Grant

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Wells Creek Section 319 Small Watersheds Nine Key Element Plan

Watershed partnerships and planning since the 1990s

MINNESOTA POLLUTION CONTROL AGENCY

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Executive summary

The Wells Creek Nine Key Element Plan (Plan) was developed to fulfill the requirements set forth by the U.S. Environmental Protection Agency (EPA) for recipients of grants appropriated by Congress under Section 319 of the Clean Water Act (EPA 2013). The requirements emphasize the use of watershed-based plans that contain the nine minimum elements documented in the guidelines and EPA's *Handbook for Developing Watershed Plans to Restore and Protect our* Waters (EPA 2008).

The Plan builds on the foundation of many levels of planning efforts, water quality conditions, implementation goals and activities, and an evaluation approach for the watershed. With the EPA approval of the Plan, the Plan will set the stage to further the previous and current restoration activities and continue efforts to achieve the water quality goals in the watershed.

Wells Creek (070400010601, 070400010602) has been identified as a priority area by many organizations and individuals over the years. It was selected by the Minnesota Department of Natural Resources (MDNR) as a test site for comprehensive watershed planning in the early 1990s. Selecting Wells Creek was based on several factors: presence of fisheries data, improving trout population, interest in trout designation for the stream, and engaged landowners working with MDNR and SWCD. At the time, MDNR's newly adopted ecosystem-based management initiative included outreach programs with citizens and local units of government, one product of that outreach was the formation of the Wells Creek Watershed Partnership (WCWP). The purposes of the WCWP were to:

- Initiate a comprehensive watershed management planning process
- Use public involvement and a jointly developed "desired future condition" as a means of integrating ecological, social, and economic values within the watershed; and
- Implement watershed goals to improve biological diversity, hydrology, and water quality while maintaining agricultural profitability

Many improvements have been realized over several decades, however there is more work to be done. Recent Minnesota Pollution Control Agency (MPCA) water quality assessments show year-round exceedances of total suspended solids standards and macroinvertebrate communities beginning to decline. The only permitted entities in the Wells Creek Watershed are feedlots, therefore water quality issues are almost entirely non-point in origin. The watershed exists in southeast Minnesota's karst landscape, where groundwater is a very important factor. Stream flow is primarily the result of groundwater emerging to the surface through natural springs and seeps.

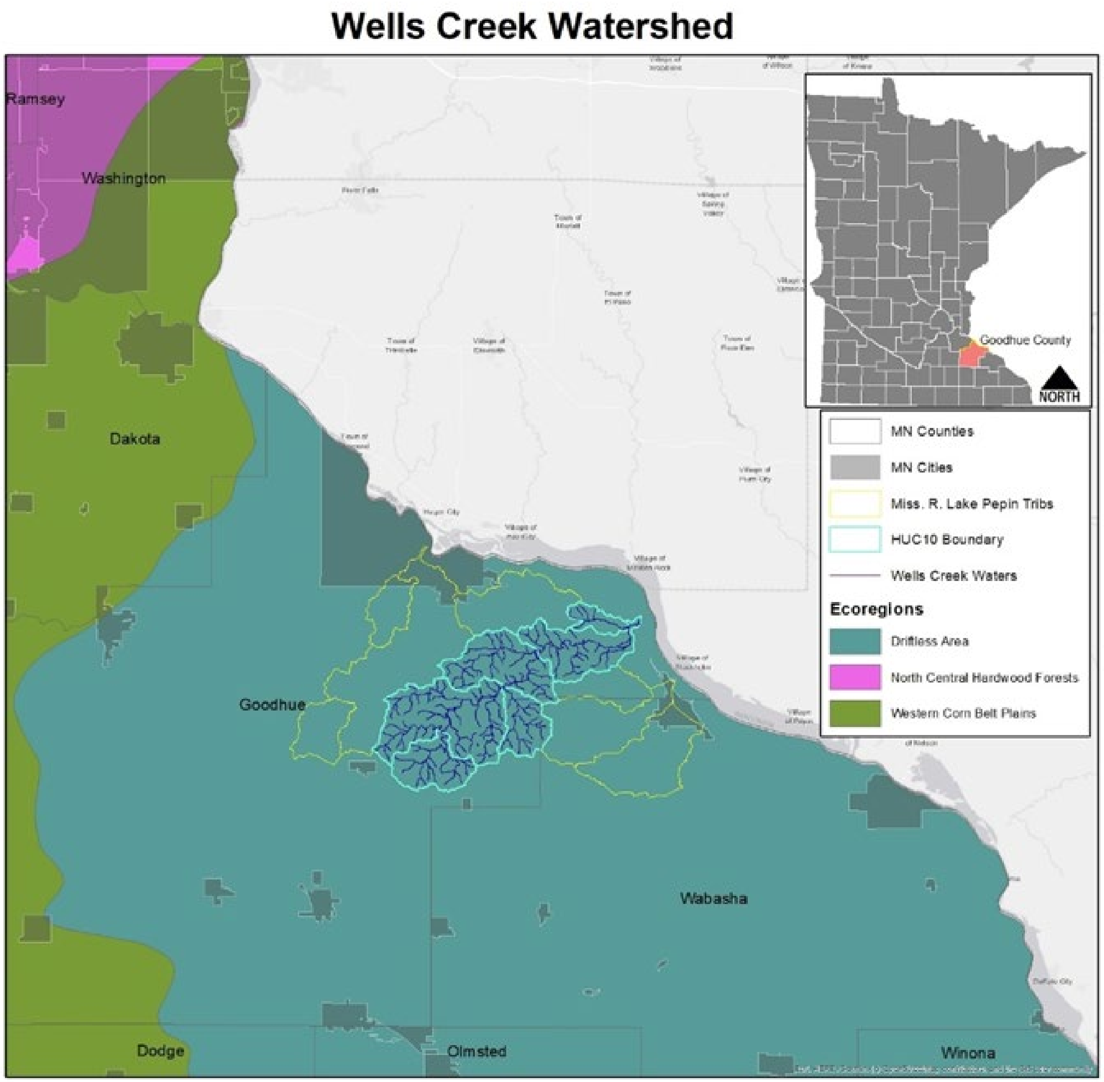
The NKE plan (in collaboration with other reports and documentation) addresses pollutants, sources and solutions in the watershed. For the purposes of the Section 319 grant program, only practices and activities eligible for funding under the EPA 2014 Section 319 program guidance and Minnesota's Nonpoint Source Pollution Program Management Plan (NPSPPMP) are eligible for Section 319 funding. All match activities must be eligible for Section 319 funding, except where noted in the NPSPPMP.

Watershed characteristics

Watershed boundaries

Wells Creek is the largest stream in the lower Mississippi River Lake Pepin Watershed located in Southeastern Minnesota, Figure 1. The Wells Creek HUC-11 watershed covers approximately 72 square miles (45,954 acres) and winds through 18 miles of blufflands before joining the Mississippi River near Old Frontenac. This watershed consists of forests, blufflands, and cultivated land, with the headwaters in rolling cropland that steeply drop through forested valleys. Located almost entirely in Goodhue County and nestled between the cities of Red Wing to the North, Lake City to the Southeast, and Goodhue to the West. The watershed is also entirely in the Driftless Ecoregion of Minnesota, primarily in the Blufflands and Coulees area, with a small portion in the Rochester/Paleozoic Plateau.

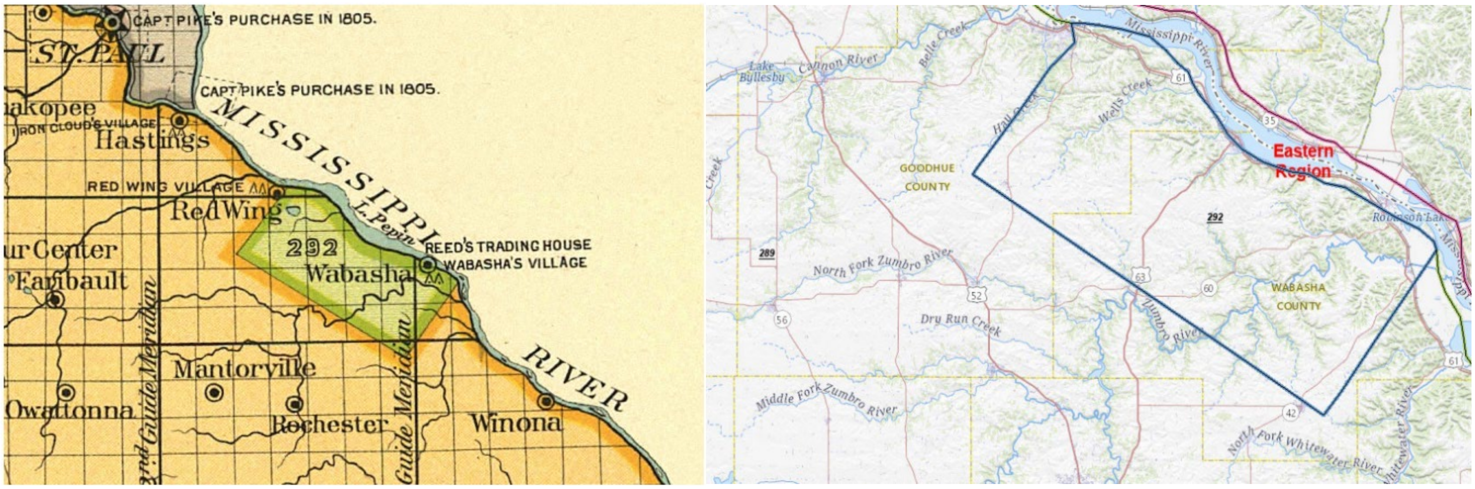
Figure 1. Map of Wells Creek watershed in Goodhue County, MN within the Driftless Area ecoregion



Acknowledgement of Place

The Wells Creek watershed is located entirely within the boundaries of the 1830 Indian Reservation at Lake Pepin, at the time known as the 'Half-Breed Tract'. Dakota people, pressed by the U.S. Government to cede land they held in Wisconsin, signed a treaty in 1830 that included a provision creating an Indian Reservation at Lake Pepin. It was intended to be the home, into perpetuity, of the mixed heritage descendants of traders and their Dakota wives. The reservation extended downriver from present-day Red Wing to Kellogg, and inland 15 miles from the shore of Lake Pepin, Figure 2a and 2b.

Figure 2a and Figure 2b. Boundaries of the 1830 Indian Reservation at Lake Pepin. Extending from Red Wing to Kellogg and inland 15 miles from the show of Lake Pepin



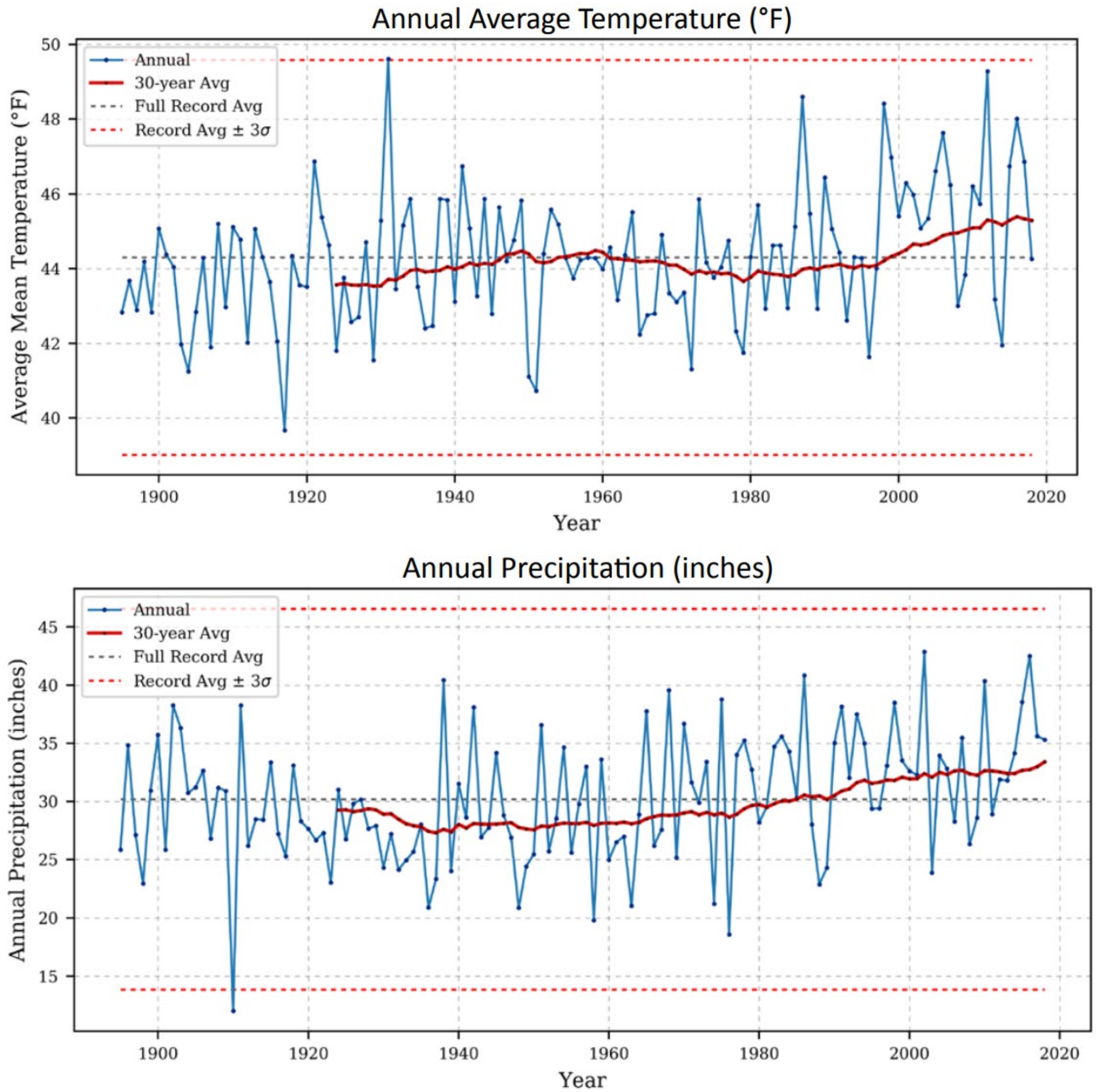
The treaty did not stop settlers and land speculators from claiming ownership of reservation land. To resolve the matter, a plan was made to identify all eligible Dakota persons and give them scrip, coupons granting each bearer rights to 480 acres within the tract, or anywhere else in the Public Domain. General Shields, appointed by the U.S. Government to carry the scrip documents from Washington D.C., arrived in Wabasha on March 23, 1857. The next day, he began distributing scrip to 638 eligible persons, or to their husband or father if they were a married woman or under the age of 21. Although the scrip was supposedly non-transferable, settlers and land speculators found the tract to be a mere complication in eventually acquiring most of the land. Some paid off the men who were related to the Dakota persons who were eligible for scrip.

Wells Creek commemorates James Wells, an early fur trader on Lake Pepin (Upham, 1920). The location of his trading post became the site of Frontenac, MN. James Wells was the scrip holder for his Dakota wife, Jane Graham Wells, and their 13 children; making him the representative of more than 6,000 acres within the tract or anywhere else in the Public Domain. Some of this scrip was claimed in what is now the Frontenac and Lake City areas and then sold to land speculators and new settlers.

Climate and precipitation

Located in the moist subtropical mid-latitude climate, Wells Creek watershed is characterized by warm and humid summers, and cold winters. The annual average temperature is 45.3 degrees Fahrenheit, however the Winter average is 18.2 and the Summer average is 69.7 degrees Fahrenheit. According to the MDNR, average annual temperatures in the watershed over the period of record (1895-2018) have increased 1.6 degrees Fahrenheit and average winter temperatures have increased 3.0 degrees, **Error! Reference source not found.**. Additionally, the MDNR reports the watershed is receiving 3.2 more inches of precipitation, on average, annually when compared to the entire climate record dating back to 1895, Figure 3b. Not only has precipitation and temperature been steadily increasing, heavy precipitation events have also increased. As storms become more frequent and intense, flooding and erosion will be an ongoing challenge.

Figure 3a. Annual average temperature and 3b. Annual precipitation in inches



Large rain events were assessed by the MDNR using available daily precipitation data from a nearby long-term monitoring station in Red Wing, MN. These data show the occurrence of 24 hour storm events of one inch and greater, over 30 year time periods, going back to the beginning of the 20th century (**Error! Reference source not found.**). The largest shift appears to be in the period of 1960-1990, where large increases in the 1-2 inch and 2-3 inch events occurred. The following period, from 1990-2020 had the most occurrences of events above 3 inches of all the periods. Both storm intensity and total annual precipitation volumes have been increasing in the watershed (MDNR 2021).

