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Grant

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Green Lake Section 319 Small Watersheds Focus Program Nine Element Plan

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Executive summary

Green Lake is the largest lake in Isanti County and it is a priority area to the local residents because of its high recreational value. The Green Lake watershed is a 12-digit Hydrologic Unit Code (HUC12) watershed (070102070503) in the Rum River HUC8 watershed (07010207). Its drainage area is approximately 25 square miles (15,988 acres) and includes the North Brook and Wyanett Creek subwatersheds along with the "local watershed" consisting of the direct lakeshed and the drainage areas to Bratlin Creek and Old Judge's Ditch.

The Green lake watershed was chosen by our partners because of the many plans and reports that help with targeting, specifically Green Lake has completed subwatershed assessments (SWA), called *The Green Lake Subwatershed Retrofit Analysis for Areas Draining Directly to the Lake* and *The Green Lake Rural Stormwater Retrofit Analysis of North Brook and Wayanett Creek*. The SWAs provide detailed information needed to target and prioritize projects and BMPs. Targeting of the critical loading sites identified by the SWAs will be the most effective and cost-efficient way to achieve the water quality standards for Green Lake. The goal of the Green Lake watershed partners is to delist Green Lake from the Minnesota 303(d) impaired waters list. Green Lake is listed for mercury and polychlorinated biphenyls (PCB) in fish tissue, fish index of biotic integrity (FIBI), and nutrients/eutrophication. The BMPs and projects chosen and described in this plan will outline the process to achieve their goals. It is expected that practices in this plan will yield reductions in P loading and increase habitat quality to achieve water quality standards for P and FIBI in ten years.

This plan will be updated every 2 years to add additional milestones and activities by utilizing the evaluation of BMPs and effectiveness monitoring to determine water quality impacts. Watershed partners will systematically identify which practices are working the best and which ones are not, and then using this information make course corrections as needed.

The Minnesota statewide mercury TMDL addresses mercury reductions in fish tissue. Atmospheric deposition of mercury goes beyond the borders of both Minnesota and the U.S., making it extremely difficult to manage. Both the mercury and PCB in fish tissue are old listings, dating back to the 1990s. It is possible that these two impairments may have improved without further action. Testing fish tissue in the future may show that some or both of these impairments have resolved.

1. Introduction

The Green Lake Section 319 Small Watershed Focus Program Nine Element (NKE) Plan was developed by compiling and synthesizing information from previous studies and planning documents conducted in the watershed. Much of the text and concepts in this NKE are derived from the various existing studies and plans in the watershed. Additional information is provided when necessary to address all of the U.S. Environmental Protection Agency's (EPA) nine key elements of a watershed-based plan. Key documents include:

- Green Lake Improvement District Lake Management Plan, 2013-2018, 2012
- Green Lake Monitoring Report, 2018
- Green Lake Tributary Monitoring Report, 2018
- Green Lake Phosphorus Diagnostic Study Technical Memo, 2019
- Final Rum River Watershed Total Maximum Daily Load, 2017
- Rum River Watershed Fish Based Lake IBI Stressor Identification Report, 2016
- Rum River Watershed Monitoring and Assessment Report, 2016
- Rum River Watershed Restoration and Protection Strategy Report, 2017
- Groundwater Report: Rum River Watershed, 2016

1.1 EPA nine elements

The intent of the Green Lake NKE is to concisely address the nine elements identified in EPA's Handbook for Developing Watershed Plans to Restore and Protect our Waters (EPA 2008 are critical to preparing effective watershed plans to address nonpoint source pollution. 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). The nine elements are listed in Table 1 along with the section of this report in which each element can be found.

Table 1. Nine elements and associated report section(s)

Section 319 Nine Elements	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 4.0
An estimate of the load reductions expected from management measures.	Section 7.0
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 7.0
An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.	Section 7.0 and 10
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 8.0
Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.	Section 7.0

Section 319 Nine Elements	Applicable Report Section
A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.	Section 7.0
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 7.0
A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item h immediately above.	Section 9.0

1.2 Nonpoint source (NPS) pollution management

Numerous nonpoint pollution management activities and planning efforts have been and are being conducted in the Green Lake NKE project area. The Green Lake Improvement District Lake Management Plan (Green Lake Improvement District 2012) identified priority issues for the lake and specific objectives and actions to address those priority issues Table 2. Following recommendations from the lake management plan, a subwatershed retrofit analysis was conducted for a portion of the Green Lake watershed. The Green Lake Subwatershed Retrofit Analysis (Isanti SWCD 2014) identified potential stormwater retrofitting opportunities to reduce the amount of nutrients from stormwater runoff entering Green Lake. A variety of project types were identified in the analysis. These efforts resulted in extensive education and outreach, monitoring, and project implementation activities in the Green Lake watershed.

