Grant

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West Indian Creek Section 319 Small Watersheds Nine Key Element Plan

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Executive summary

The West Indian 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).

This 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.

West Indian Creek (070400040510) has been identified as a priority area by many organizations and individuals over the years. This is primarily due to the presence of areas of outstanding biodiversity significance, high conservation value forests, and one of the state's largest maze caves which all help to support 15 state-listed rare plant species, two state-listed rare bird species, threatened bat populations, and an important trout community. Even with these exceptional resources, West Indian Creek is not immune to water quality issues. It can be found on the Minnesota's 303(d) List of Impaired Waters with excessive *Escherichia coli* (*E. coli).* Additionally, there are high concentrations of total suspended solids (TSS) and a significant rising trend in nitrate concentrations. Although West Indian Creek does not have nitrogen, phosphorus, or total suspended solids impairments, the Zumbro River Watershed Restoration and Protection Strategy (WRAPS) report does have measureable goals for these pollutants in the Lower Zumbro Hydrologic Unit Code (HUC) 10 watershed. These goals, which are consistent with Minnesota's Nutrient Reduction Strategy, include 20% nitrogen and 12% phosphorus by 2025. Additionally, there is a 40% nitrogen load reduction goal for 2040.

As the only permitted entities in the watershed are feedlots and small quarries, the solution to addressing water quality issues is in the nonpoint sources. These are chiefly cultivated lands as the primary land use and aging septic systems likely as the secondary source. In addition to its unique biology, West Indian Creek is also unique because it 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. Because of this, the contributing area to West Indian Creek cannot be restricted to the surficial watershed if true improvements are to be made in the water quality. The larger, groundwater contributing area must be carefully considered as well.

The primary strategies for addressing water quality issues in West Indian Creek are both social and technical. Relationships, trust, and knowledge will continue to be built and resource concerns will be addressed with various best management practices (BMPs). Key BMPs include feedlot and septic improvements, vegetative filter strips, nutrient management including source control (rate and timing) and conservation crop rotation and cover. Critical areas to be prioritized include uplands and headwaters of the watershed along with agricultural fields in continuous or near continuous corn production.

Introduction

Document overview

The intent of this document is to concisely address the nine elements identified in EPA's *Handbook for Developing Watershed Plans to Restore and Protect our Waters* (EPA 2008) that are critical to preparing effective watershed plans to address nonpoint source pollution. The EPA emphasizes the use of watershed-based plans containing the nine elements in Section 319 watershed projects in its guidelines for the Clean Water Act Section 319 program and grants (EPA 2013).

This Plan's foundation is the data collection, analysis, and development of plans from multiple sources and scales. Most of the monitoring and planning efforts sponsored by the state (Intensive Watershed Monitoring (IWM), Assessments, total maximum daily loads (TMDL), Watershed Restoration and Protection Strategy (WRAPS), One Watershed One Plan (1W1P), etc.) are conducted and report on as Hydrologic Unit Code - eight (HUC-8) watersheds. These foundational efforts provide the support and understanding to develop the very targeted and detailed Focus Grant Workplans for small watersheds. Instead of broad strategies, this Focus Grant Workplan will delve into specific and targeted actions to achieve water quality goals in the West Indian Creek Watershed.

This nine element plan is intended to be a living document. It is the intent of the implementing organizations in this watershed to make steady progress in terms of pollutant reduction. The response of the streams will be monitored and subsequently evaluated as management practices are implemented. The management approach to achieving the goals should be adapted as new monitoring data is collected and evaluated. This approach is commonly called the "adaptive management approach" Continued monitoring and "course corrections" responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in is watershed. Management activities will be changed or refined to efficiently meet the goals of this plan. This is only one of many steps along the path to water quality goals in the West Indian Creek Watershed.

The intent of the nine elements and the EPA watershed planning guidelines is to provide direction in developing a sufficiently detailed plan at an appropriate scale so that problems and solutions are targeted effectively. The nine elements are listed in Table 1 along with the section of this report in which nine element can be found.

Table 1. Nine elements references

Section 319 Nine Element	Applicable Report Section
Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan	Section 5
An estimate of the load reductions expected from management measures	Section 7.1 & 9.2
A description of the nonpoint source management measures that will need to be implemented to achieve load reductions in element b, and a description of the critical areas in which those measures will be needed to implement this Plan.	Section 9.1

Section 319 Nine Element	Applicable Report Section
An estimate of the amount of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this Plan.	Section 9.1
An information and education component used to enhance public understanding of the project and encourage the public's early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.	Section 2.2.2 & Section 9.1
Schedule for implementing the nonpoint source management measures identified in this Plan that is reasonably expeditious.	Section 9.1
A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.	Section 9.1
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	Section 9.1
A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item h immediately above.	Section 9.1 & 9.3

Public participation approach

West Indian Creek was identified as a priority in Wabasha County by the Zumbro River Watershed Partnership in the early 2000s and staff at the Wabasha Soil and Water Conservation District (SWCD) have sought funding to support work in this small watershed for several years. Efforts in 2006 included West Indian Creek watershed landowner contact via mailing and telephone communication as well as informational meetings. Another outreach effort was initiated in 2018 in preparation for a number of grant applications. This included another round of landowner contact via mailing and telephone communication as well as some door-to-door contact. The outreach that began in 2018 included over 400 staff hours.

Watershed description

Physical and natural features

Watershed boundaries

West Indian Creek Watershed is part of the Zumbro River Watershed located in Southeastern Minnesota (Figure 1). All of the land in this part of Minnesota was surrendered by the Dakota people by the treaty made with the upper bands, signed at Traverse de Sioux, July 22, 1851, and with the lower bands signed at Mendota, August 5, 1851. The watershed is in and to the northeast of the city of Plainview, Minnesota and is entirely contained in Wabasha County. The watershed is a HUC12, 070400040510, in the Lower Zumbro River subwatershed and is approximately 27 square miles (17,187 acres). The creek is approximately 10.13 miles long with more than 10 small, protected tributaries. The creek empties into the Zumbro River near the town of Theilman, Minnesota. From Theilman, the Zumbro River travels 23.93 miles and drains to the Mississippi River near Kellogg, Minnesota. West Indian Creek is one of 18 designated trout streams in Wabasha County. Roughly one quarter, or 3,843 acres of the uppermost section of the watershed is located within the Rochester/Paleozoic Plateau Upland Ecological Classification System Subsection, whereas the remaining 13,344 acres of the watershed is in the Blufflands and Coulees Subsection. Here at the boundary of the Rochester Plateau and the Blufflands is an area of transition between a level to rolling plateau and dissected landscapes. In the Rochester Plateau, the depth of drift over bedrock can be between 10-100 feet, whereas in the Blufflands it varies between 0-50 feet. In both subsections, loess (wind-blown silt) soils can be 30 feet thick on broad ridge tops to less than one foot on valley walls. Moving north or downstream in West Indian Creek, cutting into the valley, depth to bedrock decreases, sedimentary rocks are often exposed in valley walls, and springs of groundwater are more widespread.

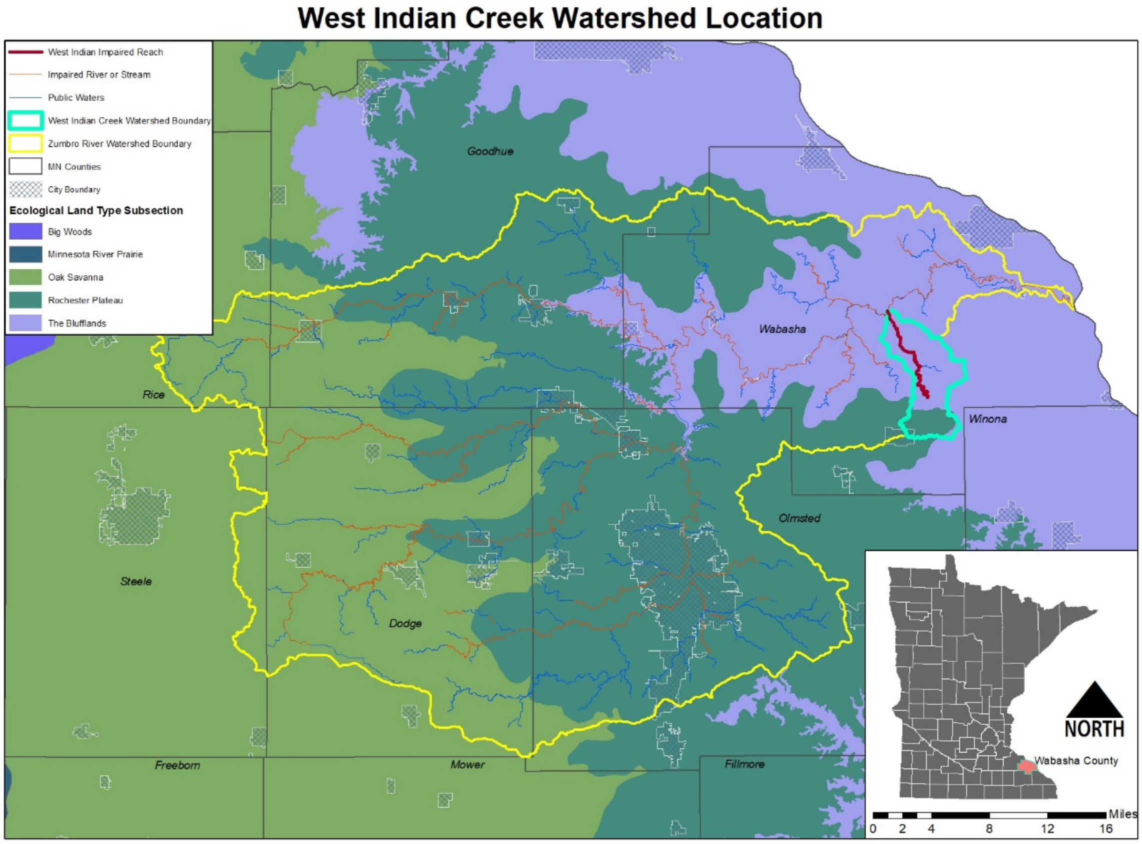


Figure 1. West Indian Creek Watershed location

General hydrology

West Indian Creek has nearly 68 mapped intermittent and perennial stream miles, of this, 12.3% are classified has perennial and 87.6% are classified as intermittent. According to the Minnesota Statewide Altered Watercourse Project, West Indian Creek has 53% natural stream channels, 16% altered channels, and 0% impounded. 31% are classified as 'no definable channel' as shown in Figure 2. Situations where a water course would be classified as "non definable channel" are:

- Water courses crossed by row crops or other tillage,
- Water courses 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, water course 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.

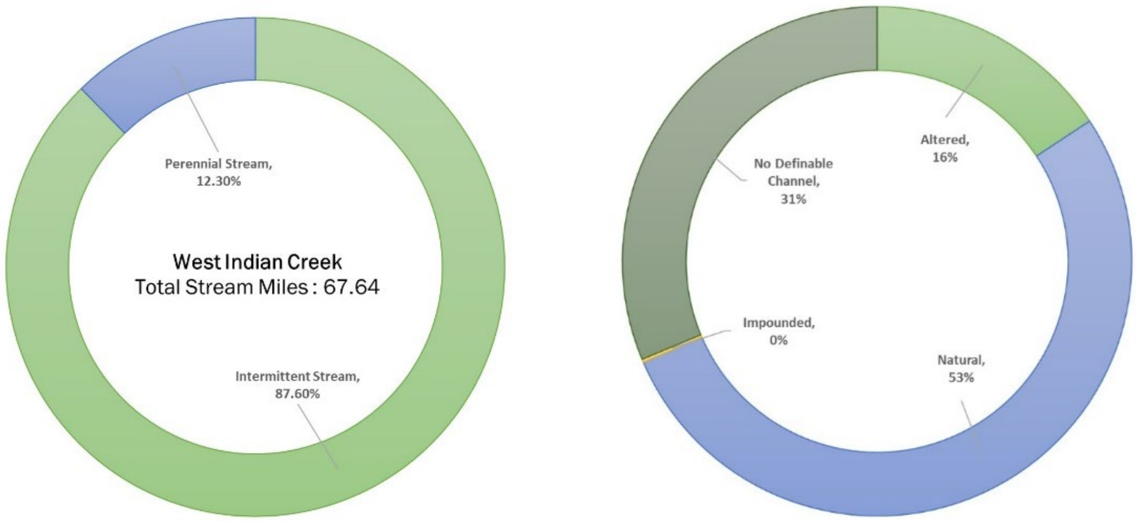


Figure 2. Description of total stream miles in West Indian Creek Watershed

Climate and precipitation

West Indian Creek Watershed is located between two climate zones, moist subtropical mid-latitude climates and moist continental mid-latitude climates. These zones are characterized by warm and humid summers and cold winters. Average annual temperatures over the period of record (1895-2019) has ranged from 38.65 to 48.91 degrees Fahrenheit.

According to the Minnesota State Climatology Office Gridded precipitation database, the 1891 to 2010 normal warm season (May-September) precipitation for the West Indian Creek Watershed is 21.38 inches. The precipitation departure from historic average, or recent average annual precipitation (1989-2018) compared to the average for the entire climate record (1895-2018) shows that all of S.E. Minnesota has received three to four more inches of rain annually. Figure 3 shows the warm season precipitation totals for 1891 through 2019 in Highland Township, Wabasha County, Minnesota. The orange line in this figure is the warm season 'normal' precipitation total. Figure 3 shows that Highland Township, where the West Indian Creek Watershed is located, has consistently received higher than normal precipitation for the last five years. 1998 through 2002 is the only other five year period with consistent above normal warm season precipitation for the entire climate dataset, dating back to 1891.

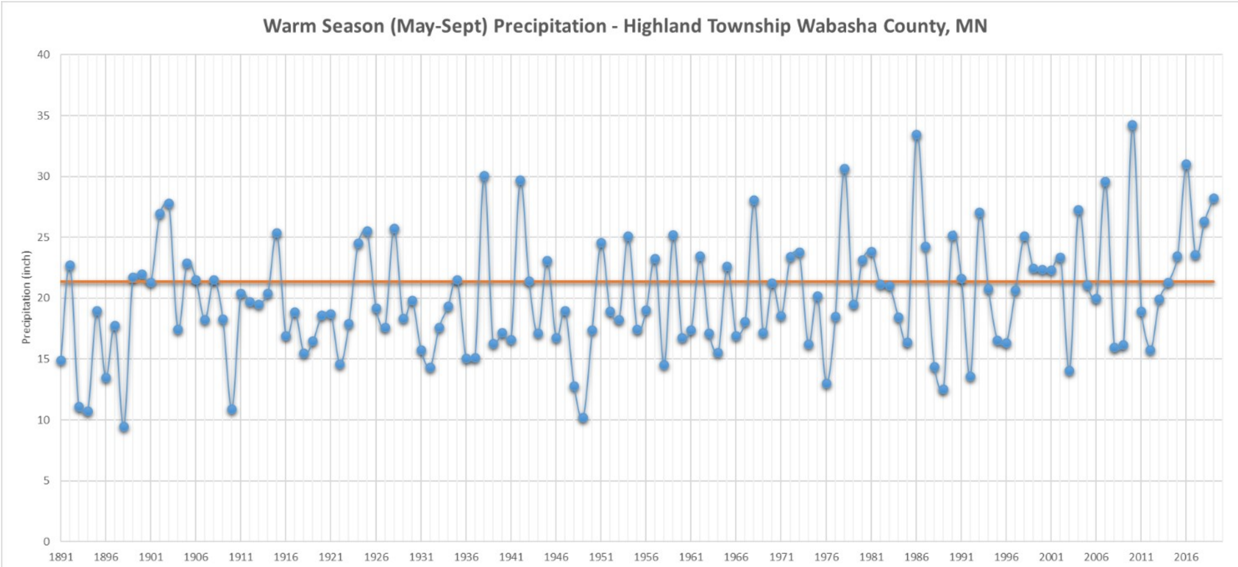


Figure 3. Warm season precipitation 1891-2016

Wetlands data

The U.S. Fish and Wildlife Service National Wetlands Inventory (NWI) has identified 359 acres of various types of wetlands in the West Indian Creek Watershed. The various types and areas are expanded on in Table 2 below, the primary type is hardwood wetland which comprises 231.6 acres or 64.5% of the wetland area.

Table 2. NWI inventory in West Indian Creek Watershed

National Wetlands Inventory Type	Acres in West Indian Creek Watershed
Hardwood Wetland	231.6
Non-Vegetated Aquatic Community	59.2
Seasonally Flooded/Saturated Emergent Wetland	48.9
Shallow Marsh	13.3
Shallow Open Water Community	4.47
Artificially Flooded Shallow Marsh	0.81
Artificially Flooded Non-Vegetated Aquatic Community	0.51
Shrub Wetland	0.15

Surface water

As is discussed in subsequent sections (Geology, Groundwater Resources) it has been argued that the two classical components of the hydrological cycle – "groundwater" and "surface water" – should be referred to as "water resources" and treated as a single unique system in Southeastern Minnesota (MPCA, 2017b).

Department of Natural Resources (DNR) stream survey notes from 1954 state that the source of West Indian Creek is a spring in the stream channel (Image 1), and that springs are numerous along the entire stream.

Image 1. Spring flowing into West Indian Creek in the DNR/TU habitat improvement project being completed 2020-2021

Topography/elevation data

The topography of the West Indian Creek Watershed includes rolling hills, hollows, caves, sinkholes, and dramatic bluffs and valleys (Image 2).

Image 2. Outcropping of bedrock in West Indian Creek Watershed

The lowest point in the watershed is 725 feet above mean sea level and the highest point in the watershed is 1,214 feet above mean sea level. (Figure 4). An example of the rolling hills in the West Indian Creek Watershed is shown in Image 3.

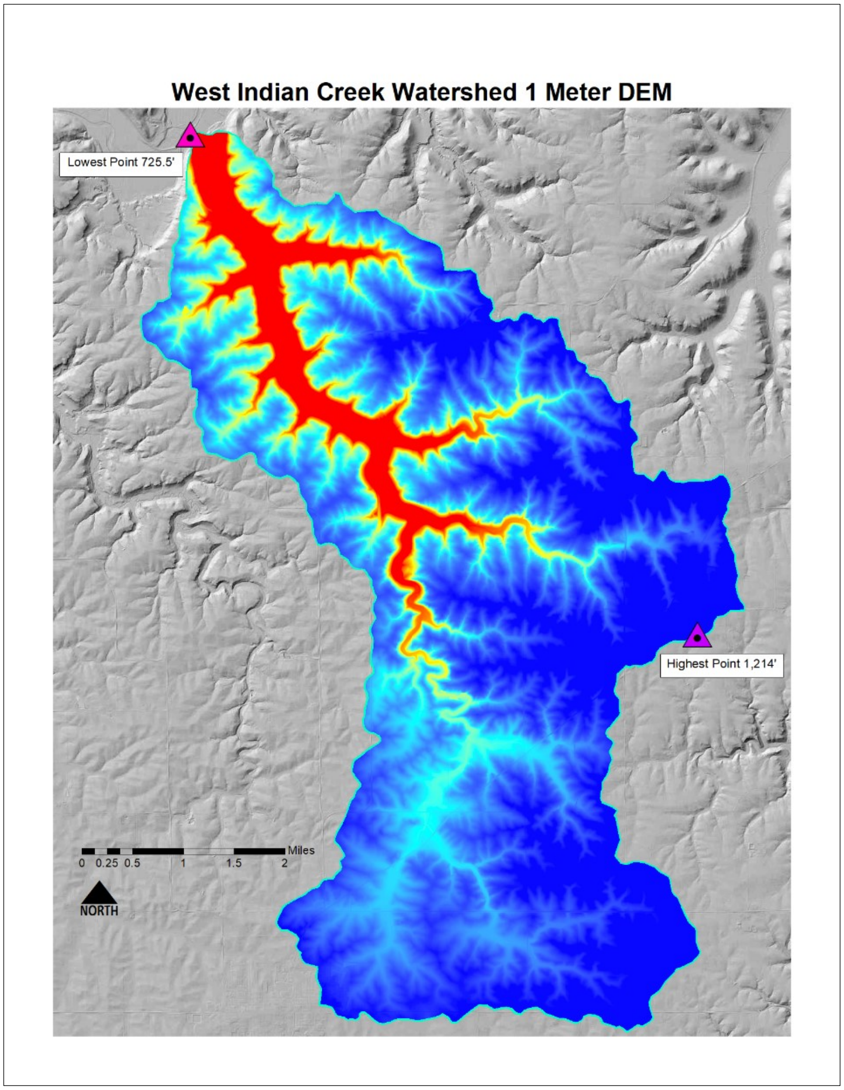


Figure 4. One meter digital elevation model of West Indian Creek Watershed

Image 3. Example of rolling fields in the headwaters/uplands of West Indian Creek Watershed

Geology

While most of Minnesota was once covered with glaciers that left behind deposits of rock, sand, and soil known as drift, southeast Minnesota was untouched by those processes. 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 is characterized by 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.

These habitat conditions include:

- Cool water in summer
- Water that's warmer than air temperatures during the winter
- Relatively stable stream flows

These unique conditions allow trout to continue to grow throughout the year, including through the winter, and provide consistent, ideal conditions for adult trout and for developing eggs in the streambed. The spring water emerging from limestone bedrock enriches the water with essential minerals for aquatic insects and other creatures, which contributes to prime conditions for healthy populations of trout and other coldwater dependent species. (MPCA, 2017b, DNR).

Geology in Southeast Minnesota and the Zumbro River Watershed is characterized by karst features (Figure 5). These geologic features occur where limestone is slowly dissolved by infiltrating rainwater over the course of millions of years, sometimes forming hidden, rapid pathways from pollution release points to drinking water wells or back to surface water. 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 hydrological cycle – "groundwater" and “surface water” – should be referred to as “water resources” and treated as a single unique system in Southeastern Minnesota (MPCA, 2017b).

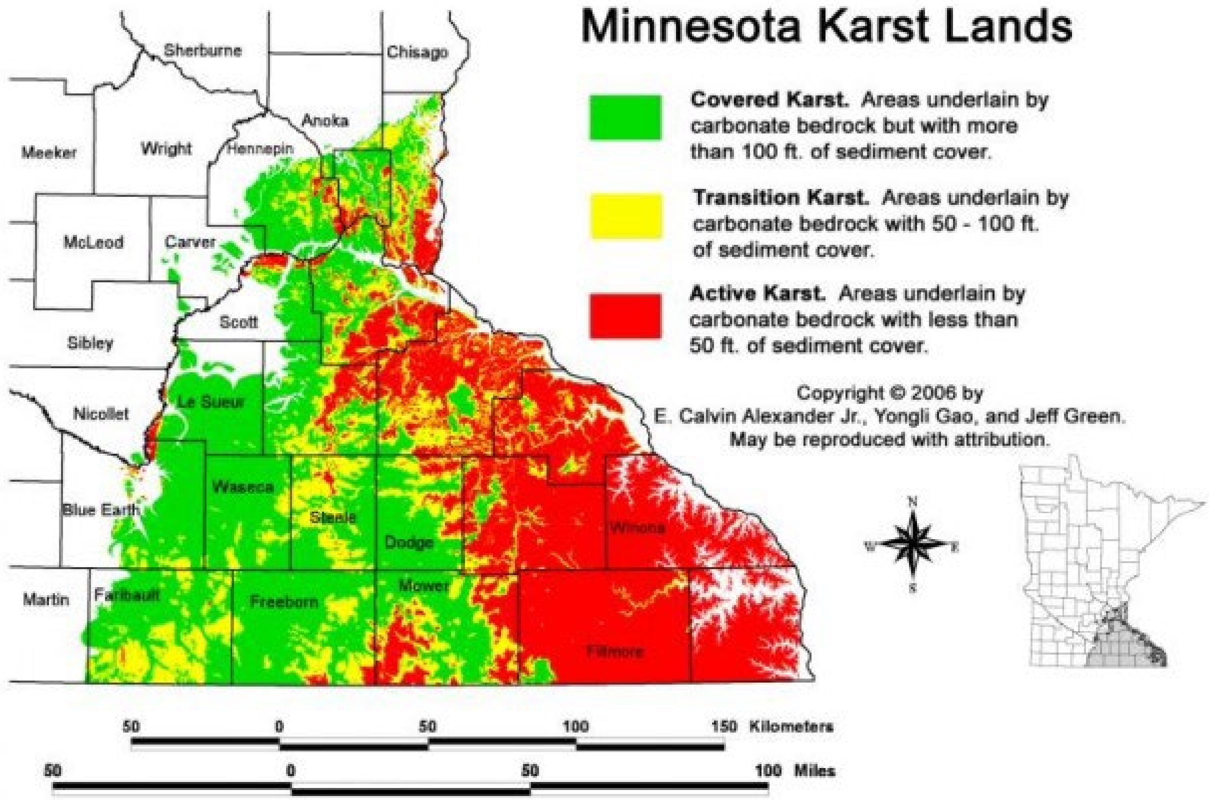


Figure 5. Karst lands in Minnesota (source: Alexander, Gao, & Green 2007)

Kruger Cave, one of the largest maze caves in the state, is another significant natural feature that occurs within the boundaries of state forest land in the West Indian Creek Watershed (Figure 6).

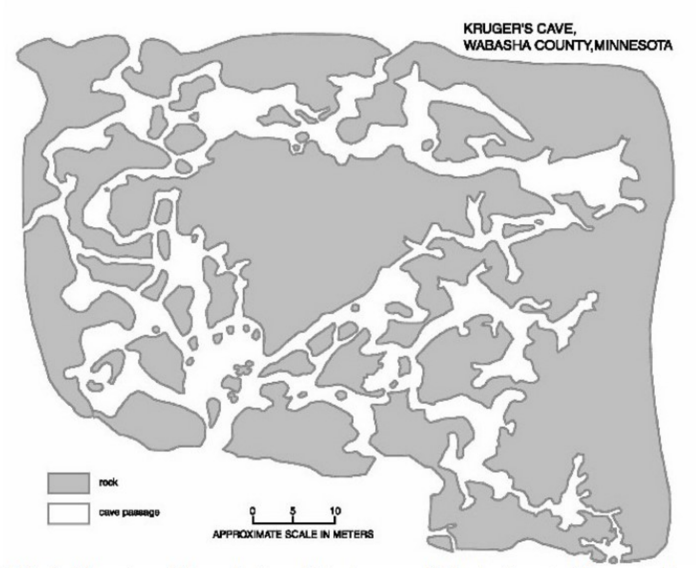


FIG. 5. Plan view of Kruger's Cave, Plainview area, Wabasha County, Minnesota (from a drawing by David Gerboth, Minnesota Speleological Survey; Runkel *et al.*, 2007a).

Figure 6. Kruger's Cave, Wabasha County

Soils

The soils in the West Indian Creek Watershed primarily consist of the Downs series in the uplands, Barremills series on the slopes, and Frontenac-Minneiska-and other series in the valleys (Figure 7). The Downs series is made up of deep, well drained soils formed in loess. Most areas in the watershed where the Downs series is present are considered either prime farmland or farmland of statewide importance. Areas with the Downs soil series and higher slopes (>9) are not considered prime farmland, these areas are often utilized for pasture or are wooded or have a combination of both. The 1965 Wabasha County Soil Survey notes that some Downs series soils with 2 - 6% slopes had been moderately eroded, 2-4 inches of the surface layer had been lost to erosion. Additionally, the soil survey notes that some areas had lost 5- 9 and even 10 inches of the surface layer where slopes are 6-12 or 12-18%. The Barremills series is described as very deep, moderately well drained soils on hills. These are soils that formed in a thin layer of slope alluvium over loess. Although the Natural Resources Conservation Services (NRCS) soil series description states that the Barremills soils are used for cropland, with common crops of corn, small grains, and hay; most areas where this series is present in the West Indian Creek watershed are not considered prime farmland because the slopes are often too high.

According to the NRCS Soils Survey information, roughly 71% of the soils are optimal for farming (Figure 8), however these soils still require good management practices, as outlined in the Natural Resources Conservation Service Field Office Technical Guide (FOTG) for Minnesota. For example, soil capability Class IIe are soils that are subject to moderate erosion if not protected, 92% of the Class IIe capability soils are considered prime farmland. Additionally, 99% of the soils in the farmland of statewide importance category in West Indian Creek watershed are of the Class IIIe Capability group. These soils are subject to severe erosion if they are cultivated and not protected.