Table 1a. Average seasonal temperatures, Table 1b. 24 hour rain event intensity totals over 30 year time periods (MDNR 2021)

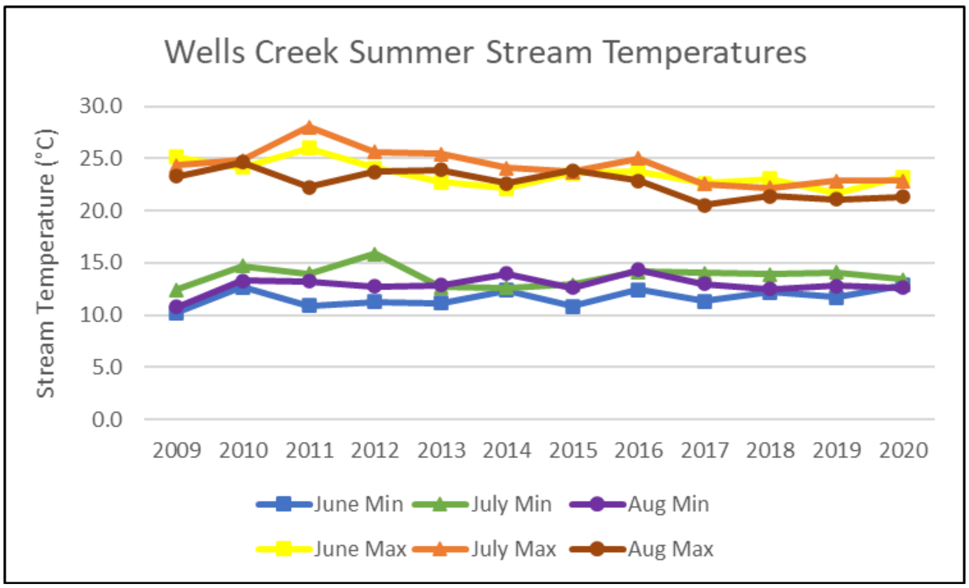
Watershed Average

Time period	Value
Annual	45.3°
Winter (Dec. - Feb.)	18.2°
Spring (March - May)	45.1°
Summer (June - Aug.)	69.7°
Fall (Sept. Nov.)	48.1°

Time Period	1-2"	2-3"	3-4"	+4"
1900-1930	135	18	2	1
1930-1960	122	18	5	3
1960-1990	153	30	4	2
1990-2020	177	34	6	6

Despite the increases in air temperatures, stream temperature annual minimum and maximum values from continuous monitoring in Wells Creek, **Error! Reference source not found.**, appear to show no trend over the last decade. Increased precipitation may be leading to an increase in groundwater fed base flows regionally, which may be keeping stream temperatures consistent despite the increases in air temperature. It will be important to continue monitoring these trends over time to ensure the protection of these cold-water ecosystems.

Figure 4. Minimum and maximum summer stream temperatures in Wells Creek 2009-2020



Topography / elevation

In Wells Creek watershed, gently rolling uplands in the west give way to steep bluffs and forested hillsides as you move east, Figure 4. Where these steep lands intersect the valley floor, springs indicate the beginnings of Wells Creek. Tributaries, springs, groundwater, and runoff contribute additional flow to Wells Creek as it winds 18 miles through the valley to its mouth at the Mississippi River (Robbins 1996). The highest elevation in the watershed is 375 meters (1230 feet) above sea level and the lowest is 203 meters (670 feet) above sea level, giving the watershed 172 meters (564 feet) of elevation change. Much of this elevation change occurs in the lower half of the watershed.

Figure 5. Image of one biological monitoring station on Wells Creek

Wells Creek, and many other streams in the Driftless region of Minnesota, is often described in two unique sections primarily defined by topography. A large amount of erosion occurs in Upper Wells Creek, where the stream and tributary gradients are much steeper. Sediment erosion and deposition occurs in Lower Wells Creek, where stream and tributary gradients are lower. Through MDNR's Watershed Assessment of River Stability and Sediment Supply (WARSSS) work, a longitudinal elevation profile was produced for Wells Creek (Figure 5), this profile shows the change point between Upper and Lower Wells Creek. This change occurs roughly where Goodhue County 45 meets Goodhue County 2.

Figure 6. Wells Creek longitudinal profile

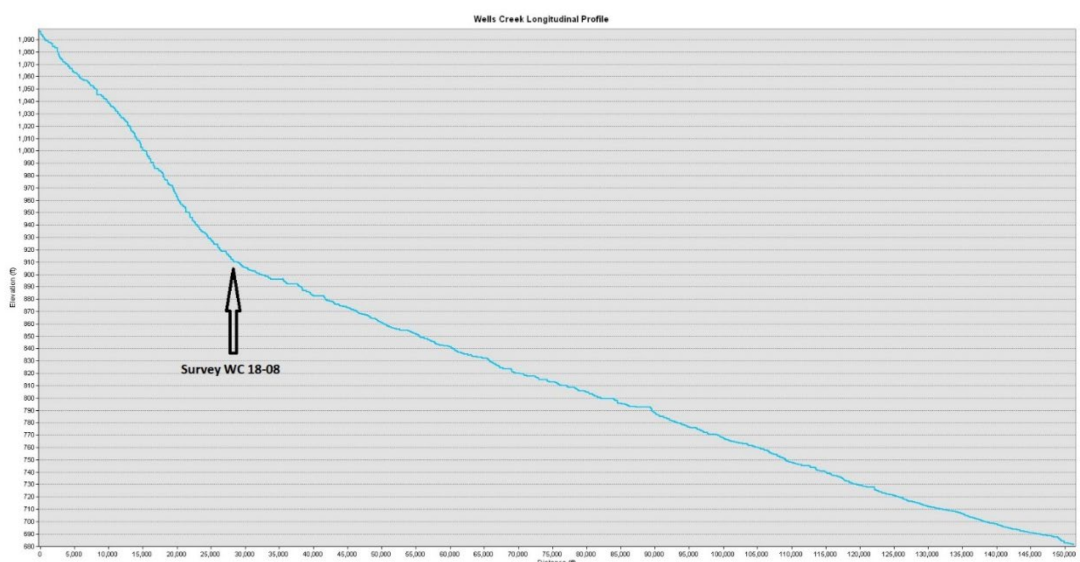
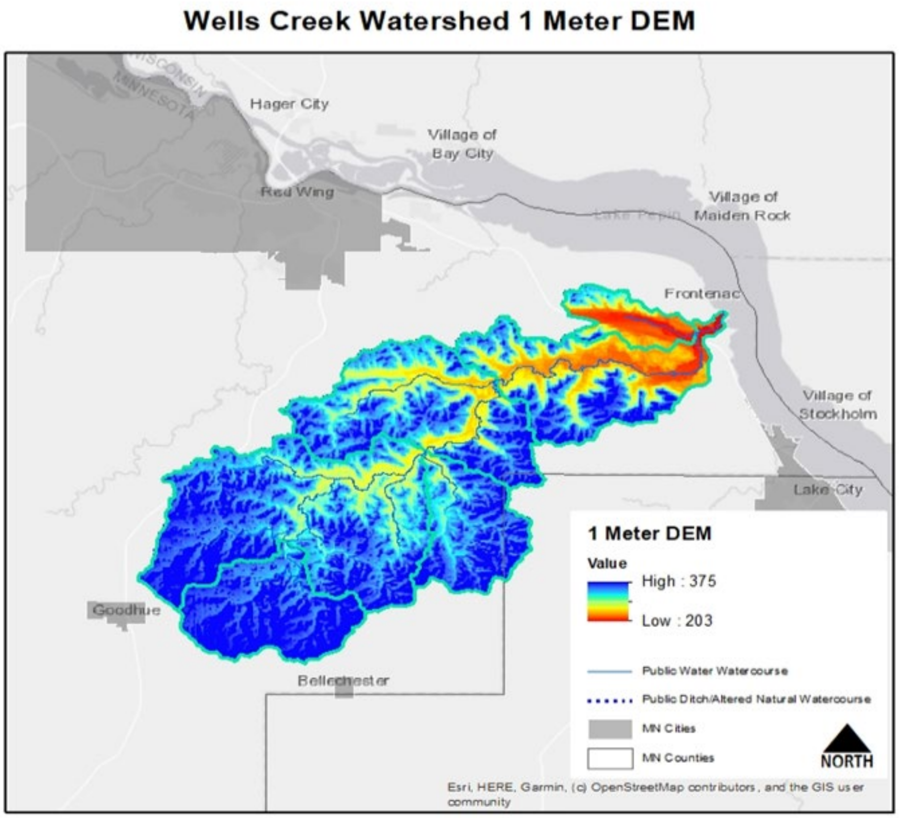


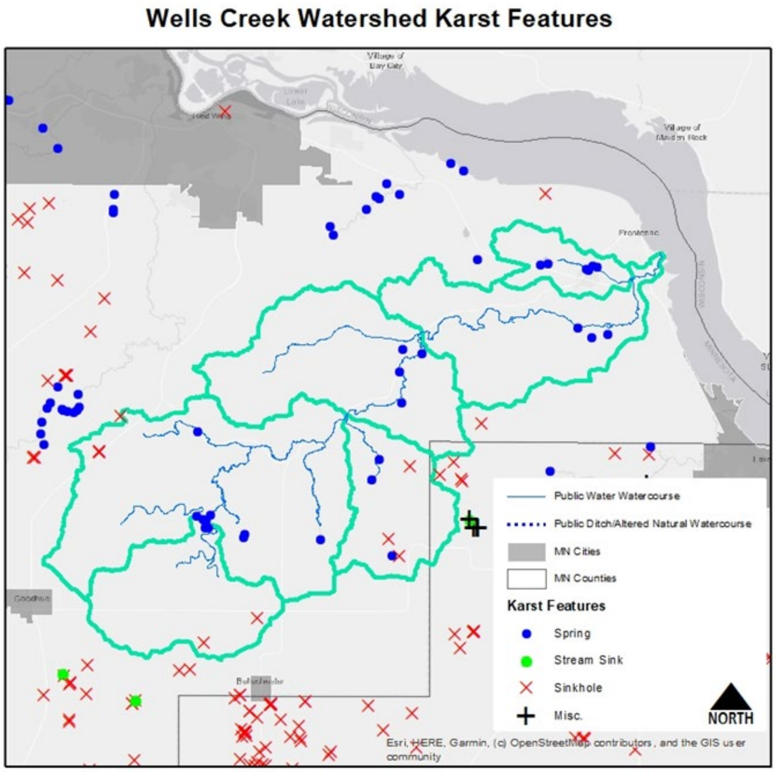
Figure 7. One meter digital elevation model (DEM) Wells Creek watershed



Geology

The Driftless Area is a geographic region covering parts of southwest Wisconsin, southeast Minnesota, northeast Iowa, and a small part of northwest Illinois. The distinctive landscape of the Driftless Area is characterized by craggy limestone, sandstone valleys, and steep hillsides. This ancient terrain has one of the highest concentrations of limestone spring creeks in the world. The groundwater that feeds the streams in southeast Minnesota helps maintain stable habitat conditions favored by trout and the insects they feed on.

Figure 8. Karst features in and around Wells Creek watershed



Geology of southeast Minnesota is distinguished by karst features. In karst, water dissolves fractures and joints in the limestone bedrock over millions of years, forming a network of interconnected underground pathways that can carry groundwater long distances at speeds up to miles per day. These pathways can be hidden and form rapid pathways from pollution release points to drinking water wells or back to surface waters. Surface water and groundwater are so closely connected in karst areas that the distinction between the two is difficult to determine. Groundwater may emerge as a spring, flow a short distance above ground, only to vanish in a disappearing stream, returning to groundwater conduits and perhaps re-emerging farther downstream again as surface water. It has been argued that the two classical components of the hydrologic cycle- “groundwater” and “surface water”- should be referred to as “water resources” and treated as a single unique system in southeastern Minnesota (MPCA, 2017). **Error! Reference source not found.** shows some karst features in the Wells Creek area, primarily springs and sinkholes. This is not a complete inventory of karst features, but rather those that have been reported to the MDNR.

General hydrology

Wells Creek watershed has more than 170 miles of mapped intermittent and perennial streams, of this, 16% are classified as perennial and 84% are intermittent. The MN’s Administrative Rule 7020.0300 Subpart 13a refers to the United States Geological Survey’s identification of intermittent stream; which is defined as “A stream that flows only when it receives water from rainfall or springs, or from some surface source such as melting snow.”

According to the Minnesota Statewide Altered Watercourse Project, Wells Creek watershed has 43% natural stream channels, 21% altered channels, and 3% impounded. 33% are classified as ‘no definable channel’, situations where a watercourse would be classified as ‘no definable channel’ are:

- Watercourses crossed by row crops or other tillage,

- Watercourses that are indistinct or do not exist on light detection and ranging (LiDAR) imagery in non-wetland areas,
- A flowline that does not have an associated Digital Raster Graphic, watercourse is either a new, likely altered watercourse or a mistake,
- Flowlines designated as pipelines,
- The surrounding terrain was recently urbanized, mined, or otherwise developed,
- Wetland area with indistinct/indefinite watercourse, or
- Watercourse channel is dry in most years and frequently grassy, wide and shallow in LiDAR.

Figure 9a. Percentage of perennial and intermittent stream channel in Wells Creek watershed, 9b. Percentage of natural, altered, or impounded stream channels in Wells Creek watershed

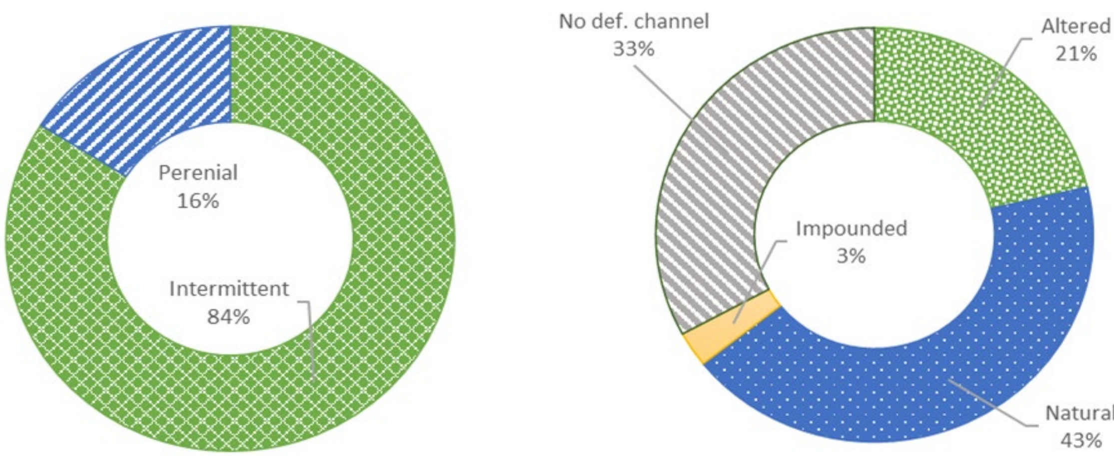
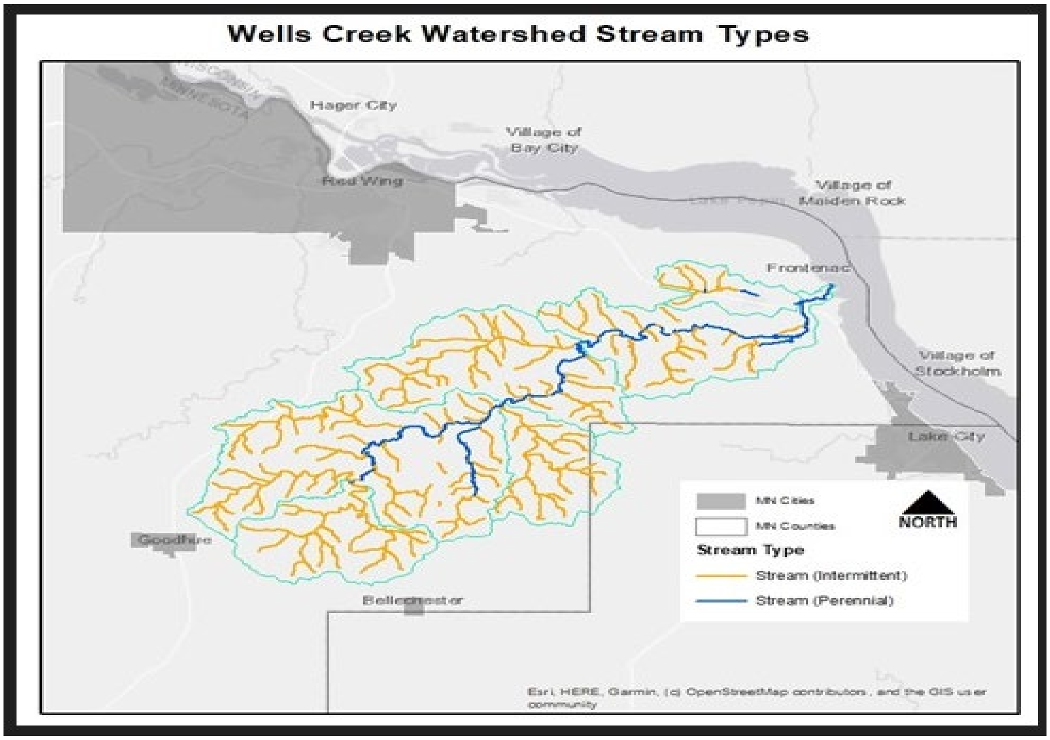


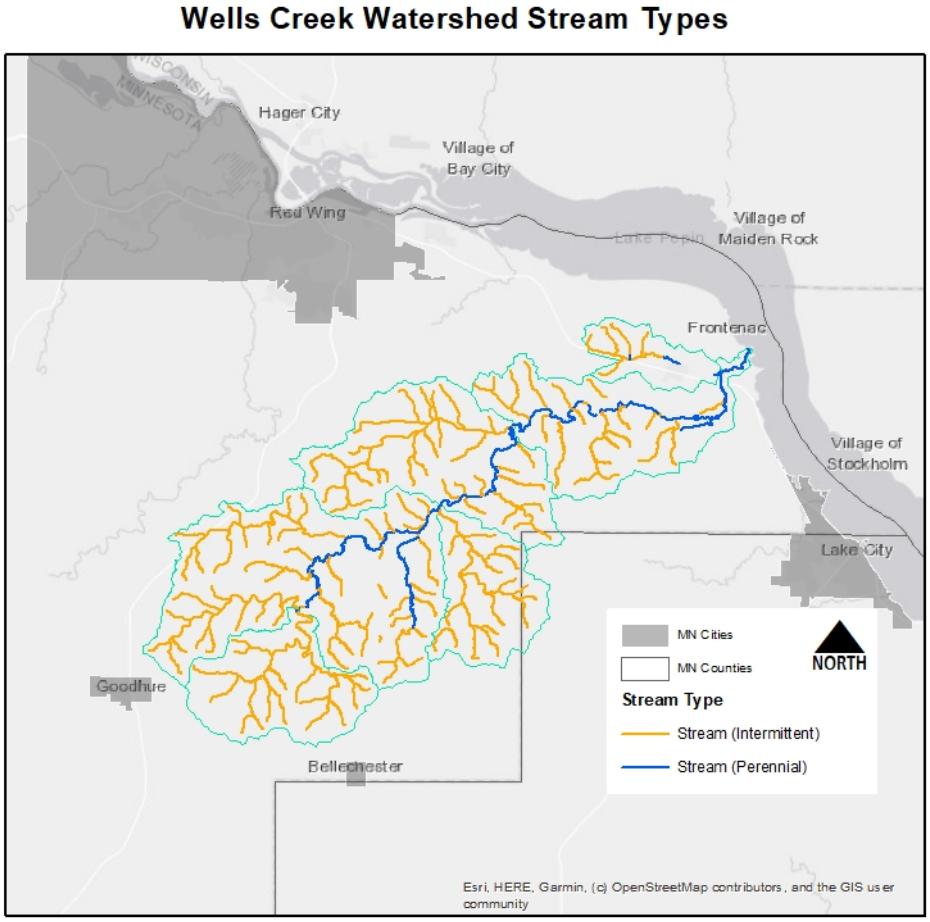
Figure 10. Map of perennial and intermittent stream channels in Wells Creek watershed



Surface water and Ground water resources

As discussed in the Geology section, it has been argued that the two classical components of the hydrological cycle - 'ground water' and 'surface water' - should be referred to as 'water resources' and treated as a single unique system in Southeastern Minnesota. This relationship is made clear through the Karst Features map above and the groundwater pollution vulnerability map below. The karst features map displays several springs in the watershed, and a few sinkholes, however there are likely more springs and sinkholes in the watershed than are shown on the map.