Table 2. Priority issues from the Green Lake Improvement District Lake Management Plan

Priority Issue	Objectives
Water Quality	Maintain intact shoreline buffers and re-vegetate areas of erosion into Green Lake
	Show a positive trend in trophic status of Green Lake
	Manage subsurface sewage treatment systems
Aquatic Invasive Species	Users of public access points to Green Lake understand the urgency of aquatic invasive species prevention and have tools to ensure they do not introduce any
	Management of current aquatic invasive species in Green Lake
Land Management/Zoning	Property owners and users of Green Lake understand potential impacts of their land use and boating activities on lake
Fisheries	Work with DNR to preserve the habitat and support the fishery of lake

A TMDL for Green Lake was completed in 2017 as part of the Final Rum River Watershed Total Maximum Daily Load (MPCA 2017). General restoration strategies for the lake were included in the Rum River Watershed Restoration and Protection Strategy Report (MPCA 2017). The *Green Lake Phosphorus Diagnostic Study* (Wenck 2019) was recently completed by incorporating more recent data in the development of an updated phosphorus budget for the lake and watershed. The diagnostic study included management recommendations to achieve the phosphorus reductions needed to meet the water quality goal for the lake.

1.3 Watershed partners

Several agencies and organizations have been active in one or more watershed management-related activities in the Green Lake watershed. These entities form the basis of the watershed management team for the Green Lake NKE. A list of these with a brief description of their involvement is given in Table 3.

Table 3. Agencies and organizations participating in watershed activities in the Green Lake watershed

Entity	Description of Activities
Isanti Soil and Water Conservation District	Provide financial and technical assistance to landowners in order to implement conservation projects. Coordinate with partners to improve water quality.
Isanti County Zoning	Enforce wetland, shoreline, and SSTS ordinances. Coordinate AIS program.
Isanti County Ditch Authority	Manage 103E Ditches, coordinate with SWCD and Zoning to include conservation drainage management practices are included in management of ditches.
Green Lake Improvement District	Work with lakeshore owners to implement shoreline restoration program, coordinate with local and state agencies to manage lake health, collect water quality data.
The Nature Conservancy	Provide assistance for water quality protection.
Rum River Watershed 1W1P Partners	Coordinate watershed management priorities and funding.
Wyanett Township	Manage Township roads, manage the Feldspar public lake access and work with other government units to assist with water management.
Spencerbrook Township	Manage Township roads, work with other government units to assist with water management.
USDA – NRCS	Provide financial and technical assistance to implement agricultural conservation practices.
Minnesota Department of Natural Resources	Issue public waters permits and aquatic plant management permits. Manage fish resources, the state public lake access, and North Brook Aquatic Management Area.
Minnesota Pollution Control Agency (MPCA)	Provide funding assistance to implement conservation practices.
Minnesota Department of Agriculture	Implement the Minnesota Agricultural Water Quality Certification Program which helps producers implement practices to improve water quality.
Volunteer Water Monitors	Collect water quality data.
Private Landowners	Implement conservation practices to improve water quality. Influence other landowners to do similar work.

2. Watershed description

The Green Lake watershed is located in west-central Isanti County, approximately 6.8 miles east of Princeton (Figure 1). The watershed area is approximately 15,988 acres (about 25 square miles). For the purposes of this NKE, the subwatersheds to North Brook and Wyanett Creek are considered “major tributary subwatersheds” and the remaining project area is considered the “local watershed” and includes the drainage areas of Bratlin Creek and Old Judge’s Ditch.