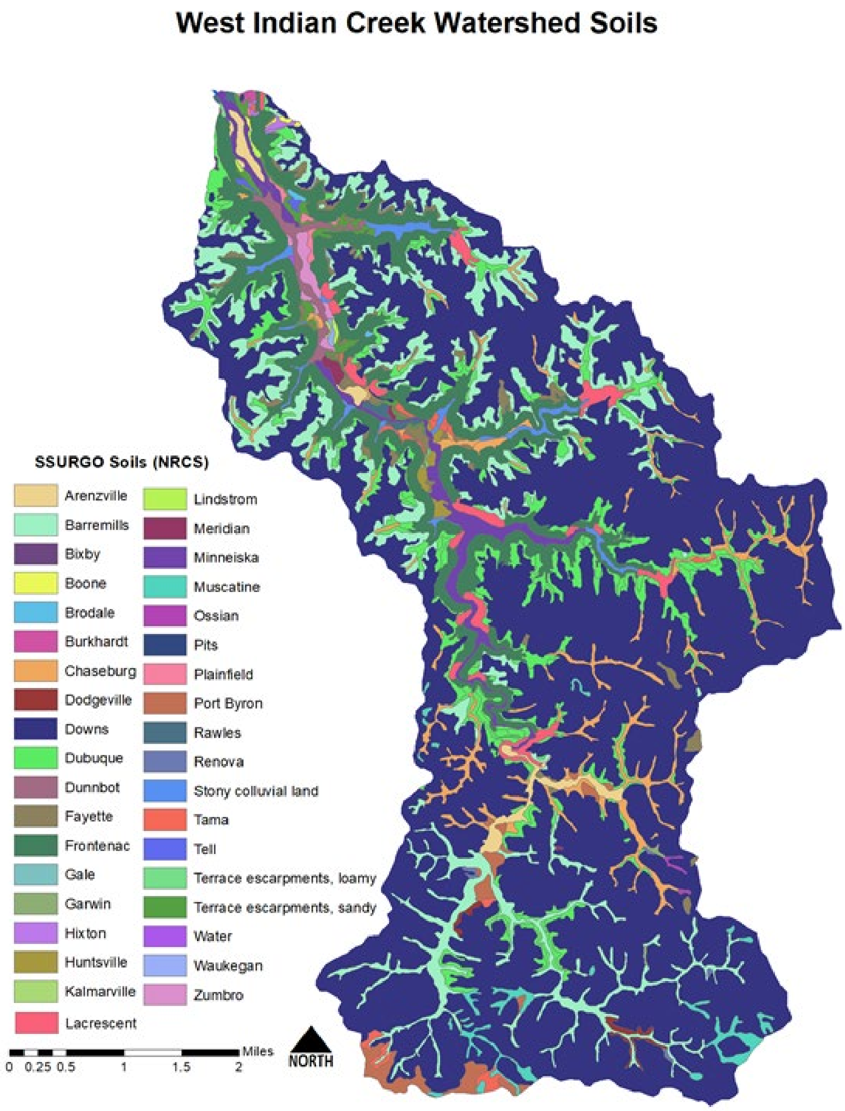


Figure 7. Soil types in the West Indian Creek Watershed

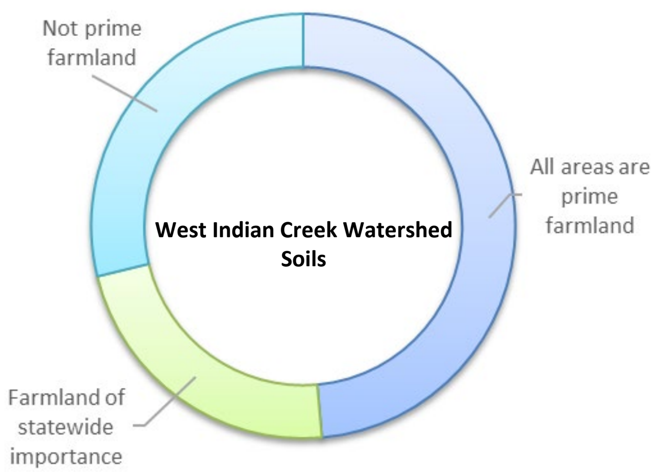


Figure 8. West Indian Creek Watershed farmland ranked soils

Groundwater resources

Karst aquifers, like those commonly used for drinking water supplies in the Zumbro River Watershed, are very difficult to protect from activities at the ground surface because pollutants can be quickly transported to drinking water wells or surface water. The Karst features and regions are illustrated in Figure 10. Because of The rapid transport of pollutants to drinking water, the best strategy to protect groundwater in this watershed is pollution prevention from common sources like row-crop agriculture, septic systems, abandoned wells, and Animal Feedlot Operations (MPCA, 2017b).

The Drinking Water Supply Management Area for the City of Plainview is located at the headwaters of the West Indian Creek Watershed. This area is a source of regional groundwater recharge and is considered vulnerable to surface contamination. Water chemistry results from the two public wells show that they are impacted by nitrate and have other markers of surface water influence. Groundwater flow paths in the Jordan aquifer move from the Plainview area toward West Indian Creek, a local discharge point. (J. Ronnenberg, personal communication, 2019)

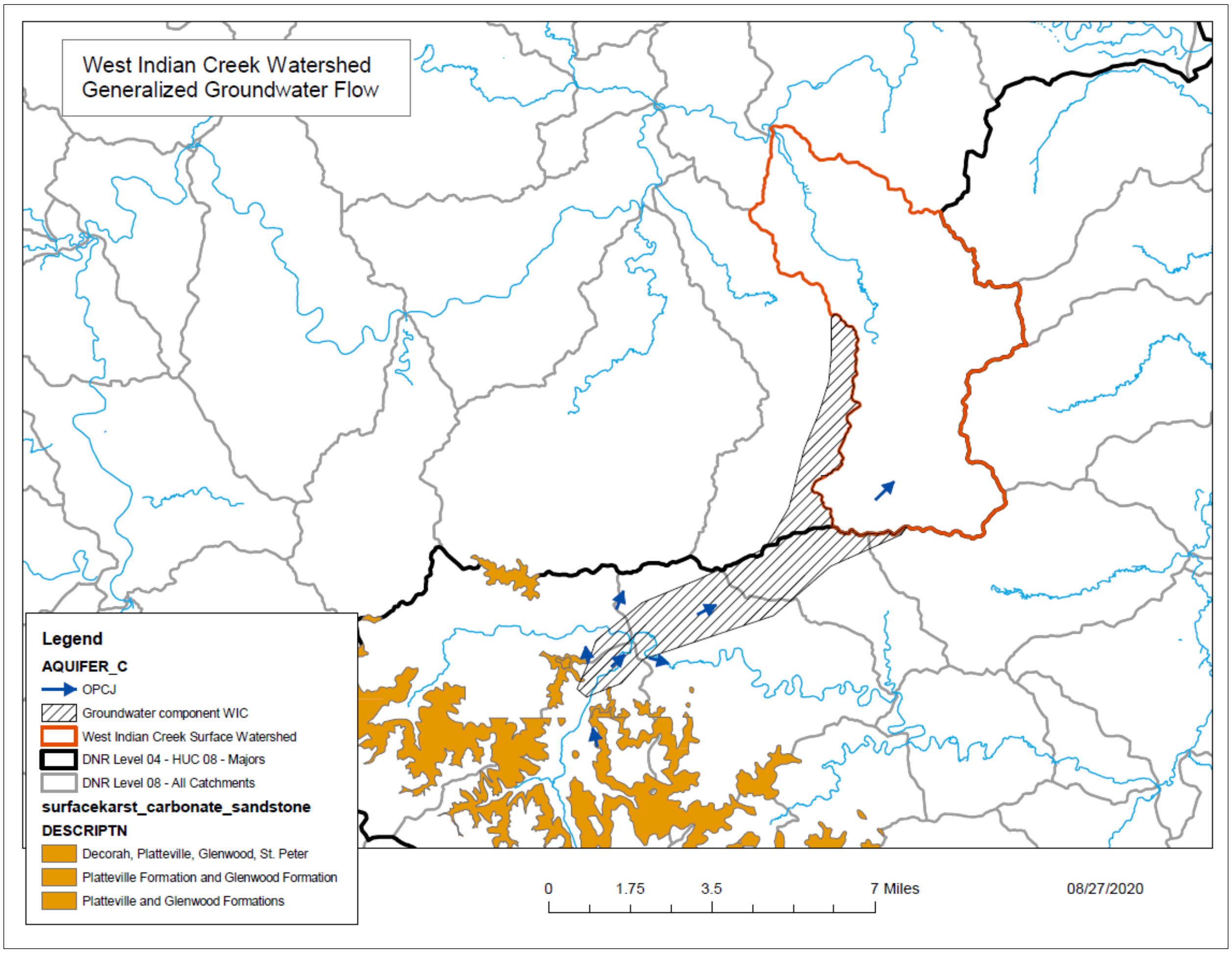


Figure 9. Groundwater flow paths in the West Indian Creek Watershed (provided by the MDH, 2020)

In addition to Plainview, there are at least two other public water supply wells in the watershed. These are non-community wells, and as such, lack the resources available to municipalities to control land use in the areas outside of their own properties. These systems would benefit from the assistance of BMP promotion and implementation that reduces contaminant leaching, such as nitrate and bacteria (J. Ronnenberg, personal communication, 2019).

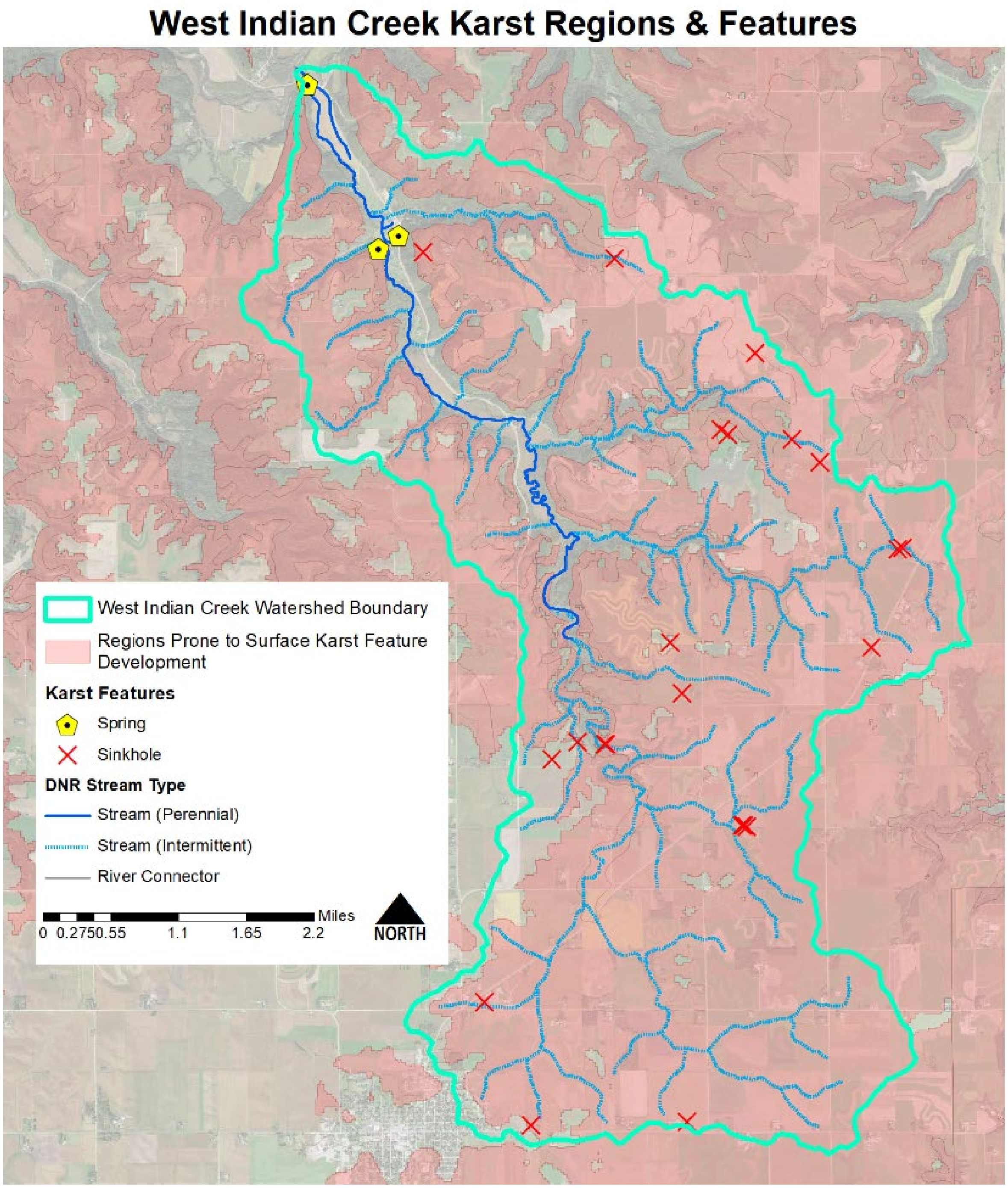


Figure 10. Karst regions and features in the West Indian Creek Watershed (Minnesota DNR, 2020)

Image 4. Newly mapped spring in the West Indian Creek Watershed

There are three mapped springs in the West Indian Creek Watershed; however, this is likely not a comprehensive representation given these springs are located far downstream on West Indian Creek. While walking two small sections of West Indian Creek (around two stream miles) on September 30th, 2020, staff discovered, mapped, and sampled nine additional springs (Image 4). There are 23 mapped sinkholes in the watershed, again this is likely not a comprehensive representation. A verified sinkhole is direct evidence that karst processes are active both on the surface and in a karst aquifer in the subsurface. The absences of sinkholes on the land surface, however, does not imply the absence of active karst processes on the surface or of a karst aquifer in the subsurface.

DNR stream survey notes from 1954 state that small springs are numerous along the whole of West Indian Creek and that the source of the entire stream is a spring in the stream channel.

Vegetation

Pre-settlement vegetation in the West Indian Creek Watershed consisted of primarily (65%) oak openings and barrens. The lower West Indian Creek valley, extending from the confluence with the Zumbro River to where MPCA's long term monitoring site is now located, was Aspen-Oak land. The uplands of the small watershed were prairie, comprising nearly 20% of the watershed. A small corner (2%) of the far headwaters area was classified as Big Woods-Hardwoods, made up of oak, maple, basswood, and hickory trees.

Vegetation changed significantly with agricultural settlement of Wabasha County in the 1850s. At that time, a 200 acre farm was considered large and the primary crops included wheat, barley, rye, corn, and oats. Farmers generally had a more diverse array of crops and in the early 1900s, strip and contour farming were promoted. More recently, farms and individual fields have increased in size and focused on corn and soybean production. Table 13 provides the current percentages crops in the watershed and Figure 12 provides current land cover.

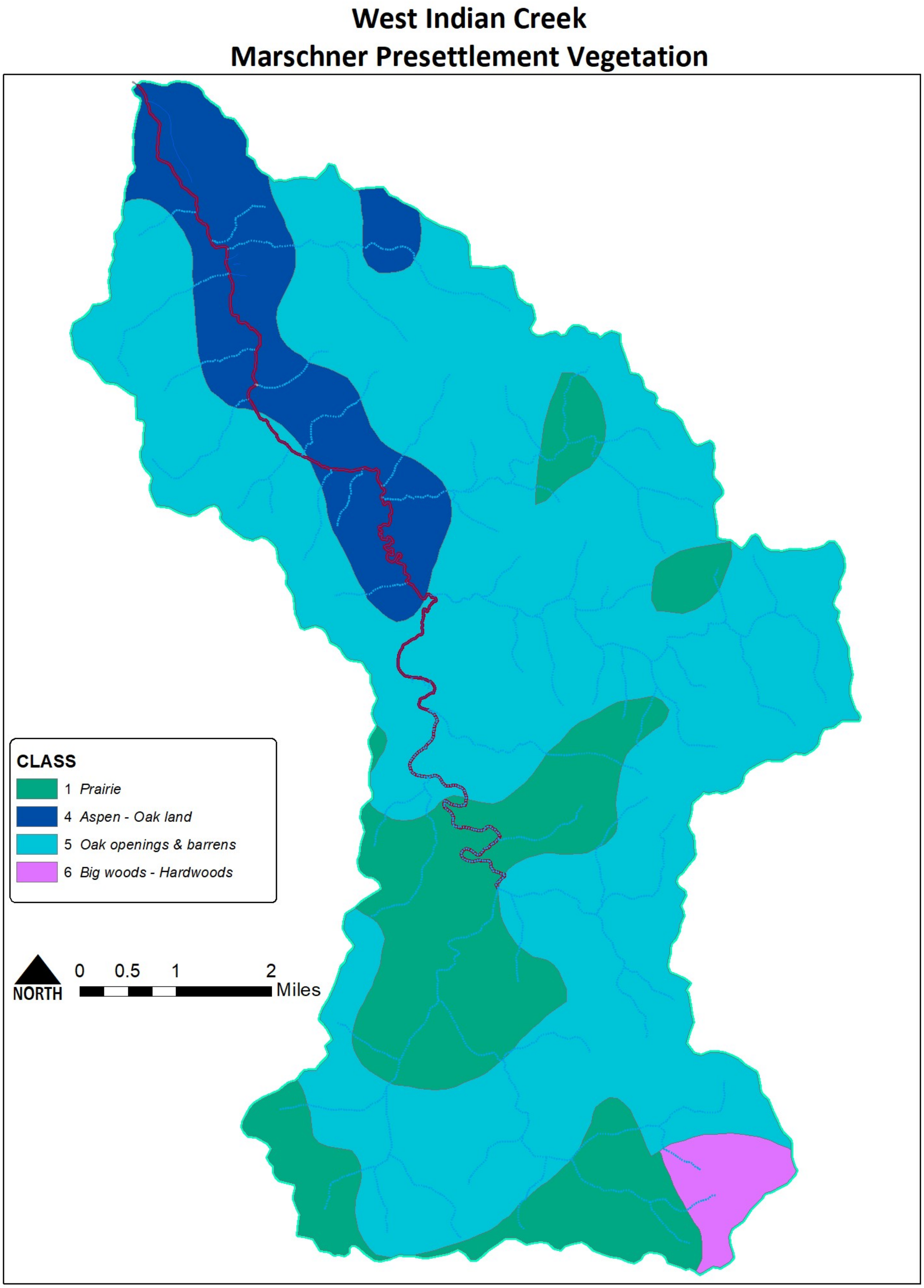


Figure 11. West Indian Creek Marschner pre-settlement vegetation map

Exotic and invasive species

The introduction and establishment of non-native invasive insect, disease, and plant species is a concern for natural resource managers. Invasion of forest ecosystems by non-native invasive species can cause significant economic losses and expenditures for control because they destroy or displace native plants and animals, degrade native species habitat, reduce productivity, and disrupt forest ecosystem processes such as hydrological patterns, soil chemistry, moisture holding capability, and susceptibility to erosion (DNR, 2013) Examples of non-native invasive species with known adverse effects on Minnesota forest resources include: white pine blister rust, gypsy moth, and European buckthorn. There is potential for significant adverse impacts from other species present, such as: emerald ash borer, garlic mustard, reed canary grass, multiflora rose, exotic honeysuckle, spotted knapweed, wild parsnip, and oriental bittersweet. Many of these invasive species are known to be found in the West Indian Creek watershed as well as the surrounding area. In addition to those already listed, poison hemlock and Canada thistle have also been identified in the watershed.

Sensitive areas and endangered species

West Indian Creek Watershed contains 293 acres of designated High Conservation Value Forest part of the Richard J. Doerer Memorial Hardwood State Forest. The HCVF comprises extensive slopes and bottomland located along three miles of West Indian Creek and contains the most diverse and intact stretch of valley in the county. The northern half of the HCVF contains over 121 acres of designated primary old-growth forest in addition to slopes with high-quality maple-basswood and oak forests, moist and dry cliffs, and critically imperiled seepage swamp native plant communities. Additional features that contribute to the site's designation include the presences of cave bat hibernacula and an abundance of rare plant and wildlife species.

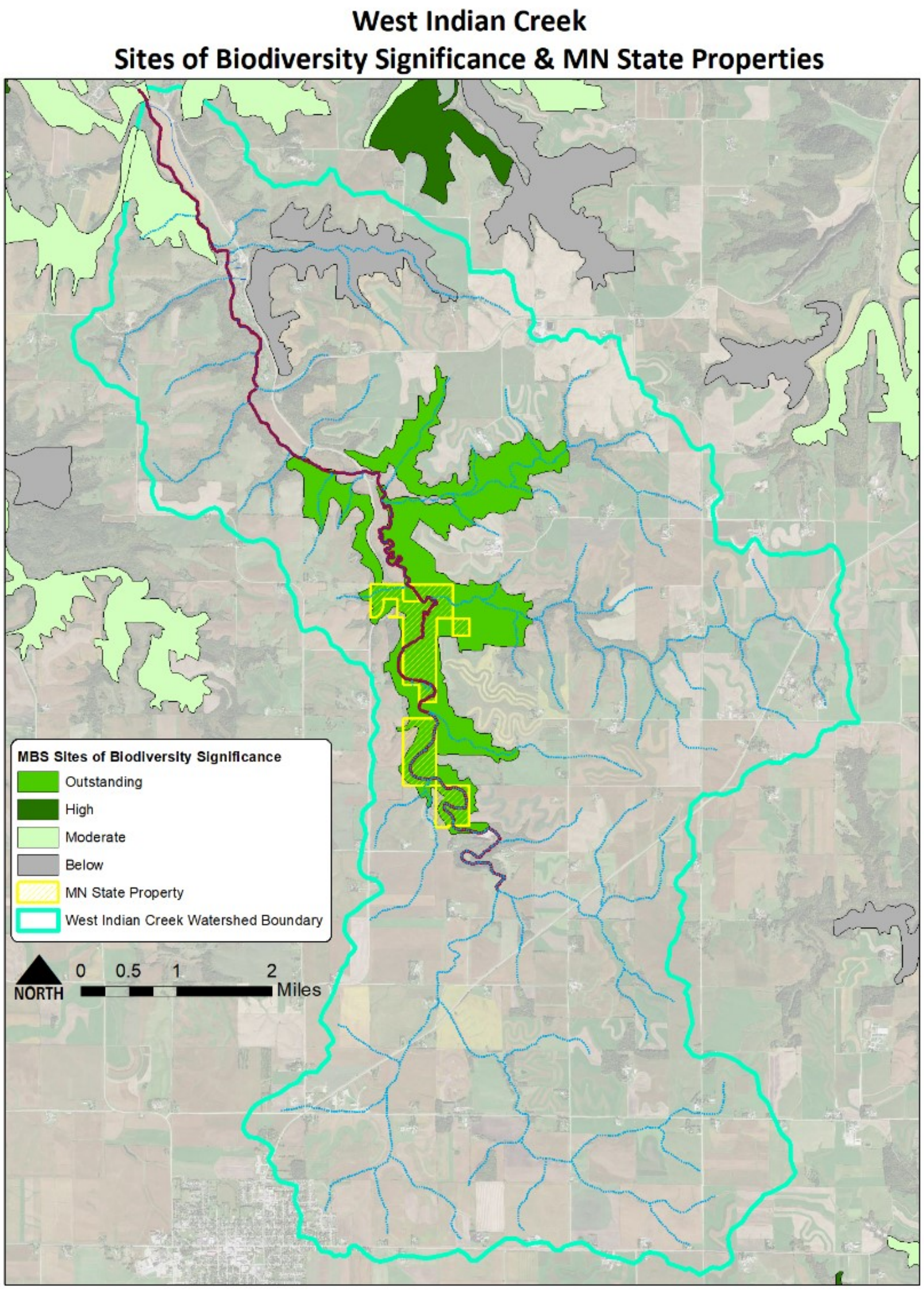


Figure 12. Sites of biodiversity significance and Minnesota state properties

Old-growth forests are quite rare in Minnesota. Originally comprising slightly over half of pre-settlement forested lands, widespread clear-cut logging has resulted in a 96% decline of old-growth forests by 2000. Designated old-growth forest stands are now protected from harvest to provide unique habitat for native wildlife and plants, act as genetic reservoirs for unique genetic material, understand how intensive management affects natural forest conditions, and for the enjoyment of outdoor enthusiasts. These forests typically contain trees older than 120 years, standing and fallen dead trees, and have experienced minimal levels of human disturbance. Three designated old-growth forest stands remain in the Zumbro River Watershed, occurring adjacent to one another within the West Indian Creek HCVF. These include a 32 acres stand dominated by black ash, a 31 acres stand composed largely of sugar maple, and a 53 acre stand consisting mostly of red oak. (MPCA, 2017b).

The Upper West Indian Creek Valley area is one of the most biologically significant forested areas in Wabasha County and, among similar valleys in Southeast Minnesota, is of outstanding biological significance (Figure 12). Within the watershed is 1,276.69 acres of outstanding biodiversity significance, this area is located along the upper reaches of West Indian Creek. The site supports a high quality and diverse array of forest communities including lowland hardwood forest, maple-basswood forest, mesic oak forest, white pine-hardwood forest, oak woodland, mixed hardwood seepage swamp, and algific talus slope. The area contains important geologic features including moist and dry cliffs and several caves. At least one of the caves present on the site was used by hibernating bats. Small bluff prairies occur atop several of the dry cliffs. The creek is a state-designated trout stream fed by springs and seeps that emerge in the area. There are also 185.88 acres of moderate biodiversity significance, and 372.81 acres of negative/below biodiversity significance. The 372.81 acres and remaining 15,351.62 acres of the watershed are lands where native plant communities have been seriously altered or destroyed by human activities such as farming, recent logging, draining, and development according to the Minnesota Biological Survey (MBS).

The area supports multiple populations of fifteen state-listed plants and two state-listed bird species. The Upper West Indian Creek valley is of statewide significance due to its large contiguous acreage of native plant communities, the quality of these communities, the presence of rare specialized habitats, and the large concentration of rare plants and animals, occurring in a large, intact natural landscape (DNR, 2013).

In 1978 the DNR acquired some land in the Upper West Indian Creek Valley. At that time there was a known population of Snow Trillium, a state special concern species, present. For that reason, the site was designated a Natural Heritage Registry Site shortly after its acquisition (DNR, 2013).

At this time the state of Minnesota owns 308.73 acres of primarily outstanding biodiversity significant land within the West Indian Creek Watershed (Figure 12).

Land use and land cover

According to the 2016 National Land Cover Database, the primary land use in the West Indian Creek Watershed is cultivated cropland, which makes up around 59% of the land area. Another 14% of the land use is attributed to hay and pasture lands for a total of around 73% of the watershed being utilized for agriculture. There are 22 registered animal feedlots within the watershed. The next largest land cover category is deciduous forest at 16.8% of the watershed area. Less than 5% of the watershed area is developed. The land use and registered feedlots are displayed in Figure 13.