Figure 11. Map of perennial and intermittent stream channels in Wells Creek watershed

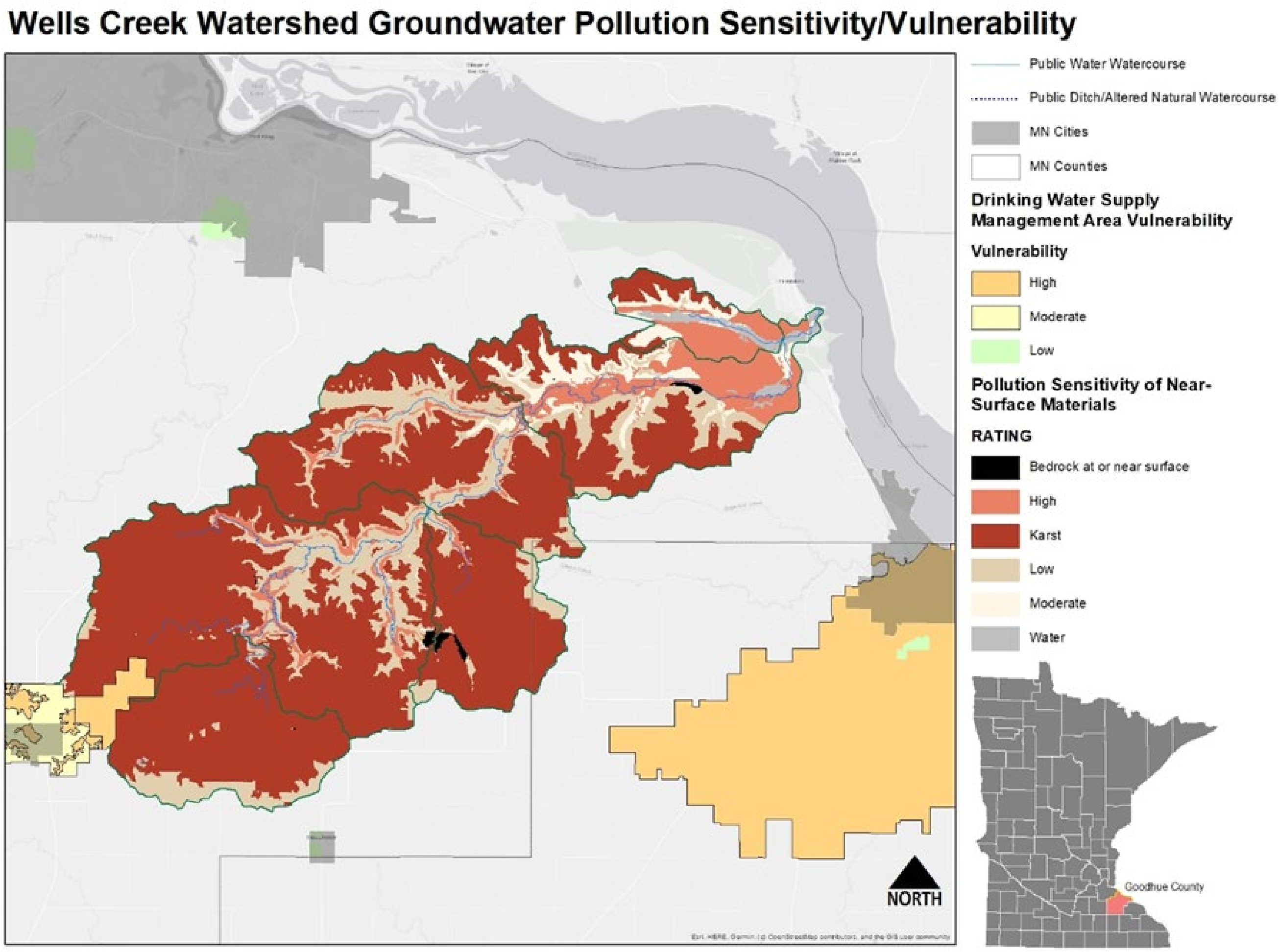


The MDNR discharge measurements collected to better define groundwater interaction with the mainstem of Wells Creek indicate that groundwater and surface water interactions are not uniform along the length of Wells Creek. In the headwaters, for the first 3.2 stream miles, baseflows slowly increase, yet in the middle section, the next 9 stream miles, baseflows increase at a faster rate per mile. Then, in the farthest downstream section, Wells Creek is a losing stream. Losing stream reaches are those where a significant amount of its water flows underground into an aquifer. This is a clear indication of the changing hydrogeology underlying Wells Creek. In the headwaters, baseflow is supported by the Prairie du Chien and upper portion of the Jordan aquifers. The middle section is supported by the Jordan and Franconia aquifers, and in the final section, Wells Creek crosses an ancient Mississippi River channel filled with well sorted glaciofluvial sands. It is thought that the glaciofluvial sands have a greater transmissivity than the sandstone aquifers resulting in recharge of the sand aquifer by Wells Creek. The potentiometric surface of this surficial sand aquifer is controlled by the water levels in the Mississippi River's Lake Pepin. (MDNR 1994 Discharge Report)

Tributary baseflow discharge to the mainstem represents only a small portion of total baseflow. Tributaries on the south side of the mainstem contribute more baseflow than those on the west and north sides of the mainstem. Regional groundwater flow direction in the Jordan aquifer suggests a greater potential for tributary baseflow in tributaries on the south side of the mainstem of Wells Creek.

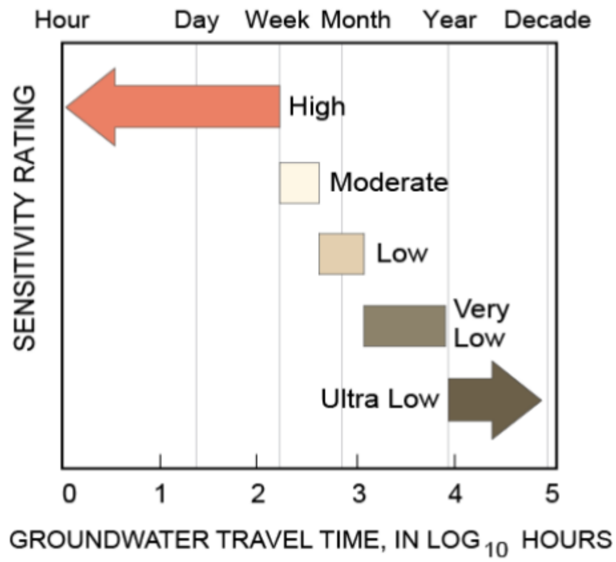
The groundwater pollution vulnerability map (**Error! Reference source not found.**) shows almost the entire watershed having a 'Karst' or Very High sensitivity rating. The map also shows Drinking Water Supply Management Areas (DWSMAs) and their vulnerability rating. All of these, again, indicate the significant connection between surface and groundwater resources, which presents strengths and weaknesses. Drinking water for the watershed's residents is wholly provided by groundwater (Minnesota Department of Health, 2019). Understanding pollution sensitivity is integral in preventing groundwater pollution. Many land-use activities (including row crop agriculture, stormwater, septic systems, and tanks/landfills) within the watershed could contaminate groundwater if pollutants are not carefully managed, especially in areas of high pollution sensitivity and karst geology (MDH, 2019). Activities on the land surface can also affect groundwater levels by reducing infiltration (groundwater recharge); these activities include tiling, changes in vegetation, increased areas of impervious surface, and changing surface or stormwater flow.

Figure 12. Wells Creek watershed groundwater pollution sensitivity map



The watershed has approximately 143 wells with known locations, ranging from 90 feet to 760 feet deep, that provide drinking water to residents. Private well users are not afforded the same water quality safeguards as people who get their water from public water systems. While public water systems ensure water is safe for the end-user, private well users are responsible for understanding the risks and proper well maintenance, testing regularly, and treating the water when necessary (MDH, 2019). Nitrate in groundwater is a top concern in southeastern Minnesota because of the threat to drinking water wells. State agencies and local partners are committed to protecting human health and the environment and are working to develop collaborative plans to address nitrate contamination in southeastern Minnesota and ensure residents have drinking water that meets the Safe Drinking Water Act standard for nitrate.

Figure 13. Groundwater sensitivity ratings and travel time



Soils

According to the NRCS Soil Survey data, roughly 38% of the soils in Wells creek watershed are considered prime farmland, and an additional 22% is considered farmland of statewide importance. Another 38% of the soils are considered not prime farmland as shown in **Error! Reference source not found.**.

Figure 14. Wells Creek watershed percentages of each farmland soil classification

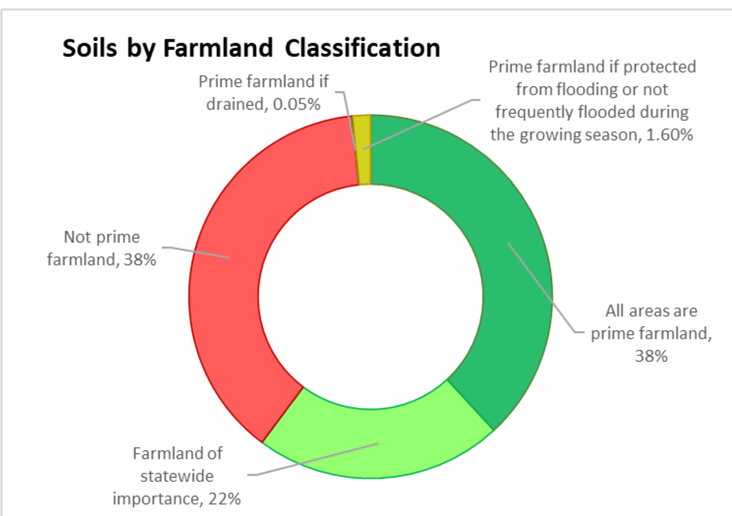
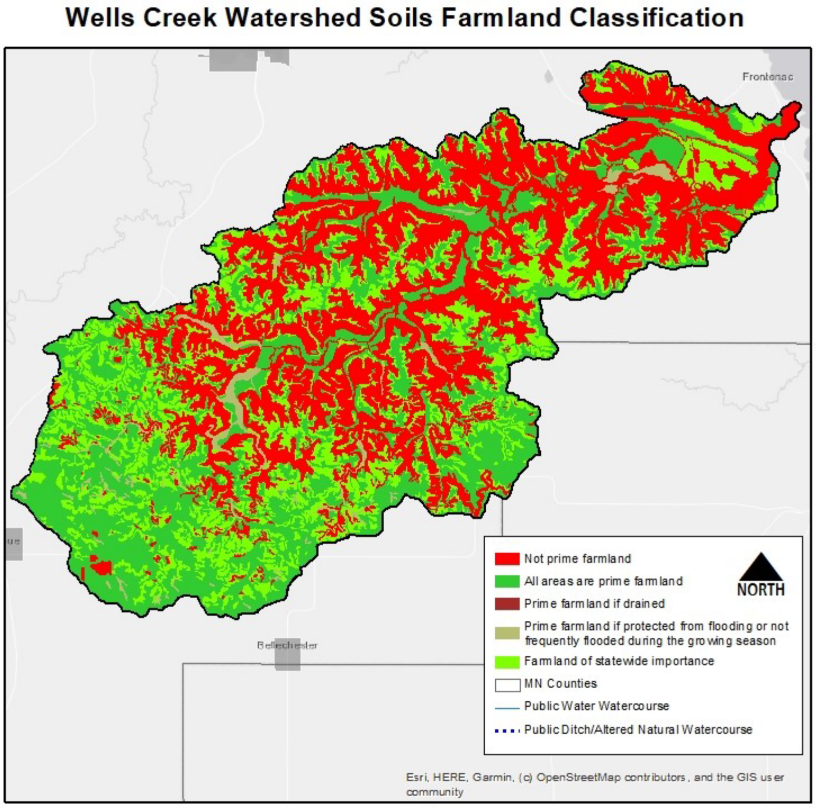


Figure 15. Farmland soils classification map Wells Creek watershed

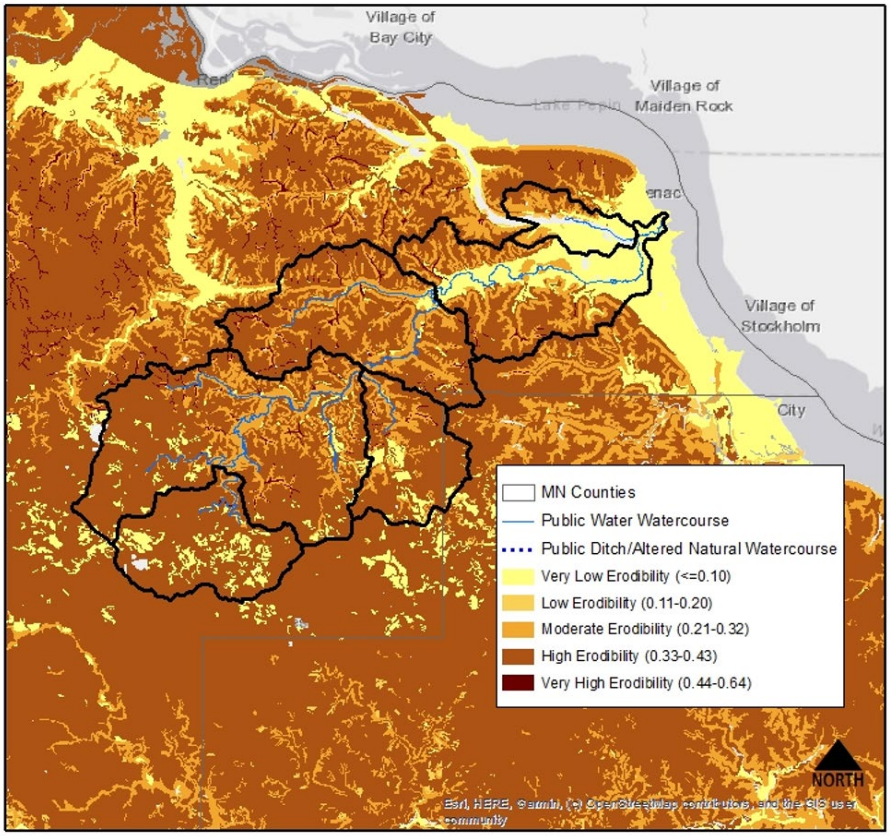


Soil erodibility is the intrinsic susceptibility of a soil to erosion by runoff and raindrop impact. In general, the following affect soil erodibility:

- Increasing amounts of soil organic matter result in decreasing values of soil erodibility.
- Soil type impacts soil erodibility.
- Coarse sand particles are too large to transport.
- Clays are cohesive with good soil structure and it is difficult to dislodge soil particles.
- Silts and fine sands are not cohesive and are easily transported.
- Texture is the principal factor affecting soil erodibility, but structure, organic matter, and permeability also contribute.
- Soil erodibility values range from 0.02-0.69, with smaller values representing lower erodibility and larger values representing higher erodibility. (MPCA Stormwater Manual).

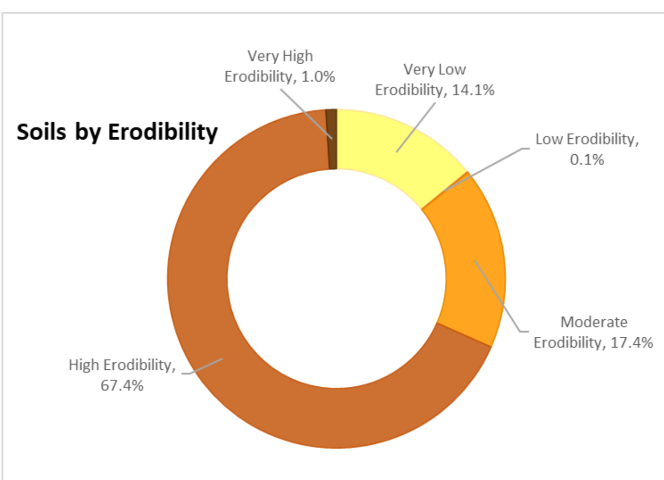
The soils of Wells creek watershed are roughly 67% highly erodible, 17% moderately erodible, and 14% very low erodibility.

Figure 16. Soil erodibility map of Wells Creek watershed



Farming in the watershed depends, to a large extent, on the cultivation of highly erodible soils. The historical cultivation of highly erodible soils has resulted in the loss of topsoil. The large majority of the highly erodible, cultivated land had sufficient soil loss at the time of the Goodhue County Soil Survey (conducted between 1940 and 1972) to be classified as 'eroded' (MDNR, soil erosion in Wells Creek watershed 1995). The employment of soil health practices and erosion reducing best management practices are essential to keeping the prime farmland soils in the Wells Creek Watershed.