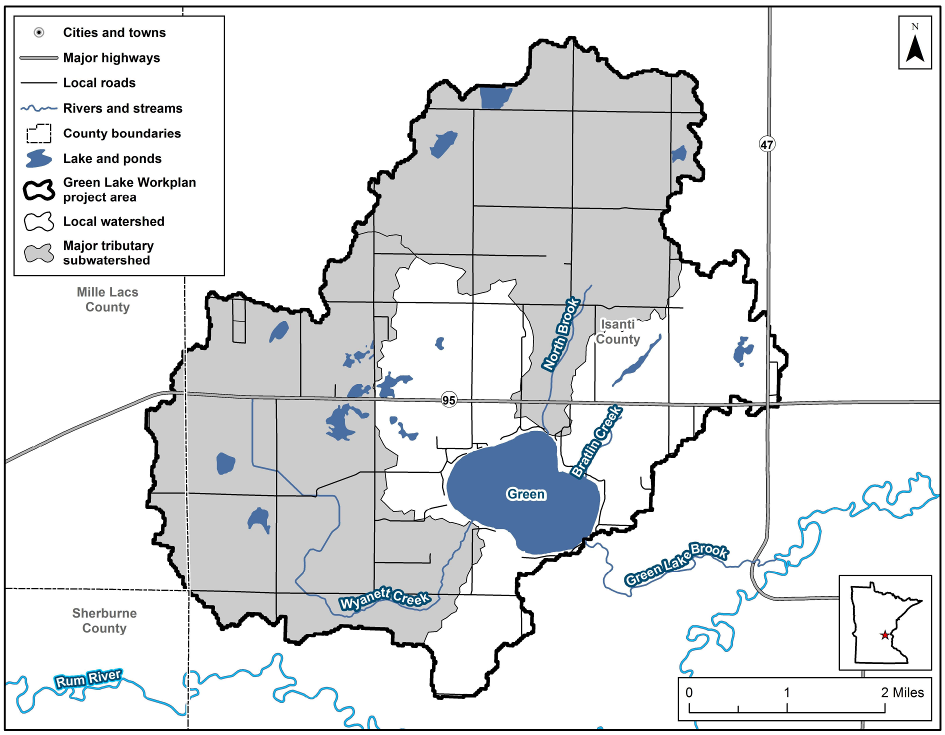


Figure 1. Green Lake Watershed

2.1 Topography and drainage

The Green Lake Watershed (HUC12 070102070503) is located in the south-central portion of the Rum River watershed (Middle Rum River HUC10 0701020705), which flows from Mille Lacs Lake to the Mississippi River in Anoka, Minnesota. Green Lake receives water via precipitation, overland flow, and several tributaries. The main inlets to Green Lake are Wyanett Creek, North Brook, and Bratlin Creek (Figure 1). Old Judge’s Ditch located on the western side of Green Lake near 335th Avenue also discharges to the lake. Green Lake Brook is the outlet to Green Lake and sends water to the Rum River (Green Lake Improvement District 2012). During extreme spring water levels, Green Brook flow can reverse into Green Lake from downstream (DNR Lake Files; via Perleberg 2006). The elevation of the watershed ranges from 918.6 – 1,121 feet (280.2 – 308.5 meters) above sea level (Figure 2).

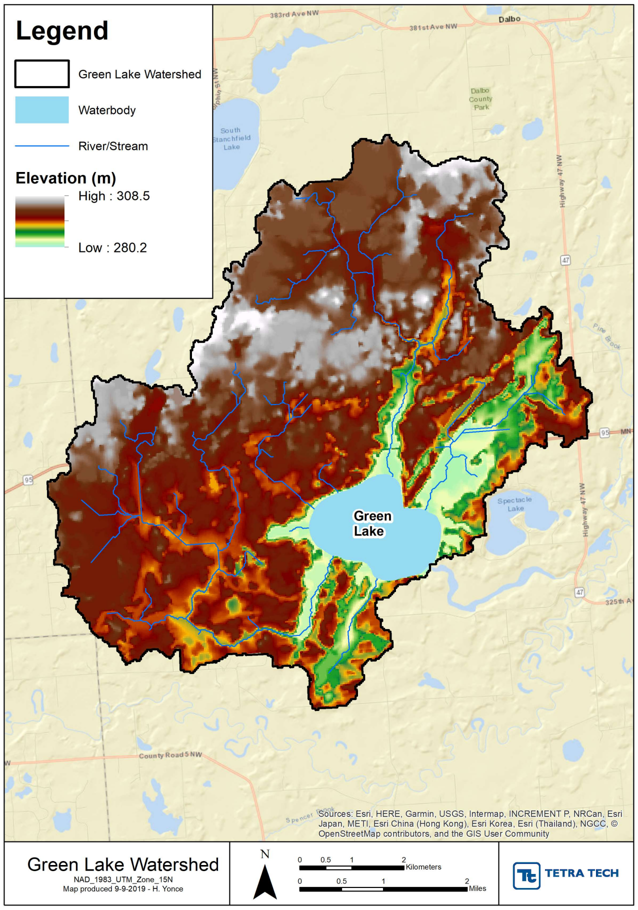


Figure 2. Topography of the Green Lake watershed

2.2 Geology and soils

Green Lake is situated in the North Central Hardwood Forests ecoregion in the Anoka Sand Plain, an outwash plain characterized by thin layers of sand and silt with numerous bogs and depressions (Borgstrom 2016). The geology of the watershed is dominated by sand and gravel glacial sediments overlying Precambrian sandstone, siltstone and conglomerate and Paleozoic sandstone, siltstone and shale.

