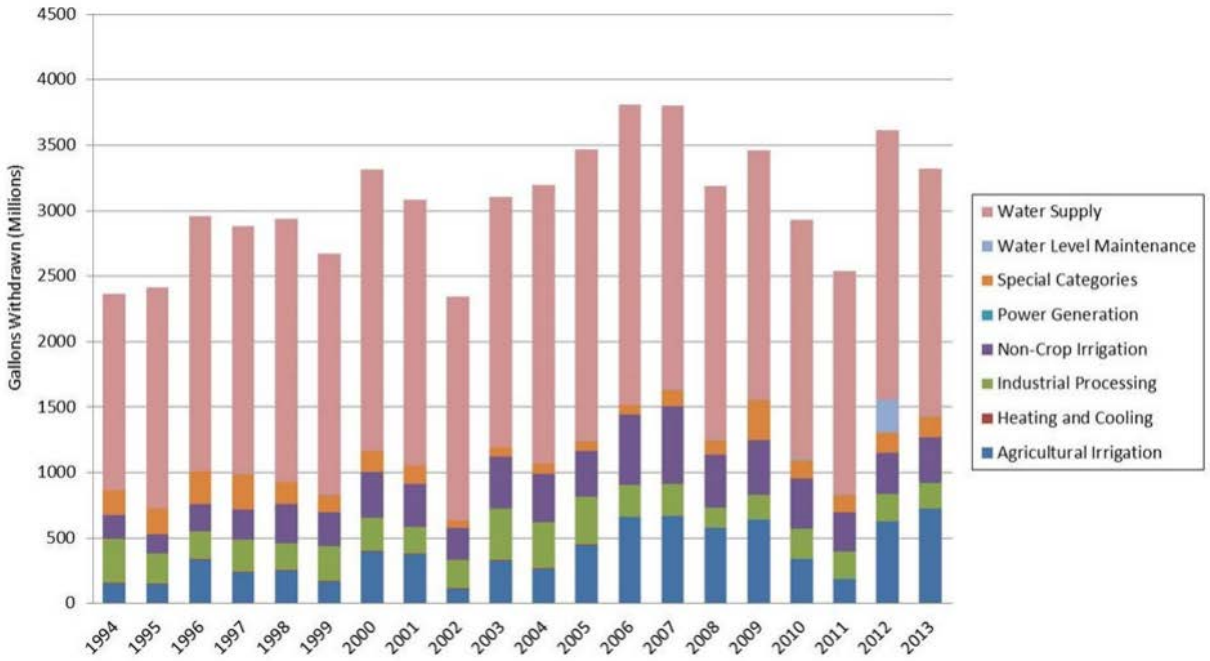

Figure 45: High Capacity Water Withdrawals 1994 – 2013 (MPCA, DNR)

From 1994 to 2013, irrigation, both crop and non-crop, has increased significantly. The other specified uses have not exhibited any significant trends. The majority of the irrigation withdrawals are taking place in the southern third of the watershed, where sandy soils require additional irrigation to provide for effective crop production.

Total groundwater withdrawals tend to be increasing. Total withdrawals increased from approximately 2.5 billion gallons of water in 1994 to 3.3 billion gallons of water in 2013. The most significant increase was for irrigation use. This includes both agricultural and non-agricultural irrigation. A smaller increase was found in surface water withdrawals, which increased from 89.9 million gallons of water in 1994 to 91.4 million gallons of water in 2013.

It is noteworthy that water appropriations data presented here is only for permitted wells. Permits are required only for appropriations of more than 10,000 gallons per day or one million gallons per year. There are many wells, including private residential wells, in the watershed that are excluded from the data presented but cumulatively pump large volumes of groundwater.

It is also noteworthy that some portions of the watershed share aquifers with the larger Twin Cities metropolitan area. Large pumping volumes in the metro could affect aquifers in portions of the watershed that are seemingly distant from the metro. Moreover, rural portions of the Rum River watershed are known to be important areas for recharging aquifers that serve the metro.