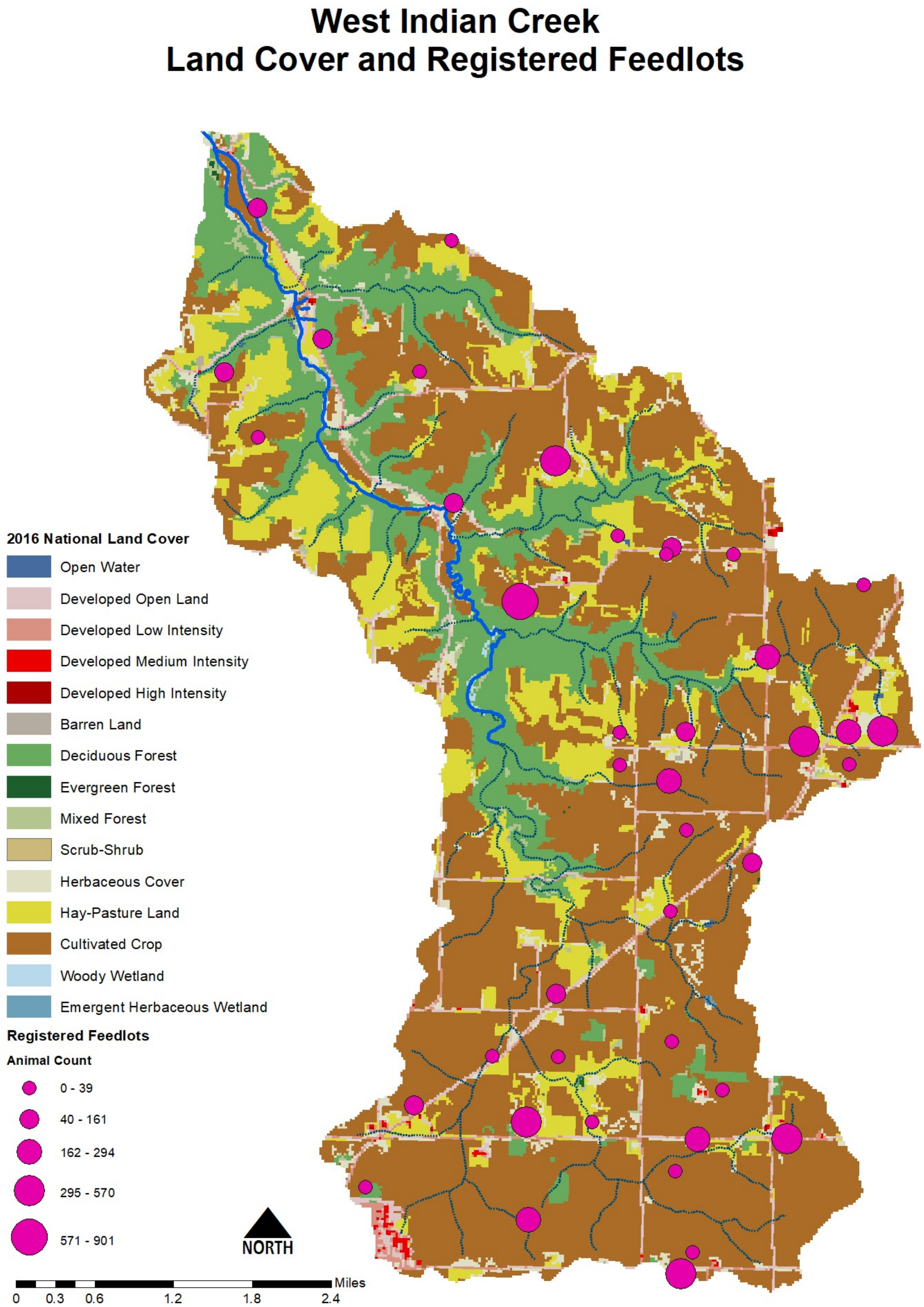


Figure 13. Land cover and registered feedlots in the West Indian Creek Watershed

Agricultural practices

West Indian Creek Watershed has been subject to extensive row crop agriculture for the last century and beyond, as can be seen in the first aerial image taken of the area in 1949 (Image 5). According to the

USDA's ACPF six-year land use summary table, the watershed's agricultural land is 29% corn/soybean rotation, 29% pasture/grass/hay, 18% corn/perennial rotation, and 14% continuous corn. The remaining 10% is in various forms of corn rotation. With the large number of dairies and other animal operations, field application of manure is common throughout the watershed.

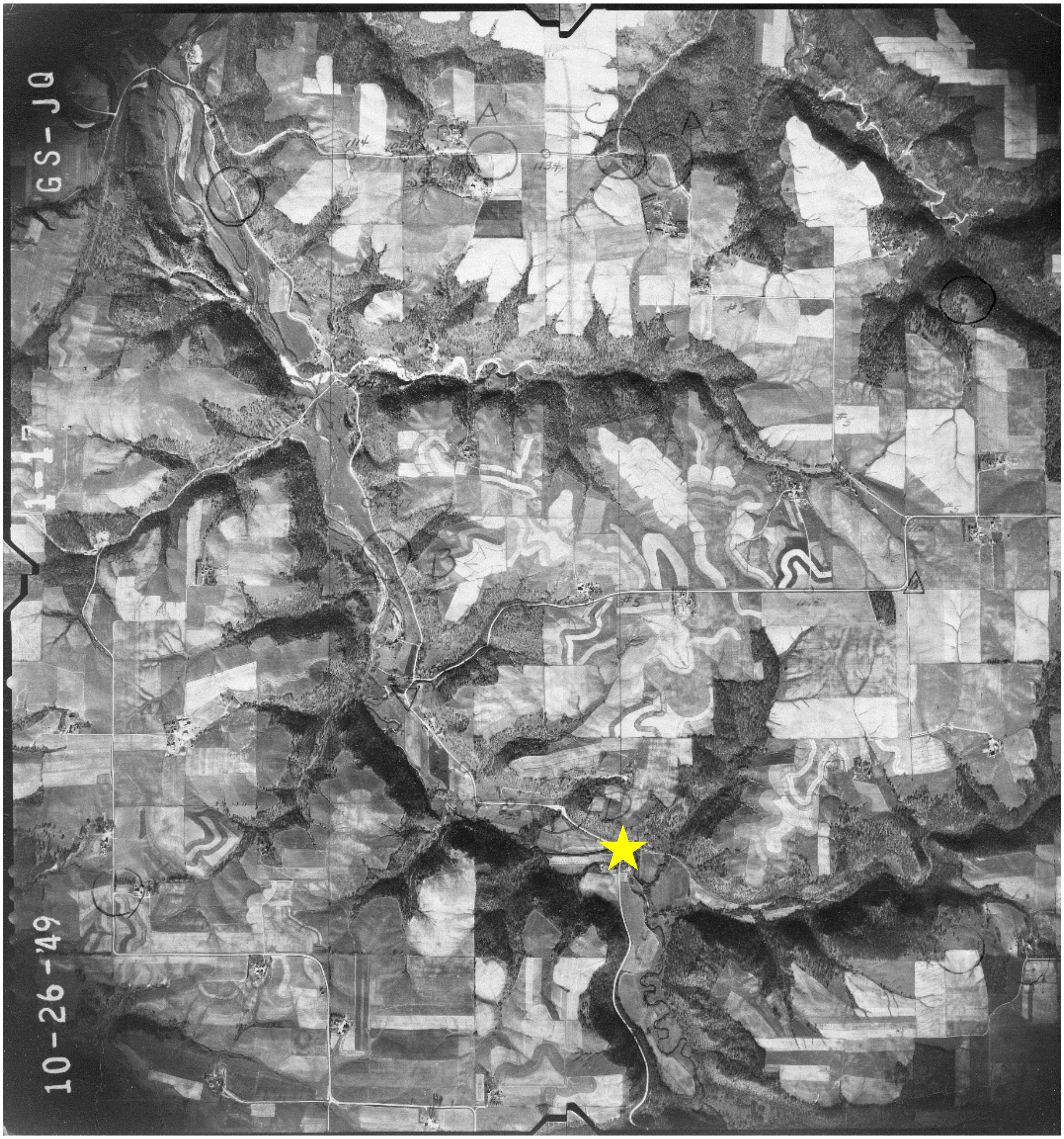


Image 5. First aerial image of much of West Indian Creek Watershed, 1949, with MPCA's long-term monitoring site marked.

Farming began here in the 1850s and has played a major role in the area's economy. Agricultural practices have changed over the years, primarily by increasing in size and uniformity. Much of the landscape is use for two crops, corn and soybeans. Machinery used for production has also increased in size, making strip cropping less practical. Dairy, poultry, swine, and beef cattle farms have been present in the area since the late 1800s and similarly, have increased in size, especially dairy farms in this area.

Effective in September 2020, is Minnesota's Groundwater Protection rule (Minn. R. ch. 1573) which focuses on restrictions to fall application of nitrogen fertilizer in areas with vulnerable groundwater or protected areas around a public well known as a drinking water supply management area (DWSMA) with nitrate-nitrogen concentrations at or in excess of 5.4 mg/L. The vast majority of the West Indian Creek watershed has been included in the vulnerable groundwater area where fall application of nitrogen fertilizer is restricted, shown in purple in Figure 14. Additional restrictions are applicable to the area shown in green, the Drinking Water Supply Management Area of Plainview, Minnesota.

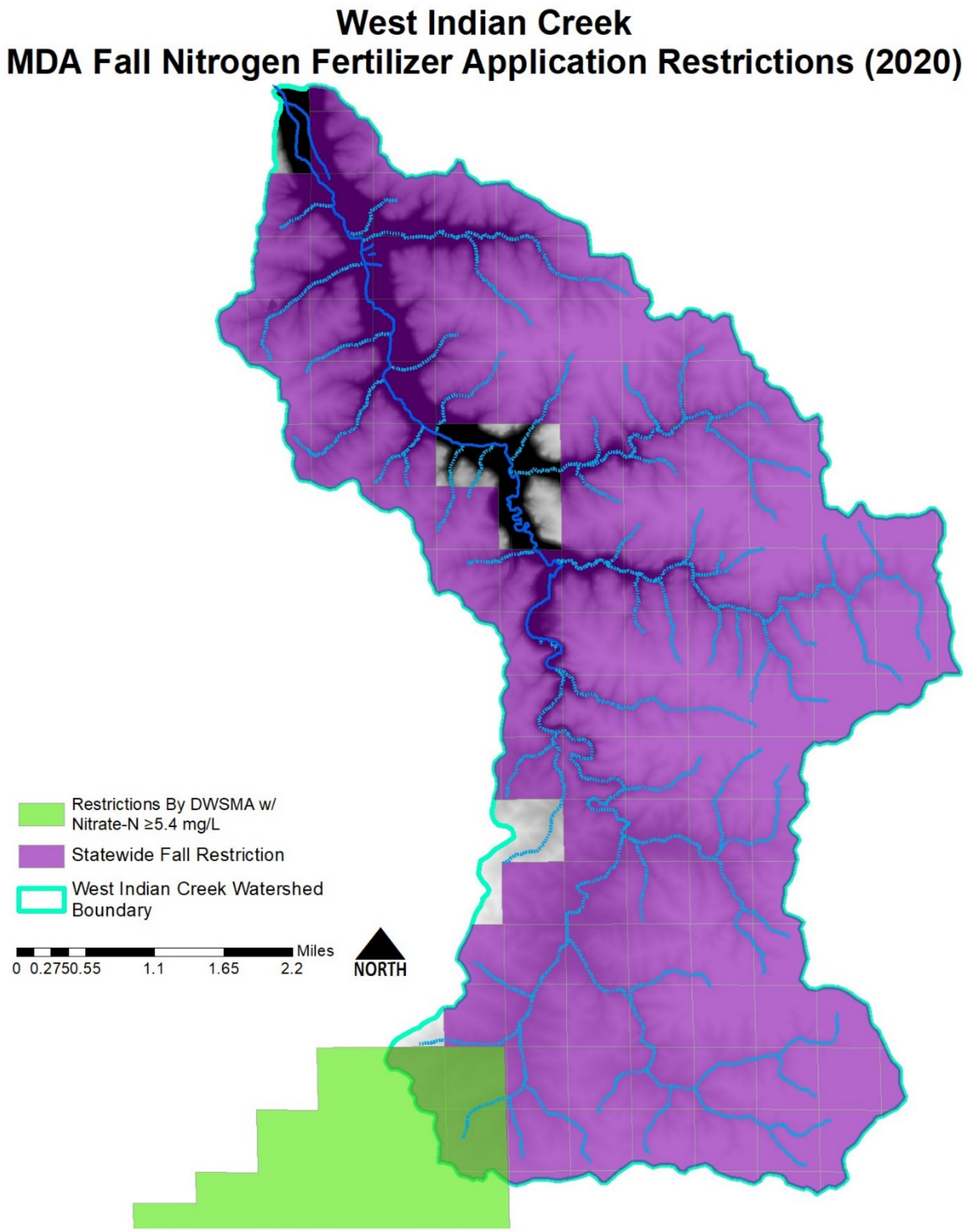


Figure 14. Minnesota Department of Agriculture nitrogen fertilizer application restrictions (2020)

Mining activities

There are three quarries within the watershed boundaries. Two have been permitted for several years, and one is currently initiating the permitting process. All permitted sites are permitted for construction sand and gravel mining. At these sites, there is no dewatering and stormwater is contained on site and allowed to infiltrate.

Fisheries

Much of West Indian Creek is designated by DNR as a trout stream with protected tributaries and by MPCA as a Class 2Ag water (Image 6). Class 2Ag waters are protected for general cold water aquatic life and habitat. These are waters capable of supporting and maintaining a balanced, integrated, adaptive community of cold water aquatic organisms having a species composition, diversity, and functional organization comparable to the median of biological condition gradient level 4. West Indian Creek supports naturally reproducing populations of both brown and brook trout as well as slimy sculpin. The trout fishery of West Indian Creek is highly valued by DNR and fishing organizations. The two habitat improvement and stream restoration projects within the watershed are a clear indication of the value of its fishery.

Image 6. Section of habitat improvement project completed by Trout Unlimited and DNR on West Indian Creek

Developed areas

The boundaries of the city of Plainview extend into the West Indian Creek watershed, comprising about 1.05% of the watershed area. Additionally, the Whippoorwill Campground occupies around 71 acres in the watershed with around 100 RV sites and a restaurant and banquet hall.

According to the 2019 Cropland Data Layer, only 5% of the watershed is developed. Two percent of the developed land is low intensity and the remaining three percent is considered open space. Less than 0.3% of the watershed is considered medium and high intensity development.

Relevant Authorities

There are various agencies and local organizations involved in the restoration of the West Indian Creek Watershed. Table 3 describes the different agencies and authorities potentially involved in West Indian Creek.

Table 3. Relevant authorities in the West Indian Creek Watershed

Level of Government	Agency	Authorities
Federal	U.S. Environmental Protection Agency	Clean Water Act National Pollutant Discharge Elimination System(NPDES) Safe Drinking Water Act Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
	U.S. Army Corps of Engineers	Rivers & Harbors Act, Sec. 10 Clean Water Act Section 404 Permits
State	Minnesota Pollution Control Agency	Water Quality Certification, Sec. 401 of Clean Water Act Surface Water Standards Water Quality Monitoring & Assessment Impaired Waters List NPDES permits Feedlot Regulation Subsurface Sewage Treatment Systems (above 10,000 gal/day)
	Department of Natural Resources	Public Waters Work Permits Surface Water Appropriation Permits Surface Water Hydrology Programs Preliminary Well Assessment Shoreland Management
	Board of Water & Soil Resources	Comprehensive Watershed Management Plans Groundwater Protection Plans Soil & Water Conservation District Oversight MN Wetland Conservation Act
	Minnesota Department of Agriculture	Monitoring of agricultural chemicals, Groundwater Protection Rule
	Minnesota Department of Health	Well Management Program Wellhead Protection Safe Drinking Water Act Health Risk Limits Source Water Assessments
County	Wabasha County Soil & Water Conservation District	Wetland Conservation Act Rules & Administration MN Buffer Rule compliance Local zoning ordinances
	Wabasha County	Local ordinances Subsurface Sewage Treatment Systems (under 10,000 gal/day)

Demographic characteristics

Population

There are nearly 350 land owners in the West Indian Creek Watershed and 389 address points, 58% of these address points occur in the city of Plainview which occupies 181 acres or 1.05% of the watershed. The remaining 98.9% of the watershed includes 163 address points.

The median age of individuals living in Highland Township was estimated to be 47 according to the Unites States Census Bureau. Additional age breakdown is presented in Table 4.

Table 4. Percentage of population by age group in the West Indian Creek Watershed

Age Group	% of Township Population
Under 5 years	4.1%
5 to 17 years	17.3%
18 to 24 years	9.7%
25 to 44 years	18.5%
45 to 54 years	17.1%
55 to 64 years	23.3%
65 to 74 years	3.9%
75 years and over	6.2%

The population of the area is predominantly white and English speaking, with less than 1% being non-white or speaking another language. Estimates of individuals in Highland township who were born in Minnesota are between 90% and 95%.

There is no significant growth anticipated for the area over the next 10 years.

Economics

Median individual income in Highland Township was estimated by the United States Census Bureau at $35,238 in 2018. The percentage of individuals for whom poverty status is determined to be at or above 150% of the poverty level in Highland Township was estimated at 88.2% in 2018.

Watershed conditions

Water quality standards

The federal Clean Water Act requires states to designate beneficial uses for all waters and develop water quality standards to protect each use. Water quality standards consist of several parts:

- Beneficial uses – identify how people, aquatic communities, and wildlife use our waters
- Numeric criteria – amounts of specific pollutants allowed in a body of water and still protects it for the beneficial uses
- Narrative criteria – statements of unacceptable conditions in and on the water
- Antidegradation protections – extra protection for high-quality or unique waters and existing uses

Together, the beneficial uses, numeric, and narrative criteria, and antidegradation protections provide the framework for achieving Clean Water Act goals.

Minnesota's water quality standards are provided in Minn. R. ch. 7050. All current state water rules administered by the MPCA are available on the Minnesota water rules page (https://www.pca.state.mn.us/water/water-quality-rules).

Designated Beneficial Uses

The beneficial uses for public waters in Minnesota are grouped into one or more classes as defined in Minn. R. ch. 7050.0140. The classes and beneficial uses are:

- Class 1 – domestic consumption
- Class 2 – aquatic life and recreation
- Class 3 – industrial consumption
- Class 4 – agriculture and wildlife
- Class 5 – aesthetic enjoyment and navigation
- Class 6 – other uses and protection of border waters
- Class 7 – limited resource value waters

The aquatic life use class now includes a tiered aquatic life uses (TALU) framework for rivers and streams. The framework contains three tiers-exceptional, general, and modified uses.

All surface waters are protected for multiple beneficial uses.

Numeric Criteria/ State Standards

Narrative and numeric water quality criteria for all uses are listed for three common categories of surface waters in Minn. R. ch. 7050.0220. The four categories are:

- Cold water aquatic life and habitat, also protected for drinking water: classes 1B, 2A, 2Ae, or 2Ag; 3A or 3B; 4A and 4B; and 5
- Cool and warm water aquatic life and habitat and wetlands: classes 2B, 2Be, 2Bg, 2Bm, or 2D; 3A, 3B, 3C, or 3D; 4A and 4B or 4C; and 5
- Limited resource value waters: classes 3C; 4A and 4B; 5; and 7

The narrative and numeric water quality criteria for the individual use classes are listed in Minn. R. ch. 7050.0221 through 7050.0227. The procedures for evaluating the narrative criteria are presented in Minn. R. ch. 7050.0150.

The MPCA assesses individual waterbodies for impairment for class 2 uses – aquatic life and recreation. Class 2A waters are protected for the propagation and maintenance of a healthy community of cold water sport or commercial fish and associated aquatic life and their habitats. Class 2A waters are also assessed against the drinking water standard for nitrate. Class 2B waters are protected for the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish, and associated aquatic life and their habitats. Both class 2A and 2B waters are also protected for aquatic recreation activities including bathing and swimming.

Protection for aquatic recreation entails the maintenance of conditions safe and suitable for swimming and other forms of water recreation. In streams, aquatic recreation is assessed by measuring the concentration of *Escherichia coli (E. coli)* in the water, which is used as an indicator species of potential waterborne pathogens.

Protection of aquatic life entails the maintenance of a healthy aquatic community as measured by fish and macroinvertebrate indices of biological integrity (IBIs). Fish and invertebrate IBI scores are evaluated against criteria established for individual monitoring sites by waterbody type and use subclass (exceptional, general, and modified).

General use waters harbor “good” assemblages of fish and macroinvertebrates that can be characterized as having and overall balanced distribution of the assemblages and with the ecosystem functions largely maintained through redundant attributes. Modified use waters have been extensively altered through legacy physical modifications, which limit the ability of the biological communities to attain the general use. Currently the modified use is only applied to streams with channels that have been directly altered by humans (e.g., maintained for drainage, riprapped).

The ecoregion standard for aquatic recreation protects lake users from nuisance algal bloom conditions fueled by elevated phosphorus concentrations that degrade recreational use potential.

Antidegradation Policies/Procedures

The purpose of the antidegradation provisions in Minn. R. ch. 7050.0250 through 7050.0335 is to achieve and maintain the highest possible quality in surface waters of the state. To accomplish this purpose:

1. Existing uses and the level of water quality necessary to protect existing uses shall be maintained and protected.
2. Degradation of high water quality shall be minimized and allowed only to the extent necessary to accommodate important economic or social development.
3. Water quality necessary to preserve the exceptional characteristics of outstanding resource value waters shall be maintained and protected.
4. Proposed activities with the potential for water quality impairments associated with thermal discharges shall be consistent with section 316 of the Clean Water Act, United States Code, Title 33, Section 1326.

West Indian Creek Standards and criteria

Most of the waters with designated beneficial uses in the West Indian Creek watershed are classified as 2Ag, general cold water use. There are just over 3.5 miles of the upper and lower portions of West

Indian Creek that are classified as 2Bg, general cool or warm water use. The water quality standards and criteria used in assessing these streams include the parameters provided in Table 5.

Table 5. Parameter and class standards and criteria in West Indian Creek Watershed

Parameter	Class 2Ag Standards & Criteria	Class 2B 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 April 1-Oct 31	
Nitrogen, Nitrate	10 mg/L	N/A
Dissolved oxygen	Daily minimum of 7.0 mg/L	Daily minimum of 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	
Stream eutrophication	Based on summer average concentrations for the South River Nutrient Region: TP ≤150 µg/L Chlorophyll-*a* ≤35 µg/L Diel DO flux ≤4.5 mg/L Five-day BOD ≤3.0 mg/L If TP criterion is exceeded and no other variable is exceeded, the eutrophication standard is met	Based on summer average concentrations for the South River Nutrient Region: TP ≤150 µg/L Chlorophyll-*a* ≤40 µg/L Diel DO flux ≤5.0 mg/L Five-day BOD ≤3.5 mg/L If TP criterion is exceeded and no other variable is exceeded, the eutrophication standard is met
Biological indicators	Southern cold water streams Fish IBI numeric threshold: 50 Macroinvertebrates IBI numeric threshold: 43	Southern streams Fish IBI numeric threshold: 50 Low-gradient southern forest streams Macroinvertebrate IBI numeric threshold: 43

Available monitoring and resource data

West Indian Creek is part of the DNR southeast Minnesota long term monitoring program. Biologic sampling began here in 1981 with annual samples being collected since 1999. The DNR also has notes and water quality data from stream surveys completed in 1954 and 1975. The Minnesota Pollution Control Agency (MPCA) also has a long term monitoring site on West Indian Creek (Image 7), where water chemistry samples have been collected since 2007. MPCA's dataset includes the parameters and corresponding number of measurements in Table 6.

Table 6. Parameter and the number of measurements since 2007 in West Indian Creek Watershed

Parameter	Number of measurements
Dissolved oxygen	78
E. coli	38
Inorganic nitrogen	211
pH	77
Phosphorus	156
Specific Conductance	77
Total Suspended Solids	176
Volatile Suspended Solids	176
Transparency (Secchi)	247
Temperature	102
Turbidity	158
Discharge (continuous)	221,820
Temperature (continuous)	128,484
Turbidity (continuous)	228,527

Image 7. MPCA long-term monitoring site on West Indian Creek

Water quality data (impairments and threats)

The Clean Water Act, Section 303(d) requires TMDLs to be developed for surface waters that do not meet applicable water quality standards necessary to support their designated uses. A TMDL determines the maximum amount of a pollutant a receiving water body can assimilate while still achieving water quality standards and allocates allowable pollutant loads to various sources needed to meet water quality standards. Currently, there are only two listed impairments in the West Indian Creek watershed (Table 7). The impairments affect aquatic consumption and aquatic recreation based on mercury in fish tissue and *E. coli* bacteria concentrations. More information regarding the *E. coli* impairment and other threats to the West Indian Creek watershed are described in the following pages.

Table 7. Listed impairments in the West Indian Creek Watershed

Resource of Concern	Description	Waterbody Identification (WID)	Use Class	Year Added to List	Impairment	TMDL Status
West Indian Creek	T109 R11W S21, south line to T109 R11W S6, north line	07040004-542	1B, 2Ag, 3B	2016 2008	Aquatic recreation: *E. coli* Aquatic consumption: Mercury in fish tissue	Approved

E. coli

Table 8 presents *E. coli* sample data collected from 2009-2011, this data is the basis for the only 303(d) listed impairment for West Indian Creek. These values are within the average of the streams having *E. coli* impairments in the Zumbro River watershed and neighboring Cannon River and Root River watersheds.

Table 8. *E. coli* monitoring data 2009-2011

Listed Waterbody Name	Reach AUID	WQ Station ID	No. Samples above 126 MPN/100mL	E. coli Geomean (MPN/100 mL)	Sample Date
West Indian Creek	07040004-542	S004-452	14/18	344.9	2009-2011
		S005-733	15/18	285.4	2009-2011

The presence of fecal pathogens in surface water is a regional problem in southeast Minnesota. Minnesota's 2020 303(d) List of Impaired Waters includes 154 stream reaches impaired by fecal pathogens in the Cedar River and Lower Mississippi River Basins in 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 Evidence of Naturalized Stress-Tolerant Strains of *E. coli* in municipal waste water treatment plants). *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 in the Great Lakes.

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).

Data from MPCA's IWM conducted in 2009-2010 show chronically elevated bacteria levels. Two of the 36 samples collected and analyzed exceed the individual sample standard of 1260 cfu/100 mL, with three additional samples having greater than 1000 cfu/100 mL. June through August all exceed the monthly geometric mean standard of 126 cfu/100 mL. In the Zumbro River Watershed, all cold water streams, where sufficient data was available for assessment, did not meet aquatic recreation standards due to bacteria issues (MPCA, 2016). A TMDL study for West Indian Creek was completed and approved by EPA in February 2018. Based on the load duration curve, Figure 15, the loading capacities and allocations in Table 9 were developed. There are no permitted wastewater facilities or MS4 communities within the drainage area, therefore there is no Waste Load Allocation.

Figure 15. *E. coli* load duration curve from the West Indian Creek Watershed *E. coli* TMDL Report

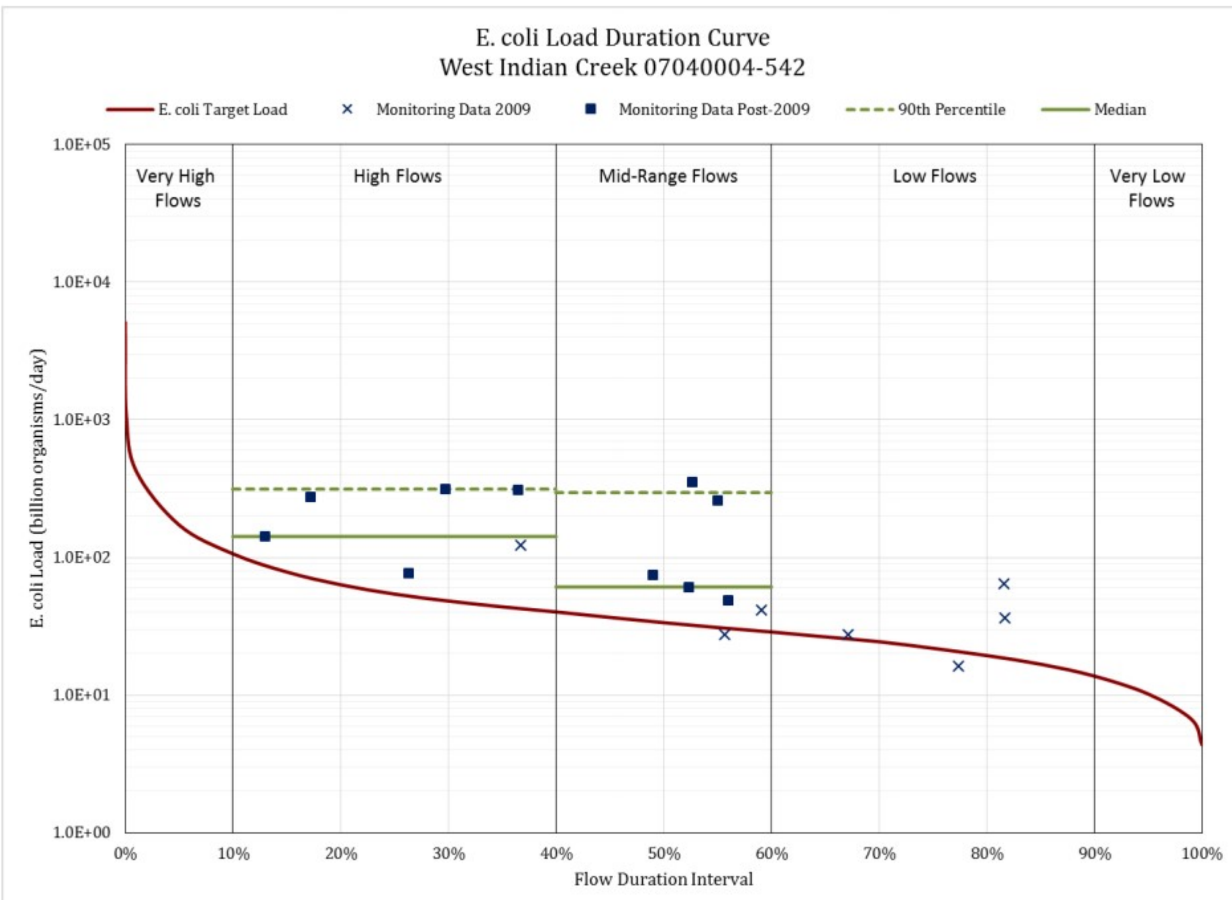


Table 9. West Indian Creek *E. coli* TMDL

West Indian Creek 07040004-542 TMDL Summary	Flow Regime				
	VHigh	High	Mid	Low	VLow
	Billions of Organisms/day				
***E.coli* Loading Capacity (TMDL)**	172.67	54.29	33.67	21.92	10.19
Wasteload Allocation (WLA)	NA	NA	NA	NA	NA
Load Allocation	155.40	48.86	30.30	19.73	9.17
10% Margin of Safety	17.27	5.43	3.37	2.19	1.02

Total suspended solids and turbidity

Total Suspended Solids (TSS) data collected in West Indian creek indicate that the stream could be listed as impaired, however aquatic life measurements were good enough to prevent the listing at the time of the most recent assessment. TSS standards are set to protect aquatic life, as such if excess TSS were an issue in West Indian Creek one would expect the aquatic life itself to respond. MPCA assessment policy is to conclude ‘inconclusive’ in situations where the parameter indicates impairment; however the aquatic life data is not congruent. This ‘inconclusive’ conclusion is reported to the EPA as ‘insufficient information’. Protection is warranted to prevent further degradation and impairment. West Indian Creek could be heading towards impairment without further action to prevent it.