Soils can be classified according to the hydrologic soil group that describes in part the runoff potential and infiltration properties of the soil. Hydrologic soil group classifications across the watershed are largely classified as A (low runoff potential, high infiltration rates), with a smaller amount of D soils (high runoff potential, low infiltration rates), and in the furthest north part of the watershed some B soils (moderate infiltration) (Figure 3).

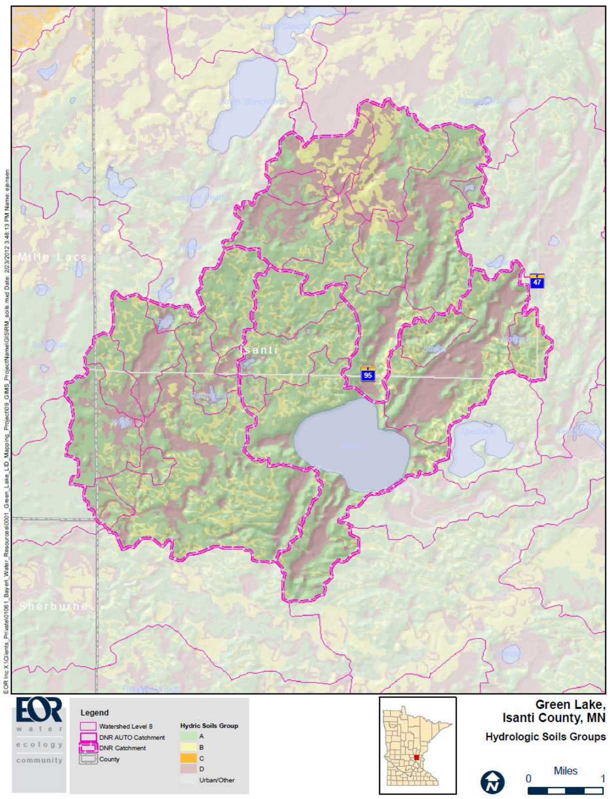


Figure 3. Hydrologic soil groups in the Green Lake watershed (EOR 2012)

2.3 Waterbodies

Green Lake (30-0136-00) is the largest lake in Isanti County, Minnesota. The waterbody covers approximately 833 acres with a littoral area of 357 acres and a shore length of 4.61 miles. The maximum lake depth is 28 feet, the mean depth is about 16 feet, and the lake is classified as a "deep lake" for management and regulatory purposes. The lake is a general elliptical shape from the northwest to southeast, which provides a long wind fetch. The drainage area to the lake is large with a watershed to lake-surface area ratio of about 19:1.

Green Lake has one public access maintained by the DNR on the northern side of the waterbody. Green Lake has an Osgood Index Value of 2.7, suggesting that periodic mixing occurs due to its surface area, fetch, and depth structure (MPCA 2017). Additional physical characteristics of Green Lake are provided in Table 4. A map of lake bathymetry is provided in Figure 4. The outlet of Green Lake is Green Lake Brook.

There are four named tributaries that drain into Green Lake: North Brook, Wyanett Creek, Bratlin Creek, and Old Judge's Ditch. North Brook and Wyanett Creek are the largest tributaries. Two smaller tributaries are Old Judge's Ditch that flows into the western side of the lake, and Bratlin Creek that flows north to south into the eastern side of the lake, east of North Brook.