Figure 17. Wells Creek watershed soil erodibility percentages

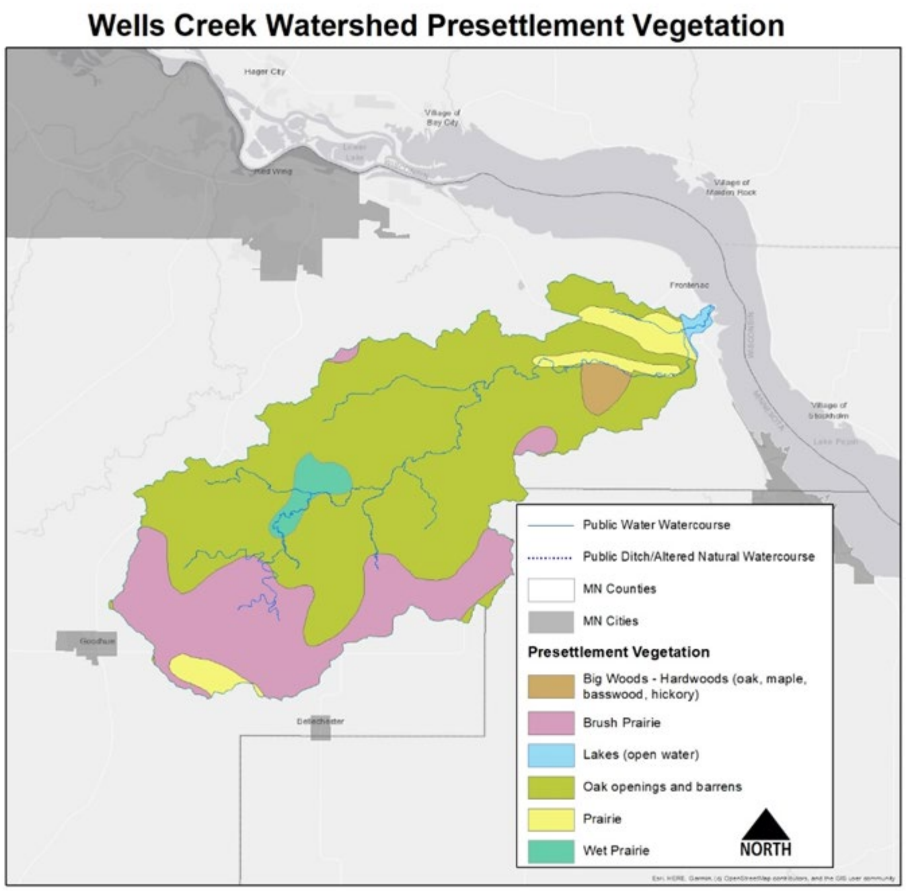


Vegetation

The watershed is included in the homelands of the Dakota people and prior to European colonization there was very little human impact to the landscape. By 1850, small farm fields dotted the valley bottoms and uplands, population began to grow rapidly until the turn of the century when most of the farmable land was in small grain production. Logging, farming, and development pressures ultimately removed most of the native vegetation. As a result, the quality of the land and water resources has been diminished by increased runoff and erosion.

Prior to European settlement of the area, the Wells Creek watershed was dominated by oak openings and barrens, and brush prairie. Small patches of prairie, wet prairie, and hardwoods were also present. Today, the landscape of Wells Creek watershed looks quite different (discussed in Land use + Land cover section).

Figure 18. Pre-settlement vegetation map of Wells Creek watershed



Sensitive areas + endangered species

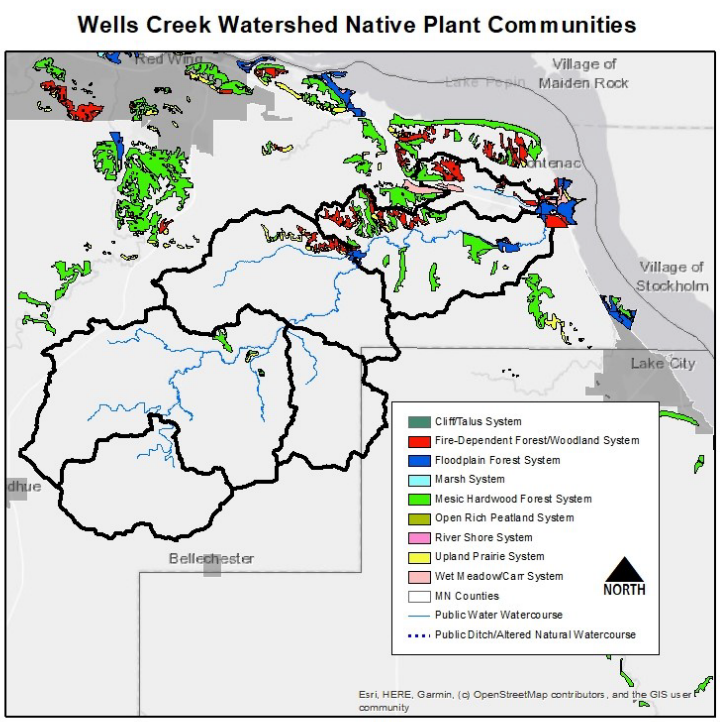
In addition to the springs, sinkholes, and other unique physical features of the watershed, there are also many unique biological features. Data from the Minnesota Biological Survey shows several areas containing native plant communities, these are groups of native plants that interact with each other and their surrounding environment in ways not greatly altered by modern human activity or by introduced plant or animal species. These native plant communities are important areas for conservation. Areas that are not mapped as native plant communities primarily represent:

- Land where modern human activities such as farming, overgrazing, wetland drainage, recent logging and residential and commercial development have destroyed or greatly altered the natural vegetation.
- Native plant communities that were below minimal size criteria.

Six different natural community types exist within the Wells creek watershed: Oak forest, Maple-Basswood forest, Floodplain forest, Oak Woodland brush, Bedrock bluff prairie, and Willow swamp. Additionally, there are groundwater dependent native plant communities including, fens/seepage wetlands and forested wetlands. A significant tract of maple-basswood forest lies within the statutory boundaries of Frontenac State Park. Sugar maple, basswood, and northern red oak dominate the canopy of the north to east facing slopes. Wells creek flows through a large tract of floodplain forest before emptying into Lake Pepin. Seasonally flooded, this lowland forest is dominated by silver maple, cottonwood, and black willow. A mix of oak species, including northern red oak, bur oak, northern pin oak, and white oak occurs in the oak forest scattered throughout the lower part of the watershed.

A few bluff prairies persist on the south to west facing slopes within the watershed. On these steep slopes where shrubs have not replaced prairie species, big and little bluestem, Indian grass, side oats grama, prairie dropseed, porcupine grass, plains nuhly, birdfoot coreopsis, gray goldenrod, silky aster, prairie violet and leadplant are common. One parcel of willow swamp extends along Highway 61 and the railroad track. This wet shrub community is dominated by willows and red-osier dogwood; herbaceous species that are characteristic of emergent marsh.

Figure 19. Map of native plant communities present in Wells Creek watershed and surrounding area



There are also several areas with biodiversity significance designations, primarily high significance with a small area of outstanding biodiversity significance. In 2001, the Wells Creek Watershed Partnership (with support of Goodhue County and the MDNR) issued an extensive natural resources inventory of the Lower Wells Creek Watershed. The extensive study concluded that Wells Creek provides a critical corridor between the Mississippi River and the surrounding large natural areas within the watershed.

Several state-listed plant and animal species have been documented within the watershed:

Endangered:

Kitten tails (*Besseya bullii)*

Peregine Falcon (*Falco peregrinus)*

Threatened:

Sterile sedge (*Carex sterilus)*

Valerian (*Valeriana Edulis* spp. *Ciliata)*

Bald eagle (*Haliaeetus leucocephalus)*

Special Concern:

Squirrel corn (*Dicentra canadensis)*

Canadian black snakeroot (*Sanicula canadensis)*

Ginseng (*Panax qumquefolium)*

Red-shouldered hawk (*Buteo lineatus)*

Fox snake (*Elaphe vulpina)*

Racer *(Columber constrictor)*

Gopher snake (*Pituophis melanoleucus)*

Figure 20. Map of significant sites of biodiversity in Wells Creek watershed

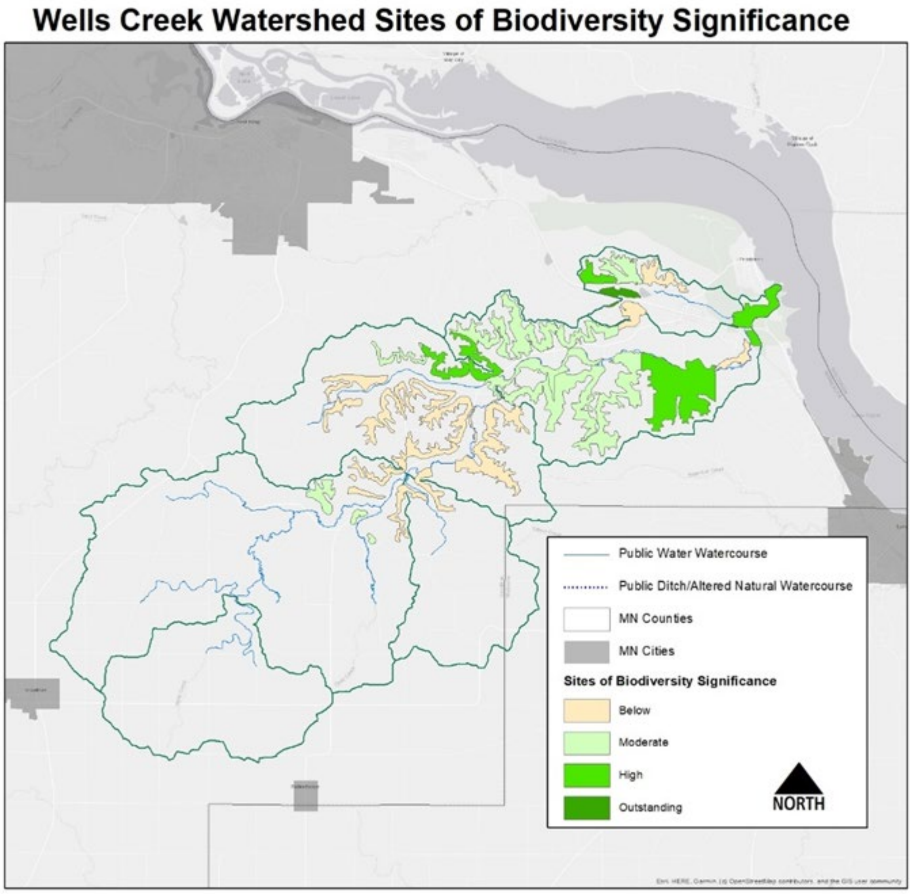
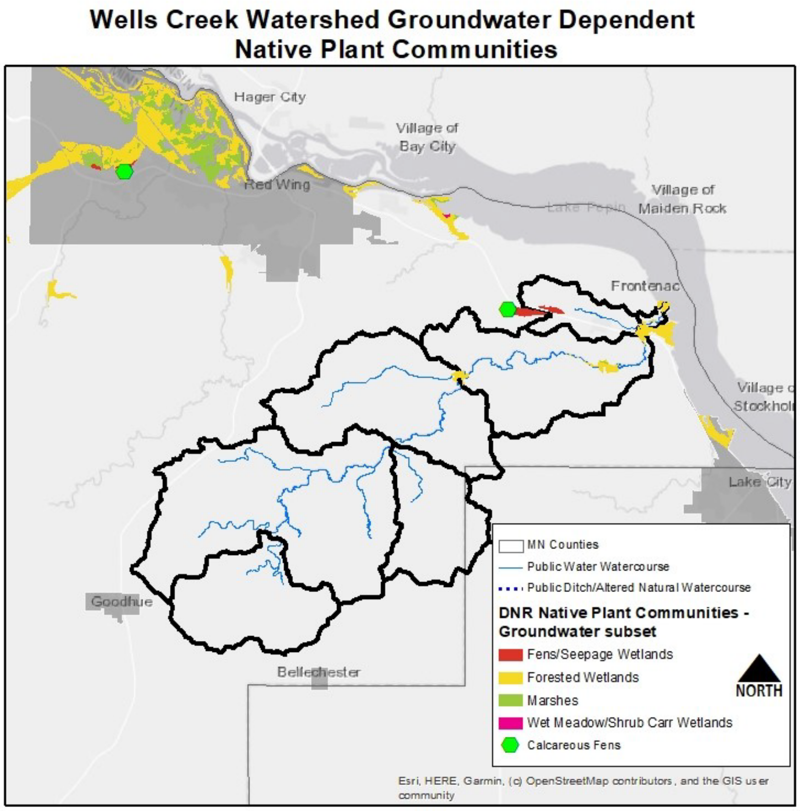


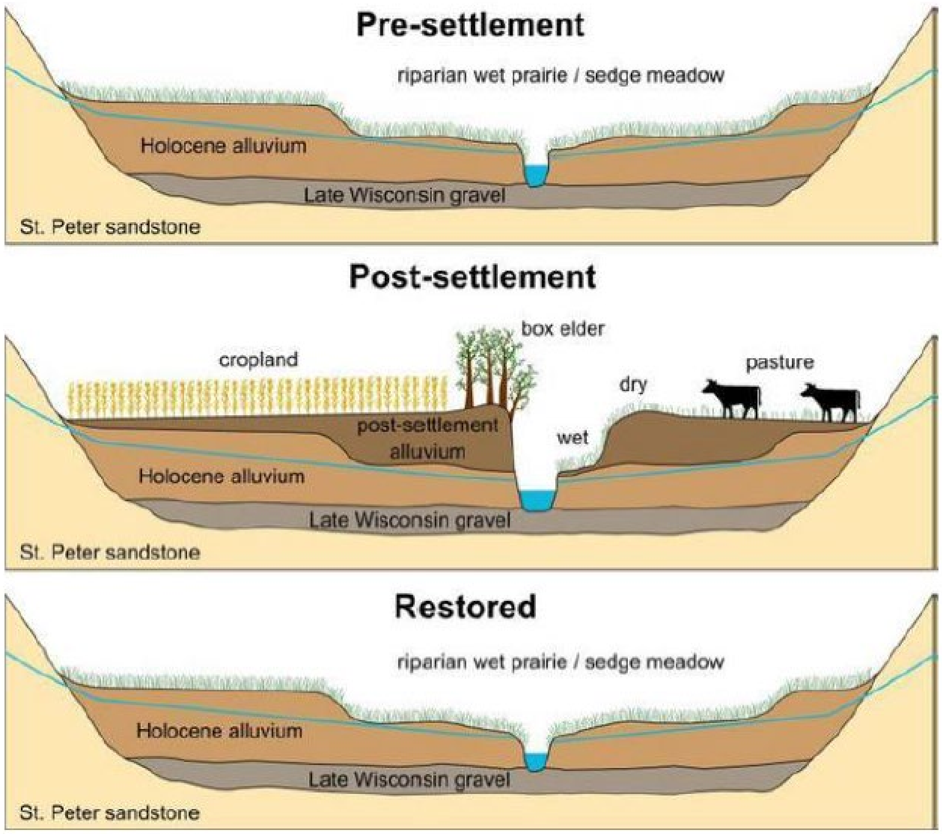
Figure 21. Map of groundwater dependent native plant communities in Wells creek watershed



Land use + land cover

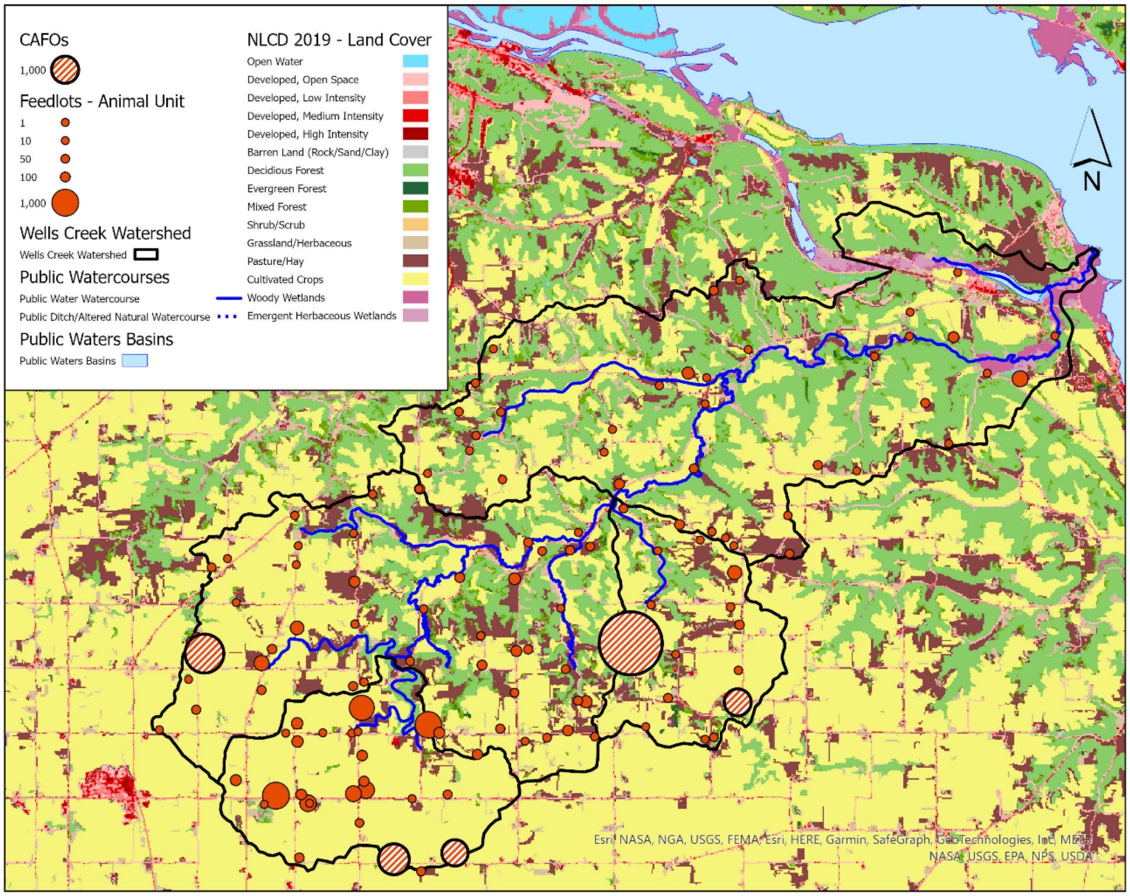
By 1850, small farm fields dotted the valley bottoms and uplands, and the population began to grow rapidly until the turn of the century when most of the farmable land was in small grain production. By the late 1920s, tractors became common, allowing farmers to plant and harvest larger fields (Historic context study of MN farms 2005). This land conversion and subsequent geomorphic alteration in the Driftless Area has been studied, and results show that conversion to agricultural land use greatly accelerated soil erosion (Beach 1994; Faulkner 1998; Knox 2006; Stout et a. 2014; and Trimble 2009). Much of this erosion was deposited on the valley floodplains adjacent to the channels, as illustrated in **Error! Reference source not found.**. Stream and landform surveys show Wells Creek has experienced similar impacts from land conversion.