Nitrogen

Nitrate is one of the most common contaminants of groundwater in Minnesota and is a public health concern when found in groundwater used for drinking water. The Safe Drinking Water Act standard for nitrate in drinking water is 10 mg/L. The U.S. Geological Survey found that concentrations over 1 mg/L nitrate indicate human influence (USGS, 2010)

MPCA’s Zumbro River WRAPS report showed a concerning statistically significant rising nitrate trend through 2016 (Figure 16). Recent data confirms that nitrate concentrations in West Indian Creek have continued to rise since. Figure 16 presents the previous analysis through 2015 and the updated analysis through 2019. The dataset shows a statistically significant increasing trend in nitrate concentration in West Indian Creek. Additionally, the updated analysis suggests that the rate of increase in nitrate concentration has also risen slightly as evidenced by the increased slope of the linear regression line. At the current rate of increase, West Indian Creek could reach or exceed the water quality standard for nitrate (10 mg/L) in 2053.

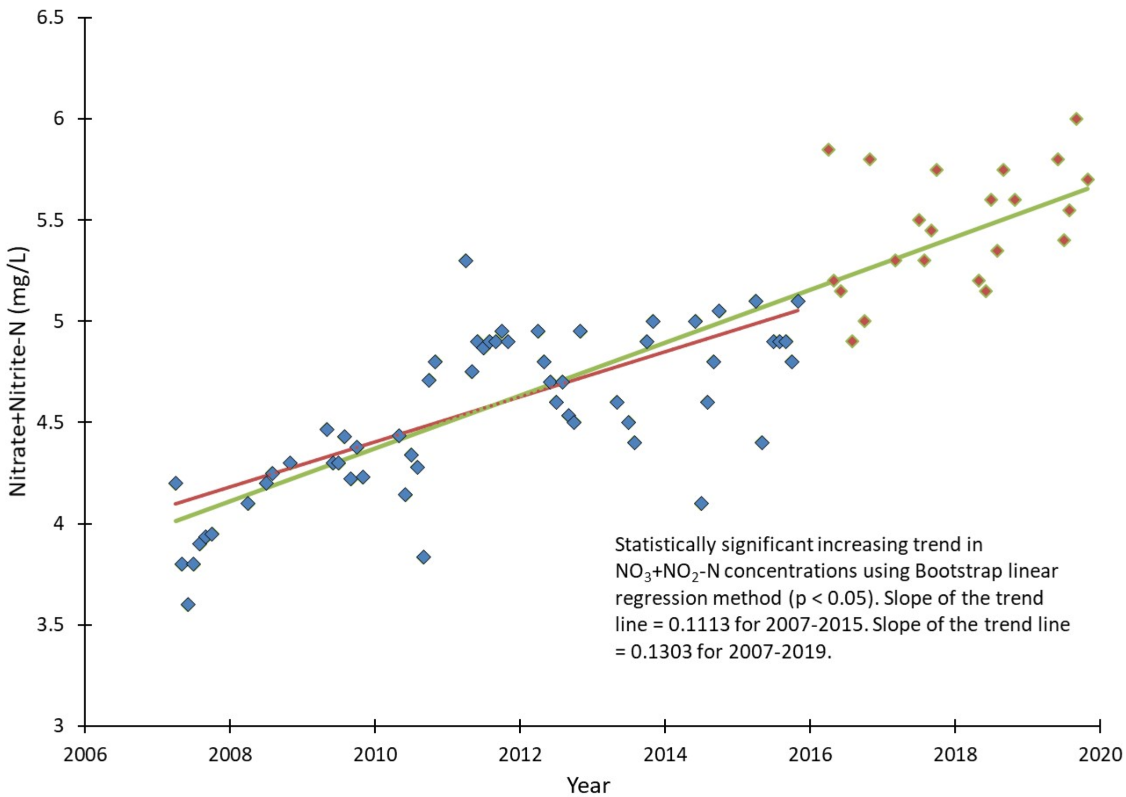


Figure 16. Baseflow concentrations of nitrate in the West Indian Creek Watershed 2006-2019

County Well Index wells are illustrated in Figure 17. Private wells tested through the MDA Township Testing Program show that ≥10% of the wells in the West Indian Creek Watershed contain ≥10 mg/L Nitrate-N (MDH, 2019). Testing also showed that 23.4% of the wells tested in Highland, 33.8% in Plainview, and 10.8% in Glasgow townships exceed the health standard for nitrate in drinking water. Karst features, including sinkholes, springs, caves, disappearing streams, and blind valleys, can be a direct link between surface and ground water. The direct link between surface and ground water makes the area's groundwater more susceptible to contamination from surface water pollution. This makes protection of surface water a high priority in this area since it can be a direct threat to human health (Wabasha County, 2015).

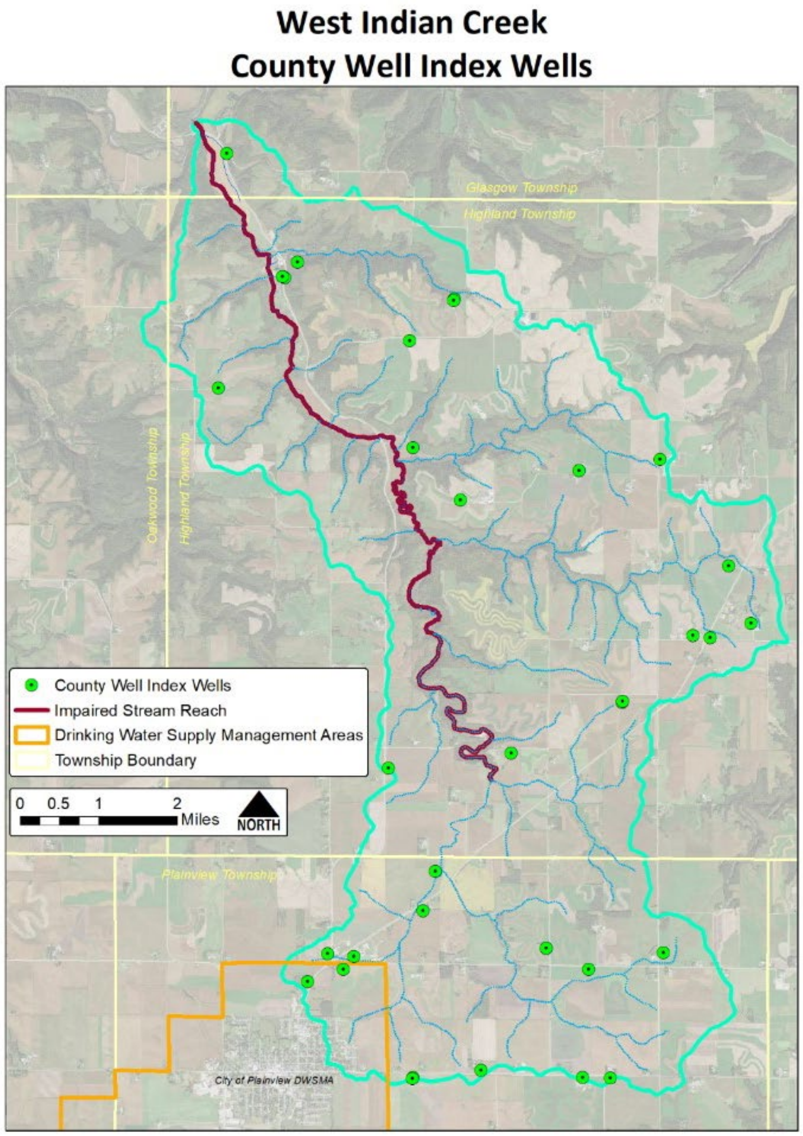


Figure 17. West Indian Creek County Well Index wells

All residents of Wabasha County rely on groundwater for their drinking water and 1/3 of residents are served by private wells. In the West Indian Creek watershed most of the drinking water wells are privately owned. These wells are not provided the program oversight and resources that public water supply wells receive through the Safe Drinking Water Act and Wellhead Protection Program. Access to water testing and BMP for land treatment and sanitary systems is essential in these areas. Well management and Subsurface Sewage Treatment System (SSTS) services would help individual land owners have more control over reducing their own health risks (J. Ronnenberg, personal communication, 2019) A small portion of the City of Plainview's Drinking Water Supply Management Area is contained in West Indian Creek Watershed. The City of Plainview has two community wells, both have an increasing trend in nitrate concentrations since the late 1990s.

Phosphorus

Phosphorus is also frequently an issue in agricultural landscapes. The summer baseflow average total phosphorus in West Indian Creek from 2007 to 2019 is 74.4 µg/L. The summer stormflow average total phosphorus is 2,489.8 µg/L. Water quality assessments completed in 2015 indicate that river eutrophication was inconclusive due to TP exceeding the standard; however, there is no data to support assessment of the response variables.

Flow Data

Average baseflow in West Indian Creek is between 6.5 and 7.2 cubic feet per second (cfs). The highest recorded flow is 3,907 cfs (08/11/2016) and the lowest recorded flow is 3.82 cfs (6/10/2015) (Figure 18).

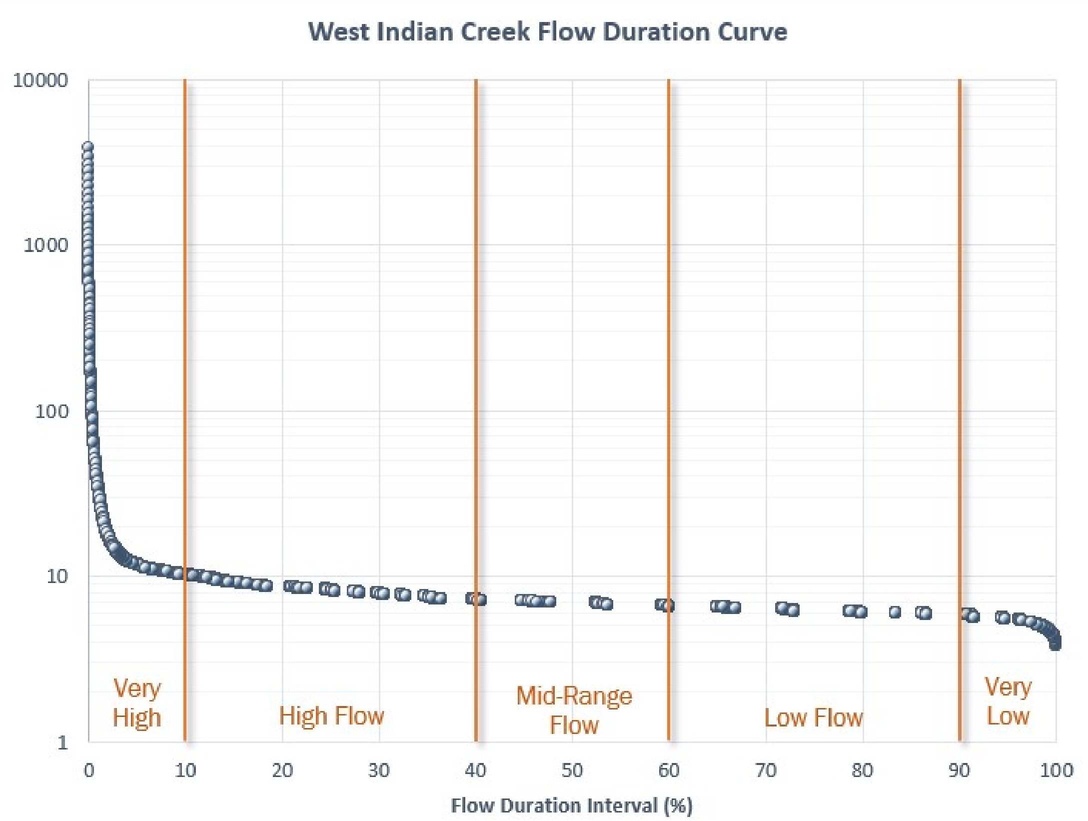


Figure 18. West Indian Creek Flow data

The average number of events (flow >10 cfs) each year between 2007 and 2017 is 4.45 (Table 10). Between years, events vary quite a bit with regards to maximum flow; however, on average, flows peak and return to normal within one to three days.

Table 10. Warm season flow averages for West Indian Creek 2007-2017

Year	Warm Season Average Flow (cfs)
2007	11.89
2008	6.52
2009	7.12
2010	8.20
2011	8.56
2012	7.10
2013	7.83
2014	7.57

Year	Warm Season Average Flow (cfs)
2015	5.99
2016	11.70
2017	11.55
2018	10.79
2019	11.07
overall	8.91

Table 11. Flow events in West Indian Creek 2007-2019

Year	No. of Events	Max. Flow (cfs)	No. of Days w/ Flow >10 cfs	Max. No. of Consecutive Days w/ Flow >10 cfs
2007	5	1417	9	3
2008	4	99	3	2
2009	3	390	2	1
2010	7	1087	16	8
2011	4	216	11	4
2012	5	225	7	2
2013	9	50	15	5
2014	6	530	16	5
2015	6	228	8	2
2016	6	3908	14	5
2017	7	444	93	35
2018	8	695	69	19
2019	10	663	144	54

Although no formal analysis has been completed regarding this, it has been the general observation of both MPCA and DNR staff that baseflow in West Indian Creek has increased. Recent studies have found that increased precipitation combined with recent changes in land cover, land use, and artificial drainage are responsible for increased stream flows in the Midwest, Minnesota, and southeast Minnesota (Dadaser-Celik et al 2009; Lenhart and Nieber 2011, Zumbro Watershed Partnership, 2012).

Across Minnesota there has been a 20% increase in the number of one inch rains and a 65% increase in the number of three inch rains. Since 2000 widespread rains of more than six inches are four times more frequent than in the previous three decades (DNR, 2019). According to the DNR, southeast Minnesota now receives three to four more inches of rain than the historic average. The effects of these changes can be significant in the karst region. The steep hills and shallow, fractured bedrock are conducive to rapid movement of rainfall and snowmelt from the landscape to streams. Higher stream flows exacerbate the problem of turbidity and sedimentation through increased channel erosion (Zumbro Watershed Partnership, 2012).

Biological data

Fish and macroinvertebrates

The MPCA staff sampled fish and benthic macroinvertebrates of West Indian Creek in 2012. Both fish and macroinvertebrates were found to be meeting biologic criteria and supporting aquatic life uses (MPCA, 2016). The MPCA and DNR find fish and bugs to be doing well in West Indian Creek, the heavy use of this stream by anglers would also suggest that stream biology is in good condition. Additional review of the macroinvertebrate data and comparison with the Southern Coldwater Median (for stations meeting the macroinvertebrate IBI threshold) is provided in Table 12. Overall, from a biological standpoint, the metrics do not strongly implicate nitrate as a stressor, but they also do not deny it as a possibility. The taxa percent of trichoptera and nitrate index score are very close to the median, but just slightly below. Trichoptera are included in this analysis because they have been found to be generally sensitive to increasing nitrate. Related to that, the number of nitrate intolerant taxa and percentage of nitrate tolerant taxa are slightly better than the median. (T, Schauls 2020)

Table 12. MIBI data compared with the Southern Coldwater Median

	TrichopteraChTxPct	**Nitrate Index Score**	**Nitrate Intolerant Taxa**	**Nitrate Tolerant Taxa**	**Nitrate Tolerant Pct**
12LM014 (2012)	**16.6**	3.08	**2**	16	**48.1**
Southern Coldwater Median (for stations meeting the MIBI threshold)	*16.7*	*3.04*	*1*	*14*	*56.9*
Expected response to stress	↓	↑	↓	↑	↑

A quantile regression analysis of Southern Coldwater Macroinvertebrate stations in Minnesota shows a 75% probability that a stream with 12 mg/L or greater nitrate will have a macroinvertebrate index of biotic integrity (MIBI) score below the threshold of 46.1. It was also found that for a stream with 6 mg/L or greater nitrate, there is a 50% probability of the MIBI being below the impairment threshold. Given the nitrate concentrations in West Indian Creek are nearing 6 mg/L and continuing to increase, it is reasonable to conclude that the macroinvertebrate community is vulnerable to impairment due to increasing nitrate. (T, Schauls 2020)

West Indian Creek is part of the DNR's southeastern long-term monitoring program. Fish sampling began there in 1981, with annual samples being collected since 1999. Figure 19 shows data collected by DNR since 2003, including the index of biotic integrity for fish (FIBI) (which has a maximum achievable value of 120) and the Minnesota Stream Habitat Assessment results for each year (maximum achievable value of 100). Also included on the figure is MPCA's FIBI threshold for West Indian Creek of 50.

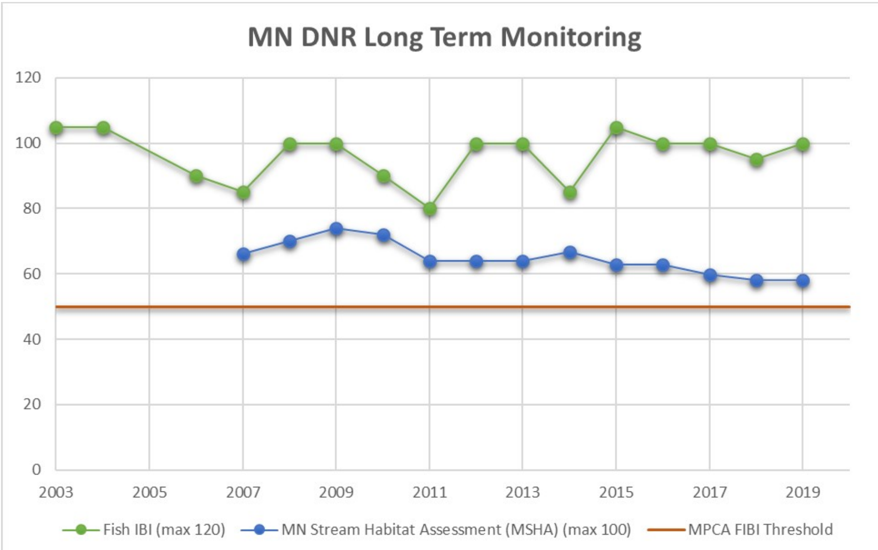


Figure 19. Long-term biological monitoring by DNR 2003-2019

Stream corridor data

Minnesota's Buffer Law (Minn. Stat. § 103F.48) requires perennial vegetative buffers of up to 50 feet along lakes, rivers, and streams and buffers of 16.5 feet along public drainage ditches. These buffers help filter out phosphorus, nitrogen, and sediment. The deadline for implementation of buffers on public waters was November of 2017. The Wabasha SWCD reports 100% compliance with the buffer law.

Stream habitat and corridor improvement projects have been carried out by partnerships with DNR, private land owners, and Trout Unlimited. A stream corridor improvement project, on 0.8 miles of West Indian Creek, was completed in 2012. The second began work in the spring of 2020 on 2.16 miles of West Indian Creek. Both of these projects include sloping and stabilization of stream banks, reconnecting the stream to its floodplain, installation of soil erosion blankets, and adding native plant species.

Pollutant source assessment

The primary pollutant sources in West Indian Creek watershed are nonpoint. There are a limited number of permitted point sources within the watershed.

Nonpoint source

Table 13 provides data from the Minnesota 2019 Cropland Data Layer of relative agricultural land use quantities. In total, this sums to between 73-74% of the land area of the West Indian Creek Watershed is used for agriculture.

Table 13. Percentage of agricultural land by planting in the West Indian Creek Watershed

Land use	Percentage of watershed area
Corn	40%
Grassland/pasture	14%
Soybean	10%
Alfalfa	9%
Sweet corn	1%
Total	74%

Corn is the single largest user of nitrogen fertilizer on Minnesota's landscape. Most corn in Minnesota is either continuous corn (corn following corn) or in a rotation following soybeans (UMN Extension, 2018). A literature review of a large number of worldwide drainage studies shows annual nitrate-N loss via tile lines varies from 0- 124 lbs/ac. Although, West Indian Creek watershed does not have a significant amount of tile drainage, the karst landscape provides a similar environment for pollutant leaching. A University of Minnesota (UMN) Extension study of the effect of different cropping systems on drainage discharge volume, nitrate-nitrogen concentration and loss in subsurface tile drained fields showed that continuous corn cropping systems have the highest nitrate-nitrogen loss rates, Table 14.

Table 14. Nitrogen loss by cropping systems

Cropping system	Total discharge (four-year)	Nitrate-N (four-year)	
		Concentration (ppm)	Loss (lbs/acre)
Continuous corn	30.4 inches	28	194
Corn-soybean	35.5 inches	23	182
Soybean-corn	35.4 inches	22	180
Alfalfa	16.4 inches	1.6	6
Conservation Reserve Program (CRP)	25.2 inches	0.7	4

In 2011, a soil-water monitoring network was implemented in southeast Minnesota with the main purpose of identifying the range of nitrate-nitrogen concentrations leaching from various land cover and management types under various climatic conditions. From 2011 through 2015, nearly 60 lysimeters on

21 sites covering 10 different types of land use were sampled. In Figure 20, over 2,500 samples are summarized and average nitrate concentrations are displayed above each land cover type.

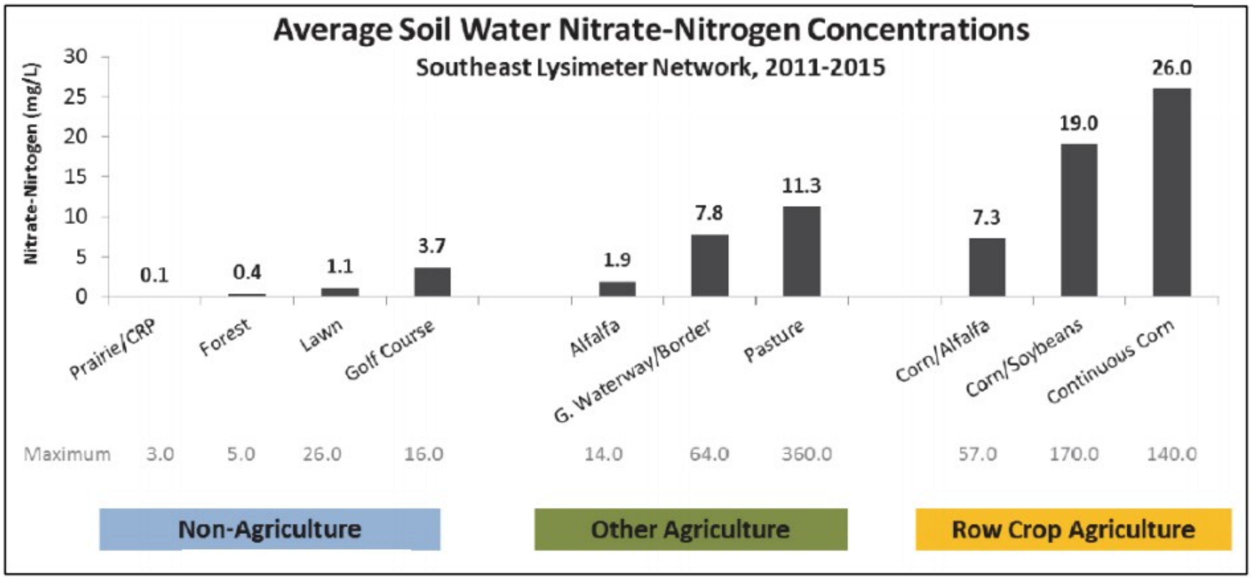


Figure 20. Average soil water nitrate-nitrogen concentrations in the West Indian Watershed, 2011-2015 (SE Lysimeter Network) (Figure 24, Zumbro WRAPS)

Additionally, an analysis of the relationship between base flow nitrate concentrations in southeast Minnesota trout streams and percentage of row crop land in the watersheds of these streams (Watkins et al, 2013) produced a statistically significant linear relationship. This analysis indicates that a watershed of approximately 60% corn and soybean acres corresponds to exceedances of Minnesota's drinking water nitrate-nitrogen standard of 10 mg/L. This conclusion is supported by the findings of Nitrogen in Minnesota Surface Waters, which describes similar relationships between nitrogen in surface waters and "leaky soils below row crops", which include areas of shallow depth to bedrock such as the trout stream region of southeast Minnesota.

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, 2017b). 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 West Indian Creek are cropland runoff, atmospheric deposition, and streambank erosion.

The Root River Field to Stream Partnership (RRFSP), a unique water monitoring project in southeast Minnesota, uses both edge-of-field and in-stream monitoring to characterize water quality in three study areas within the Root River Watershed. The Root River watershed is located one county to the south of West Indian Creek and contains a number of streams very similar to West Indian, including Bridge Creek. A number of key observations and recommendations from the data collected by RRFSP from 2010 to 2018 include:

- Dissolved phosphorus losses were highest in March and often occur when the ground is frozen. Incorporation of fertilizer and proper management of soil test phosphorus levels will help reduce these losses.
- Nearly 80% of the sediment loss occurred during May and June. During this critical time, fields were prepared for planting, but not at full canopy. Total phosphorus loss is closely linked to soil loss. Good soil conservation practices will help reduce these losses.
- Most nitrogen is lost through sub-surface leaching. Reducing nitrate leaching losses is challenging, but a very important task. Fine-tuning nitrogen rates, split applying nitrogen,

crediting legumes and manure, growing perennials, and using cover crops are important practices.

- Over 50% of the annual nutrient and sediment losses typically occurred during one to two rain events each year.

Subsurface sewage treatment systems (SSTS)

Wabasha County's 2015 water plan estimates that 78% of SSTS (septic systems) are compliant, 18% are considered failing, and approximately 7% are believed to be imminent public health threats (IPHT). Examples of systems that would be considered IPHT are those where sewage backs up into a house, surfacing systems, 'straight pipes' (meaning they discharge to a ditch or river), or cesspools. Failing SSTS are those that could not meet the vertical separation distances in the soil and are considered to be failing to protect groundwater (Wabasha County, 2015). SSTS are inspected for compliance at point of sale or issuance of building permits.

One way to estimate the number of SSTS in the watershed is to utilize the known number of wells, however, this is not the most accurate way to estimate in Wabasha County. Another way to estimate is by the number of rural address points, of which there are 143 in the watershed. Using this estimate, approximately 25 SSTS are failing and 10 are IPHTs.