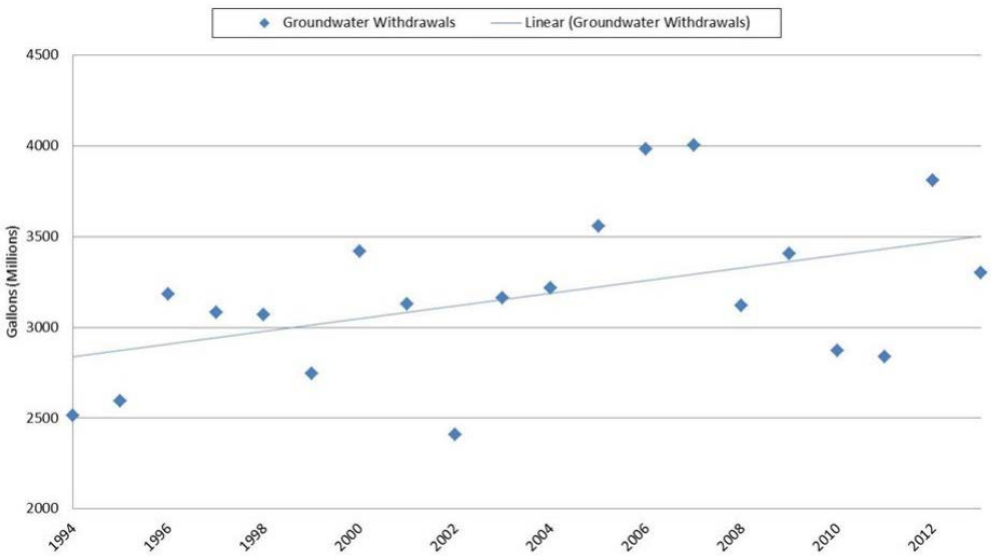

Figure 46: Rum River Watershed Total Annual Groundwater Withdrawals 1994 – 2013 (MPCA)

Groundwater recharge is an important consideration when evaluating the ability of the aquifers to support total withdrawals. Recharge is variable, changing by location and over time. To estimate groundwater recharge, the MPCA, in coordination with the USGS, has developed a statewide estimate of recharge rates.

In the Rum River Watershed the annual potential recharge rate is estimated to be an average of 6.4 inches per year. By comparison, the statewide average is approximately four (4) inches per year. As a result, the Rum River Watershed has a higher than average potential for groundwater recharge.

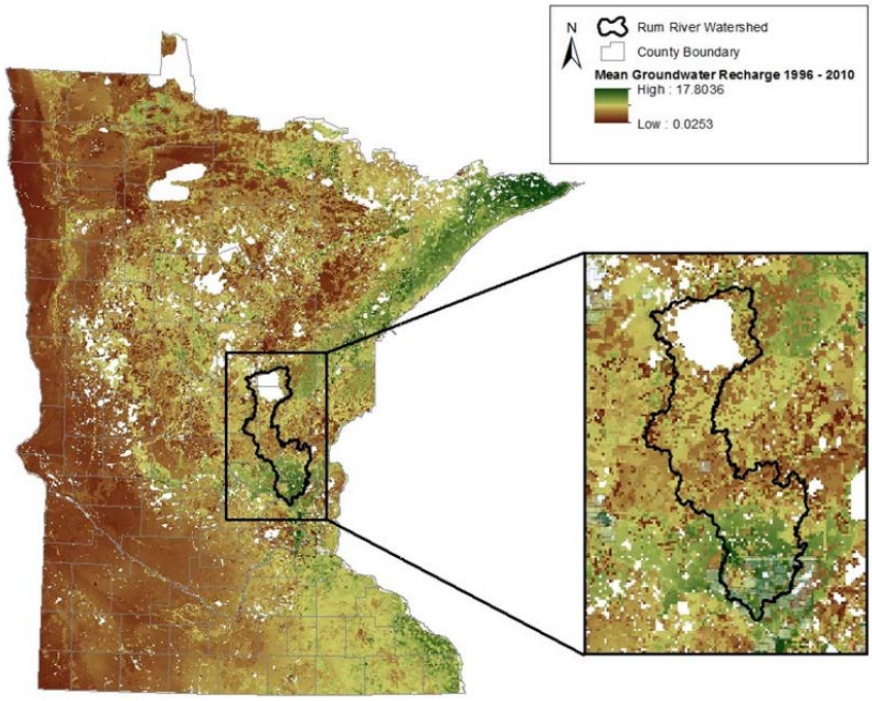

Figure 47: Average Annual Potential Recharge Rate to Surficial Materials 1996 – 2010 (MPCA)

Actual recharge rates can be evaluated by reviewing withdrawals and groundwater aquifer elevations. The DNR tracks the elevations of groundwater aquifers across the state through the use of various monitoring wells. This data provides the elevations of groundwater aquifers, reflecting the fluctuations of the water table as it rises and falls. While fluctuations in the water table elevations are evident, there is no statistical trend in depth to groundwater.