Figure 22. Diagram of floodplain change in the Driftless Area and one of many restoration options, from Booth and Loheide, 2010



The major land uses in the watershed today are roughly 50% cultivated crops, 25% forest, and 12% pasture/hay. Much of the steeper hillsides have tree cover with patches of grassland on the warmer south facing slopes, but a good portion of the relatively flatter areas along the stream channel are pasture, especially in the upper half of the watershed. Concerns from heavy grazing include reduction of canopy cover, which limits stream shading, and direct impacts livestock can have on streambanks (MDNR 2021). According to Goodhue County records, there are 95 feedlots in the watershed with a total of 16,032 animal units, Figure 21. The bulk of the animal agriculture takes place in Upper Wells Creek, where there are 14,788 animal units. Overall, 44% of the animal units are attributed to dairy operations, 30% to swine, and 25% to beef.

Figure 23. Map of land cover and registered feedlots in Wells Creek watershed



Fisheries/Biology

The MDNR designated Wells Creek as a trout stream in 1946, however by 1959, surveys determined the waterbody was no longer suitable for trout. Warm water temperatures and excessive suspended sediment made it impossible for trout to survive. The 1959 survey notes “The lower 13.3 miles of the creek are not suitable as trout waters and are unfavorable for most fishes except a few species of minnows and rough fish.” Further surveys in 1974 and 1986 found stream conditions had worsened; high water temperatures, high silt, phosphorus, and nitrogen concentrations hindered trout reproduction and survival. Trout populations were estimated at 14 adult trout per mile. Efforts by the MDNR to stock thousands of trout in Wells Creek from 1947-1986 were mostly unsuccessful until the 1990s when some evidence of natural reproduction and survival were noted, at this time, trout populations were estimated at 45 adult brown trout per mile. The original 1959 survey also noted "No stream improvement measures are planned but conservation and public interest could be better served if a good watershed improvement program were initiated and maintained.”

Figure 24. Image of MDNR staff during fish shocking demonstration on Wells Creek

An annual fish sampling station was established in 2010 by the MDNR to assess stocking efforts and overall health of Wells Creek. Right away the MDNR began to realize that the trout population was not being driven by stocking (Stauffer, 2022). Through their annual surveys, the MDNR concluded natural reproduction of trout was high enough that stocking was no longer necessary and thus was discontinued in 2016.

In 2011, MPCA staff reviewed water quality and biological data to determine whether the designated use classification of Wells Creek warranted a revision. Water temperature data and the presence of cold water fish and macroinvertebrate taxa indicated that Wells Creek and an unnamed tributary, locally known as Rock Creek, should be redesignated as Class 2A: Waters that permit the propagation and maintenance of a healthy community of cold water aquatic biota. These waters shall be suitable for aquatic recreation of all kinds, including bathing. This class of surface waters is also protected as a source of drinking water. This designated use rule change became effective June, 2020. Despite this change, at the time this report is released, Wells Creek is still not designated as a trout stream by the MDNR. It will be important to continue to monitor the stream temperature in Wells Creek and its tributaries to ensure the protection of the cold water species present.

Figure 25. Image of Wells Creek

Water Quality Standards

The designated use classifications are nearly identical to the map of intermittent and perennial stream reaches in Wells creek watershed with the mainstem and a couple tributaries being designated 2A and all other tributaries designated 2B. The applicable water quality standards for these designated use classifications are provided in **Error! Reference source not found.**.

Figure 26. Map of designated use classifications in Wells Creek watershed

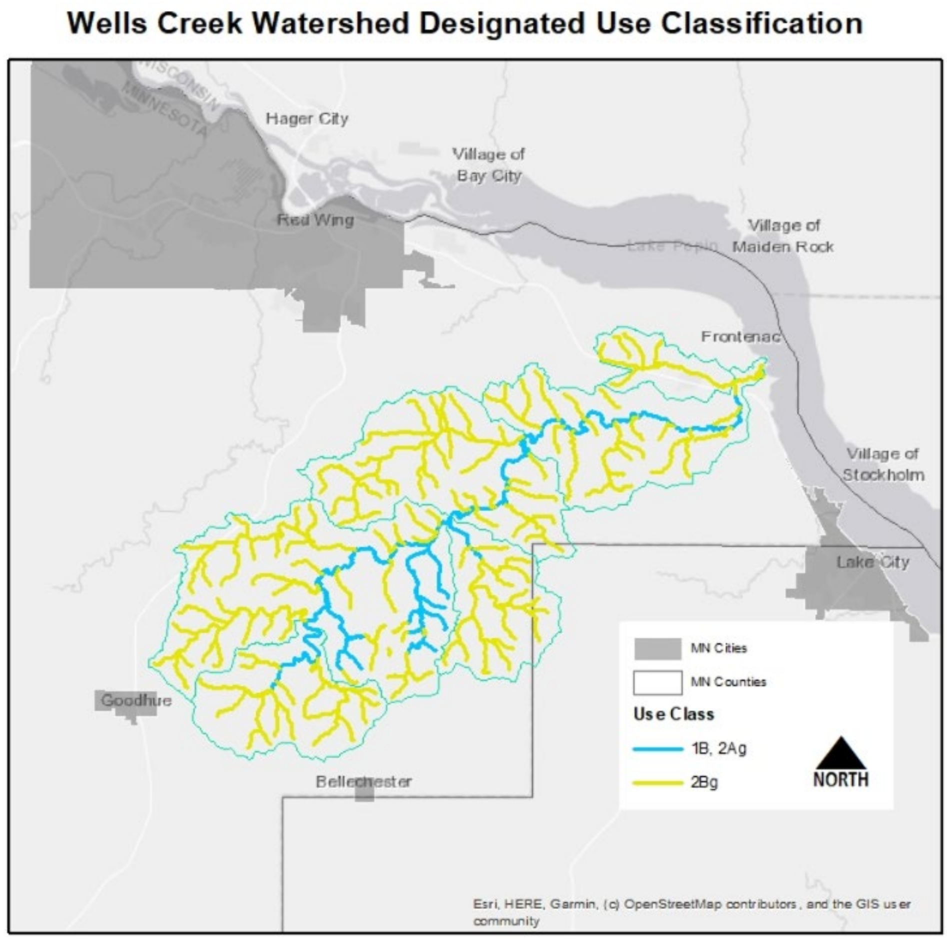


Table 2. Water quality standards applicable to Wells Creek

Parameter	Class 2Ag, 1B Standards & Criteria	Class 2Bg Standards & Criteria
E. coli	Not to exceed 126 organisms per 100 mL as a geometric mean of not less than 5 samples representative of conditions within any calendar month, nor shall more than 10% of all samples taken during any calendar month individually exceed 1260 organisms per 100 mL. Applies only April 1-Oct 31	
Nitrogen, Nitrate	10 mg/L*	N/A*
Dissolved oxygen	Daily minimum: 7.0 mg/L	Daily minimum: 5.0 mg/L
pH	To be between 6.5 and 8.5 pH units	To be between 6.5 and 9 pH units
Total suspended solids (TSS)	10 mg/L, not to be exceeded more than 10% of the time between April 1-Sept 30	65 mg/L, not to be exceeded more than 10% of the time between April 1-Sept 30
Chloride	Chronic: 230 mg/L Maximum standard: 860 mg/L Final Acute Value: 1720 mg/L	
Biological indicators	Southern cold water streams Fish IBI numeric threshold: 50, Macroinvertebrates IBI numeric threshold: 43	Southern streams Fish IBI numeric threshold: 50
Temperature	no material increase	5˚F above natural in streams based on monthly average of the maximum daily temperatures, except in no case shall it exceed the daily average temperature of 86˚F

Available data

A significant amount of water quality data is available for Wells Creek. MPCA has collected data at Wells Creek since 2000. Multiple samples are collected each month during the open water seasons by the Watershed Pollutant Load Monitoring Network since 2008. Available water chemistry data is summarized in **Error! Reference source not found.**. Fisheries data is also available from the MDNR's long term monitoring site in Wells Creek.

Table 3. Water quality data available for Wells Creek watershed

Parameter	Number of measurements
Dissolved oxygen	312
Bacteria (Fecal coliform/*E. coli*)	51
Inorganic nitrogen	415
pH	310
Phosphorus	590

Parameter	Number of measurements
Specific Conductance	317
Total Suspended Solids	399
Volatile Suspended Solids	219
Transparency (Secchi)	650
Temperature	584
Turbidity	259
Discharge (continuous)	68,972
Temperature (continuous)	65,737
Turbidity (continuous)	43,129

In addition to the data collected by the MPCA and MDNR, Discovery Farms Minnesota – a farmer-led effort to gather field scale water quality information under real world conditions to provide practical, credible, site-specific information to enable better farm management- in partnership with MN Agricultural Water Resource Center, the MN Department of Agriculture (MDA), University of MN, and Goodhue County SWCD operated an edge-of-field monitoring effort in Wells Creek watershed.

Table 4. Wells Creek Discovery Farms site details

Discovery Farm ID	County	Farm Type	Minor Watershed	Drainage Area (acres)	Dominant Soil Type	Station Type	Crop Rotation	Years Monitored
GO1	Goodhue	Beef-Swine	Wells Creek	6.3 overland	Well drained silty loam	Edge-of-Field	Corn-Alfalfa	2011-2017

Monitoring equipment was installed at the site in the Fall of 2010 including: 2.5 foot flume at field edge, H2 axiom datalogger, FTS tipping budget rain gage, FTS air temperature and humidity sensor, OTT CBS high accuracy bubbler and ISCO 6712 portable automated sampler, APG ultrasonic transducer, Campbell Scientific CS650 soil moisture probe and depth integrated soil temperature probe.

The data obtained from the Discovery Farms effort provides a baseline for agricultural sources.

Key findings of monitoring at Schafer Farms GO1:

- Cover crops worked well with the Schafer Farms farming system, but also presented some management challenges
- Total surface runoff was similar to other Discovery Farms Minnesota sites
    - Surface runoff occurred on an average of 7 days/year with 7% of the precipitation that fell at this site leaving the field as surface runoff
- There was more runoff during snowmelt conditions and less during the growing season
    - Runoff documented at the Wells Creek Discovery Farms station is similar to other Discovery Farms stations in Minnesota and Wisconsin, where the majority of runoff volume occurs under frozen conditions. If the length of time the ground is frozen decreases, the amount of infiltration should increase. With increased temperatures there may be a sizable increase in the adoption of cover crops in the watershed. Under a traditional corn/soybean rotation,

cover crops often run up against hard frost in early October, limiting plant growth going into the winter.

- 70% of soil loss occurred in June, similar to other Discovery Farms Minnesota sites
- Schafer Farms' thoughtful management along with maintenance of conservation practices worked to protect water quality in this region of the state
    - Even though the slope at this site was much higher than other Discovery Farms sites, the combination of well-drained soils, field management (perennial crops and cover crops) and conservation practices (waterways and farming on the contour) provided high levels of infiltration, resulting in less runoff during the growing season

Table 5. Wells Creek Discovery Farms site cropping systems and annual soil loss

Water Year	Cover Crop	Crop	Annual Soil Loss (lb/ac)
2011	-	Alfalfa	47
2012	-	Alfalfa	22
2013	Rye	Corn silage	205
2014	Rye	Corn silage	307
2015	Rye	Corn silage	1,033
2016	-	Corn silage	2,623
2017	-	Alfalfa	135

DF Average: 434 lb/ac

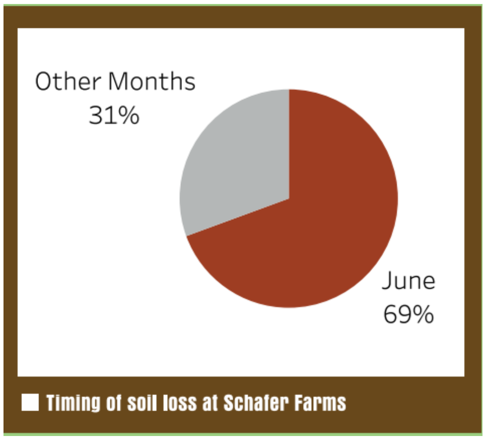
Annual soil loss at Schafer Farms

Even well drained soils infiltrate little water when frozen, especially at greater slopes. As a result, 76% of the total runoff at this site occurred as snowmelt runoff when soils were frozen.

Soil loss measured during years where Schafer Farms grew alfalfa was much lower than in years where corn was grown, 68 pounds per acre during alfalfa compared to 1,042 pounds per acre during corn. Perennial vegetation on the landscape plays a large part in reducing the volume of water and sediment leaving the small study area. Also, it is important to note, that during the years where alfalfa was grown, there was minimal soil disturbance taking place due to the lack of tillage between cropping systems. This adds to the fact that reducing soil disruption can increase soil health.

Soil loss increased each year corn was grown on the study field (2013-2016). In 2016 it became apparent that the grass waterway in the field needed maintenance, as water had begun flowing parallel to the waterway along the grass edges, creating significant erosion. The waterway was reshaped in the fall of 2016 to allow water to flow into the grass area. This waterway re-construction, along with the lack of cover crop and soil disturbance from injection of manure and tillage, contributed to higher soil losses in 2016.

Figure 27. Soil loss in the month of June compared to the rest of the year at Wells Creek Discovery Farms site



The month of June was critical for soil loss, this month is high risk because of a combination of low soil cover and intense rainfall events. Providing soil protection during this time period can reduce soil loss.

MAWRC Report Schafer.cdr (discoveryfarmsmn.org)

Impairments

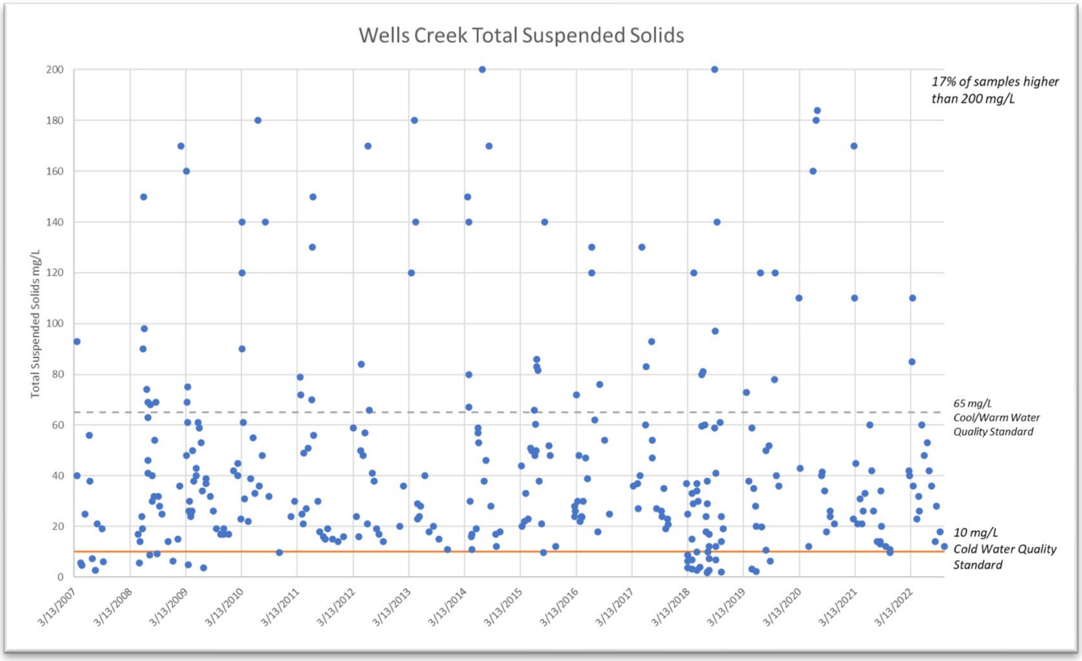
Table 6. Wells Creek watershed waterbodies on 303(d) List of Impaired Waters

Resource of Concern	Waterbody Identification (WID)	Use Class	Year Added to List	Impairment	TMDL Status
Wells Creek	07040001-708	1B, 2Ag	2012	*E. coli*	Approved 2015
Wells Creek	07040001-708	1B, 2Ag	2022	Total Suspended Solids (TSS)	*N/A*

Despite soil conservation efforts, which began in the early 1900s, and continued improvements in landscape sensitive farming techniques, water quality and habitat have fluctuated over time in Wells Creek. Most recently, MPCA's 2020 water quality assessment of Wells Creek found healthy aquatic life communities, but suspended sediment concentrations regularly exceeding the limit set to protect aquatic life. Daily elevated suspended sediment concentrations coupled with a slight decrease in macroinvertebrate communities, resulted in the addition of Wells Creek (07040001-708) to the 2022 303(d) List of Impaired Waters.