Streambank erosion

During dry conditions, atmospheric deposition is the more prominent source of phosphorus; however under wet conditions, streambank erosion becomes the most significant source of phosphorus (MPCA, 2017b). As shown in Image 8 and Image 9, streambank erosion has been an enduring issue in the West Indian Creek Watershed even in the state forest land. The DNR has noted moderate streambank erosion for several years during their biological monitoring in West Indian Creek. Streambank erosion is also one of the most significant sources of sediment to West Indian Creek.

Image 8. Eroding stream banks in state forest land

Hydrological Simulation Program – FORTRAN (HSPF) modeling in the Zumbro River watershed show the top nonpoint sources of sediment and phosphorus are the result of upland runoff from highly erodible or unstable soils and bed and bank erosion.

Image 9. DNR Streambank erosion north of Plainview where land owner plans stream straightening Aug. 29, 1947

Atmospheric deposition

HSPF modeling for the Zumbro River watershed, the HUC-8 that contains the West Indian Creek watershed, include a pre-settlement atmospheric nitrogen deposition rate of approximately 0.50 kg-N/ha/year. This value originates from a joint National Park Service (NPS) and U.S. Fish and Wildlife Service (USFWS) effort to develop deposition analysis thresholds (FLAG 2002). The HSPF modeling also included a baseline or present-day scenario atmospheric deposition rate of approximately 20 kg-N/ha/year. This results in approximately 139,100 kg-N/year in West Indian Creek watershed.

Registered and unregistered feedlots

Animal waste containing fecal bacteria can be transported in watershed runoff to surface waters. The MPCA regulates animal feedlots in Minnesota. The primary goal of the state program for Animal Feeding Operations (AFOs) is to ensure that surface waters are not contaminated by the runoff from feeding facilities, manure storage or stockpiles, and cropland with improperly applied manure. Livestock also occur at hobby farms and small-scale farms that are not large enough to require registration, but may have small-scale feeding operations and associated manure application or stockpiles. All feedlots in Minnesota are regulated by Minn. R. ch. 7020.

The composition of the AFOs (22 registered as of May 2020) in West Indian Creek Watershed is approximately 59% dairy, 34% beef cattle, 6% swine. The largest is 468 animal units or 750 animals and the average is 193 animal units or 212 animals. In Minnesota, AFOs are required to register an animal feedlot capable of holding 50 or more animal units (AUs), or a manure storage area capable of holding the manure produced by 50 or more AUs, and an animal feedlot capable of holding 10 or more and fewer than 50 AUs, or a manure storage area capable of holding the manure produced by 10 or more and fewer than 50 AUs, that is located within shoreland. Further explanation of registration requirements can be found in Minn. R. ch. 7020.035.

Of the approximately 22 registered feedlots in the small watershed, there are no active NPDES permitted operations and none are classified as CAFOs. There are an additional 23 feedlots within a 0.5 mile radius of the West Indian Creek Watershed boundary with active registrations. This includes, 2 large operations with NPDES permits. These additional feedlots include 1,165 beef cattle, 5,504 dairy cattle, and 70 chickens. Although the registered address of these feedlots do not fall within the HUC12 boundary, many of their owners/operators also operate agricultural fields within the watershed and apply manure within the watershed. Manure is likely spread throughout the watershed year round, depending on storage capacity of each facility. Table 15 summarizes the feedlot characteristics of all registered feedlots that affect the West Indian Creek Watershed.

In addition to Minn. R. ch. 7020, Wabasha County has ordinances for new feedlots. New feedlots are prohibited within the floodplain and shoreland; 100 feet from private wells (sealed and unsealed); 1,000 feet from community wells; 300 feet from sinkholes; 200 feet from adjoining property lines or road right of way; 1,000 feet from city limits, schools, churches, platted subdivisions, parks, and neighboring feedlot.

Feedlot regulations are in place to minimize the risk of pollution, however there is always a potential for pollution. Feedlots that are at a higher risk for contributing *E. coli* to surface waters are those with open lots and/or are located in shoreland areas, feedlots with no manure storage, and feedlots with a pasture component in shoreland areas. The presence of karst also adds more risk for these operations.

Table 15. Feedlot characteristics of 45 registered feedlots in West Indian Creek area.

Feedlot Characteristic	# of Registered Feedlots (total 45)
Dairy	27
Swine	2
No manure storage	22
Within 300 ft of River/Stream	3
Within Shoreland	4
Within 1000 ft of Waterbody	4

Point sources

Feedlots and CAFO permits

No feedlots in the West Indian Creek Watershed are classified as CAFOs and none are NPDES/SDS permitted. There are 2 NPDES permitted feedlots within 0.5 miles of the West Indian Creek Watershed.

Mines and Other Pollutant Sources

There are three quarries within the watershed boundaries. Two have been permitted for several years, and one is currently initiating the permitting process. All permitted sites are permitted for construction sand and gravel mining. At these sites, there is no dewatering and stormwater is contained on site and allowed to infiltrate. As such, these sites are not considered to be significantly contributing to the pollutant loading in the West Indian Creek Watershed. If these operations were to expand to a point where dewatering would be necessary for operation, a DNR review and permit would be required.

Table 16. Gravel extraction and mining permits in West Indian Creek Watershed

Permit No.	Operator	Permit Type	Site Name	Condition
MNG490308	Bennett & Sons Sand & Gravel	Construction Sand & Gravel Mining	Grant (Wilson) Pit (J1-1446)	No dewatering, stormwater contained & infiltrated
MNG490115	Bruening Rock Products, Inc.	Crushed Stone	Mischke Quarry-Wabasha Quarry (J2-1422)	No dewatering, stormwater contained & infiltrated
TBD	Johnson Rock Products, Inc.	TBD	TBD	TBD

Pollutant loads and water quality

Estimate of existing pollutant loads

Existing loads of *E. coli* are provided from the Zumbro River Watershed TMDL report and illustrated in Figure 21. Data collected for the TMDL show *E. coli* loads range from 27.75 to 351.58 billion organisms per day in the middle range flow zone.

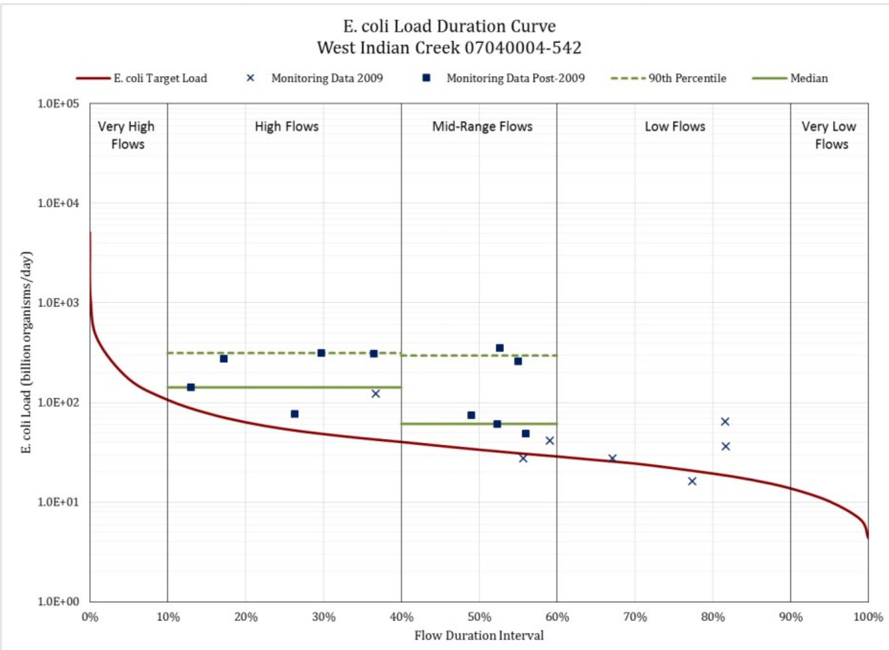


Figure 21. *E. coli* load duration curve (MPCA, TMDL, figure XXX)

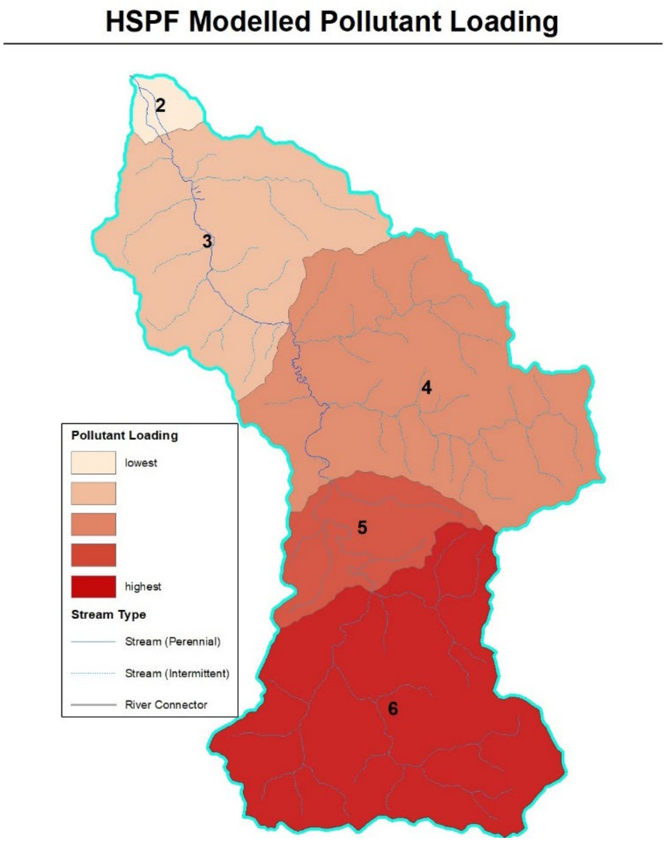
The HSPF modeling completed by Limnotech Inc. in 2016 and 2019 provides the following estimates of pollutant loading in the West Indian Creek watershed, summarized in Table 17.

Table 17. Watershed yield, TSS, TP, and TN in West Indian Creek Watershed

Sub-watershed ID	Watershed yield (inches)	Sediment yield (lbs/ac/yr)	Total Phosphorus (lbs/ac/yr)	Total Nitrogen (lbs/ac/yr)
2	9.64	257.71	0.30	5.93
3	9.49	252.97	0.35	8.12
4	9.67	306.59	0.47	10.8
5	9.45	375.49	0.63	14.35
6	9.37	616.21	0.79	16.48

Subwatershed 6 is the upstream most subwatershed and 2, the downstream most, just before the confluence with the Zumbro River. Yields for all pollutants (sediment, total phosphorus, and total nitrogen) increase from downstream to upstream, with the highest yields occurring in subwatershed 6 and lowest yields occurring in subwatershed 2. This coincides with the amount of cultivated acres, highest amounts of cultivated acres being in subwatershed 6.

Figure 22. HSPF modeled subwatersheds and relative pollutant loading



Future/buildout pollutant load estimates

There is no information available for future build out within the watershed, no significant increase in development is expected in the watershed area.

Identification of Critical Areas

Various tools and models have been used to target and prioritize management activities in the Zumbro River Watershed. This plan used these tools to begin identifying the critical areas contributing the most sediment and nutrients in the West Indian Creek Watershed. Further analysis using individual components of the tools provide the next level of critical area identification for use in targeting specific areas for implementation activities.

Using this multi-step approach, critical area delineation is presented as a decision tree (Figure 23). Although there are five areas identified as critical, based on the loading type and parameter, these will work together to target the most critical delivery areas. Cropland and forestry are the priority areas to address, as determined by the partners and models. Cropland in riparian areas

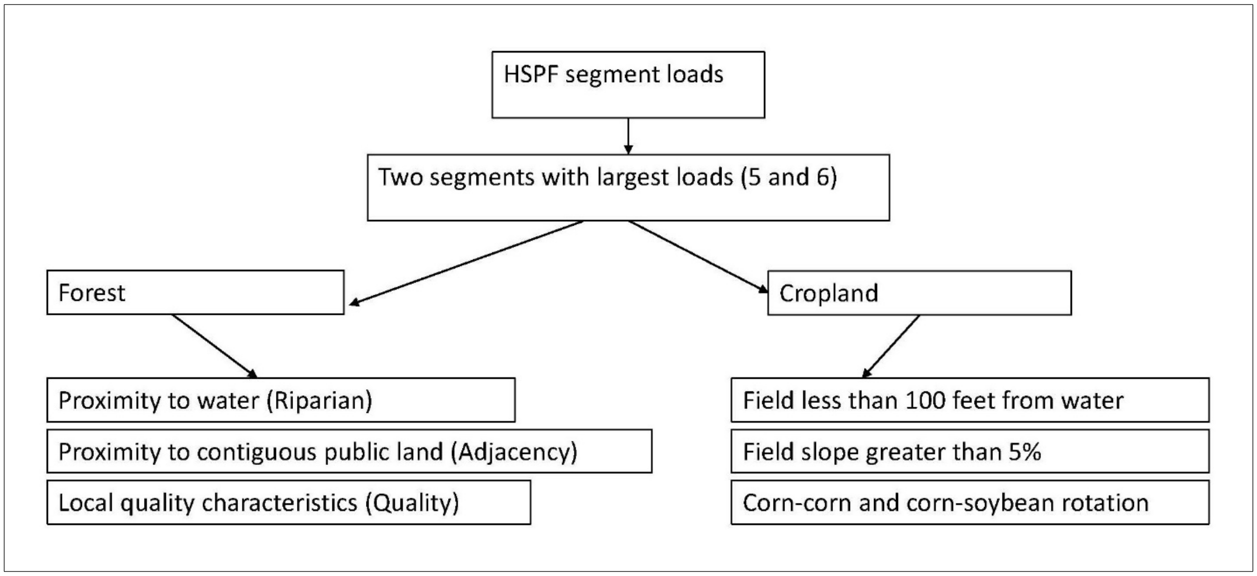


Figure 23. Schematic of critical area decision tree.

HSPF load estimates identify the two upper watershed model segments as the largest pollutant load segments of the five segments used in the model (Figure 22). The largest source is cropland runoff in the two segments followed by forest runoff and septic loading. The two segments are the first tier of critical areas in the watershed in implementing structural and nonstructural practices. Critical areas within the forest areas in these subwatersheds include proximity to water (i.e., riparian areas), proximity to contiguous public land (protected forest areas), and local quality characteristics identified by landowners and forest resource managers. Critical areas within the cropland areas in these subwatersheds include proximity to water (i.e., fields less than 100 feet from water, field slopes greater than five percent, and fields with corn-corn and corn-soybean rotations) (Figure 24). Proximity to water and slope steepness are criteria in ACPF used to identify areas with the highest runoff risk for identifying the locations for potential structural BMPs. Riparian area critical zones are identified by the potential runoff delivery through them and the depth of the shallow water table beneath the areas with high potential for each representing the critical riparian areas for management. Potential runoff delivery across the riparian areas will be identified as areas with a gully signature with the LiDAR digital elevation model (DEM). Examples of these areas are illustrated in Figure 24 and Figure 25.

The initial focus in implementing this plan will be the cropland critical areas. Increasing water storage through structural and non-structural practices in these upland, headwater sub-watersheds will have numerous benefits by reducing pollutants and runoff. Non-structural practices including perennial and cover crops and nutrient management will be most beneficial in the upland areas especially those with continuous corn, near continuous corn, and corn-soybean rotation. As landowner and operator contacts are made in these critical areas, farms with feedlots with potential runoff concerns and properties with aging and potentially failing septic systems will be identified as *E. coli* source critical areas in a second tier of priorities for implementation. Pollution risks to private wells and flooding risks in floodplain areas will also be used in prioritizing BMP implementation within the critical areas. Collaboration with the programs of other Minnesota State agencies, including state forest land and riparian easements with the DNR, and DWSMA protection with MDH and MDA, will also be used to coordinate priorities within the watershed

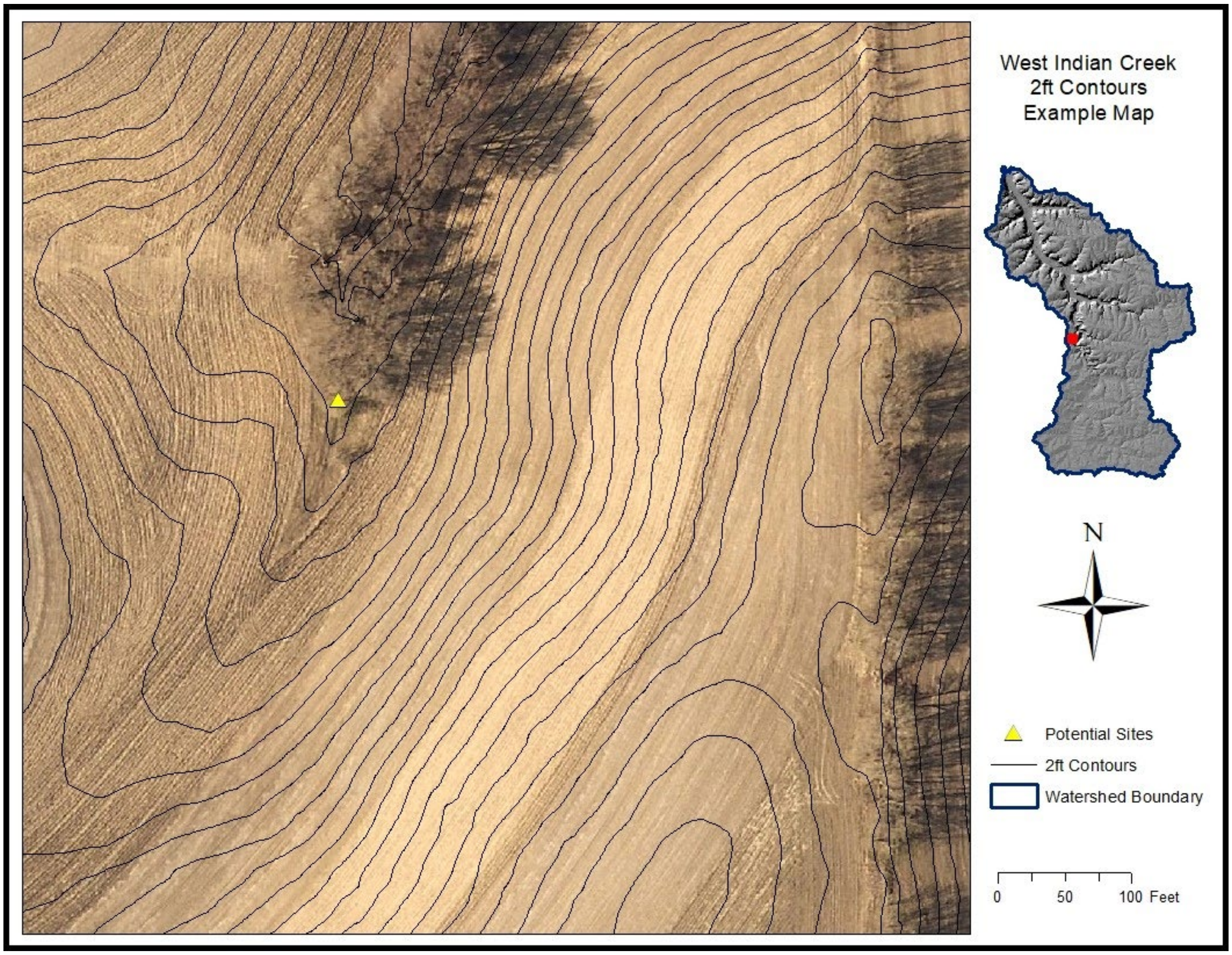


Figure 24. Potential structural BMP site using 2-foot contour DEM map

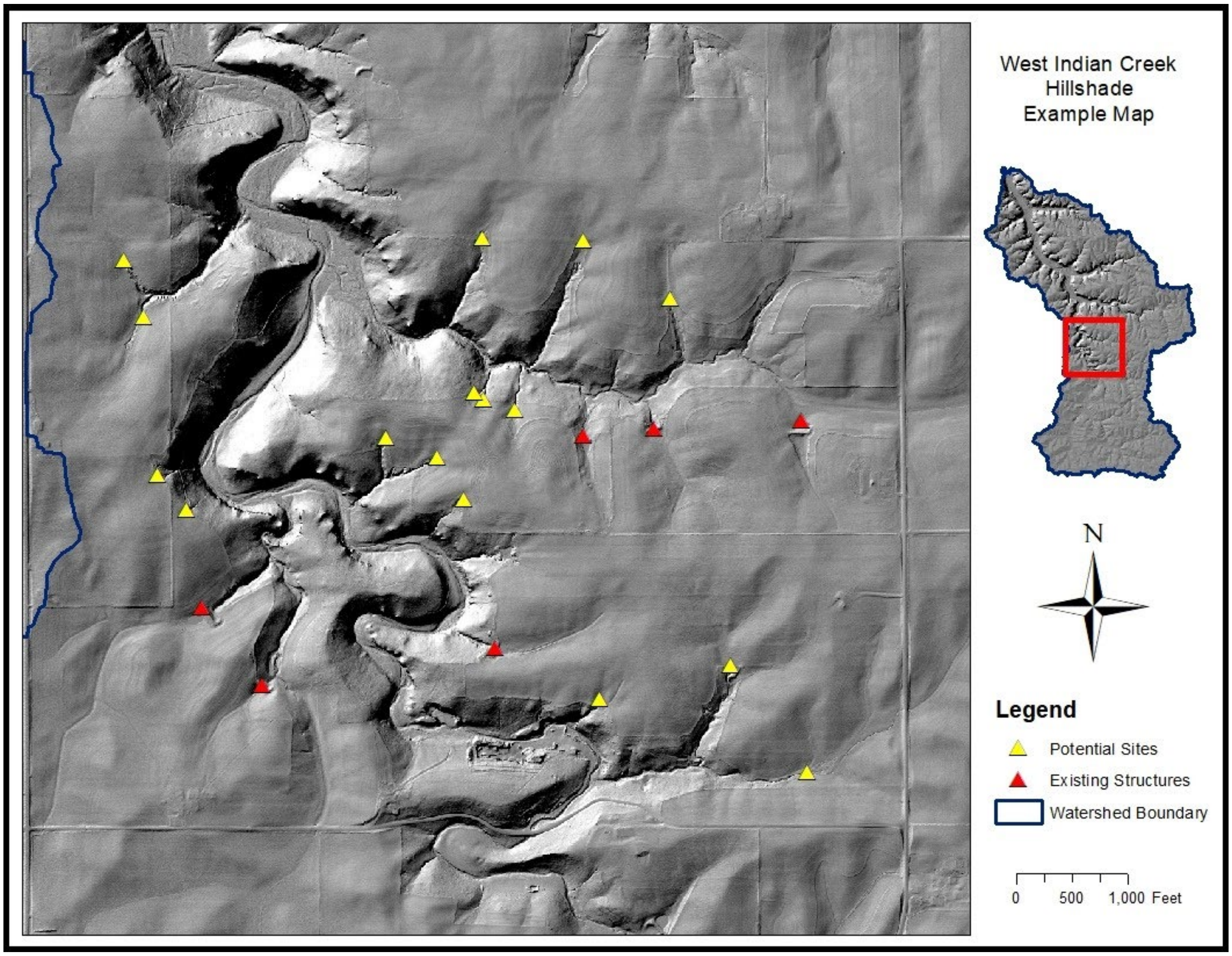


Figure 25. Existing and potential structural BMP sites illustrated with hillshade map

Cropping history records provide an additional identification of critical areas based on crop rotations that tend to have higher sediment and nutrient losses. Losses tend to be greatest in fields with corn-corn (continuous corn or near continuous corn production) and corn-soybean rotations (Figure 27). These areas are identified as critical relative to crop rotations used. Spatial analysis revealed fields with continuous corn, near continuous corn, and corn-soybean rotations account for 14, 10, and 29 percent, respectively.

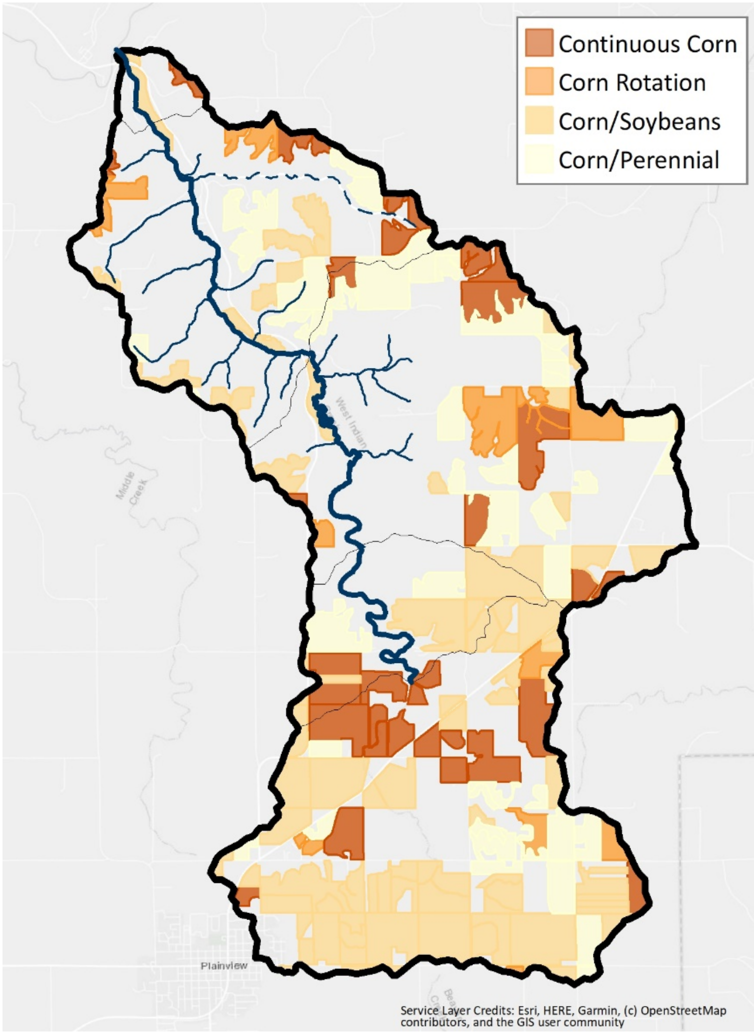


Figure 26. Agriculture land used for growing corn in West Indian Creek Watershed

Critical areas of forest land in the watershed that will be addressed were identified using the Riparian, Adjacent, Quality (RAQ) scoring system developed by BWSR and SWCD Technical Service Area 8 to identify the highest value forest land to maximize the return on investment for public benefits for forest management activities. The priority critical areas are based on the individual forest parcels' proximity to water (Riparian), proximity to contiguous tracts of existing county, state, or federal land (Adjacency), and local quality characteristics of the parcel (Quality) using a 0-3 point scale for each factor. Quality characteristics included: springs, trout streams, sites of biodiversity significance, rare species, DNR wildlife action rank (med-high or high), wellhead protection/DWSMAs, old growth forest, et. al. Parcels with RAQ scores greater than five (out of 9 points) are considered first priority areas. Percent slope, percent land cover, and TNC resiliency and connectivity measures were also used along with RAQ to identify high priority work areas.

Riparian area critical zones are identified by the potential runoff delivery through them and the width of the shallow water table beneath the areas with high potential for each representing the critical riparian areas for management. Both forest and cropland areas are found to be in the riparian area.

Additional critical areas for *E. coli* specifically, include properties with aging and potentially failing septic systems and feedlots throughout the watershed, large and small.

Priority infrastructure areas part of cropland, really, maybe a bit forest, critical infrastructure that needs to be protected by the work in critical areas.

The Wabasha County Highway Department has identified the upland areas of West Indian Creek as an area where upland storage would have a positive effect on road/bridge infrastructure (Figure 27) (D. Flesch, personal communication, 8/30/18). Key locations include the County Road 4 Bridge, the Whippoorwill Campground, and County Road 86 bridge.