Table 4. Green Lake Select Morphometric and Watershed Characteristics (MPCA 2017)

Characteristics	Green Lake	Source
Lake-Surface Area (acres)	833	DNR LakeFinder
Number of Islands	0	
Percent Lake Littoral Surface Area	43%	DNR LakeFinder
Drainage Area, Including Lake acres(ac)/square kilometers(km2)	15,887ac/64.3 km2	Model Subwatersheds
Watershed Area to Lake Area Ratio	19.1:1	Calculated
Wetland Area (% of watershed)	21.7	University of Minnesota (2016]
Number of Upland Lakes	Numerous small	U.S. Geological Survey topographic maps
Number of Perennial Inlet Streams	2	U.S. Geological Survey topographic maps
Lake Volume (acre-feet (ac-ft)/cubic hectometers(hm3))	13,499ac-fl/ 16.7 hm^3	DNR LakeFinder
Mean Depth (ft/ m)	16.2 ft/4.9 m	DNR LakeFinder
Annual Lake-Level Fluctuations (ft): typical, maximum	1-4+ ft	DNR Lake Levels
Maximum Depth (ft/m)	28 ft/ 8.5 m	DNR LakeFinder
Maximum Fetch Length (miles(mi)/ Kilometers (km))	1.57mi/2.53km	Measured in Google Earth
Lake Geometry Ratio	5.0	Calculated
Osgood Index	2.7	Calculated
Estimated Water Residence Time (years)	1.4 years	Calculated
Public Access	1	DNR
Shore Land Properties	164	Isanti County
DNR Fisheries Class	27	DNR

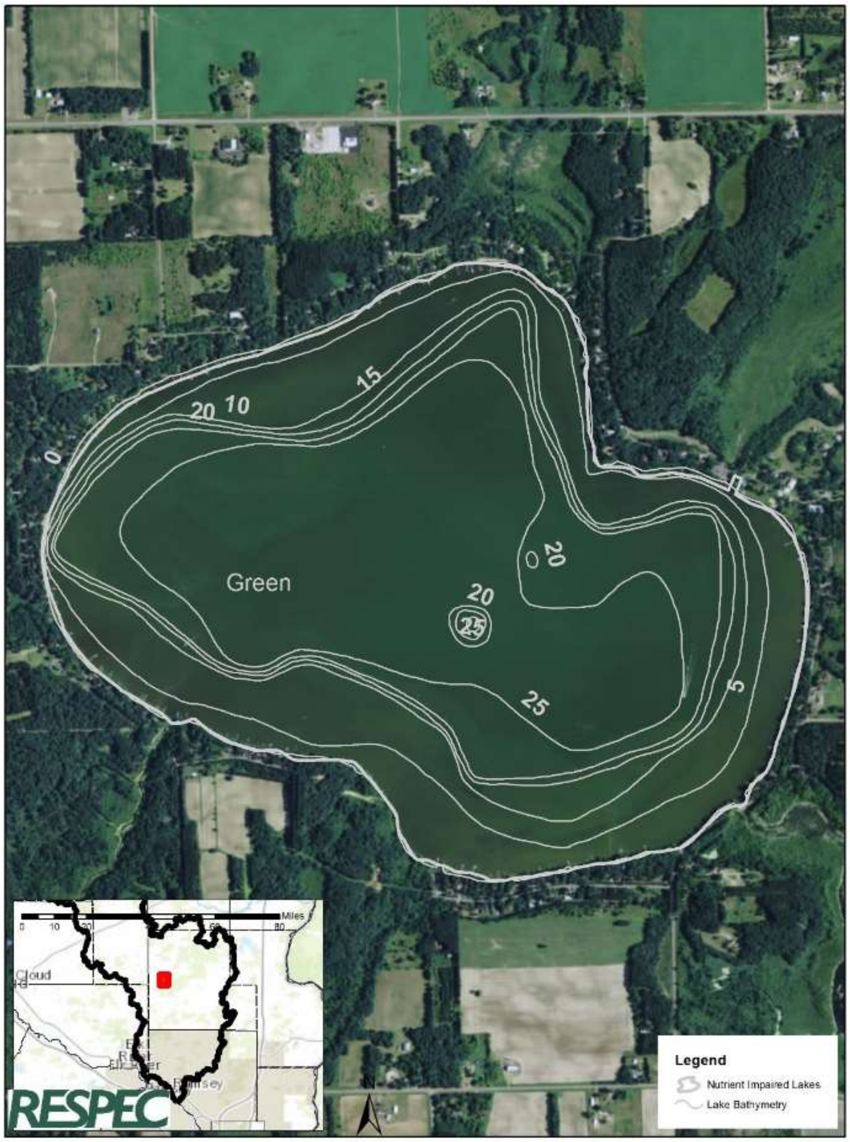


Figure 4. Green Lake Bathymetry (MPCA 2017)

2.4 Aquatic habitat and wetlands

Green Lake is a designated infested water for aquatic invasive species. Curlyleaf pondweed was first noted in a 1971 survey of the lake. Eurasian watermilfoil was found in the lake in 2000. Both species were found during the lake stressor identification process (Borgstrom 2016).