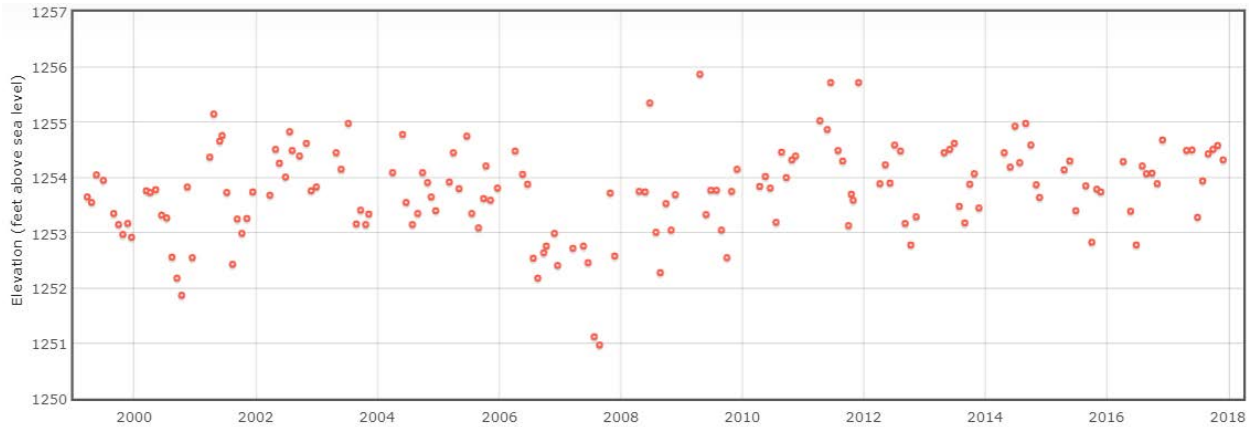

Figure 48: Groundwater Elevations, Wahkon 1998 – 2018 (DNR)

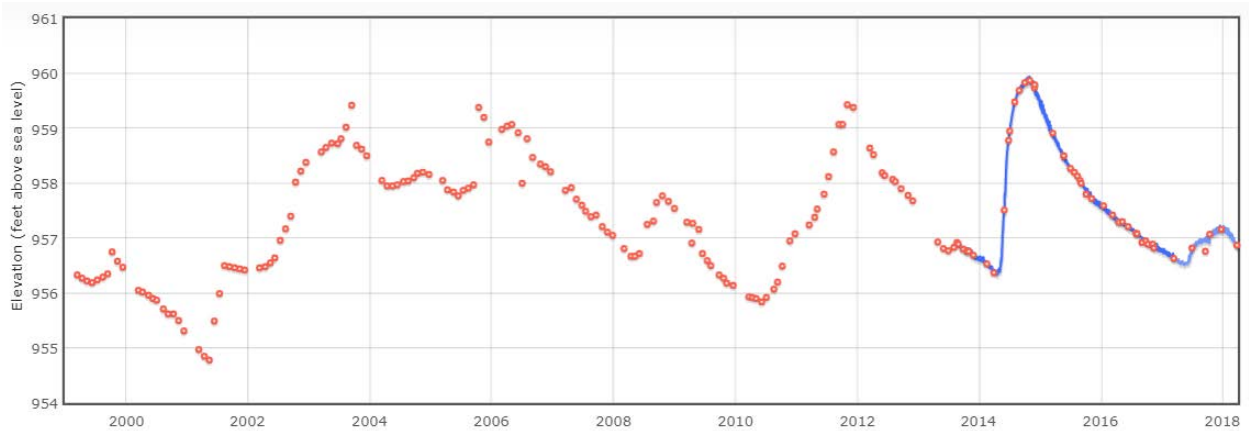

Figure 49: Groundwater Elevations, Princeton 1999 – 2018 (DNR)