A robust data set was reviewed with the newly applied Class 2A cold water total suspended solids (TSS) standard of 10 mg/L. MPCA found that more than 95% of samples over the last decade exceeded the standard, additionally, there were several observations of extremely high TSS concentrations, over 500 mg/L, and a maximum TSS concentration of 3,000 mg/L during an extreme flow event in 2010. Secchi disk measurements over the last decade also show 50% of the 219 observations were below the secchi recommendation, with several below 15 centimeters, indicating high levels of sediment. Exceedances in TSS and secchi measurements occur consistently over all seasons and all ten years of the assessment cycle. (2021 Watershed assessment and trends update https://www.pca.state.mn.us/sites/default/files/wq-ws3-07040001e.pdf)

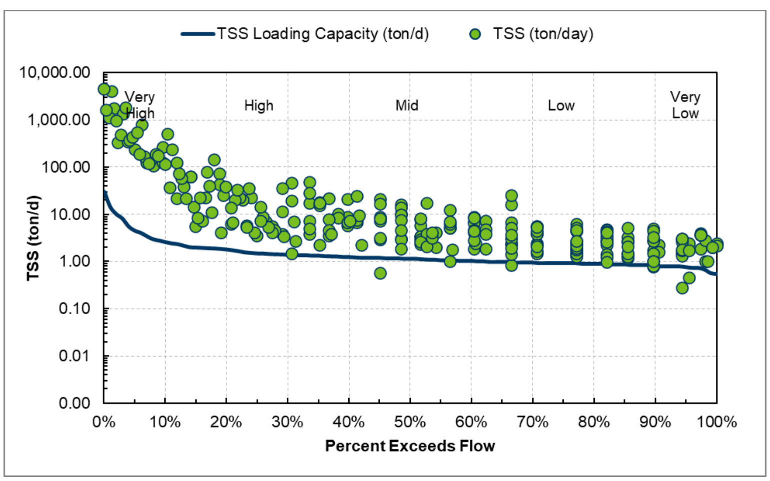
Figure 28. Discrete total suspended solids sample data for Wells Creek watershed 2007-2022



An additional analysis of daily modeled TSS concentrations from the MPCA's Load Monitoring program site on the Highway 61 bridge also support a TSS impairment. Specifically, of the April to September assessment period, daily modeled concentrations from 2009-2017, 99.2 % of days exceed the 10 mg/L 2A standard.

Although a Total Maximum Daily Load (TMDL) report has not been produced for TSS in Wells Creek, a load duration curve was developed showing nearly all available TSS measurements above the loading capacity at all flows. The load duration curve clearly illustrates that sediment is a problem in Wells Creek.

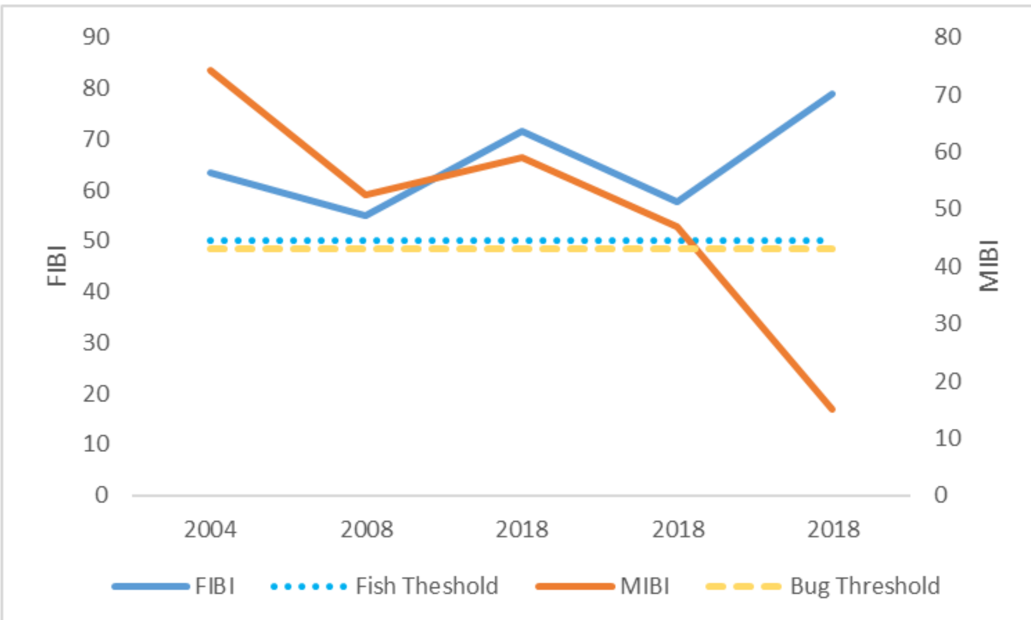
Figure 29. Wells Creek total suspended solids load duration curve



The TSS is an aquatic life indicator parameter. Suspended solids directly impact aquatic life by clogging fish gills and impeding their vision, this makes finding food and hiding from predators more difficult. Additionally, suspended solids reduce light penetration, reducing the ability of aquatic plants' production of food and oxygen. Excess suspended solids can also absorb solar radiation and raise the temperature of a stream, which can reduce dissolved oxygen. When excess sediment is able to settle out of the water column, it causes siltation. This changes the stream habitat, can smother bottom-dwelling organisms and eggs, and cover breeding areas.

Despite high sediment levels in Wells Creek, MPCA's most recent water quality assessment did not find any impaired aquatic life communities in Wells Creek. According to MPCA and MDNR's monitoring data, fish in Wells Creek are doing well, with year-to-year variability within normal range. However, benthic macroinvertebrate data exhibits a decreasing trend as you move further upstream; there is also evidence that macroinvertebrate condition has worsened in Wells Creek since 2004. This may be a signal that the macroinvertebrate community is becoming stressed.

Figure 30. Wells Creek fish and aquatic macroinvertebrate data 2004-2018

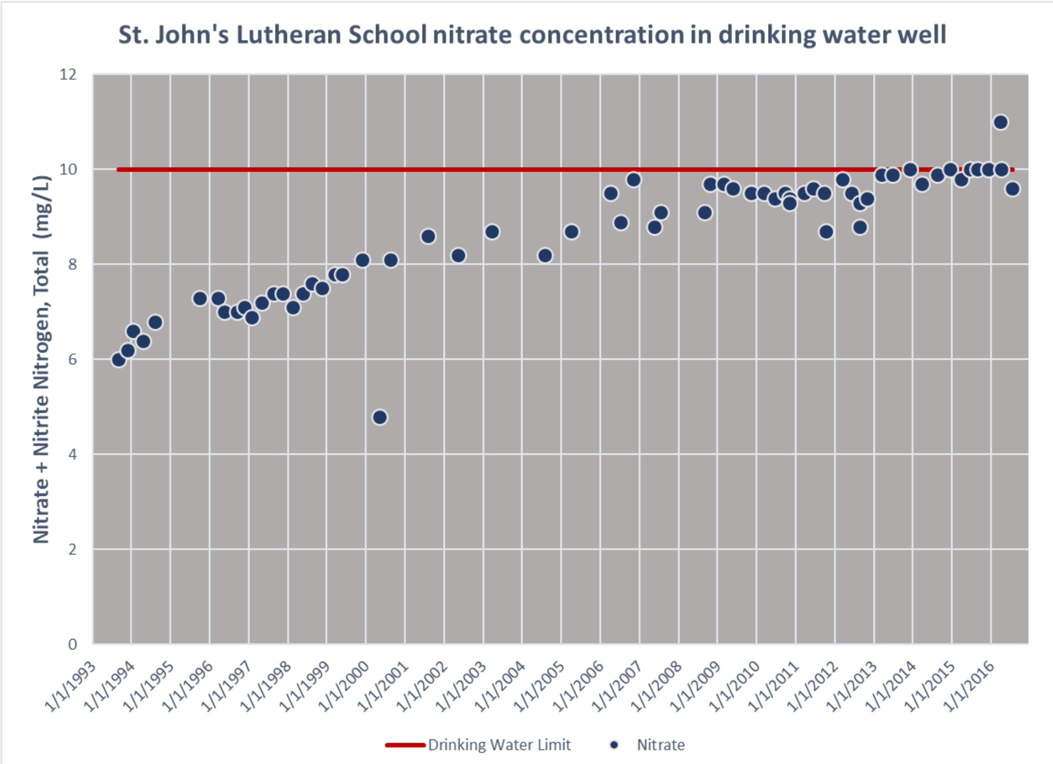


The MPCA's 2020 Mississippi River- Lake Pepin Stressor Identification Report found that the biggest threats to fish and macroinvertebrates in the watershed are excess sediment, increased stream flows (flow alteration), and habitat degradation. Other characteristics of Wells Creek may be helping to minimize the impact of elevated TSS, such as adequate stream temperatures, dissolved oxygen, and food.

Although fish and macroinvertebrate communities are healthy, protection strategies that reduce or capture overland flow, increase infiltration, and improve soil health are necessary to mitigate stream flows and sustain current biological conditions. Elevated stream flows can negatively impact variables such as in-stream habitat availability and quality, and nutrient and sediment loading (MPCA, 2020).

Reviews of total phosphorus (TP) concentrations in Wells Creek found a range of 0.03 to 3.82 mg/L. In general, the average TP concentration from 2010 to 2015 was 0.215 mg/L and increased to 0.4 mg/L in 2016-2019. This appears to coincide with an increase in median stream flow and annual precipitation (MPCA, 2020). The TP often exceeds the water quality standard set for Wells Creek during high flow conditions, however the other parameters used along with TP to evaluate eutrophication (chlorophyll-*a*, biochemical oxygen demand, dissolved oxygen flux, and pH flux) are within healthy limits. Although eutrophication and TP are not currently driving the impairment in Wells Creek, reducing TP loading is important for maintaining and improving conditions in the watershed and downstream waters like Lake Pepin and the Mississippi River, as well as for achieving the goals set in Minnesota's Nutrient Reduction Strategy.

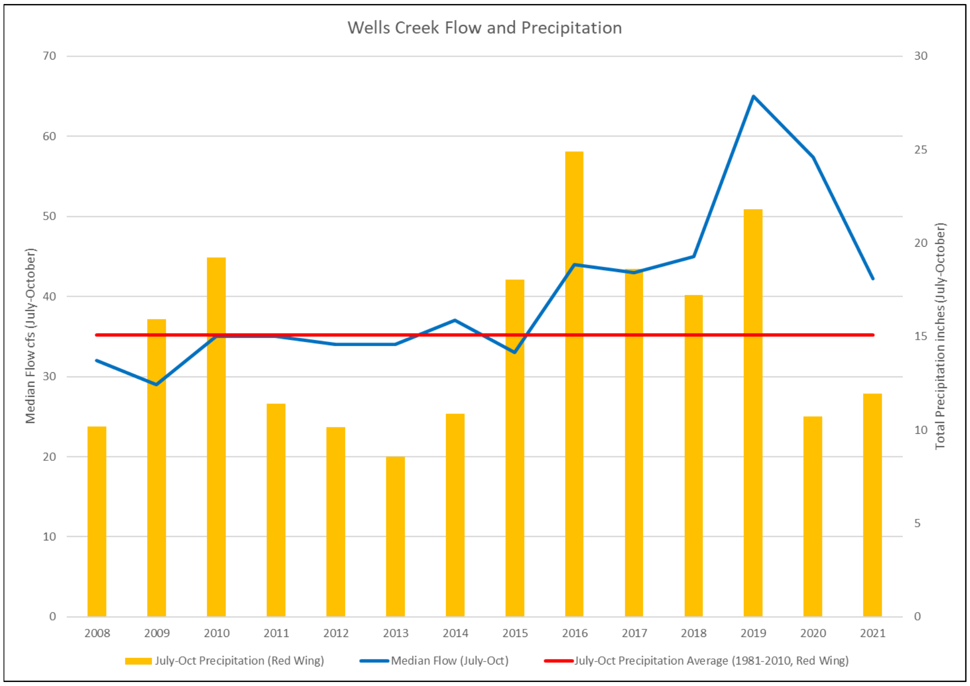
Figure 31. Nitrate concentration of St. John's Lutheran School well 1993-2016



Nitrate concentrations in Wells Creek are generally below five milligrams per liter, less than one half of the state standard for cold-water streams (10 mg/L). However, the 2015 Mississippi River Lake Pepin WRAPS document discusses the need for nitrate reductions in St. John's Lutheran Church and School Drinking Water Supply Management Area (DWSMA) at the headwaters of Wells Creek watershed. Since the 2015 report was published, nitrate concentrations in the St. John's well water continued to rise, **Error! Reference source not found.**, and a new well was installed in 2016.

Nitrate in groundwater is an issue that has been developing in southeastern Minnesota for several decades. The geology and activities on the land surface make it more likely for higher concentrations of nitrate in groundwater in southeaster Minnesota. Nitrate is a particular concern for those who get their drinking water from private wells in eight counties in southeast Minnesota: Olmsted, Goodhue, Dodge, Wabasha, Fillmore, Mower, Winona, and Houston. Many streams in southeast Minnesota are fed by groundwater springs, like Wells Creek, thus areas with elevated nitrate in groundwater can also have higher nitrate in streams with can cause stress to aquatic biological communities.

Figure 32. Wells Creek flow and precipitation 2008-2021



Other impairments in Wells Creek include an *Escherichia coli* (*E. coli*) impairment added in 2012. A Total Maximum Daily Load was developed for this impairment and it was approved by the U.S. Environmental Protection Agency (EPA) in 2015. The MPCA's 2020 assessment of Wells Creek did confirm the impairment still exists.

The presence of fecal pathogens in surface water is a regional problem in southeast Minnesota. Minnesota's 2022 303(d) list of impaired waters includes 169 stream reaches impaired by fecal pathogens in the Cedar River and Lower Mississippi River Basins of Minnesota. Water quality monitoring over several decades has shown widespread exceedances of state and federal water quality standards for fecal coliform bacteria throughout the basin.

E. coli is proposed to have two primary habitats, the first being the intestinal tracts of mammals and birds, and the second being the nonhost environment (water/sediment) (Zhi, S et.al., 2016). *E. coli* and other fecal indicator bacteria (FIB) were thought to survive poorly in the nonhost environment. Because of this, elevated levels of FIB in surface waters are often blamed on run off from feedlots and manure amended agricultural land, septic system leakage, untreated sewage from sewer overflows, human recreation, wildlife, and urban runoff. (Booth et al., 2003, Chalmers et al., 1997, Cox et al., 2005, Coye and Goldoft, 1989, Dufour, 1984a, Haile et al., 1999, Novotny et al., 1985, Wells et al., 1991) In recent years though, more and more studies have reported the growth and persistence of *E. coli* in various natural environments. (Byappanahalli et al., 2003, Carrillo et al., 1985, Whitman and Nevers, 2003) Byappanahalli et al. reported the persistence and growth of E. coli in soils and riparian sediments of Indiana and also in coastal forest soils from the Great Lakes watershed (Byappanahalli et al., 2003, Byappanahalli et al., 2006). Similarly, Ishii and coworkers provided evidence supporting the long-term survival and growth of E. coli in Lake Superior watersheds of Minnesota (Ishii et al., 2006a, Ishii et al., 2007). In addition to soils and water, *E. coli* can be found to associate with the filamentous macroalga Cladophora (Ishii et al., 2006b, Whitman et al., 2003) and periphyton communities (Ksoll et al., 2007) also harbor large concentrations of *E. coli* in the Great Lakes.

Additionally, hydrogeologic features in southeast Minnesota have the potential to favor the survival of fecal coliform bacteria. Cold water, shaded streams, and sinkholes may protect fecal coliform from light, heat, drying, and predation (MPCA, 1999).

In the Mississippi River-Lake Pepin tributaries Watershed, all cold water streams, where sufficient data was available for assessment, did not meet aquatic recreation standards due to bacteria issues.

Figure 33. Image of biological monitoring crew in Wells Creek

Element a. Sources Identified

An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (b) immediately below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed (e.g., X numbers of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded streambank needing remediation).

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The primary pollutant sources in Wells Creek watershed are nonpoint. There are a limited number of permitted point sources within the watershed and are almost entirely feedlots.

A geomorphic assessment of Wells Creek watershed was completed by the MDNR following the Watershed Assessment of River Stability and Sediment Supply (WARSSS) framework developed by D. Rosgen (2009) a method approved by the EPA to assess sediment impairments. This framework is a systematic and repeatable way of analyzing stream channel stability and sedimentation, which are critical in developing prioritized restoration and protection management strategies. The WARSSS identifies and quantifies sediment by three erosional processes: hillslope, hydrological, and channel. This detailed study includes three levels of investigation: Reconnaissance Level Assessment (RLA), Rapid Resource Inventory for Sediment and Stability Consequence (RRISSC), and Prediction Level Assessment (PLA) (MDNR 2021).

The WARSSS estimated a total sediment budget for Wells Creek watershed, summarized in **Error! Reference source not found.**. There are a limited number of road crossings in the watershed, thus the impact of roads on sediment delivery to the stream is low. In-channel sources of excess sediment, such as streambank erosion, are estimated to be the largest overall source, contributing 89% of the total sediment supply. These results are similar to other watersheds in southeast Minnesota where sediment budget studies have been completed and sediment impairments exist (Little Cannon River and Whitewater River).

Table 7. Sediment sources identified in MDNR's 2021 sediment study.