There are numerous wetland complexes within the contributing watershed ranging in size from 10 – 45 acres with many smaller wetlands and those associated with flowing waters (Borgstrom 2016, Figure 5). Approximately 21.7% of the contributing area is classified as wetlands based on the land use raster NLCD 2011. Descriptions of the National Wetland Inventory (NWI) wetland types located in the project area are provided in Table 5.

Table 5. Descriptions of the NWI wetland types in the Green Lake NKE project area

NWI wetland type	Description
1	Seasonally flooded basin or flat. Soil is covered with water or is waterlogged during variable seasonal periods but usually is well-drained during much of the growing season. Vegetation varies greatly according to season and duration of flooding: from bottomland hardwoods to herbaceous plants.
2	Wet meadow. Soil is usually without standing water during most of the growing season but is waterlogged within at least a few inches of the surface. Meadows may fill shallow basins, sloughs, or farmland sags, or these meadows may border shallow marshes on the landward side. Vegetation includes grasses, sedges, rushes and various broad-leaved plants. Other wetland plant community types include low prairies, sedge meadows and calcareous fens.
3	Shallow marsh. Soil is usually waterlogged early during the growing season and may often be covered with as much as 6 inches or more of water. These marshes may nearly fill shallow lake basins or sloughs, or may border deep marshes on the landward side. These are common as seep areas on irrigated lands. Vegetation includes grass, bulrush, spikerush and various other marsh plants such as cattail, arrowhead, pickerelweed and smartweed.
4	Deep marsh. Soil is usually covered with 6 inches to 3 feet or more of water during the growing season. They completely fill shallow lake basins, potholes, limestone sinks and sloughs, or they may border open water in such depressions. Vegetation includes cattail, reed, bulrush, spikerush and wild rice. In open areas, pondweed, naiad, coontail, water-milfoil, waterweed, duckweed, waterlily or spatterdock may occur.
5	Shallow open water. Shallow ponds and reservoirs are included in this type. Water is usually less than 10 feet deep and fringed by a border of emergent vegetation.
6	Shrub swamp. Soil is usually waterlogged during the growing season and is often covered with as much as 6 inches of water. These occur mostly along sluggish streams and occasionally on flood plains. Vegetation includes alder, willow, buttonbush, dogwood and swamp-privet.
7	Wooded swamps. Soil is waterlogged at least to within a few inches of the surface during the growing season and is often covered with as much as 1' of water. These occur mostly along sluggish streams, on old riverine oxbows, on flat uplands and in ancient lake basins. Forest vegetation includes tamarack, arborvitae, black spruce, balsam fir, red maple and black ash. Deciduous swamps frequently support beds of duckweed and smartweed. Other wetland plant community types include lowland hardwood swamps and coniferous swamps.
8	Bogs. Soil is usually waterlogged. These occur mostly in ancient lake basins, on flat uplands and along sluggish streams. Vegetation is woody or herbaceous or both, usually on a spongy covering of mosses. Typical plants are heath shrub, sphagnum moss and sedge. In the North, leatherleaf, Labrador tea, cranberry and cottongrass are often present. Scattered, often stunted, black spruce and tamarack may occur.
90	Riverine systems