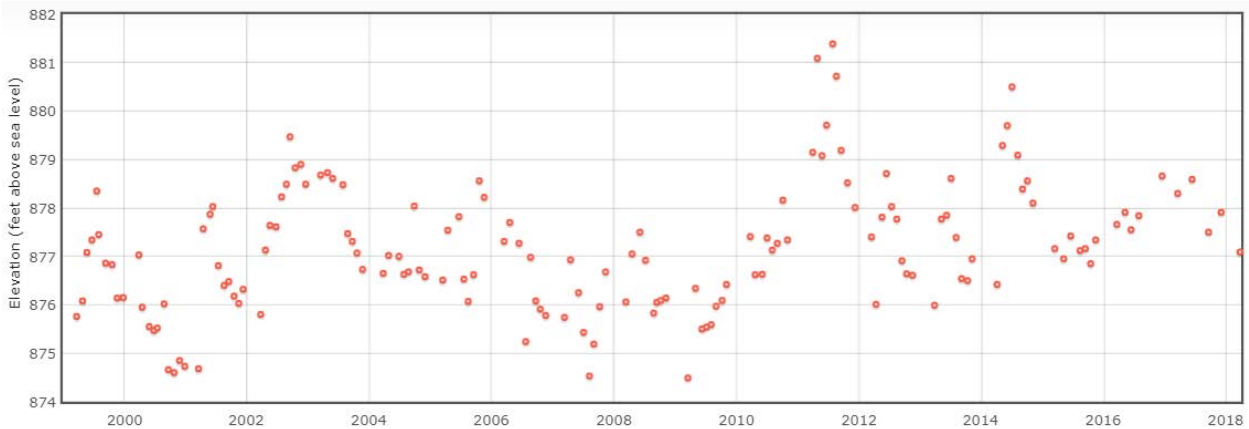

Figure 50: Groundwater Elevations, Oak Grove 1999 – 2018 (DNR)

RECREATION, HABITAT, AND RARE & ENDANGERED FEATURES

In recognition of the Rum River's outstanding scenic, recreational, natural, historical, and scientific values it was added to Minnesota's Wild & Scenic Rivers program in 1978. The Rum River was also designated as a State water trail, offering Class I and Class II rapids for canoers and kayakers throughout the summer. Fishing is another recreational opportunity on the River, with smallmouth bass, northern pike, and walleye being found by anglers in different locations along the River.

Beyond the Rum River recreational opportunities abound. Mille Lacs Lake offers world-class fishing, and was recently ranked as one of the top five bass fishing lakes in the Central region of the United States. The region also offers a plethora of other open-water fishing opportunities, with public water access sites throughout the watershed. Terrestrial recreational opportunities are also available. The watershed has many state parks and state-owned lands that are available for a variety of recreational uses. The watershed also hosts a section of the Soo Line Trail, open for motorized and non-motorized recreation.