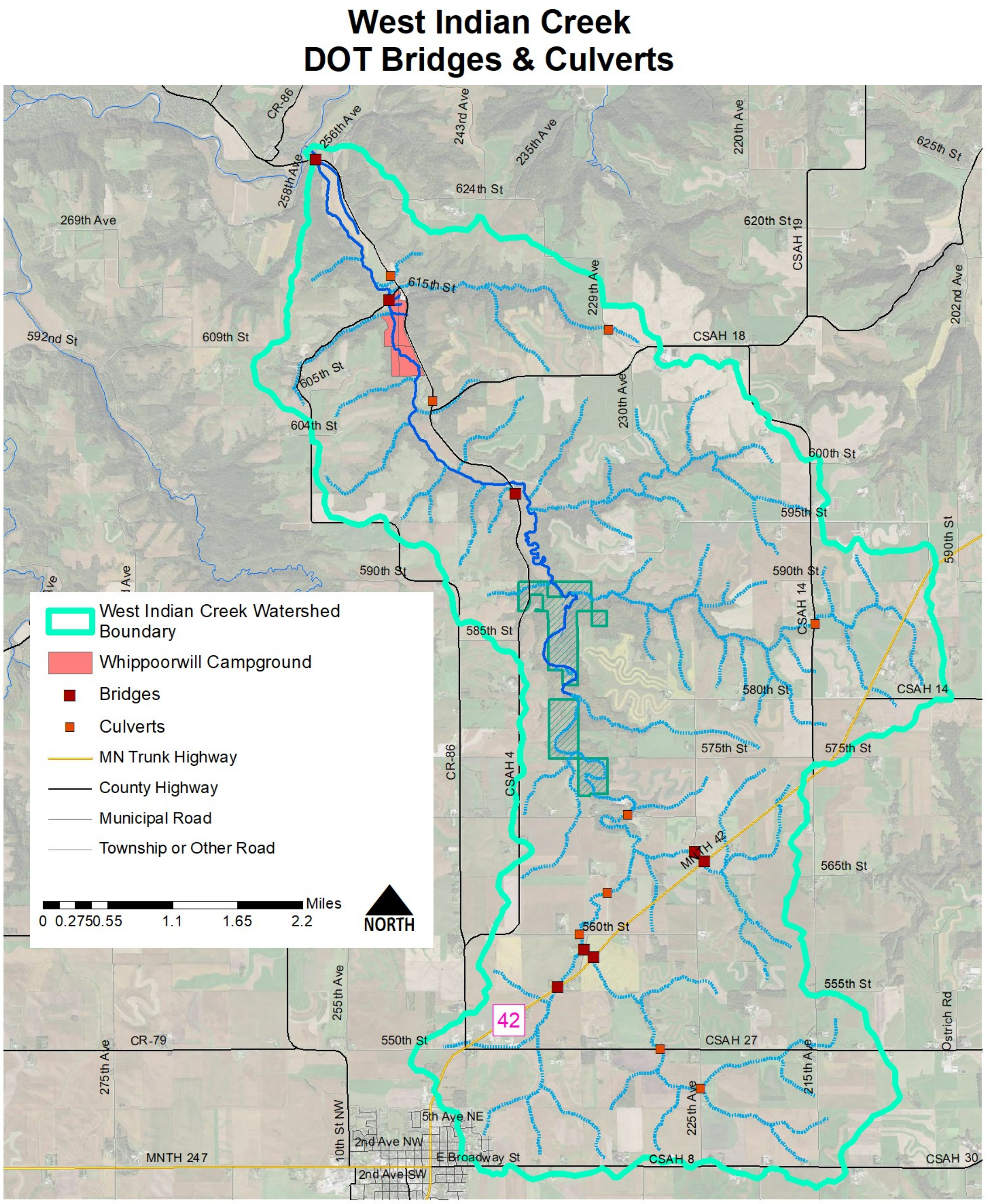


Figure 27. Bridges and culverts that would benefit from upland water retention in the West Indian Creek Watershed

Zonation and Landscape Stewardship Priority Parcel work identifies key locations of properties surrounding the Outstanding Biodiversity areas within the watershed for protection.

Watershed goals

LimnoTech Inc was contracted by the MPCA to complete HSPF modeling for the Zumbro River Watershed (Table 18). Water quality data collected between 1996 through 2018 was used to calibrate and validate the model for hydrology and water quality. Base conditions or baseline simulations, constructed on the collected water quality and quantity data, were developed for the major nutrients, phosphorus and nitrogen, and sediment. The model was also applied to evaluate various management scenarios. This provides information on how effective specific pollutant reduction practices may be for decreasing sediment and nutrient loading and improving water quality. Of the 10 different management scenarios that were developed, only the scenarios that evaluate nonpoint practices are applicable to the West Indian Creek watershed. The table below provides some of the management scenarios, descriptions, and percent load reduction for each of the subwatersheds in WIC. These scenarios are applied based on specific characteristics of each subwatershed, therefore some aspects seem to have a smaller impact on pollutant reduction than others. For example, subwatershed 2 has less cropland than subwatershed 6.

The memorandum for the HSPF model development project can be read in Appendix B.

Table 18. BMP scenarios by HSPF modeling

Management Scenario	Description	Subbasin	% Reduction from baseline for TN	% Reduction from baseline for TP	% Reduction from baseline for TSS
D Nonpoint	Conservation tillage management practices applied to 30% of the cropland acres with the highest sediment yields from model baseline landscape predictions	2	6.1%	25.7%	19.8%
		3	0.7%	3.4%	3.1%
		4	1.3%	6.14%	6.2%
		5	2.4%	11.6%	12.9%
		6	1.2%	5.5%	5.8%
G Nonpoint	Pre-settlement Vegetation, no point sources, no agricultural or developed land, and pre-settlement atmospheric nitrogen deposition rate	2	83.3%	85.2%	60.8%
		3	87.1%	87.1%	65.2%
		4	90.2%	89.9%	69.4%
		5	91.6%	89.3%	69.3%
		6	93.2%	92.2%	71.1%
WRAPS BMP	Strategies described in Zumbro River WRAPS (2017), Target P_2O_5 rate, reduced tillage, riparian buffers, cover crops, controlled drainage, alternative tile intakes, injection/incorporation of manure	2	34.8%	25.8%	11.1%
		3	34.9%	15.3%	-1.8%
		4	39.6%	22.4%	6.1%
		5	46.4%	33.6%	24.2%
		6	43.8%	34.7%	45.9%

Key pollutant load reduction targets

The Zumbro River Watershed Total Maximum Daily Load Report (2017) provides an *E. coli* TMDL for West Indian Creek, detailed in Table 19. Based on these limits and existing loads, average load reductions needed to meet the TMDL have been calculated. These include, on average, 24.9% load reduction at low flows, 48% load reduction at mid-range flows, and 28.1% reduction at high flows.

Table 19. *E. coli* TMDL summary for West Indian Creek Watershed

West Indian Creek 07040004-542 TMDL Summary	**Flow Regime**				
	VHigh	**High**	**Mid**	**Low**	**VLow**
	Billions of Organisms/day				
***E.coli* Loading Capacity (TMDL)**	172.67	54.29	33.67	21.92	10.19
Wasteload Allocation (WLA)	NA	NA	NA	NA	NA
Load Allocation	155.40	48.86	30.30	19.73	9.17
10% Margin of Safety	17.27	5.43	3.37	2.19	1.02
Average Load Reduction Needed	--	99.6	91.9	15.2	--

Although West Indian Creek does not have nitrogen, phosphorus, or total suspended solids impairments, the Zumbro River WRAPS report does have measureable goals for these pollutants in the Lower Zumbro HUC10 watershed, provided in Table 20.Taken from Minnesota's Nutrient Reduction Strategy (2014), the timeline to achieve these load reductions is by 2025. This closely coincides with the update of the Zumbro River WRAPS, which will allow for re-examination of conditions and goals.

Employing the estimates of pollutant loading provided by the HSPF modeling and pollutant load reduction goals from the Zumbro WRAPS, the following table provides an estimate of the average target pollutant loads for West Indian Creek watershed.

Table 20. Pollutant reductions for West Indian Creek Watershed

Pollutant	Pollutant Reduction Goal for Lower Zumbro HUC10	Average target load for West Indian Creek
Sediment yield	14%	317.58 lbs/ac/yr
Total Phosphorus	12%	0.47 lbs/ac/yr
Total Nitrogen	20%	6.4 lbs/ac/yr

The primary transport mechanisms for nitrate loading in surface waters of the Zumbro River watershed are tile drainage and leaching to groundwater, as a result, the response time of nitrate concentrations in wells, springs, and streams relative to changes in land use practices will vary with differing hydrogeologic settings (Runkel et al, 2014). As such, water quality changes in receiving waters cannot be the only measure of attainment of nitrogen reduction goals. Interim measures (e.g. successfully implementing combinations of BMPs) should be considered. Nitrate concentrations of soil water, shallow wells or springs in the upper bedrock units may allow for monitoring of 'middle points' between land use practices and surface water monitoring locations. Studies outside of southeastern Minnesota have concluded that some hydrogeological systems function in a manner whereby changes in base flow nitrate concentrations lag behind changes in land use practices by decades (e.g. Tesoriero et. al. 2013). The most significantly lagged response in southeastern Minnesota should be expected in the deep valleys incised into the Prairie du Chien Plateau, where significant baseflow is derived from deep, siliciclastic-dominated bedrock sources with one or more overlying aquitards (Runkel et al. 2014).

Identification of management strategies

Restoration strategies provided in the Zumbro River WRAP report are focused on core combinations of BMPs that were examined closely by technical practitioners and vetted with local stakeholders. The nutrient BMP spreadsheets for both nitrogen and phosphorus (developed by the University of Minnesota) were used to iteratively examine the combinations of practices. HSPF model scenario simulations showed general agreement with the reduction estimates provided by the spreadsheets.

The implementation strategies outlined in this plan will be achieved through an extensive partnership network, to include but not limited to NRCS, FSA, USFWS, DNR (forestry, fisheries, wildlife, waters), MDH, MDA, BWSR, MPCA, SE Landscape Committee, TNC, Fishers and Farmers, Sand County Foundation, MASWCD, Wabasha County, TU, National Fish and Wildlife Foundation, and landowners.

To achieve the 2025 nitrogen and phosphorus reduction goals, the following combination of BMPs was identified by using the BMP Tool Spreadsheet for nitrogen (Table 21) and phosphorus (Table 22).

Table 21. BMP Tool spreadsheet output for nitrogen

Nitrogen (N) BMPs	Lower Zumbro HUC-10 (05), % Adoption or Acres Treated	Zumbro HUC-8, % Adoption or Acres Treated
Acres of Cropland	**137,000**	**578,000**
Corn acres receiving target N rates, no inhibitor/shift	90% or 66,010	90% or 234,190
Fall N target rate acres receiving N inhibitor		90% or 42,500
Fall N applications switched to Spring	100% or 4,360	50% or 2,360
Tile line bioreactors		20% or 5,600
Saturated Buffers		20% or 5,600
Riparian Buffers, 100/2= 50ft wide [model adjustment]	96% or 3,670	96% or 12,600
Rye cover crop on corn/soybean acres	10% or 7,150	25% or 22,670
Short season crops planted to a rye cover	80% or 5,240	80% or 21,000
Perennial crop % of marginal corn bean acres	50% or 4,440	**20% or 6,960**
Cropland N load reduction % with these Adoption Rates or Acres Treated	24.00%	19.40%
Treatment Cost/yr.	$1,870,000	$5,960,000
N fertilizer cost savings from reduced inputs	$1,110,000	$3,620,000
Net BMP Treatment Cost	$760,000	$2,340,000

Table 22. BMP Tool spreadsheet output for phosphorus

Phosphorus (P) BMPs	Lower Zumbro HUC-10 (05), % Adoption or Acres Treated	Zumbro HUC-8, % Adoption or Acres Treated
Acres of Cropland	137,000	578,000
Target P205 rate	80% or 90,940	80% or 412,000
Fall corn fertilization to pre-plant/starter	50% or 1,950	50% or 9,000
Use reduced tillage on corn, soy, and small grains >2%	80% or 32,890	80% or 154,000
Riparian Buffers, 50 ft. wide, 100 ft. treated	95% or 10,340	95% or 32,000
Perennial crop % of marginal corn and soybean land	50% or 4,250	20% or 7,000
Rye cover crop on corn/soybean acres	7% or 7,470	10% or 34,000
Short season crops planted to a rye cover crop	80% or 5,550	80% or 22,000
Controlled Drainage		20% or 6,000

Phosphorus (P) BMPs	Lower Zumbro HUC-10 (05), % Adoption or Acres Treated	Zumbro HUC-8, % Adoption or Acres Treated
Alternative Tile Intakes		20% or 15,000
Inject/incorporate manure	50% or 7,450	50% or 24,000
Cropland P load reduction % with these Adoption Rates	16.20%	17.20%
Treatment Cost/yr	$1,500,000	$4,150,000
P fertilizer cost savings from reduced inputs	$1,330,000	$3,160,000
Net BMP Treatment Cost	$170,000	$990,000

Structural controls

During the development of the Zumbro River WRAPS, existing structural best management practices (BMP) were mapped throughout the watershed. Figure 29 shows the existing water and sediment control basins (WASCOB) in the West Indian Creek watershed as of 2014. There are 117 WASCOBs treating a total of approximately 4,598 acres or 26.7% of the watershed. The upstream most section or sub-watershed 6 has the least number of WASCOBs and acres treated at only roughly 16% of the sub-watershed treated.

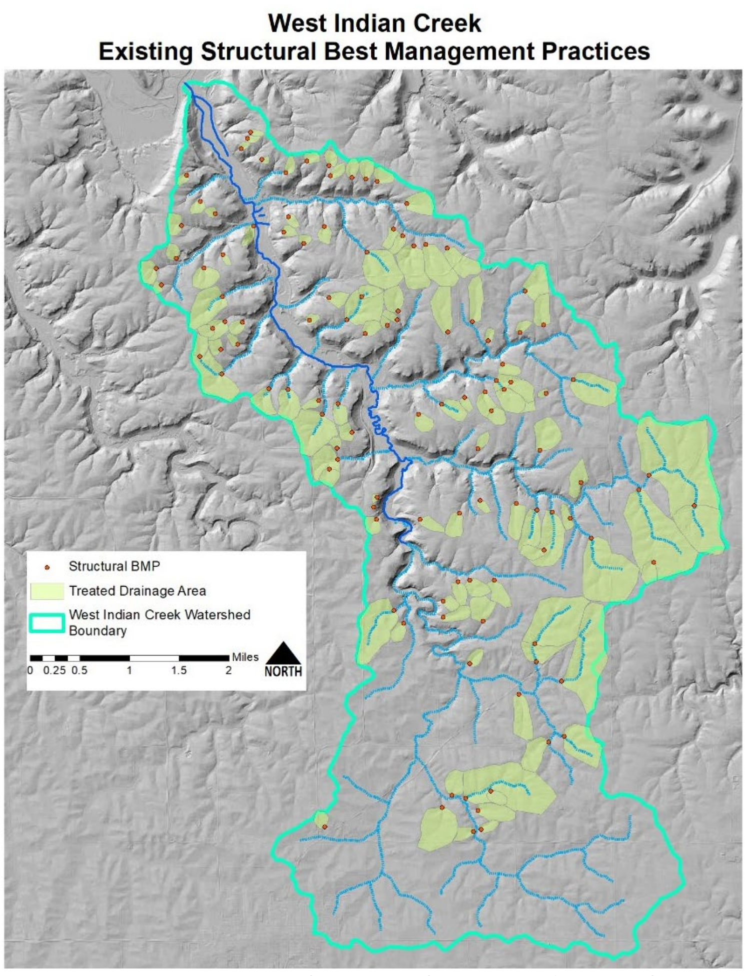


Figure 28. Existing structural BMPs in the West Indian Creek Watershed

Existing management strategies

Nonstructural controls

There are a number of existing nonstructural controls in the watershed, including the previously described stream restoration/habitat improvement projects on nearly three miles of West Indian Creek and watershed wide compliance with the Buffer Law. The Minnesota Groundwater Protection Rule with fall nitrogen fertilizer restrictions throughout the watershed take effect in September of 2020 which will help reduce nitrate from fertilizer leaching. BMPs that are installed with the support of state funds are tracked and published on MPCA's Healthier watersheds webpage. According to this database, 92 BMPs have been installed in WIC watershed since 2004. These BMPs include six acres of grassed waterway, 1,102 acres covered by nutrient management plans, more than 500 acres with reduced tillage and residue management, and various other BMPs (Table 23). These existing BMPs have not been included in the estimated pollutant load reductions presented in this plan. Additionally, Minnesota's Agricultural Water Quality Certification Program (MAWQCP) is a voluntary opportunity for farmers and agricultural landowners to take the lead in implementing conservation practices that protect our water. Those who implement and maintain approved farm management practices will be certified. There are five MAWQCP producers in the West Indian Creek Watershed.

Table 23. Summary of BMPs implemented in West Indian Creek Watershed as reported by Healthier Watersheds (eLINK reports and NRCS)

Strategy	Practice Description	Total BMPs	Installed Amount (by unit)	Units
Designed erosion control	Grassed Waterway	10	6	Acres
Nutrient management (cropland)	Nutrient Management	17	1,102	Acres
Converting land to perennials	Critical Area Planting	5	2	Acres
Living cover to crops in fall/spring	Cover Crop	4	199	Acres
Tillage/residue management	Residue and Tillage Management, No-Till	3	550	Acres
Tillage/residue management	Residue and Tillage Management, Reduced Till	3	550	Acres
Tillage/residue management	Residue Management, No-Till/Strip Till	1	83	Acres
Tile inlet improvements	Grade Stabilization Structure	2	2	Count
Tile inlet improvements	Subsurface Drain	1	729	Feet
Pasture management	Prescribed Grazing	3	52	Acres
Drainage ditch modifications	Grade Stabilization Structure	2	2	Count
Stream banks, bluffs & ravines	Grade Stabilization Structure	2	2	Count
Septic System Improvements	Septic System Improvement	1	1	Count
Crop Rotation	Conservation Crop Rotation	4	70	Acres
Feedlot runoff controls	Waste Water & Feedlot Runoff Control	1	1	Count

Strategy	Practice Description	Total BMPs	Installed Amount (by unit)	Units
Other	Karst Sinkhole Treatment	8	10	Count
Other	Roofs and Covers	4	1	Count
Other	Fence	3	15,200	Feet
Other	Forage Harvest Management	3	1,073	Acres
Other	Livestock Pipeline	2	3,050	Feet
Other	Mulching	2	0	Acres
Other	Waste Management System	2	2	Count
Other	Watering Facility	2	6	Count
Other	Comprehensive Nutrient Management Plan - Written	1	1	Count
Other	Conservation Completion Incentive Second Year	1	1	Count
Other	Cooperative Weed Management Area	1	1	Count
Other	Environmental Quality Assessment	1	1	Count
Other	Erosion Control	1	1	Count
Other	Forage and Biomass Planting	1	16	Acres
Other	Forest Management Plan - Written	1	2	Count
Other	Heavy Use Area Protection	1	2,600	Acres
Other	Waste Storage Facility	1	1	Count
Other	Waste Transfer	1	1	Count
Other	Well Decommissioning	1	1	Count

Other strategies needed to achieve goals

Structural controls

According to the NRCS, WASCOB spillways and outlets should be inspected yearly, accumulated sediment and debris should be removed on a regular basis, vegetative cover should be maintained, and any necessary repairs should be made following each large storm event. Many of the WASCOBs in the watershed have been in place for several decades and it is suspected that maintenance recommendations are often not followed, as a result, WASCOBs do not always function optimally. In addition, since many of the structures have been in place for several decades, they do not meet the updated NRCS specifications. A comprehensive inventory of WASCOBs, including operational status, should be completed to determine where maintenance should be prioritized. This could be completed through aerial imagery review. Additional modeling, such as Agricultural Conservation Planning Framework (ACPF), should be completed to prioritize locations where WASCOBs and other grade stabilization structures would be beneficial. In the Root River Field to Stream Partnership, the results of ACPF modeling help guide the field walk over process with land owners to prioritize projects on their properties.

Nonstructural Controls

Although there are many BMPs that have been installed over the last sixteen years in WIC watershed, the water quality data show that more must be done.

Given the rising trend in nitrate concentrations, it is recommended that nutrient management plans, cover crops, conservation crop rotation, and measures to increase soil health be employed at a higher rate. These strategies will work to reduce leaching and surface runoff thereby reducing pollutant concentrations in West Indian Creek.

Soil health's significance for watershed restoration and protection comes from the capacity of soils to capture and retain precipitation where it falls, thereby decreasing runoff and soil erosion, as well as nutrient (nitrogen and phosphorus) losses from cultivated landscapes. By decreasing runoff and leaching, soils have an innate capacity for improving water quality. Increasing soil organic matter and decreasing bulk density are two long-term goals that farmers can use to measure the soil health of their fields, thereby increasing the fertility of their soils and benefitting water quality. These two measures are objective, quantifiable, and inexpensive. By tracking soil organic matter and bulk density, farmers can help to achieve the water quality goals for reducing sediment, nitrogen, phosphorus, and *E. coli.*

There are environmental, agronomic, and economic benefits to increasing soil health. According to the NRCS, there are five basic principles to increasing soil health which are: armoring the soil, minimizing soil disturbance, plant diversity, continual living plant/root, and livestock integration. All of these strategies are recommended for improving the water quality of West Indian Creek.

A global framework for sustainable fertilizer management was developed through cooperative efforts of the International Plant Nutrition Institute (IPNI), The Fertilizer Institute (TFI), the Canadian Fertilizer Institute (CFI), and the International Fertilizer Industry Association (IFA), along with their members and other organizations. This framework is described as "4R Nutrient Stewardship" and is centered on four key areas of nutrient management: using the right nutrient source, applied at the right rate, at the right time, in the right place. Utilization of the 4Rs and nutrient management plans will benefit water quality in West Indian Creek.

Cover crops are recommended throughout the Zumbro River WRAPS as a cost-effective means to achieve nitrogen runoff reduction as well as to prevent leaching to groundwater. Cover crops, reduced tillage and retention basins are all recommended practices in WIC.

Forestry is a priority in Wabasha County and previous forestry based projects have yielded quantifiable water quality results using forest management practices. Thinning, invasive management, tree planting for quality and increasing quality understory on steep slopes helps improve water quality. Poor quality woodlands show earthworms often consume leaf litter and invasive species take over quality vegetation on bare slopes beneath tree cover. Both of these events make gullies and erosion to streams carrying nutrients and increasing stream sedimentation more likely. Similar issues occur with quality understory in riparian areas. Forest planting and management plans along with invasive management will be important practices to both protect and enhance water quality as well as the areas of biodiversity significance.

The landscape of WIC watershed is dominated by the presence of AFOs, with feedlots, cattle housing structures, and the fields needed to grow feed. The last of the five soil health principles is livestock integration. The benefits of returning livestock to the landscape are numerous; for soil health, for agronomic inputs, for weeds, for livestock, and for water quality. Prescribed grazing, rotational grazing, and other practices that help facilitate the return of livestock to the landscape (fencing, water supply, well testing) will be promoted.

It is important to note that these recommendations extend beyond the WIC watershed boundary as the area contributing to the flow of WIC includes a larger groundwater recharge zone (Figure 9). As described in previous sections, groundwater is a significant component here and must be taken into consideration if real impact is to be made.

Outreach and education is another important non-structural component in West Indian Creek. As was found in the RRFSP and many other projects, strong relationships are key for achieving goals and this is especially true in rural areas and in projects that require voluntary participation. The RRFSP found great success in taking time to meet with area agricultural producers, understand their operations and gather input about the best approach for field walkovers. This method, although very time intensive, resulted in 100% farmer participation in the program. (https://www.mda.state.mn.us/sites/default/files/2020-03/rrfspwalkover.pdf) Through outreach activities and one-on-one meetings, the results of water quality monitoring, BMP modeling, and other watershed efforts are discussed with farmers, landowners, fertilizer dealers, water managers, and community leaders to promote an advanced level of conservation planning and delivery in the watershed between 0.5 and 1.

Implementation program design

The West Indian Creek Watershed implementation table (Table 23) was developed following the nonpoint source management strategies described in the Zumbro River WRAP report. These management strategies were modelled for each HUC 10 basin using HSPF. Percentages of total cropland acres receiving BMPs in the Lower Zumbro HUC 10 were used as a starting point for implementation in West Indian Creek. HSPF model outputs for the non-point WRAP BMP scenario, on average, resulted in 39.9% total nitrogen, 26.4% total phosphorus, and 17.1% total suspended solids reductions in West Indian Creek watershed. Pollutant reduction goals given in the Zumbro WRAP report for the Lower Zumbro HUC 10 and in the Minnesota Nutrient Reduction Strategy are exceeded using these strategies in West Indian Creek, based on HSPF model outputs. The percent of cropland acres receiving BMPs calculated for use in the HSPF modeling in the Lower Zumbro HUC 10 were simply applied to the cropland acres in West Indian Creek as a starting point using the STEPL. The example strategies and levels of adoption were constructed during the WRAP process by Zumbro River watershed stakeholders and resource managers focused on non-point source nutrient reductions.

Even though the modeling and STEPL outputs show that these example strategies and levels of adoption exceed the pollutant reduction goals laid out in this plan, there is a local desire to have even higher rates of implementation and participation as well as inclusion of a broader set of practices. The desire for practices not included in the WRAP BMP scenario have been included in Table 23 of this plan, however the desire for higher levels of implementation and participation are not entirely reflected in the table. The implementation program presented in Table 23 represents a base-line for the West Indian Creek watershed, a base-line for levels of implementation and a base-line for associated costs. Additional implementation and participation would require additional funding.