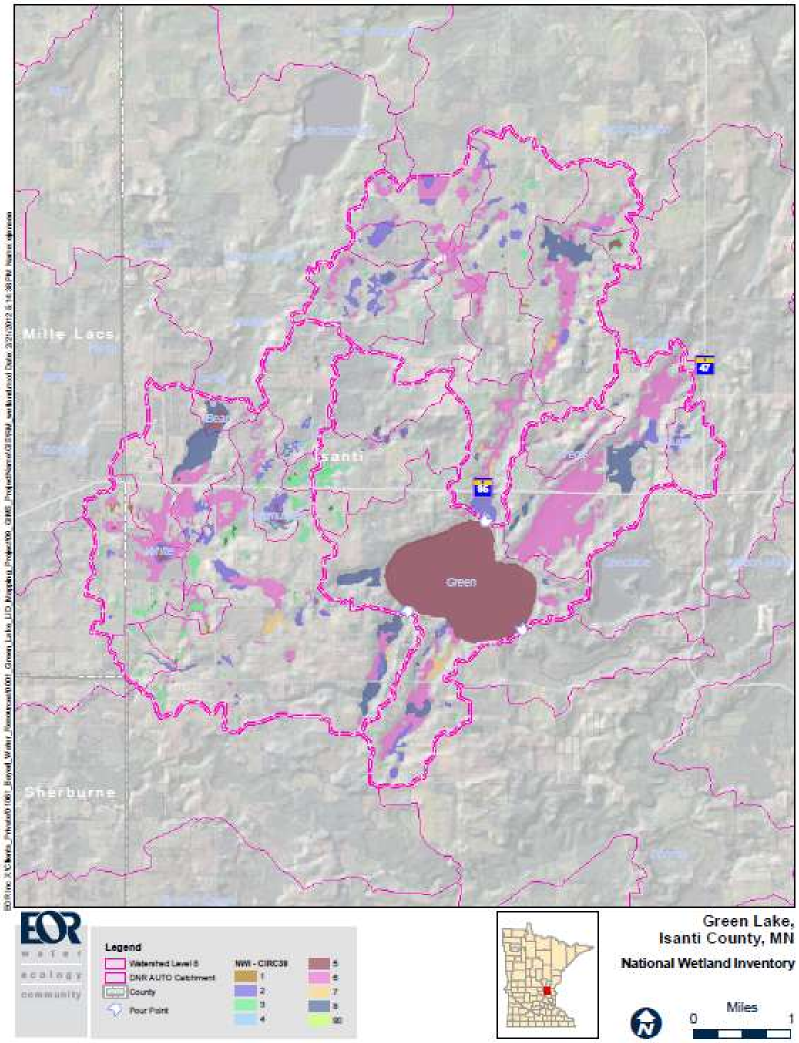


Figure 5. Wetlands in the Green Lake watershed (EOR 2012)

North Brook Aquatic Management Area

According to [Minn. Stat. 86A.05, subd. 14](), "aquatic management areas may be established to protect, develop, and manage lakes, rivers, streams, and adjacent wetlands and lands that are critical for fish and other aquatic life, for water quality, and for their intrinsic biological value, public fishing, or other compatible outdoor recreational uses."

The North Brook Aquatic Management Area is approximately 19 acres and is located along North Brook (Figure 6). It provides angler and management access, protection of critical shore land habitat, and an area for education and research. General usage activities include angling, non-motorized travel, wildlife observation, hunting, and trapping.

Figure 6. North Brook Aquatic Management Area (Image from Minnesota DNR AMA webpage)

Shoreline assessment

An assessment of Green Lake's shoreline development and disturbance was conducted in June 2013 (Borgstrom 2016). Following the lake shore assessment, Score the Shore survey protocols were used and resulted in a mean score of 55.7 (range is 0 to 100). The survey score is comprised of scores for three zones: shoreland, shoreline, and aquatic (Table 6). About 89% of the Score the Shore survey sites are classified as developed, which contributed to the low score for Green Lake as a whole (Table 7). During the survey, 32% of sites had woody habitat but there was not any emergent vegetation. Most of the undeveloped shoreline is associated with a single large parcel of land held by one owner.

Table 6. Breakdown of how each of the three zones (shoreland, shoreline, aquatic) on Green Lake scored utilizing the Score the Shore survey and a categorical interpretation (excellent, good, fair, poor) of that score (Borgstrom 2016).

Zone	Sample size	Mean zone habitat score (0-33.3)	Rating
Shoreland	37	16.2	Poor
Shoreline	37	14.4	Poor
Aquatic	37	25.1	Good

Table 7. Score the Shore survey scores overall as well as for developed and undeveloped sites on Green Lake and categorical interpretation (excellent, good, fair, poor) of that score (Borgstrom, 2016)

Broad land use classification	Sample size	Mean lakeshore habitat score (0-100)	Rating
All sites	37	55.7	Poor
Developed	33	50.6	Poor
Underdeveloped	4	98.3	Excellent