Sediment Supply Process	Total Annual sediment (tons/yr)	Percent of Total Sediment Supply
Roads	13	0%
Streambanks	9,404	89%
Surface Erosion (HSPF)	1,187	11%
Total Sediment	**10,604**	**100%**

Figure 34. Image of large eroding stream banks in Wells Creek

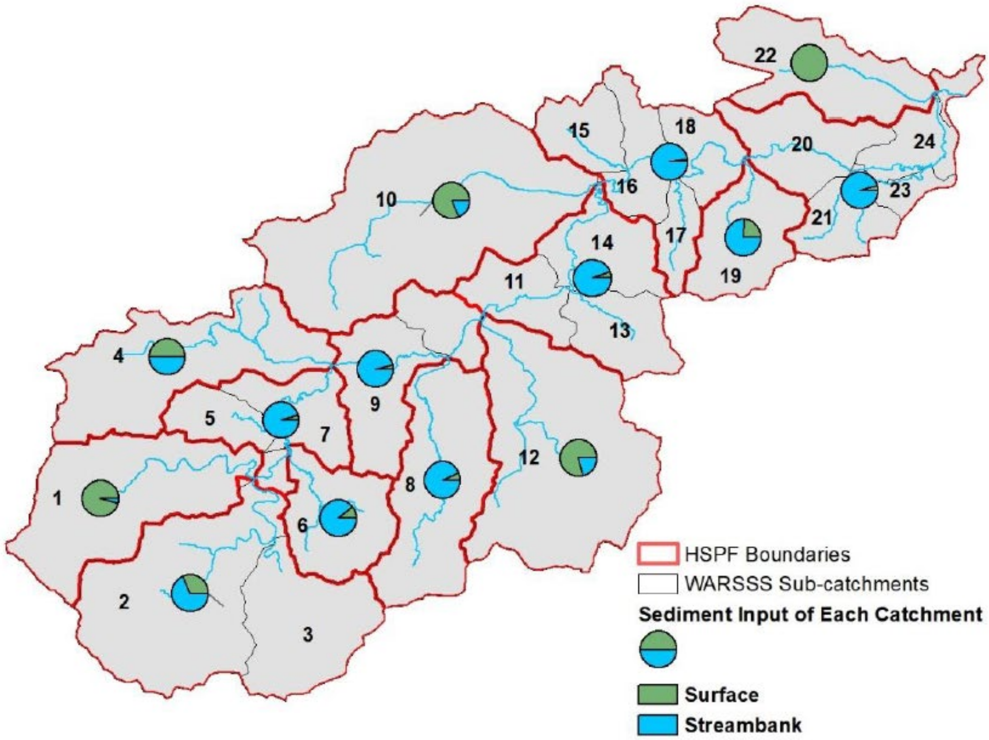
The WARSSS concluded:

"In general, around one-third of Wells Creek catchments generate the majority of excess sediment from streambank erosion. These catchments are located in the upper and middle sections of the watershed. The lower half of the watershed is affected by aggradation that is being driven by the settling of current and past sediment generated from upstream, which is creating over-wide, shallow channels prone to mass wasting or bank slumping. Although streambank erosion is the largest contributor, catchments that generate more surface erosion than in-channel erosion, and which are located in the upper parts of the watershed, need attention as well. Typical upland sediment reduction strategies and prioritization would benefit downstream catchments by reducing the sediment load and lowering the risk to future in-channel restorations.

The sediment budget of each catchment paints a picture of where to set restoration and protection priorities and the strategies likely needed to address the sources of excess sediment. "

Figure 34 shows each catchment in the Wells Creek watershed and provides a pie chart of sediment sources. Catchments with streambank erosion processes contributing 50% or more of the sediment are 2, 5, 6, 7, 8, 9, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, and 24, as identified in the WARSSS. Catchments with overland processes or surface erosion contributing more sediment than streambank are 1, 10, 12, and 22.

Figure 35. Map of sediment sources of each catchment in Wells Creek watershed, MDNR 2022



Following the WARSSS, the MDNR developed a Wells Creek Watershed Sediment Reduction Strategies report in 2022. Further analysis in 2022 provided targeting of catchments by percentage of total streambank erosion and total surface inputs.

The MDNR Fisheries' 2016 Management Plan for Wells Creek identified limiting factors of severe bank erosion and the resulting sedimentation as this limits fish production and spawning as well as invertebrate production. The plan noted that most of the riparian area is dominated by row crop agriculture. If permanent vegetation exists along the stream, it is usually a narrow-wooded corridor consisting mainly of box elder trees. These corridor types are subject to heavy shading with very little understory, often resulting in severe bank erosion. Many reaches of the stream are heavily grazed and have raw, eroded banks. Several reaches also appear to have been straightened and channelized in the past.

Overall sediment delivery from tributaries to the Upper Mississippi River in southeast Minnesota has increased substantially since European settlement and the onset of agricultural activities in the tributary watersheds (MPCA, 2017). Sediment bound phosphorus is a very common source of the nutrient, especially in watersheds with little or no point sources. The primary sources of phosphorus in surface waters of Wells Creek are cropland runoff, atmospheric deposition, and streambank erosion.

Large rain events and total annual precipitation have been increasing, it will be important to incorporate resiliency into designs for addressing overland and in-channel sediment contributions. The MDNR recommends creating or connecting stream channels to adequately sized floodplains that will provide water storage during extreme events while also reducing near-channel shear stress and streambank erosion. Similarly, incorporating water storage into projects addressing overland processes will also help build resiliency.

Figure 36. Image of significant stream bank and hillside erosion in Wells Creek watershed

More than 70% of the nitrate in Minnesota waters is coming from cropland, the rest from regulated sources such as wastewater treatment plants, septic and urban runoff, forests, and the atmosphere. Nitrate leaching into groundwater below crop fields and moving underground until it reaches streams, contributes an estimated 30% of nitrate to surface waters. Groundwater nitrate can take from hours to decades to reach surface waters.

Element b. Estimated reductions

> *An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (a) above (e.g., the total load reduction expected for dairy cattle feedlots; row crops; or eroded stream banks).*
>
> EPA *Handbook for Restoring and Protecting Our Waters*

Table 8. Implementation types, eligibility, activities, schedule, milestones, assessment criteria, costs, and estimated per practice pollutant reductions (PLET, 2024)

Type	319 Eligibility	BMP/Activity	Milestones					Assessment	Cost	Estimated reductions Up. Wells		
			2 year	4 year	6 year	8 year	10 year			N lbs/yr	TP lbs/yr	TSS t/yr
Cropland		Whole Farm Conservation Plans	1	1	1	1	1	# of plans	$50,000.00			
		Water & Sediment Control Basins	20	20	20	20	20	# of acres treated	$1,500,000.00	170.85	51.37	10.52
		Grade Stabilization Structures	20	20	20	20	20	# of acres treated	$2,000,000.00	223.92	65	6.88
		Terraces	2	2	2	2	2	# of acres treated	$100,000.00	5.86	1.7	0.18
		Grassed Waterways	2,000	2,000	2,000	2,000	2,000	# of linear feet	$65,000.00	761.64	221.11	23.37
		Site-specific nutrient management plans	600	600	600	600	600	# of acres treated	$3,000,000.00	2506.1	1684.3	0
		Grid soil sampling to guide precision nutrient application	2	2	2	2	2	# of producers engaged	$20,000.00			
		Residue and Tillage Management, Reduced Tillage	200	200	200	200	200	# of acres treated	$50,000.00	956.95	498.37	46.62
		Residue and Tillage Management, No Tillage	1944	1944	1944	1944	1944	# of acres treated	$486,000.00	6769.57	6608.73	618.95
		Conservation Crop Rotation	100	100	100	100	100	# of acres treated	$20,000.00	20.34	0	0
		Convert Marginal Row Crop Acres to Perennial Cover – Conservation Cover	200	200	200	200	200	# of acres treated	$300,000.00	5363.33	1173.87	112.23
		Cover Crops	1,000	1,000	1,000	1,000	1,000	# of acres treated	$300,000.00	5447.73	503.59	57.89
		Streambank Erosion practices/restoration- Upper Wells Creek	12,500	8,300	9,200	3,100	0	# of linear feet	$9,680,000.00	9284	3574	6826.4

Type	319 Eligibility	BMP/Activity	Milestones					Assessment	Cost	Estimated reductions Up. Wells		
			2 year	4 year	6 year	8 year	10 year			N lbs/yr	TP lbs/yr	TSS t/yr
Pastureland		Streambank Erosion practices/restoration- Lower Wells Creek	10,000	10,500	8,500	7,000	9,000	# of linear feet	$13,400,000.00	5421.78	2087.38	3986.6
		Field boarders, vegetative barriers, forest edge buffers, filter strips at the edge of fields	20	20	20	20	20	# of acres implemented	$50,000.00	272.74	64.38	6.51
	N	Enrollment in RIM, CREP, CRP, similar programs on marginal lands	200	200	200	200	200	# of acres enrolled	$1,000,000.00	5254.09	1149.72	109.52
		SWCD Technical & Administrative Assistance (FTE)	2	2	2	2	2		$2,000,000.00			
		Prescribe Grazing Management	200	200	200	200	200	# of acres treated	$200,000.00	1249.15	57.3	0
		Silvopasture	20	20	20	20	20	# of acres treated	$20,000.00	149.74	6.87	0
		Alternative water supply/ Livestock pipeline	8,000	8,000	8,000	8,000	8,000	# of linear feet	$200,000.00	0.39	0.03	0
		Heavy use area protection	8,000	8,000	8,000	8,000	8,000	# of square feet	$100,000.00	0.54	0.04	0
		Livestock exclusion fencing	10,000	10,000	10,000	10,000	10,000	# of linear feet	$250,000.00	1.29	0.03	0.01
		Well construction & pumping plant	2	2	2	2	2	# of wells/plants	$250,000.00			
		Livestock water facility	10	10	10	10	10	# of facilities	$37,500.00	19.9	1.43	0.14
		SWCD Technical & Administrative Assistance (FTE)	0.15	0.15	0.15	0.15	0.15		$150,000.00			

Type	319 Eligibility	BMP/Activity	Milestones					Assessment	Cost	Estimated reductions Up. Wells		
			2 year	4 year	6 year	8 year	10 year			N lbs/yr	TP lbs/yr	TSS t/yr
Feedlots		Livestock waste storage facilities, Milkhouse waste treatment	2	2	2	2	2	# of systems	$8,000,000.00	1539.15	284.15	0
		Filter strips around feedlots	2	2	2	2	2	# of acres treated	$5,000.00	8822.6	2148.11	0
		Small feedlot fixes	4	4	4	4	4	# of projects	$200,000.00	1550	305	0
		SWCD Technical & Administrative Assistance (FTE)	0.25	0.25	0.25	0.25	0.25		$350,000.00			
Urban	N	Well decommissioning	2	2	2	2	2	# of wells	$20,000.00			
	N (Match eligible)	Septic system upgrades	6	6	6	6	6	# of systems treated	$750,000.00	370	257	2.86
		SWCD Technical & Administrative Assistance (FTE)	0.1	0.1	0.1	0.1	0.1		$100,000.00			
Forest	N	Forest Stand Protection	240	240	240	240	240	# of acres treated	$1,200,000.00			
		Forest management plans	4	4	4	4	4	# of plans	$50,000.00			
		Address invasive species	40	40	40	40	40	# of acres treated	$100,000.00	14.81	6.25	1.64
		SWCD Technical & Administrative Assistance (FTE)	0.1	0.1	0.1	0.1	0.1		$100,000.00			
Monitoring		Inventory & Database of sinkholes	0	1	0	0	0	Inventory completed	$4,500.00			
		Inventory & status of Wells	0	1	0	0	0	Inventory completed	$4,500.00			

Type	319 Eligibility	BMP/Activity	Milestones					Assessment	Cost	Estimated reductions Up. Wells		
			2 year	4 year	6 year	8 year	10 year			N lbs/yr	TP lbs/yr	TSS t/yr
		Inventory & status of Septic systems	0	1	0	0	0	Inventory completed	$4,500.00			
		Inventory & status of Grade stabilization structures, WASCBs	1	0	0	0	0	Inventory completed	$4,500.00			
		Inventory & database of invasive species	1	0	0	0	0	Inventory completed	$4,500.00			
		Inventory of wetlands	1	0	0	0	0	Inventory completed	$4,500.00			
		Monitor effectiveness of practices using lysimeters and spring monitoring to determine observable reductions	2	2	2	2	2	# of yrs monitored	$400,000.00			
		Monitor private groundwater wells for nitrate, bacteria, and other emerging contaminants to characterize effectiveness of implementation	20	20	20	20	20	# of wells tested	$50,000.00			
		Continue pollutant load monitoring at existing long term site @ Hwy 61 (add turbidity and nitrate)	2	2	2	2	2	# of yrs monitored	$400,000.00			
		Install and Maintain stream monitoring station @ County 45 crossing of Wells Creek (Real-time-Cellular Data Collection of stage, Temp, Turbidity and N)	2	2	2	2	2	# of yrs monitored	$20,000.00			

Type	319 Eligibility	BMP/Activity	Milestones					Assessment	Cost	Estimated reductions Up. Wells		
			2 year	4 year	6 year	8 year	10 year			N lbs/yr	TP lbs/yr	TSS t/yr
		Install and Maintain stream monitoring stations at the outlets of **5** major tribs to Wells Creek (Real-time-Cellular Data Collection of stage, Temp, Turbidity and N)	2	2	2	2	2	# of yrs monitored	$100,000.00			
		Coordinate Routine Fish Surveys on the cold water tribs and the main branch of Wells Creek with the MDNR	2	2	2	2	2	# of yrs monitored	$160,000.00			
		Enroll 5 landowners into the Citizen Stream Monitoring Program in Wells Creek to collect routine field data @ 5 locations	2	2	2	2	2	# of yrs monitored	$16,000.00			
		Continue regular inspection of projects receiving state cost-share funding.	10	10	10	10	10	# of inspections	$250,000.00			
		SWCD Technical & Administrative Assistance (FTE)	0.25	0.25	0.25	0.25	0.25		$250,000.00			
Outreach		Promote 5 soil health principles (soil armoring, minimizing soil disturbance, plant diversity, continual living plant/root, livestock integration) with demonstration site and field days.	1	1	1	1	1	# of landowners contacted	$75,000.00			

	Partner with the Wells Creek Watershed Partnership in the watershed to establish a demonstration site	1	1	0	0	0	# of sites	$20,000.00			
	Host field day events	1	1	1	1	1	# of events	$25,000.00			
	Virtual Wells Creek Watershed Tour	1	1	1	1	1	# of events	$25,000.00			
	In-person Wells Creek Watershed Tour (Winter or Summer)	2	2	2	2	2	# of events	$25,000.00			
	Conduct outreach with landowners and area residents regarding forestry.	4	4	4	4	4	# of landowner contacts	$100,000.00			
	Conduct outreach with landowners and area residents regarding soil health.	4	4	4	4	4	# of landowner contacts	$100,000.00			
	Distribute information materials increasing resident awareness of groundwater issues, testing, and best management practices.	10	10	10	10	10	# of landowner contacts	$250,000.00			
	Continued outreach and compliance tracking for the 103F.48 Buffer Law.	5	5	5	5	5	# of landowner contacts	$125,000.00			
	Promote enrollment and implementation of conservation programs and practices in the watershed through distribution of educational materials and outreach.	10	10	10	10	10	# of landowner contacts	$50,000.00			

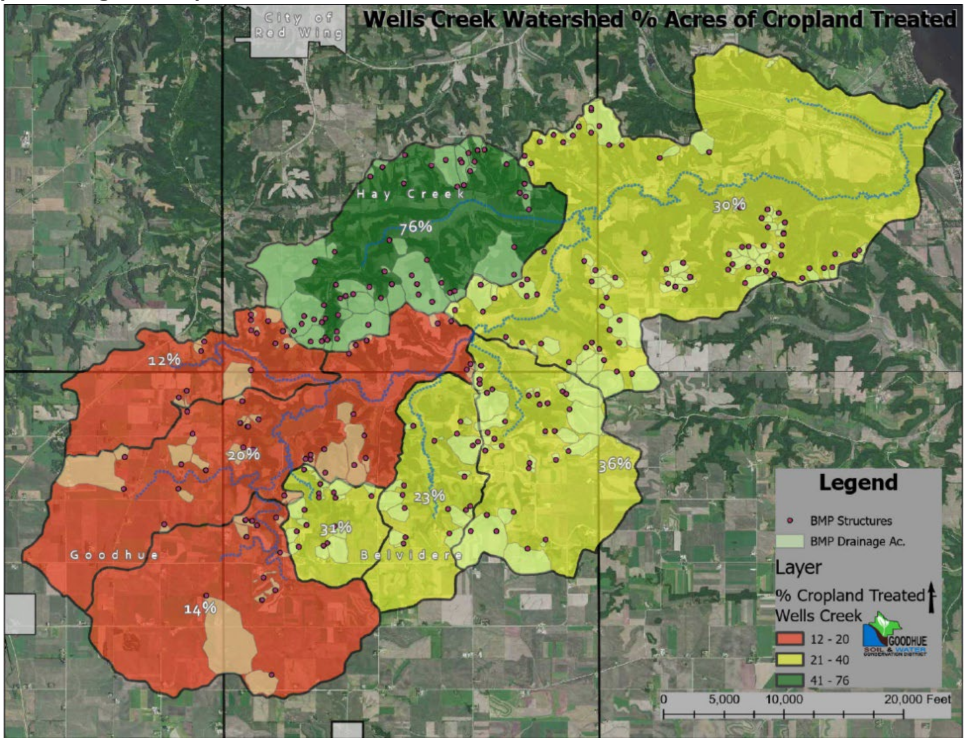
		Promote the protection of biologically significant elements in the watershed through distribution of educational materials.	5	5	5	5	5	# of landowner contacts	$25,000.00			
		Work with agriculture retailers and crop consultants on workshops / field days / other outreach activities	1	1	1	1	1	# of activities	$25,000.00			
		Conduct field walkovers, technical support, kitchen-table meetings, etc.	4	4	4	4	4	# of meetings	$20,000.00			
		Build relationships with small feedlot operators <100AU	4	4	4	4	4	# of operator connections	$20,000.00			
		SWCD Technical & Administrative Assistance (FTE)	0.1	0.1	0.1	0.1	0.1		$250,000.00			
Total									$48,911,500.00	56176.77	20749.47	11810.32

Element c. Best management practices

> *A description of the BMPs (NPS management measures) that are expected to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas (by pollutant or sector) in which those measures will be needed to implement this plan.*
>
> EPA *Handbook for Restoring and Protecting Our Waters*

The rapid movement of water through the Wells Creek watershed is well known and the SWCD has been working with landowners and producers to 'slow the flow' for many years. One of the Partnership's top goals for the watershed was increase water infiltration on the land to decrease runoff, erosion and sedimentation. Between 2009 and 2019, utilizing various state and federal grants, the SWCD helped landowners install 35 grade stabilization structures and water and sediment control basins in the watershed. The SWCD maintains an inventory of structural practices in the watershed to help assess acres treated and locations to target future implementation (**Error! Reference source not found.**). The structural practices that were implemented in this watershed over the past 80 years have had a large reduction in the amount of sediment reaching Wells Creek. The primary reason that most of these practices were installed were to prevent large gully heads from entering landowners' fields. The structures have reduced the sediment from moving down the landscape. A secondary benefit from the impoundment structures is the reduction in the rate of stormwater runoff. Field-edge peak runoff reduction values can range from 80-95% during storm events depending on the design. The numerous structures on the landscape providing this reduction has a compounding effect on the hydrologic bounce of Wells Creek.