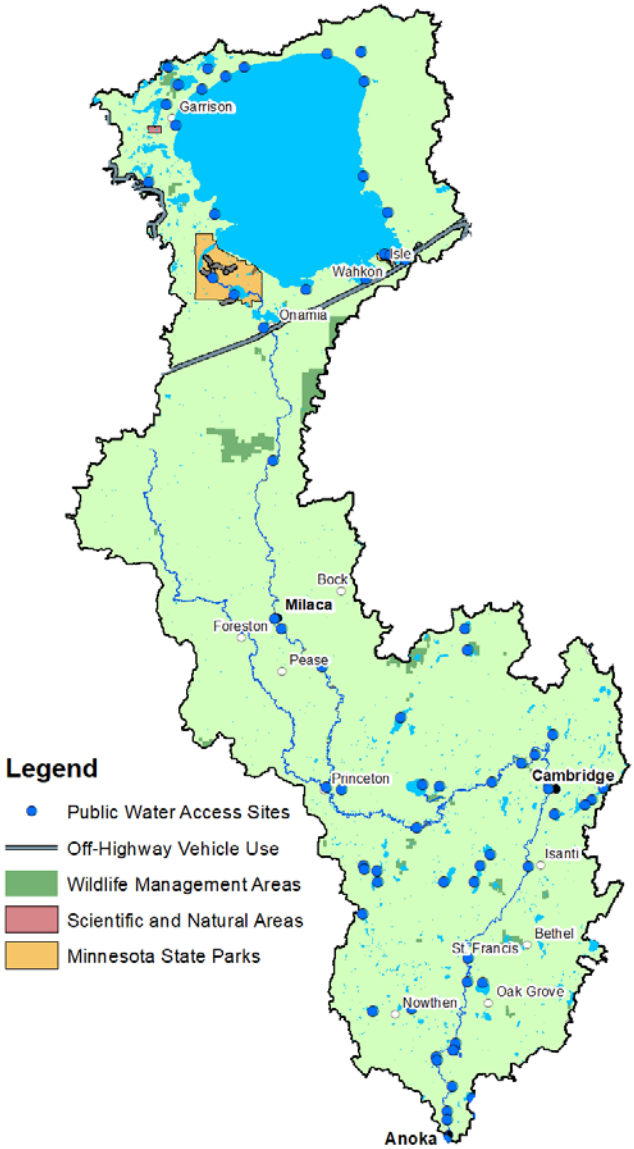

Figure 51: Recreational Resources (DNR)

State and Federal rules require the designation of endangered and threatened species. These include both plants and animals that are protected under the Federal Endangered Species Act. A species is endangered if it is threatened with extinction, a species is threatened if it is likely to become endangered, and a species is of special concern if it has unique or uncommon characteristics that warrant monitoring. There are many listed species within the watershed, including multiple mussel species found in the Rum River.

The Minnesota County Biological Survey (MCBS), a program administered by the DNR, has collected information in select locations on the presence or prevalence of rare plants, animals, and native plant communities. This has been compiled into a statewide dataset with sites ranked based on their importance for the preservation of these species and communities. There are many MCBS sites in the Rum River Watershed, particularly in the north. While many are of moderate significance, or below the minimum threshold for classification as such, there are many large areas of outstanding quality.

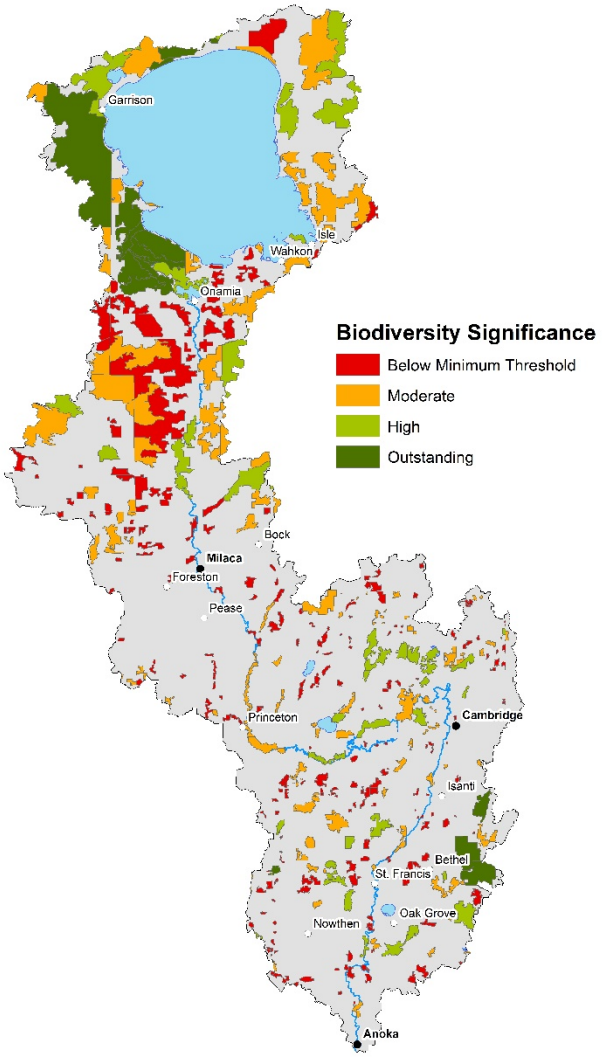

Figure 52: Biodiversity & MBS Ranking (DNR)

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