Table 24. Treatment types, milestones, goals, assessment criteria, and costs to reach water quality goals in the West Indian Creek Watershed

Treatment type	Milestones					Long-Term Goals		Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)				
Cropland									
Increase Contour Farming and Stripcropping (NRCS Code 330, 585))	44 acres	44 acres	44 acres	44 acres	44 acres	220 acres	Cooperate with agricultural producers to reduce nitrogen loading to groundwater & WIC through implementation of field practices and reduction of fertilizer rates/increased nitrogen use efficiency. Increase storage in the watershed prioritizing headwater and/or high yield subwatersheds. Reduce E. coli loading to a level safe in order to support aquatic recreation use in WIC. Reduce phosphorus load leaving WIC as called for by the nutrient reduction strategy (NRS). [nitrogen 20%, phosphorus 12%, sediment 14%, E. coli 26.8%]	# of acres treated	$3,247.50
Whole Farm Conservation Plans	5 farmers	5 farmers	5 farmers	5 farmers	5 farmers	Work with 25 farmers to develop whole farm conservation plans that list resource concerns, these plans can be revisited every 2 years to work toward implementing practices identified in the plan		# of plans developed	$250,000 plan development, $100,000 for tech assistance on revisiting plans ea yr
Increase Water and Sediment Control Basin in headwaters (NRCS Code 638)	53 acres	53 acres	53 acres	53 acres	53 acres	265 acres/30 WASCOBs		# of acres treated	$600,000.00
Increase Grassed Waterway (NRCS Code 412)	52 acres	52 acres	52 acres	52 acres	52 acres	260 acres/10 Grassed Waterways		# of acres treated	$100,000.00
Develop site-specific nutrient management plans (NRCS Code 590)	1188 acres	1188 acres	1188 acres	1188 acres	1188 acres	5940 acres/30 plans		# of acres treated	$106,920.00
Increase and incentivize gridded soil sampling to guide precision nutrient application	Engage 3 producers in gridded soil sampling and precision nutrient application and provide cost share	Engage 3 producers in gridded soil sampling and precision nutrient application and provide cost share	Engage 3 producers in gridded soil sampling and precision nutrient application and provide cost share	Engage 3 producers in gridded soil sampling and precision nutrient application and provide cost share	Engage 3 producers in gridded soil sampling and precision nutrient application and provide cost share	15 producers utilizing gridded soil sampling precision nutrient application		# of producers engaged	
Increase and incentivize Residue and Tillage Management, Reduced Till (NRCS Code 345)	160 acres	160 acres	160 acres	160 acres	160 acres	800 acres		# of acres treated	$17,208.00
Increase and incentivize Residue and Tillage	20 acres	20 acres	20 acres	20 acres	20 acres	100 acres		# of acres treated	$2,151.00

Treatment type	Milestones					Long-Term Goals		Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)				
Management, No Till (NRCS Code 329)									
Increase and incentivize conservation crop rotation (NRCS Code 328)	27 acres	27 acres	27 acres	27 acres	27 acres	135 acres		# of acres treated	$5,297.20
~~Promote conservation crop rotation~~	~~Contact 5 producers for 1:1 conversations to discuss crop rotation~~	~~Contact 5 producers for 1:1 conversations to discuss crop rotation~~	~~Contact 5 producers for 1:1 conversations to discuss crop rotation~~	~~Contact 5 producers for 1:1 conversations to discuss crop rotation~~	~~Contact 5 producers for 1:1 conversations to discuss crop rotation~~	~~25 producers with 1:1 conversations discussing crop rotation~~			~~$1,500~~
Promote 5 soil health principles (soil armoring, minimizing soil disturbance, plant diversity, continual live plant/root, livestock integration) with demonstration site and field days	Contact 3 producers for 1:1 conversations to discuss crop rotation	Contact 3 producers for 1:1 conversations to discuss crop rotation	Contact 3 producers for 1:1 conversations to discuss crop rotation	Contact 3 producers for 1:1 conversations to discuss crop rotation	Contact 3 producers for 1:1 conversations to discuss crop rotation	15 producers contacted	Increased awareness of soil health practices, Develop and maintain inventory to quantify and track extent of soil health practices used in the watershed	# of producers contacted	$100,000.00
Land retirement - Conservation Cover (NRCS Code 327)	36 acres	36 acres	36 acres	36 acres	36 acres	180 acres		# of acres treated	$58,500.00
Cover Crop (NRCS Code 340)	171 acres	171 acres	171 acres	171 acres	171 acres	855 acres		# of acres treated	$32,472.90
Land retirement - Pasture (NRCS Code)	27 acres	27 acres	27 acres	27 acres	27 acres	135 acres		# of acres treated	$34,000.00
Streambank Erosion Practices/Restoration		1 streambank restoration project covering ~0.75stream miles		1 streambank restoration project covering ~0.75stream miles		114.7 acres		# of stream miles restored	$1,000,000.00
Implement Field Borders, Vegetative Barriers, Forest Edge Buffers, or Filter Strips at edge of field (NRCS Code 386, 601, 393)	30 acres	30 acres	30 acres	30 acres	30 acres	150 acres/ Work with agricultural landowners to implement as part of their conservation plan, native grasses or hay		# of acres implemented	$110,550.00
Increase Karst Sinkhole Treatment (NRCS Code 527), Filter Strips around sinkholes (NRCS Code 393)	2 sinkholes	2 sinkholes	2 sinkholes	2 sinkholes	2 sinkholes	10 sinkholes addressed	Minimize groundwater contamination resulting from infiltration near sinkholes and other areas of karst geology through incentives and education	# of sinkholes addressed	$62,500.00
Increase the enrollment of floodplain lands in RIM,	25 acres	25 acres	25 acres	25 acres	25 acres	125 acres		# of acres enrolled	$450,000.00

Treatment type	Milestones					Long-Term Goals		Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)				
CREP, similar programs (Critical Area Planting NRCS: 342)									
SWCD Technical & Admin Assistance	0.21 FTE	0.21 FTE	0.21 FTE	0.21 FTE	0.21 FTE				$200,000.00
Pastureland									
Grazing Land Management (rotational grazing)	18 acres	18 acres	18 acres	18 acres	18 acres	90 acres	Increase rotational/managed grazing	# of acres treated	$10,000.00
Alternative Water Supply/Livestock Pipeline (NRCS Code 516)	18 acres	18 acres	18 acres	18 acres	18 acres	90 acres		# of acres treated	$10,000.00
Heavy Use Area Protection (NRCS Code 561)	2.5 acres	2.5 acres	2.5 acres	2.5 acres	2.5 acres	12.5 acres		# of acres treated	$9,225.00
Pasture & Hayland Planting (NRCS Code 550)	18 acres	18 acres	18 acres	18 acres	18 acres	90 acres		# of acres treated	$45,000.00
Livestock Exclusion Fencing (NRCS Code 382)	187 acres	187 acres	187 acres	187 acres	187 acres	935 acres	Fencing to keep livestock out of riparian areas, WASCOBS, and forest areas	# of acres treated	$32,000.00
SWCD Technical & Admin Assistance	0.15 FTE	0.15 FTE	0.15 FTE	0.15 FTE	0.15 FTE				$150,000.00
Feedlots									
Provide financial assistance for installation of Livestock Waste Handling (Livestock Waste Storage Facilities NRCS: 313, Waste Treatment Lagoons NRCS: 359, Manure Waste Treatment NRCS: 629)	1 Livestock Waste Handling System	1 Livestock Waste Handling System	1 Livestock Waste Handling System	1 Livestock Waste Handling System	1 Livestock Waste Handling System	5 Livestock Waste Handling systems	Build relationships with small feedlot operators, promote rotational grazing, reduce run off from feedlots, promote appropriate manure storage, handling, and appropriately timed land application/incorporation. Utilize MinnFarm calculator to show pollutant reductions.	# of systems installed	$1,500,000.00
Promote Filter Strips around feedlots (NRCS Code: 393)	2 acres	2 acres	3 acres	2 acres	3 acres	12 acres		# of acres treated	$7,800.00
Build relationships with small feedlot operators	3 new farmer connections	3 new farmer connections	3 new farmer connections	3 new farmer connections	3 new farmer connections	15 new farmer connections		# of farmer connections made	$150,000.00
Provide financial assistance for small feedlot fixes/improvements (Watering Facility NRCS: 614, Fence NRCS: 382, Filter Strip NRCS: 393, Vegetated Treatment Area NRCS: 635, Stormwater Runoff Control NRCS: 570, Livestock Shelter Structure NRCS: 576)	3 feedlots addressed	3 feedlots addressed	3 feedlots addressed	3 feedlots addressed	3 feedlots addressed	Improvements on 15 feedlots		# of feedlots addressed	$450,000.00

Treatment type	Milestones					Long-Term Goals		Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)				
Promote Forage and Biomass Planting, Range Planting (NRCS Code: 512, 550)	27 acres	27 acres	27 acres	27 acres	27 acres	135 acres		# of acres treated	$13,495.28
SWCD Technical & Admin Assistance	0.16 FTE	0.16 FTE	0.16 FTE	0.16 FTE	0.16 FTE				$100,000.00
Forest									
Promote Forest Stand Improvement (NRCS Code 666)	157 acres	157 acres	157 acres	157 acres	157 acres	785 acres	Protect, expand, and increase the value of forest stands and significant biodiversity	# of acres treated	$471,900.00
Provide financial and technical support to assist landowners in developing forestry plans	189 acres	189 acres	189 acres	189 acres	189 acres	945 acres		# of acres treated	$33,031.25
Work with MDNR and other partners to provide local technical assistance in support of projects addressing invasive species (NRCS Code: 314)	38 acres	38 acres	38 acres	38 acres	38 acres	190 acres		# of acres treated	$103,812.50
SWCD Technical & Admin Assistance	0.16 FTE	0.16 FTE	0.16 FTE	0.16 FTE	0.16 FTE				$100,000.00
Urban									
Provide financial assistance for Well Decommissioning (NRCS Code 351)	1 well	2 wells	2 wells	2 wells	2 wells	9 wells	Reduce E. coli loading to a safe level that supports aquatic recreation use in WIC. Remove public health threats. Remove the threat of rapid pollutant pathways found in unused wells.	# of wells treated	$18,000.00
Provide financial assistance for septic upgrades	7 systems	7 systems	8 systems	8 systems	7 systems	37 systems		# of systems treated	$259,000.00
SWCD Technical & Admin Assistance	0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE				$100,000.00
Monitoring									
Monitor effectiveness of practices using lysimeters and spring monitoring to determine what the observable reduction is for specific practices	Identify test site, begin monitoring key springs	Install lysimeters & begin monitoring	Continue monitoring & review effectiveness	Continue monitoring & review effectiveness	Continue monitoring & review effectiveness	Assess effectiveness of implementation	Monitor effectiveness of implementation at key 'middle points' between fields and stream, further understand impacts in karst landscape	2 reports discussing effectiveness	$60,000.00
Inventory of sinkholes	landowner outreach	landowner outreach	landowner outreach	Complete inventory	use information gathered to adjust plan as necessary	Guide implementation	Cooperate with and assist landowners with existing sinkholes, be a known point of contact for future sinkhole issues	Completed inventory	$25,000.00
Inventory of abandoned/outdated wells	landowner outreach	landowner outreach	Complete inventory	use information gathered to adjust plan as necessary		Guide implementation	Cooperate with and assist landowners with private wells, be a known point of contact for future private well issues. Landowners are proactive about well maintenance.	Completed inventory	$25,000.00

Treatment type	Milestones					Long-Term Goals		Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)				
Inventory of outdated SSTS	landowner outreach	Complete inventory	Use information gathered to adjust plan as necessary			Guide implementation	Cooperate with and assist landowners with SSTS. Landowners are proactive about SSTS maintenance.	Completed inventory	$25,000.00
Inventory of existing WASCOBs, including operational status	Inventory WASCOBs in subwatershed 2	Inventory WASCOBs in subwatershed 3	Inventory WASCOBs in subwatershed 4	Inventory WASCOBs in subwatershed 5	Inventory WASCOBs in subwatershed 6	Guide implementation	A comprehensive inventory of existing WASCOBs in the watershed, including operational status to guide implementation and maintenance	Completed inventory	$25,000.00
Work with DNR, MDH, and others to inventory current spring flow (location, quantity, source, and quality) monitor any changes over time to determine effectiveness of treatments	identify key springs to be monitored	install monitoring equipment, begin monitoring	Continue monitoring & review effectiveness	Continue monitoring & review effectiveness	Continue monitoring & review effectiveness	Know how changes on the land surface in WIC change spring characteristics and as a result, change WIC		Completed inventory	$70,000.00
Monitor private groundwater wells for nitrate, bacteria, and other emerging contaminants to characterize effectiveness of implementation	Identify 7 key well owners willing to participate	begin well sampling	Continue monitoring & review effectiveness	Continue monitoring & review effectiveness	Continue monitoring & review effectiveness	# of private wells monitored	Establish nitrate-nitrogen trends for monitored private wells with average concentrations ≥3ppm, identify systems with chronically high nitrate concentrations	7 Nodes filled for MDH nitrate monitoring network, establishment of targeted monitoring network	$50,000.00
Review waters not subject to buffer law to identify additional priority areas for which technical assistance can be provided to protect	remote spatial analysis to identify potential priority areas	field verify priority areas identified through remote spatial analysis	Provide technical assistance to landowners interested in protecting 33% of identified priority areas	Provide technical assistance to landowners interested in protecting 33% of identified priority areas	Provide technical assistance to landowners interested in protecting 34% of identified priority areas	A large amount of the watershed is not considered ‘public waters’ and therefore not currently subject to the MN buffer law. These areas are often found in the headwaters where increased protection would be beneficial.		Completed review of additional priority areas	$50,000.00
Database of invasive species presence	2 newspaper article/letters, 1 watershed event	2 newspaper article/letters, 1 watershed event	2 newspaper article/letters, 1 watershed event	2 newspaper article/letters, 1 watershed event	2 newspaper article/letters, 1 watershed event	10 news articles/letters, 5 events	Cooperate with and assist landowners with invasive species. Utilize UMN Extension resources that allow landowners to map invasive presence.	# of articles and events	$20,000.00
Install nested well in, including both aquifers contributing flow to WIC	work with state agencies to determine optimum well location	install nested well	Collect aquifer samples annually to analyze for nitrates, bacteria, and other emerging contaminants to characterize effectiveness of implementation	Collect aquifer samples annually to analyze for nitrates, bacteria, and other emerging contaminants to characterize effectiveness of implementation	Collect aquifer samples annually to analyze for nitrates, bacteria, and other emerging contaminants to characterize effectiveness of implementation	Installation of nested well and annual sampling			$50,000.00

Treatment type	Milestones					Long-Term Goals		Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)				
Promote citizen stream monitoring	Engage at least 2 landowners in the watershed to collect monthly stream clarity, temperature and general observations.	Maintain at least 2 landowners in the watershed to collect monthly stream clarity, temperature, and general observations	Maintain at least 2 landowners in the watershed to collect monthly stream clarity, temperature, and general observations	Maintain at least 2 landowners in the watershed to collect monthly stream clarity, temperature, and general observations	Maintain at least 2 landowners in the watershed to collect monthly stream clarity, temperature, and general observations	2 or more local landowners monitoring the stream monthly	Engage landowners in the watershed to observe general, visual stream water quality to both have more eyes on what is going on in the watershed and to give landowners and sense of ownership and connection to stream water quality.	# of landowners engaged in citizen stream monitoring	$10,000
Continue pollutant monitoring at existing long term monitoring site (S004-452) and newly established upstream site -either existing site S003-811 or further upstream and downstream site S005-733(MPCA)	Monthly baseflow sampling of TSS, Total nitrogen, Total phosphorus	Monthly baseflow sampling of TSS, Total nitrogen, Total phosphorus	Monthly baseflow sampling of TSS, Total nitrogen, Total phosphorus	Monthly baseflow sampling of TSS, Total nitrogen, Total phosphorus	Monthly baseflow sampling of TSS, Total nitrogen, Total phosphorus	Monthly baseflow sampling of TSS, Total nitrogen, Total phosphorus to determine effectiveness of implementation		Continued pollutant monitoring	
Continue fishery monitoring at existing long term monitoring site (DNR)	Annual DNR Stream assessment	Annual DNR Stream assessment	Annual DNR Stream assessment	Annual DNR Stream assessment	Annual DNR Stream assessment	Sustain or improve stream conditions and coldwater IBIs		Continued stream assessments	
Continue invasive species monitoring, specifically poison hemlock	Work with 3 landowners	Work with 3 landowners	Work with 4 landowners	Work with 3 landowners	Work with 3 landowners	Prioritize landowners adjacent to state owned land		# of landowners	$40,000.00
Continue regular inspection of projects receiving cost-share	Each project inspected 1, 5, and 10 years after installation	Each project inspected 1, 5, and 10 years after installation	Each project inspected 1, 5, and 10 years after installation	Each project inspected 1, 5, and 10 years after installation	Each project inspected 1, 5, and 10 years after installation	Maintain quality and integrity of implemented projects, inspect all funded projects		All projects inspected on a regular basis	$40,000.00
Outreach									
Identify a producer-leader in the watershed to establish demonstration site	identify 2 producers/landowners, reach out to additional key producers/landowners	2 local champion(s) reach out to other producers/landowners	Maintain 2 local champion(s)	Maintain 2 local champion(s)	Maintain 2 local champion(s)	Local champion(s) to help build relationships with producers and landowners within the watershed. Maintain 2 key local champions in the watershed.		# of local champions assisting with outreach	$10,000.00

Treatment type	Milestones					Long-Term Goals		Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)				
Host field day events		1 field day	1 field day	1 field day		3 field days		# of field days held	$12,000.00
Producer-leader demonstration site/field trials		Establish demonstration sites (2)	Maintain demonstration sites	Maintain demonstration sites	Maintain demonstration sites	40 demonstration acres	Improve the local confidence in practices recommended in this plan	# of demonstration sites	$20,000.00
Conduct outreach with landowners and area youth regarding forestry and soil health	2 newspaper article/letters, 2 outreach events	2 newspaper article/letters, 2 outreach events	2 newspaper article/letters, 2 outreach events	2 newspaper article/letters, 2 outreach events	2 newspaper article/letters, 2 outreach events	10 newspaper articles/letters, 10 outreach events	Increased awareness of forest land management and forestry industry, Increased awareness of soil health practices and more youth interest in continuing family farm	# of articles/letters and events	$25,000.00
Distribute information materials increasing resident awareness of groundwater issues, testing, and best practices	2 newspaper article/letters, 1 testing event	2 newspaper article/letters, 1 testing event	2 newspaper article/letters, 1 testing event	2 newspaper article/letters, 1 testing event	2 newspaper article/letters, 1 testing event	10 newspaper articles or letters and 5 testing events	Increased awareness of potential groundwater contamination, Increased private well owner testing	# of articles/letters and events	$10,000.00
Ongoing outreach and compliance checks for buffer law		Complete review of watershed		Complete review of watershed		Maintain 100% compliance with buff law and increase the quality of vegetation in buffers. Provide encouragement for landowner success w/ buffer law in critical areas, provide financial and technical assistance to landowners struggling with buffer law		3 year reviews of buffers completed, increased interest in managing/maintaining buffers	$3,500.00
Promote enrollment in conservation programs and protection of biologically significant elements in the watershed through distribution of educational materials	2 newspaper article/letters, staff target funding sources	2 newspaper article/letters, staff target funding sources	2 newspaper article/letters, staff target funding sources	2 newspaper article/letters, staff target funding sources	2 newspaper article/letters, staff target funding sources	10 newspaper articles/letters and new funding sources identified	Increased awareness of conservation programs and ecosystem services	# of articles/letters and funding sources	$10,000.00
Provide educational materials regarding the Minnesota Agricultural Water Quality Certification Program	1 certified farmer	1 certified farmers	1 certified farmers	1 certified farmers	1 certified farmers	5 certified farmers	Increase the number of producers certified through Minnesota's AWQCP	# of certified farmers	$25,000.00
Work with agriculture retailers and crop consultants on workshops / field days / other outreach activities	1 outreach event	1 outreach events	1 outreach events	1 outreach events	1 outreach events	5 outreach events	Foster relationships to create a more unified message and approach to agricultural production	# of outreach events	$10,000.00
Conduct field walkovers, tech support, kitchen-table meetings	3 site visits	3 site visits	3 site visits	3 site visits	3 site visits	15 site visits		# of site visits	$45,000.00
Total cost									**$7,176,610.63**

Estimated Load Reductions

Reductions have been calculated using the Spreadsheet Tool for Estimating Pollutant Load (STEPL) for the practices planned (Table 25). Reductions by land usage are summarized in Table 26. It is expected that practices described in this plan will achieve load reductions needed to meet water quality standards and goals when fully implemented. The estimated current loads using STEPL for nitrogen (N) phosphorus (P), total suspended solids (TSS), and *E. coli* are provided in the table below as well as the estimated reductions. Full details for STEPL are included in Appendix A.

Table 25. Estimated pollutant loads before and after BMPs, with estimated load reductions, in the West Indian Creek Watershed

	Estimated Current Loading				**Estimated Reduction to Loading**			
	N load	**P load**	**Sediment load**	***E. coli* load**	**N reduction**	**P reduction**	**Sediment reduction**	***E. coli* reduction**
Watershed	**lb/yr**	**lb/yr**	**t/yr**	**Billion MPN/yr**	**lb/yr**	**lb/yr**	**t/yr**	**Billion MPN/yr**
W1	10443.33	2142.732	147.64	2272.135	3788.99	1119.18	40.29	2111.64
W2	40159.99	7876.584	2036.42	14897.51	9729.33	3203.08	516.80	13571.53
W3	163760.84	25629.36	3407.23	33232.41	51331.60	12018.48	817.34	29512.65
W4	15258.42	3468.681	1049.25	9284.49	3373.79	1366.78	259.12	8756.30
W5	149490.53	27123.62	5457.94	40889.14	47631.85	11906.28	1317.19	38294.81
Total	379113.11	66240.98	12098.47	100575.7	115855.56	29613.79	2950.74	92246.93
	Estimated Future Loading (with BMPs)							
	N Load	**P Load**	**Sediment Load**	**E. coli Load**	**N reduction**	**P reduction**	**Sediment reduction**	***E. coli* reduction**
Watershed	**lb/yr**	**lb/yr**	**t/yr**	**Billion MPN/yr**	**%**	**%**	**%**	**%**
W1	6654.34	1023.55	107.35	160.49	36%	52%	27%	93%
W2	30430.66	4673.51	1519.62	1325.98	24%	41%	25%	91%
W3	112429.24	13610.89	2589.89	3719.76	31%	47%	24%	89%
W4	11884.63	2101.90	790.13	528.20	22%	39%	25%	94%
W%	101858.68	15217.34	4140.74	2594.34	32%	44%	24%	94%
Total	263257.55	36627.18	9147.74	8328.77	31%	45%	24%	92%

Table 26. Estimated percent pollution reduction by land use in the West Indian Creek Watershed

Sources	**Cropland**	**Pastureland**	**Forest**	**Feedlots**	**Septic**	**Total**
N Load (lb/yr)	30%	8%	0%	38%	100%	30%
P Load (lb/yr)	42%	13%	0%	54%	100%	44%
Sediment Load (t/yr)	26%	15%	0%	--	--	24%

Sources	Cropland	Pastureland	Forest	Feedlots	Septic	Total
E. coli Load (Billion MPN/yr)	75%	18%	0%	39%	100%	13%

The BMPs often function as a system, and the reductions summarized in Table 25 and Table 26, were modeled using the combined efficiencies of the practices (Table 28). The BMPs identified were modeled to estimate reductions by practice to inform implementation decisions and support adaptive management.

Table 27. STEPL pollutant load reduction by practice

Land use	BMP	Acres treated	N lbs/yr	P lbs/yr	Sediment t/yr	*E. coli* billion MPN/yr
Cropland	Cover Crop 3	100	531.3	170	87.8	75.1
Cropland	Nutrient Management 2	100	220.7	123.6	0	135.1
Cropland	Conservation Tillage (60% Residue or more)	100	587.3	185.4	91.4	97.6
Cropland	Land Retirement	100	1195.7	325.7	113.9	135.1
Cropland	Grassed Waterways	100	461.6	190	73.6	45
Cropland	Perennial Crop	100	565.2	139.3	59.3	75.1
Cropland	Land Retirement - Pasture	100	955.1	239.9	89	0
Cropland	Contour Farming	100	596.5	199.4	83.1	0
Cropland	WASCOB (Water & Sediment Control Basin)	100	1074.6	319.2	106.8	45
Cropland	Streambank Erosion Practices	100	1146.1	330.2	106.8	45
Pastureland	Grazing Land Management (rotational grazing w/ fenced areas)	100	242.3	36.9	18.2	65.6
Pastureland	Alternative Water Supply	100	57.6	9.5	5.7	65.6
Pastureland	Heavy Use Area Protection	100	86.6	16.7	10.1	0
Pastureland	Pasture & Hayland Planting	100	53.7	3.3	0	0
Pastureland	Livestock Exclusion Fencing	100	120.4	29.9	18.8	65.6
Feedlots	Waste Mgmt System	1	2433.1	322	0	0
Feedlots	Filter Strip	1	0	304.1	0	0
Feedlots	Runoff Mgmt System	1	2281	268.3	0	0

Monitoring Approach

As is outline in previous sections, state of Minnesota agencies and local partners, including the Wabasha County SWCD, have identified West Indian Creek as a priority stream. This is evident from the long term biological and chemical monitoring completed by the DNR and MPCA in West Indian Creek since 2007. Regular biological and chemical monitoring will continue with the DNR and MPCA as it has since 2007 at least through the duration of this project. Proposed monitoring sites are shown on Figure 30.

To determine the effectiveness of treatments proposed in this plan, additional monitoring will be required. Previous sections discuss the importance of groundwater in this watershed and that nitrate concentrations of soil water and shallow wells or springs in the upper bedrock units may allow for monitoring of middle points between land use practices and surface water monitoring stations. This type of monitoring can help address the issues of lag time of groundwater dominated systems, where nitrate concentrations in surface water can lag changes in land use practices by decades. Installation of lysimeters below the root zone of targeted agricultural fields will show whether land use changes such as cover crops and nutrient management are reducing the amount of pollutants leaching into the subsurface. Nested monitoring wells in the two aquifers contributing to West Indian Creek will show whether land use practices within the surficial watershed are making a difference in pollutant concentrations in the groundwater. If no significant change is shown over time, it is anticipated that the larger groundwater contributing area (subsurface watershed) should be included in the project. Groundwater monitoring will be completed in consultation with Minnesota Departments of Health and Agriculture as well as the Minnesota Geologic Survey.

Additional discharge and pollutant monitoring downstream, near the confluence with the Zumbro River will help isolate effectiveness of implementation and other changes in the different areas of the watershed, as well as the overall pollutant load being delivered from West Indian Creek to the Zumbro River and any reductions thereof. Connecting localized and broader changes in the water quality with land use changes and implementation of BMPs within West Indian Creek and sharing this information and feedback with local partners will hopefully keep them invested in the process and will help inform how well the BMPs are performing. The collected information can also be used in watershed predictive models to provide better estimates of effectiveness of BMPs especially in the unique landscape of southeastern Minnesota.

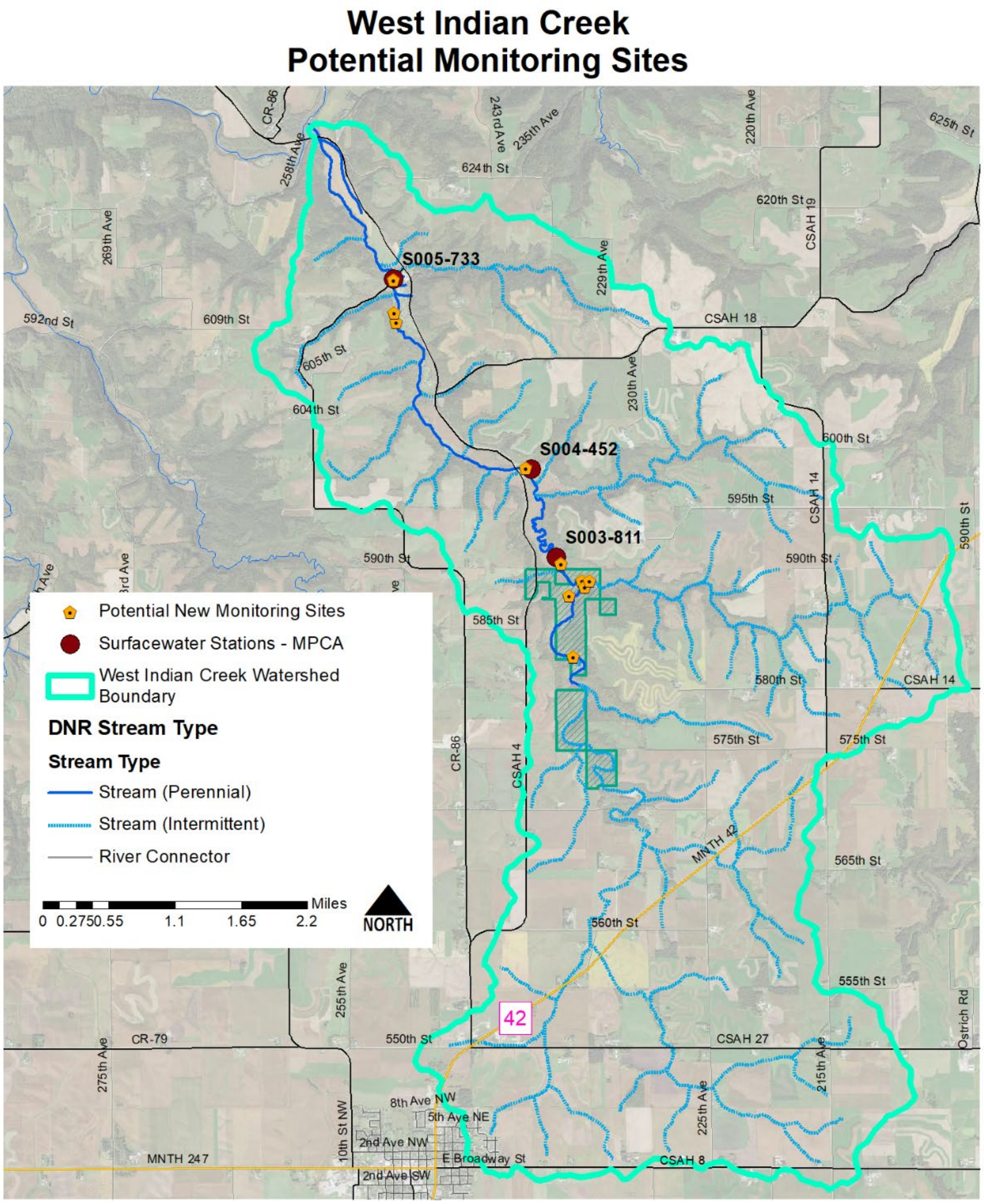


Figure 29. Potential monitoring sites for the West Indian Creek Watershed

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Appendix A
STEPL output and assumptions

The STEPL was used to estimate P, TSS, and *E. coli* loads and reductions for the watershed. The loads estimated in STEPL were comparable with the loading that was estimated using HSPF-SAM for the development of the draft TMDLs in the watershed.