Figure 37. Map of Goodhue SWCD's inventory of structural practices implemented in Wells Creek watershed and percentage of cropland treated



The MPCA's WRAPS report recommended a variety of strategies to reduce nutrients and sediment including land use ordinances, streambank restorations, structural impoundment BMPs, and land retirement. These and other BMPs were modeled using HSPF to determine pollutant reduction potential. The BMP scenario that yielded the greatest reduction was scenario 10: 50% of cropland acres treated with conservation tillage, 30% of cropland acres utilizing cover crops, and 30% of cropland drain to sedimentation ponds. This scenario resulted in a 47.2% reduction in annual sediment yield, 15% reduction in total phosphorus, and 16% reduction in total nitrogen. The second most successful scenario was the same as scenario 10 but removed the sedimentation ponds. This scenario, number 9, resulted in 37.9% sediment yield reduction, and 14.5% and 15.4% total phosphorus and total nitrogen reductions. Scenario 8 evaluated the use of just sedimentation ponds; 50% of cropland acres drain to sedimentation ponds. This scenario resulted in 33.5% reduction of sediment yield.

Recommendations from the WARSSS, WRAPS, HSPF modeling, and SWCD work indicate the upland portions of the watershed would benefit most from BMPs that promote infiltration and reduce rapid runoff: cover crops, grassed waterways, water and sediment control basins, grade stabilizations, filter strips, reduced tillage, and forest edge buffers. Practices that would benefit the valley bottoms include streambank and habitat restorations, cover crops, grassed waterways, filter strips, land retirement, feedlot exclusions, and streambank stabilization.

A new list of BMPs has been developed for this plan, following the recommendations of the various reports and modeling. This list includes: water and sediment control basins, grade stabilization structures, terraces, grassed waterways, reduced and no tillage, conservation crop rotation, perennial cover, cover crops, streambank restoration, field boarder filter strips and forest edge buffers, enrollment in Conservation Reserve Program (CRP) and similar programs.

Element d. Expected costs and technical assistance

An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement the entire plan (include administrative, Information and Education, and monitoring costs). Expected sources of funding, States to be used Section 319, State Revolving Funds, USDA's Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant Federal, State, local and private funds to assist in implementing this plan.

The estimated costs of the activities in this plan are shown in Table 8**Error! Reference source not found.**. The costs to implement this NKE plan are estimated at $48,911,500.00 when fully implemented.

Funding for this plan will be through Section 319 funding, BWSR One Watershed One Plan (1W1P) funding, implementation grants, NRCS/EQIP funding, Conservation Stewardship Program, landowner cost share, and other opportunities.

Implementation of the activities in this plan will occur with a wide range of people and organizations beginning with watershed landowners and residents and extending through local government units, state agencies, and federal agencies (**Error! Reference source not found.**).

Table 9. Partners' Potential Roles and Responsibilities

	Partner	General Roles	Potential Responsibilities
Citizen Groups	Landowners and Residents	Provide input, information & feedback	Provide local perspectives
		Share information	Share information
		Provide leadership	Monitor or allow monitoring of projects
		Collaborate on projects development	Implement resource improvement projects
Non-Profit Organizations	Wells Creek Watershed Partnership (facilitated by Goodhue Soil and Water Conservation District)	Provide a forum for broad implementation and management discussions Help coordinate implementation efforts	Maintain record of discussions Organize meetings Discuss implementation priorities
Local Government	Goodhue County Soil & Water Conservation District (Assisted by Technical Service Area VIII)	Serve on many state and local conservation-based committees	Maintain list of potential and finished projects
		Design and implement technical conservation projects, forest management plans, invasive species control, shoreline stabilization, tree planting, water sampling, soil sampling, etc.	Provide technical assistance to landowners/projects
		Manage grant projects	Provide cost-share opportunities
		Pursue and develop funding proposals	Write funding requests
		Conduct landowner outreach and community engagement	Contractor facilitation and project management
		Initiate and maintain landowner contacts and relationships	Conservation project development
		County weed inspection	Design and create outreach materials GIS mapping and data collection
	Goodhue County (Highway and Environmental Services)	Serve on the 1W1P Policy and Advisory Committees	Maintain and construct transportation infrastructure
		Oversee county roads	Consult implementation plan in zoning decisions

	Partner	General Roles	Potential Responsibilities
		Enforce planning & zoning	Keep partners aware of opportunities
		Enforce wetland rules, construction setbacks and lot width, and SSTS.	Provide project management
		Jurisdictional drainage authority	Manage and maintain drainage systems under their jurisdiction in accordance with MN Statute 103E.
	Wells Creek Watershed 319 Workgroup	Provide input, information & feedback	Provide local/technical perspectives
		Share information	Share information
		Provide leadership	Monitor or allow monitoring of projects
		Collaborate on projects development	
State Government	Minnesota Board of Water and Soil Resources	Serve on the 1W1P Advisory Committee	Keep partners aware of opportunities
		Administer MN Clean Water Fund Projects	Provide project management
		Provide technical assistance	
		Lead HUC-8 based Landscape Stewardship Planning efforts	
		Serves on County Technical Evaluation Panels for wetland permits	
	Minnesota Department of Natural Resources (Divisions of Fisheries, Forestry, Wildlife, and Ecological and Water Resources)	Serve on the 1W1P Advisory Committee	Review/approve projects under Minnesota DNR programs
		Administer DNR programs, issue Public Waters Permits, conduct wetland rule enforcement	Provide cost-share assistance for conservation projects
		Provide technical assistance for hydrology, fisheries, geomorphology, and forestry	Provide technical comments on project design
		Assist in development and evaluation of project proposals	Assist landowners with design and implementation of conservation projects
	Minnesota Pollution Control Agency	Serve on the 1W1P Advisory Committee	Oversee implementation plan
		Administer MPCA and Section 319 funding programs	Keep partners aware of opportunities

	Partner	General Roles	Potential Responsibilities
		Provide technical assistance for water quality Assist in development and evaluation of project proposals	Provide data administration
Federal Government	Environmental Protection Agency (Region 5)	Provide Section 319 grants and guidance	
	Natural Resources Conservation Service	Serve on the 1W1P Advisory Committee Provide technical review Administer U.S. Department of Agriculture (USDA) funding programs	Make Committee aware of funding opportunities Landowner engagement and education Provide cost-share assistance for conservation projects Assist landowners with design and implementation of conservation projects
	Federal Emergency Management Agency	Provide floodplain mapping Provide hazard mitigation funding and assistance	Updated floodplain maps Hazard mitigation planning and grants

Element e. Education and outreach

An information/education component that will be implemented to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, implementing and maintaining the NPS management measures that will be implemented.

In 1994, formation of the Wells Creek Watershed Partnership (Partnership) brought together local citizens and natural resource professionals as a prototype watershed management effort to share ideas and information, and to develop a vision for the future of the watershed. (Florence Township Comprehensive Plan, 2013) The Partnership defined and adopted several guiding ecological principles for protecting and enhancing the watershed, including:

- The health of natural communities depends on their size. Smaller and fragmented natural communities support fewer species and are vulnerable to extinction. Planning improves connectivity of these natural communities and avoids fragmentation of contiguous habitats.
- People are part of nature. The decisions and actions of humans are a major force in shaping the natural resources of the watershed.
- Species are interdependent, and humans do not understand all of the interactions within natural communities.
- Introductions of invasive and exotic species reduce native diversity, the quality of habitat and the health of natural areas.
- Planning should consider ecological boundaries and long timeframes.

The Partnership held several events to engage and inform the community about Wells Creek, they conducted surveys, developed a volunteer monitoring network, and coordinated with universities and state agencies until the early 2000s. Since the formation of the Partnership, an annual meeting and picnic has been held every year for residents in the watershed. These gatherings regularly draw up to 100 residents to share and learn about Wells Creek. MDNR staff provide a fish electro-shocking demonstration and other staff share information about available programs and data.

Figure 38. Image of 2022 Wells Creek Watershed Partnership annual picnic

The Partnership and watershed residents have been included in the 319 Small Watershed Focus grant process since the SWCD began considering the program in 2020. Presentations have been made at three Partnership annual meetings, and an information meeting was held in the spring of 2023. The SWCD has also repeated one of the early Partnership surveys, asking residents about the condition of Wells Creek.

The Partnership will be an important companion in the implementation of this Plan and the Implementation table includes several outreach activities including: watershed tours, field day events, workshops, and more. One high priority outreach activity included in the plan is establishing a demonstration site within the watershed. This site will be operated by a local agricultural producer and will demonstrate the BMPs called for in this plan, such as the Five Soil Health Principals (soil armoring, minimizing soil disturbance, plant diversity, continual living plant/root, and livestock integration), cover crops, reduced and no till management, and others. The demonstration site will serve as a live example of the benefits and challenges of the recommended BMPs and a great location for field days- another outreach activity in this plan, providing area producers to opportunity to see the BMPs in action before making the investment and change in their own operation. Additionally, watershed tour will be planned, virtually and in person to highlight successful BMPs and problem areas. The primary audience of the outreach efforts are watershed landowners and agricultural producers, as well as agriculture retailers and crop consultants working in the area.

Planning partners for this grant are also agency leads in comprehensive watershed management planning that is occurring at a HUC8 level, which includes the Wells Creek watershed. Similar planning efforts are identified in the Greater Zumbro Comprehensive Watershed Management Plan that address sediment in many of our local streams.

Element f. Reasonably expeditious schedule

A schedule for implementing the activities and NPS management measures identified in this plan that is reasonably expeditious.

Timelines for the proposed implementation are shown in **Error! Reference source not found.**.

Implementation activities described in **Error! Reference source not found.** will yield estimated reductions greater than estimated reductions desired to reach water quality standards and nutrient reduction goals within 10 years. This schedule will be updated using adaptive management as funding, partnerships, effectiveness of implementation, and new information becomes available.

Element g. Milestones

A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.

The milestones **Error! Reference source not found.** provide interim, measurable milestones for determining successful implementation of practices in **Error! Reference source not found.**. The milestones in this plan serve the purpose of measuring continuous progress toward the restoration and protection of the Steamboat River Watershed.

Table 10. Milestone table Wells Creek (PLET, 2024).

Wells Creek	Indicator	Milestones			Total
		Short Term (Yrs 0-4)	Mid Term (Yrs 4-8)	Long Term (Yrs 8-10)	
	Total Suspended Solids (t/yr)	6,504	4,308	996	11,808
	Phosphorus (lbs/yr)	9,129	7,980	3,384	20,493
	Nitrogen (lbs/yr)	24,744	21,758	9,304	55,806

Element h. Assessment criteria

> *A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.*

Employing the sediment load provided by the PLET modeling and the necessary reduction from the load duration curve to meet the sediment loading capacity of Wells Creek, a minimum reduction of 90% of the current sediment load is needed to meet Minnesota's cold water total suspended solids standard. The sediment load provided by PLET is 8,893.65 tons per year and the loading capacity of Wells Creek is 889 tons per year. Therefore, to meet the water quality standard of 10 mg/L, resource managers and landowners must reduce sediment in Wells Creek 8,004 tons per year, a substantial goal in a challenging landscape.

The assessment criteria for this watershed are designated in 4-year increments and the unit of measure is described in **Error! Reference source not found.**. The assessment criteria and achievement of milestone goals will be used to measure the accomplishment of this NKE plan. It is difficult to anticipate the response of the stream to BMPs within a 10-year period. While water chemistry and other water quality monitoring is considered the gold standard, to encourage the continued adoption and support of these efforts, alternative and additional measures must be employed. The connection of BMPs on the landscape to the response in chemistry changes can be difficult to communicate to the public. The milestones described in Table 8 offer an alternative means of measuring, and importantly, communicating the successes to support the forward momentum of implementation adoption. There are estimated reductions associated with these practices which will allow watershed professionals to have an approximate idea of the loading changes to be expected. These milestones are to ensure that the expected reductions are taking place. Traditional water quality monitoring (chemical, sediment, and biological) and the visual inspections of the watershed demonstrate success. Visual inventories of streambank erosion, gullies, and field runoff can be the leading indicator of the success of implementation.

Adaptive management

Adaptive management is an approach to water quality restoration efforts where BMP implementation efforts are combined with an on-going evaluation of the water quality issues. Effects of implemented BMPs are reflected by adjustments to the resource goals, implementation plan and/or implementation efforts when needed. Adjustments are made to incorporate the knowledge gained through the combined efforts. Adaptive management—sometimes referred to as adaptive implementation—is critical when various uncertainties are significant in a watershed (Shabman et al., 2007). This approach is essentially a "learning while doing" approach. It means that uncertainty is not forgotten once implementation begins. Rather, a focus is placed on reducing the uncertainty present through implementation, monitoring and evaluation, research, and experimentation. The knowledge gained through these efforts is then focused on reducing the uncertainties in the implementation approaches and/or water uses and criteria. The approach goes beyond just asking "when" in implementation to include "where, what, how and why" (Shabman et al., 2007).

Uncertainties related to the water quality criteria, modeled numbers, sediment sources and aquatic life stressors are present in the various Wells Creek reports, even though much was learned through these studies. Through an adaptive management approach, this initial implementation plan has been developed to begin implementation activities, continue survey and inventory efforts and evaluate the progress toward meeting the aquatic life goals for the river. As this work is completed, the implementation goals, priorities and BMPs will be examined and revised, as needed.

The Wells Creek 319 workgroup anticipates a review process to take place every four years, including an assessment of partnership operations and self-assessment of workload and delivery of implementation actions. The assessment will consider the pace of progress toward the plan goals and will provide additional data that may impact plan priorities and help define future implementation activities. Over the life of the nine-key element plan, information may arise that warrant revisions to the plan. New priority issues may emerge or strategies may need to be adjusted. The relative importance of existing issues may change based on monitoring data, modeling results, or shifting priorities of the partners.

At the time of writing the plan, the partnership developed the following prompts and associated responses to help guide the adaptive management approach:

- Are the most significant sediment sources being addressed?
  - If not: identify barriers, re-evaluate the sources, determine whether different funding sources are needed to target sources.
- Is voluntary BMP adoption meeting the targets in the plan?
  - If not: Consider putting additional funds toward field walk overs and outreach staff for making one on one connections with producers, find ways to leverage more watershed-based implementation funding or increasing cost-share on projects, increase development of outreach materials to targeted areas to better communicate the issues and the need to work collaboratively to meet our water quality goals
- Are the installed BMPs performing as intended and are load reduction trends reflecting the estimated milestones?
  - If not: Consider an assessment of what other BMPs would have a larger impact for this area such as water storage practices and find additional funding sources, consider is more monitoring is needed to assess upstream sources, consider if additional modeling is needed to assess increased precipitation or hydrology changes.
- Are risks to under-represented populations being mitigated?
  - If not: Consider putting additional funding into outreach staffing and development of materials for communicating risks and working together on solutions with other agencies and partners

Element i. Monitoring

The monitoring & evaluation component to track progress and evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

Water quality monitoring in the Wells Creek watershed will be conducted at **two** established MPCA stream sampling stations: 1) S004-859 which is an MPCA and DNR Cooperative Stream Gaging site and long term MPCA Pollutant Load Monitoring site, with data published to https://www.dnr.state.mn.us/waters/csg/site.html?id=38006002 and https://public.tableau.com/app/profile/mpca.data.services/viz/WatershedPollutantLoadMonitoringNetworkWPLMNDataViewer/ProgramOverview This site is located 1.5 miles upstream from the mouth of Wells Creek 2) at Goodhue County road 45 crossing of Wells Creek. At these stations sondes equipped with turbidity, nitrate, and temperature sensors will be installed, and samples will regularly be collected to ensure accuracy of the continuous monitoring equipment. The sampling regime will include both field and laboratory measurements. Field measurements include DO, temperature, pH, conductivity, and Secchi tube readings. Upstream and downstream photos will be taken. Laboratory analysis will consist of TSS, nitrite + nitrate (NO_2+NO_3-N) and total phosphorus. Five additional sites will be established following the same methods at the outlets of five main tributaries to Wells Creek.

At least five volunteer stream monitors will be recruited to collect routine field data at five stream locations. Goodhue SWCD will partner with DNR to coordinate routine fish surveys on the cold water tributaries and the main branch of Wells Creek. Groundwater will also be monitored through private drinking wells, nitrate, bacteria, and emerging contaminants will be monitored. In-field lysimeters will be used to monitor effectiveness of practices implemented and springs will be monitored as a mid-point for determining effectiveness of practices.

Inventories of sinkholes, wells, septic systems, grade stabilization structures, water and sediment control basins, invasive species, and wetlands will be developed.

See **Error! Reference source not found.** for additional monitoring efforts.

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