The reductions for BMPs identified in the ten-year milestone table were summed and entered as combined efficiency practices in STEPL. Reduction efficiencies for *E. coli* were assumed from MPCA (2011) and Wright Water Engineers, Inc. (2010) and added to the "BMPList" worksheet in STEPL. The practices and assumed reduction efficiencies are shown in Table 32. The Combined Efficiencies of the BMPs with area of subwatershed treated is described in Table 28. The treatment efficiencies for the BMPs that are not in the original list of BMPs and reduction efficiencies (BMPList) in STEPL were assigned based on the similarity of the treatment processes with selected BMPList practices.

Combined pollutant reduction efficiencies for subwatersheds

The STEPL program for modeling watershed reductions calculates the efficiencies of combined BMPs by land use. When BMPs are combined on the area of landscape, the efficiency of removal of the pollutant is changed. Each of the combined BMPs for land use and subwatershed is described in Table 28.

Table 28. Combined efficiencies of BMPs by land use and subwatershed in the West Indian Creek Watershed

Combined efficiencies for BMPs and acres treated as STEPL inputs for West Indian Creek subwatershed 1					
Cropland					
Area (ac)	**BMP**	**N**	**P**	**TSS**	***E. coli***
10.6	Cover Crop 3 (Group A Traditional Early Planting Time) (High till only for TP and Sediment)	0.28	0.28	0.74	0.5
73.78	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.56	0	0.9
11.18	Conservation Tillage 2 (Equal or more than 60% residue)	0.33	0.33	0.77	0.65
2.24	Land Retirement	0.93	0.84	0.96	0.9
10.6	Streambank Erosion Practices	0.9	0.9	0.9	0.3
1.7	Perennial Crop	0.42	0.3	0.5	0.5
1.7	Land Retirement - Pasture	0.75	0.59	0.75	0
111.8	Total acres and combined efficiencies	0.344	0.545	0.271	0.76
Pastureland					
Area (ac)	**BMP**	**N**	**P**	**TSS**	***E. coli***
1.5	Livestock Exclusion Fencing - WASCOBs	0.203	0.304	0.62	0.65
20	Livestock Exclusion Fencing - Forest	0.203	0.304	0.62	0.65
1	Alternative Water Supply	0.133	0.115	0.187	0.65
1	Grazing Land Management (rotational grazing w/ fenced areas)	0.62	0.65	0.6	0.65

1	Pasture & Hayland Planting (Forage Planting)	0.181	0.15	0	0
0.5	Heavy Use Area Protection	0.183	0.193	0.333	0
25	Total acres and combined efficiencies	0.142	0.199	0.376	0.402
Feedlot					
Area (ac)	BMP	N	P	TSS	*E. coli*
1	Waste Mgmt System	0.8	0.9	0	0.9
0.25	Filter strip	0	0.85	0	0.3
1.25	Total acres and combined efficiencies	0.4	0.556	0	0.488
Combined efficiencies for BMPs and acres treated as STEPL inputs for West Indian Creek subwatershed 2					
Cropland					
Area (ac)	**BMP**	**N**	**P**	**TSS**	***E. coli***
134.12	Cover Crop 3 (Group A Traditional Early Planting Time) (High till only for TP and Sediment)	0.28	0.28	0.74	0.5
931.78	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.56	0	0.9
141.18	Conservation Tillage 2 (Equal or more than 60% residue)	0.33	0.33	0.77	0.65
28.24	Land Retirement	0.93	0.84	0.96	0.9
29.98	Grassed Waterways	0.253	0.45	0.62	0.3
21.2	Perennial Crop	0.42	0.3	0.5	0.5
21.2	Land Retirement - Pasture	0.75	0.59	0.75	0
104.1	Streambank Erosion Practices	0.9	0.9	0.9	0.3
1411.8	Total acres and combined efficiencies	0.331	0.535	0.265	0.76
Pastureland					
Area (ac)	**BMP**	**N**	**P**	**TSS**	***E. coli***
20.25	Livestock Exclusion Fencing - WASCOBs	0.203	0.304	0.62	0.65
339.04	Livestock Exclusion Fencing - Forest	0.203	0.304	0.62	0.65
20.8	Alternative Water Supply	0.133	0.115	0.187	0.65
20.8	Grazing Land Management (rotational grazing w/ fenced areas)	0.62	0.65	0.6	0.65
20.8	Pasture & Hayland Planting (Forage Planting)	0.181	0.15	0	0
2	Heavy Use Area Protection	0.183	0.193	0.333	0
423.69	Total acres and combined efficiencies	0.089	0.124	0.231	0.251
Feedlot					
Area (ac)	**BMP**	**N**	**P**	**TSS**	***E. coli***
2.5	Waste Mgmt System	0.8	0.9	0	0.9
2	Filter strip	0	0.85	0	0.3
2	Runoff Mgmt System	0.75	0.75	0.7	0.5
6.5	Total acres and combined efficiencies	0.35	0.545	0.14	0.385
Combined efficiencies for BMPs and acres treated as STEPL inputs for West Indian Creek subwatershed 3					
Cropland					
Area (ac)	**BMP**	**N**	**P**	**TSS**	***E. coli***

222.5	Cover Crop 3 (Group A Traditional Early Planting Time) (High till only for TP and Sediment)	0.28	0.28	0.74	0.5
1545.8	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.56	0	0.9
234.21	Conservation Tillage 2 (Equal or more than 60% residue)	0.33	0.33	0.77	0.65
46.8	Land Retirement	0.93	0.84	0.96	0.9
111.33	Grassed Waterways	0.253	0.45	0.62	0.3
35.1	Perennial Crop	0.42	0.3	0.5	0.5
35.1	Land Retirement - Pasture	0.75	0.59	0.75	0
111.33	WASCOB (Water & Sediment Control Basin)	0.82	0.85	0.9	0.3
2342.17	Total acres and combined efficiencies	0.31	0.521	0.257	0.76
Pastureland					
Area (ac)	BMP	N	P	TSS	*E. coli*
20.25	Livestock Exclusion Fencing - WASCOBs	0.203	0.304	0.62	0.65
475.56	Livestock Exclusion Fencing - Forest	0.203	0.304	0.62	0.65
40	Alternative Water Supply	0.133	0.115	0.187	0.65
40	Grazing Land Management (rotational grazing w/ fenced areas)	0.62	0.65	0.6	0.65
40	Pasture & Hayland Planting (Forage Planting)	0.181	0.15	0	0
4	Heavy Use Area Protection	0.183	0.193	0.333	0
619.81	Total acres and combined efficiencies	0.072	0.097	0.176	0.194
Feedlot					
Area (ac)	**BMP**	**N**	**P**	**TSS**	***E. coli***
3	Waste Storage Facility	0.9	0.9	0.9	0.9
4.5	Waste Mgmt System	0.8	0.9	0	0.9
6	Filter strip	0	0.85	0	0.3
6	Runoff Mgmt System	0.75	0.75	0.7	0.5
19.5	Total acres and combined efficiencies	0.36	0.545	0.23	0.385
Combined efficiencies for BMPs and acres treated as STEPL inputs for West Indian Creek subwatershed 4					
Cropland					
Area (ac)	**BMP**	**N**	**P**	**TSS**	***E. coli***
76.67	Cover Crop 3 (Group A Traditional Early Planting Time) (High till only for TP and Sediment)	0.28	0.28	0.74	0.5
532.69	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.56	0	0.9
80.7	Conservation Tillage 2 (Equal or more than 60% residue)	0.33	0.33	0.77	0.65
16.14	Land Retirement	0.93	0.84	0.96	0.9
30.4	Grassed Waterways	0.253	0.45	0.62	0.3
12.1	Perennial Crop	0.42	0.3	0.5	0.5
12.1	Land Retirement - Pasture	0.75	0.59	0.75	0
46.3	WASCOB (Water & Sediment Control Basin)	0.82	0.85	0.9	0.3
807.1	Total acres and combined efficiencies	0.315	0.525	0.26	0.76
Pastureland					

Area (ac)	**BMP**	**N**	**P**	**TSS**	***E. coli***
1.5	Livestock Exclusion Fencing - WASCOBs	0.203	0.304	0.62	0.65
45	Livestock Exclusion Fencing - Forest	0.203	0.304	0.62	0.65
5.29	Alternative Water Supply	0.133	0.115	0.187	0.65
5.29	Grazing Land Management (rotational grazing w/ fenced areas)	0.62	0.65	0.6	0.65
5.29	Pasture & Hayland Planting (Forage Planting)	0.181	0.15	0	0
1	Heavy Use Area Protection	0.183	0.193	0.333	0
63.37	Total acres and combined efficiencies	0.055	0.073	0.126	0.14
Feedlot					
Area (ac)	**BMP**	**N**	**P**	**TSS**	**E. coli**
1	Waste Mgmt System	0.8	0.9	0	0.9
1.5	Filter strip	0	0.85	0	0.3
2.5	Total acres and combined efficiencies	0.2	0.544	0	0.338
Combined efficiencies for BMPs and acres treated as STEPL inputs for West Indian Creek subwatershed 5					
Cropland					
Area (ac)	**BMP**	**N**	**P**	**TSS**	***E. coli***
411.21	Cover Crop 3 (Group A Traditional Early Planting Time) (High till only for TP and Sediment)	0.28	0.28	0.74	0.5
2856.8	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.56	0	0.9
432.85	Conservation Tillage 2 (Equal or more than 60% residue)	0.33	0.33	0.77	0.65
86.57	Land Retirement	0.93	0.84	0.96	0.9
86.57	Grassed Waterways	0.253	0.45	0.62	0.3
65.9	Perennial Crop	0.42	0.3	0.5	0.5
65.9	Land Retirement - Pasture	0.75	0.59	0.75	0
216.4	Contour Farming	0.37	0.44	0.7	0
106.3	WASCOB (Water & Sediment Control Basin)	0.82	0.85	0.9	0.3
4328.5	Total acres and combined efficiencies	0.303	0.511	0.255	0.745
Pastureland					
Area (ac)	**BMP**	**N**	**P**	**TSS**	***E. coli***
20	Grazing Land Management (rotational grazing w/ fenced areas)	0.62	0.65	0.6	0.65
20	Alternative Water Supply	0.133	0.115	0.187	0.65
5	Heavy Use Area Protection	0.183	0.193	0.333	0
20	Pasture & Hayland Planting (Forage Planting)	0.181	0.15	0	0
9.75	Livestock Exclusion Fencing - WASCOBs	0.203	0.304	0.62	0.65
74.75	Total acres and combined efficiencies	0.023	0.023	0.025	0.034
Feedlot					
Area (ac)	**BMP**	**N**	**P**	**TSS**	**E. coli**
5	Waste Storage Facility	0.9	0.9	0.9	0.9
4	Waste Mgmt System	0.8	0.9	0	0.9

4.4	Filter strip	0	0.85	0	0.3
10	Runoff Mgmt System	0.75	0.75	0.7	0.5
23.4	Total acres and combined efficiencies	0.42	0.54	0.32	0.40

STEPL inputs

The STEPL model allows users to enter information about each of the subwatersheds. This is described in Table 29.

Table 29. Watershed land use input in acres for the West Indian Creek Watershed

Watershed	Urban	Cropland	Pastureland	Forest	Feedlots	% feedlot paved	Total
W1	4.4	111.8	38	137.8	2	0-24%	294
W2	195.3	1411.8	1040	1295.9	10	0-24%	3953
W3	156.15	2342.17	1930.83	1240.45	30	0-24%	5699.6
W4	48.1	807.1	264.3	332	4	0-24%	1455.5
W5	322.29	4328.9	956.1	139.7	36	0-24%	5783.99

SSTS reductions

The STEPL model does not include the estimated pollutant reductions in the watershed reduction table. Instead, the reductions associated with the replacement and upgrades of the SSTS in West Indian Creek Watershed are summarized in Table 30.

Table 30. STEPL output for SSTS *E. coli* load reductions in the West Indian Creek Watershed

Number of SSTS in subwatersheds, population per SSTS and failure rates								Hourly Load		
Watershed	# of SSTS	Pop per SSTS	Failure rate	Failing SSTS	Pop on failing SSTS	Failing SSTS gal/day	Failing SSTS flow L/hr	N load lb/hr	P load lb/hr	*E. coli* MPN/hr (billion)
1	3	2.43	25%	0.75	1.8225	127.575	20.122	0.003	0.001	190754.95
2	21	2.43	25%	5.25	12.7575	893.025	140.853	0.019	0.007	1335284.68
3	45	2.43	25%	11.25	27.3375	1913.625	301.827	0.040	0.016	2861324.32
4	14	2.43	25%	3.5	8.505	595.35	93.902	0.012	0.005	890189.78
5	60	2.43	25%	15	36.45	2551.5	402.437	0.053	0.021	3815099.09

Annual Load			Load after Reduction		
N load lb/yr	P load lb/yr	*E. coli* billion MPN/yr	N load lb/yr	P load lb/yr	*E. coli* billion MPN/yr
23.3	9.1	1671.0	0	0	0
163.2	63.9	11697.1	0	0	0
349.7	137.0	25065.2	0	0	0
108.8	42.6	7798.1	0	0	0
466.3	182.6	33420.3	0	0	0

STEPL assumptions

There are assumptions made to effectively use the STEPL mode to calculate watershed pollutant reduction. The STEPL was used to estimate phosphorus and E. coli loads and reductions for the watershed. The default sediment, phosphorus, and nitrogen reduction efficiencies were used. Reduction efficiencies for E. coli were assumed from MPCA (2011) and Wright Water Engineers, Inc. (2010) and added to the BMP List worksheet. Some of the assumptions are described below.

- Feedlot land uses are assumed to have roughly 2 acres of strictly feedlot area. This does not include barns where animals are housed or pastures.
- Watershed land use areas were obtained using a combination of HSPF subwatershed areas and six year cropping history / land use information obtained from the ACPF database.
- The general pollutant reduction goals were taken from the NRS recommendations for the Lower Zumbro, West Indian *E. coli* TMDL mid-range flow reductions, and Zumbro River WRAPS BMP scenario.
- The number of total cropland areas assumed to receive BMPs for P reduction (Zumbro WRAPS report (Table 31). These assumptions were calculated to fit the West Indian Creek Watershed, as described in the Estimated Load Reduction section.

Table 31. Percentage of acres needed to achieve P reductions in the Lower Zumbro River Watershed

Management practice	Lower Zumbro River Watershed
Target P2O5 rate	66.0%
Use reduced tillage on corn, soy, and small grains	24.0%
Riparian buffers, 50ft wide, 100 ft treated	7.5%
Perennial crop % of marginal corn ^ soybean land	3.1%
Rye cover crop on corn and soybean acres	5.5%
Short season crops planted to a rye cover crop	4.1%
Controlled drainage	0%
Alternative tile intakes	0%
Inject/incorporate manure	5.4$

Table 32. STEPL practices, efficiencies and assumptions for the West Indian Creek Watershed

	N	P	Sediment	E. coli	Assumptions and additions
Cropland					
0 No BMP	**0**	**0**	**0**	**0**	**Added all E. coli efficiencies**
Bioreactor	**0.453**	**ND**	**ND**	**0.9**	**Assume treats 20 acres**
Buffer - Forest (100ft wide)	0.478	0.465	0.586	0.9	
Buffer - Grass (35ft wide)	0.338	0.435	0.533	0.65	
Conservation Cover	0.204	0.15	0.2	0.5	Added Conservation Cover, assuming same efficiencies as STEPL practice Cover Crop 3
Conservation Tillage 1 (30-59% Residue)	0.15	0.356	0.403	0.3	

	N	P	Sediment	E. coli	Assumptions and additions
Conservation Tillage 2 (equal or more than 60% Residue)	0.25	0.687	0.77	0.65	
Contour Farming	0.279	0.398	0.341	ND	
Controlled Drainage	0.388	0.35	ND	ND	
Cover Crop 1 (Group A Commodity) (High Till only for Sediment)	0.008	ND	ND	ND	
Cover Crop 2 (Group A Traditional Normal Planting Time) (High Till only for TP and Sediment)	0.196	0.07	0.1	ND	
Cover Crop 3 (Group A Traditional Early Planting Time) (High Till only for TP and Sediment)	0.204	0.15	0.2	0.5	
Critical Area Planting	0.898	0.808	0.95	0.9	Added cropland Critical Area Planting, assuming same efficiencies as STEPL practice land Retirement
Detention Basin	0.253	0.308	0.4	0.3	Assume each basin is 10 acres and each basin treats 100 acres. Assume same efficiencies as STEPL practice Terrace.
Diversions	0.898	0.808	0.95	0.9	Added Diversions, assuming same efficiencies as STEPL practice Land Retirement
Drainage Water Management	0.253	0.308	0.4	0.3	Added Drainage Water Management, assuming same efficiencies as STEPL Practice Terrace, assume 50 acres treated per practice
Field Borders	0.253	0.308	0.4	0.3	Added Field Borders, assuming same efficiencies as STEPL practice Filter Strips (Terrace)
Filter Strips	0.253	0.308	0.4	0.3	Added Filter Strip, assuming same efficiencies as STEPL practice Terrace, assume 50 acres treatment per acre of filter strip (assume 1,000 ft=1 acres)
Filtration Practices	0.253	0.308	0.4	0.3	Added Filtration Practices, assuming same efficiencies as STEPL practice Terrace, assuming 40 acres treated per practice
Grade Stabilization Structures	0.253	0.308	0.4	0.3	Added Grade Stabilization Structures, assuming same efficiencies as STEPL practice

	N	P	Sediment	E. coli	Assumptions and additions
					Terrace, assume 40 acres treated per practice.
Grassed Waterways	0.253	0.308	0.4	0.3	Added Grassed Waterways, assume 1,000 ft of grassed waterways treats 50 acres, assume same efficiencies as STEPL practice Terrace
Impoundment	0.898	0.808	0.95	0.9	Added Impoundment, assume same efficiencies as STEPL practice Land Retirement
Land Retirement	0.898	0.808	0.95	0.9	Added Nutrient/Manure Management, Assuming same efficiencies as STEPL practice Nutrient Management 1, increased e. coli efficiencies to .9
Manure/Nutrient Management	0.154	0.45	ND	0.9	
Nutrient Management 1 (Determined Rate)	0.154	0.45	ND	0.5	
Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.56	ND	0.9	
Residue/Tillage Management	0.15	0.356	0.403	0.3	Added Residue/Tillage Management, assuming same efficiencies as STEPL practice Conservation Tillage 1
Saturated Buffer	0.338	0.435	0.533	0.65	Added Saturated Buffer, assuming same efficiencies as STEPL practice Buffer-Grass; Assume 1,000 ft with treatment as 40 ac/mil (1/8 mile width) as Two-Stage Ditch
Side water inlets	0.253	0.308	0.4	0.3	Added Side Water inlets, assumed same efficiencies as Terrace
Streambank Erosion Practices	0.253	0.308	0.4	0.3	Added Streambank Erosion Practices, assuming same efficiencies as STEPL practice Terrace, assuming 5 practices treat 100 acres
Streambank Stabilization and Fencing	0.75	0.75	0.75	0.3	
Terrace	0.253	0.308	0.4	0.3	
Two-Stage Ditch	0.12	0.28	ND	0.3	
WASCOB (Water and Sediment Control Basin	0.253	0.308	0.4	0.3	Added WASCOB, assuming the same efficiencies as Terrace, assuming 40 acres treated per WASCOB

	N	P	Sediment	E. coli	Assumptions and additions
Water Control Structures	0.253	0.308	0.4	0.3	Added cropland Water Control Structures, assuming same efficiencies as STEPL practice Terrace, assume 40 acres treated per practice installed
Wetland Restoration	0.898	0.808	0.95	0.9	Added Wetland Restoration, assuming same efficiencies as STEPL practice Land retirement assuming 40 acres treated per acre of wetland
Pastureland					
0 No BMP	**0**	**0**	**0**	**0**	
30m Buffer with Optimal Grazing	0.364	0.653	ND	0.65	
Alternative Water Supply	0.133	0.115	0.187	0.65	
Cattle Exclusions	0.203	0.304	0.62	0.65	Added pastureland Cattle Exclusions, assuming same efficiencies as STEPL practice Livestock exclusion fencing
Critical Area Planting	0.175	0.2	0.42	ND	
Fencing and Watering Projects	0.203	0.304	0.62	0.65	Added pastureland Fencing and watering projects, assuming same efficiencies as STEPL practice Livestock Exclusion Fencing
Forest Buffer (minimum 35 feet wide)	0.452	0.4	0.533	ND	
Grass Buffer (minimum 35 feet wide)	0.868	0.766	0.648	ND	
Grazing Land Management (rotational grazing with fenced areas)	0.43	0.263	ND	0.65	
Heavy Use Area Protection	0.183	0.193	0.333	ND	
Litter Storage and Management	0.14	0.14	0	ND	
Livestock Exclusion Fencing	0.203	0.304	0.62	0.65	
Multiple Practices	0.246	0.205	0.221	ND	
Pasture and Hayland Planting (also called Forage Planting)	0.181	0.15	ND	ND	
Prescribed Grazing	0.408	0.227	0.333	ND	
Rotational Grazing	0.43	0.263	0.333	0.65	Added pastureland Rotational Grazing, assuming same efficiencies as STEPL practice Grazing Land Management, and

	N	P	Sediment	E. coli	Assumptions and additions
					TSS reduction from Prescribed Grazing
Streambank Protection w/o Fencing	0.15	0.22	0.575	0.3	
Streambank Stabilization and Fencing	0.75	0.75	0.75	0.65	
Use Exclusion	0.39	0.04	0.589	0.9	
Winter Feeding Facility	0.35	0.4	0.4	ND	
Forest					
0 No BMP	**0**	**0**	**0**	**0**	
Road dry seeding	ND	ND	0.41	ND	
Road grass and legume seeding	ND	ND	0.71	ND	
Road hydro mulch	ND	ND	0.41	ND	
Road straw mulch	ND	ND	0.41	ND	
Road tree planting	ND	ND	0.5	ND	
Site preparation/hydro mulch/seed/fertilizer	ND	ND	0.71	ND	
Site preparation/hydro mulch/seed/fertilizer /transplants	ND	ND	0.69	ND	
Site preparation/steep slope seeder/transplant	ND	ND	0.81	ND	
Site preparation/straw/ crimp seed/fertilizer/ transplant	ND	ND	0.95	ND	
Site preparation/straw/ crimp/net	ND	ND	0.93	ND	
Site preparation/straw/net/ seed/fertilizer/ transplant	ND	ND	0.83	ND	
Site preparation/straw/ polymer/seed/fertilizer/ transplant	ND	ND	0.86	ND	
Feedlots					
0 No BMP	**0**	**0**	**0**	**0**	
Diversion	0.45	0.7	ND	ND	
Filter strip	ND	0.85	ND	0.3	
Runoff Mgmt System	ND	0.825	ND	0.5	
Solids Separation Basin	0.35	0.31	ND	ND	
Solids Separation Basin w/Infilt Bed	ND	0.8	ND	0.9	
Terrace	0.55	0.85	ND	ND	

	N	P	Sediment	E. coli	Assumptions and additions
Waste Mgmt System	0.8	0.9	ND	0.9	
Waste Storage Facility	0.65	0.6	ND	0.9	
Urban					
0 No BMP	**0**	**0**	**0**	**0**	
Alum Treatment	0.6	0.9	0.95	ND	
Bioretention facility	0.63	0.8	ND	0.9	
Bioretention practices	0.63	0.8	0.85	0.95	Added Urban STEPL Bioretention practice, efficiencies for TSS and E. coli based on MN Stormwater manual (https://stormwater.pca.state.mn.us/index.php/Calculating_credits_for_bioretention)
Combined BMPs-Calculated	0	0	0	0	
Concrete Grid Pavement	0.9	0.9	0.9	ND	
Dry Detention	0.3	0.26	0.575	ND	
Extended Wet Detention	0.55	0.685	0.86	0.9	
Filter Strip-Agricultural	0.5325	0.6125	0.65	0.3	
Grass Swales	0.1	0.25	0.65	ND	
Infiltration Basin	0.6	0.65	0.75	0.9	
Infiltration Devices	ND	0.83	0.94	ND	
Infiltration Trench	0.55	0.6	0.75	ND	
LID*/Cistern	0	0	0	0	
LID*/Cistern+Rain Barrel	0	0	0	0	
LID*/Rain Barrel	0	0	0	0	
LID/Bioretention	0.43	0.81	ND	ND	
LID/Dry Well	0.5	0.5	0.9	ND	
LID/Filter/Buffer Strip	0.3	0.3	0.6	ND	
LID/Infiltration Swale	0.5	0.65	0.9	ND	
LID/Infiltration Trench	0.5	0.5	0.9	ND	
LID/Vegetated Swale	0.075	0.175	0.475	ND	
LID/Wet Swale	0.4	0.2	0.8	ND	
Oil/Grit Separator	0.05	0.05	0.15	ND	
Porous Pavement	0.85	0.65	0.9	ND	
Raingardens	0.6	0.65	0.75	0.9	Added Urban STEPL raingardens, assuming same efficiencies as STEPL practice Infiltration basin (urban)
Sand Filter/Infiltration Basin	0.35	0.5	0.8	ND	
Sand Filters	ND	0.375	0.825	ND	
Settling Basin	ND	0.515	0.815	ND	
Vegetated Filter Strips	0.4	0.4525	0.73	ND	

	N	P	Sediment	E. coli	Assumptions and additions
Weekly Street Sweeping	ND	0.06	0.16	ND	
Wet Pond	0.35	0.45	0.6	ND	
Wetland Detention	0.2	0.44	0.775	ND	
WQ Inlet w/Sand Filter	0.35	ND	0.8	ND	
WQ Inlets	0.2	0.09	0.37	ND	

Table 33. Current loading and estimated pollutant reductions for BMPs described in this plan

	Estimated Current Loading by subwatershed				**Estimated Reduction to Loading**			
	N load (no BMP)	**P load**	**TSS load**	***E. coli* load**	**N reduction**	**P reduction**	**TSS reduction**	***E. coli* reduction**
Watershed	**lb/yr**	**lb/yr**	**t/yr**	**billion MPN/yr**	**lb/year**	**lb/year**	**t/year**	**billion MPN/yr**
W1	10443.33	2142.732	147.64	2272.135	3788.99	1119.18	40.29	2111.64
W2	40159.99	7876.584	2036.42	14897.51	9729.33	3203.08	516.80	13571.53
W3	163760.84	25629.36	3407.23	33232.41	51331.60	12018.48	817.34	29512.65
W4	15258.42	3468.681	1049.25	9284.491	3373.79	1366.78	259.12	8756.30
W5	149490.53	27123.62	5457.94	40889.14	47631.85	11906.28	1317.19	38294.81
Total	**379113.11**	**66240.98**	**12098.47**	**100575.7**	**115855.56**	**29613.79**	**2950.74**	**92246.93**
	Estimated Future Loading							
	N load (with BMP)	**P load (with BMP)**	**TSS load (with BMP)**	***E. coli* load (with BMP)**	**N reduction**	**P reduction**	**TSS reduction**	***E. coli* reduction**
Watershed	**lb/yr**	**lb/yr**	**t/yr**	**billion MPN/yr**	**%**	**%**	**%**	**%**
W1	6654.34	1023.55	107.35	160.49	36%	52%	27%	93%
W2	30430.66	4673.51	1519.62	1325.98	24%	41%	25%	91%
W3	112429.24	13610.89	2589.89	3719.76	31%	47%	24%	89%
W4	11884.63	2101.90	790.13	528.20	22%	39%	25%	94%
W5	101858.68	15217.34	4140.74	2594.34	32%	44%	24%	94%
Total	**263257.55**	**36627.18**	**9147.74**	**8328.77**	**31%**	**45%**	**24%**	**92%**

Appendix B
Zumbro River Watershed HSPF Model Development Project – Phase II Memorandum

Insert https://www.pca.state.mn.us/sites/default/files/wq-iw9-20o.pdf here

Appendix C Root River Field Runoff Field to Stream Partnership

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https://www.mda.state.mn.us/sites/default/files/2019-10/rootrivfieldrunoff2019.pdf