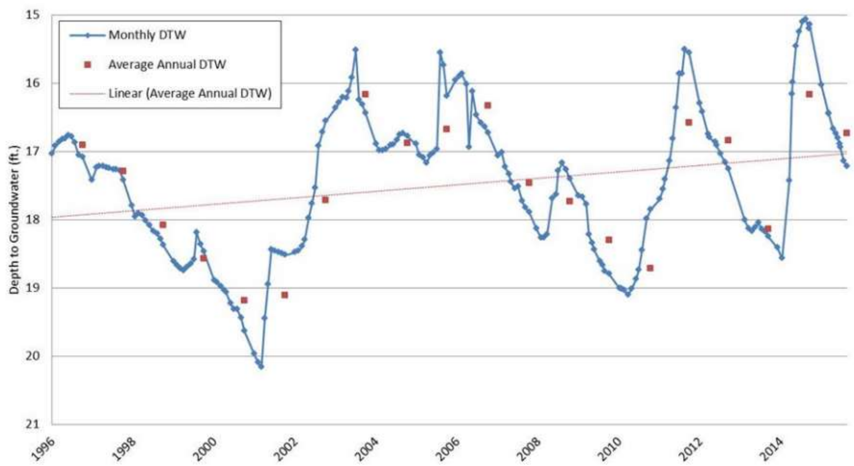
The *Green Lake Subwatershed Retrofit Analysis for Areas Draining Directly to the Lake* (Isanti SWCD 2015) describes the lakeshore of Green Lake as mostly intensely managed by homeowners. Lawn mowing to the water's edge, sand beaches, beach raking, and aquatic vegetation removal are commonplace. Rock riprap and retaining walls are present in some areas. The analysis still found that much of the lakeshore is a candidate for lakeshore restorations (44% of the lakeshore and 95 potential sites). In addition, the Lake Improvement District has identified lakeshore restorations as a priority in its lake management plan.

2.5 Groundwater

The Green Lake region is underlain by the Metro Province Groundwater District. This groundwater district is characterized by "sand aquifers in generally thick (greater than 100 feet) sandy and clayey glacial drift overlying Precambrian sandstone and Paleozoic sandstone, limestone, and dolostone aquifers".

The Metro Province contains surficial and buried aquifers: the St. Peter aquifer, Prairie du Chien-Jordan, Franconia Ironton-Galesville and Mt. Simon-Hinckley aquifers. Glacial sand and gravel aquifers are shallow and occur as result of glacial influences, and they are found in outwash plains, along river and in old lake beds throughout the state.

The buried sand and gravel aquifers include the Quaternary Buried Artesian Aquifer (QBAA), the Quaternary Buried Unconfined Aquifer, and the Quaternary Buried Undifferentiated Aquifer. It is from these aquifers that the majority of wells in this region of Minnesota yield the greatest amount of groundwater (MPCA 1998). Other important sources of groundwater are the surficial sand and gravel aquifers, which consist of well-sorted outwash deposits. Two main aquifers included in this category are the Quaternary Water Table Aquifer (QWTA) and the Quaternary Undifferentiated Unconfined Aquifer. In the Rum River watershed, the QWTA and QBAA aquifers are the primary Quaternary sources for groundwater withdrawal. The Rum River Groundwater Report details depth to groundwater at well 30005 near Green Lake (Figure 7).



DTW = Depth to water

Figure 7. Depth to groundwater for observation well 30005 near Princeton and Green Lake 1996-2005 (MPCA 2016a).

2.6 Land use

Land cover for the Green Lake watershed is provided in Figure 10. Natural areas make up 41% of the watershed including forest, wetlands, herbaceous cover and open water. Hay and pasture account for 14% of the watershed. The remaining watershed is in cultivated crops (40%) or is developed (5%). Note that about 3% of the watershed changed from cultivated land to developed land between 2006 and 2011 based on NLCD results; however, generally there has been very little change in land cover over the past two decades.

The shoreline on Green Lake is developed with residential homes and a public boat access on the north end of the lake (Perleberg 2006). Many of the developed lots along Green Lake have tree cover canopy that is not recognized in the 2011 NLCD dataset (Figure 8). The greatest concentration of residential development in the contributing watershed is on the shores of Green Lake. The shoreline is developed on all but one 0.22 mile stretch along the point on the southern shore. Currently, there are 198 residential lots adjacent to Green Lake that are not public land, and there are an additional 54 lots within 1,000 feet of the shore and within the contributing watershed that have houses or cabins on them (Borgstrom 2016). There are about 32 docks per mile of shoreline (Beck et al. 2013).

Table 8. Land cover and use (excluding the area of Green Lake)

	Developed	Forest	Grassland	Pasture	Cropland	Wetland	Feedlot	Total
Wyanett Creek	430	1,324	668	9	1,764	1,308	3	5,506
North Brook	268	883	934	22	1,375	1,282	14	4,779
Green Lake	372	1,494	687	10	1,213	1,002	0	4,778
Total	1,070	3,702	2,289	41	4,352	3,592	17	15,063

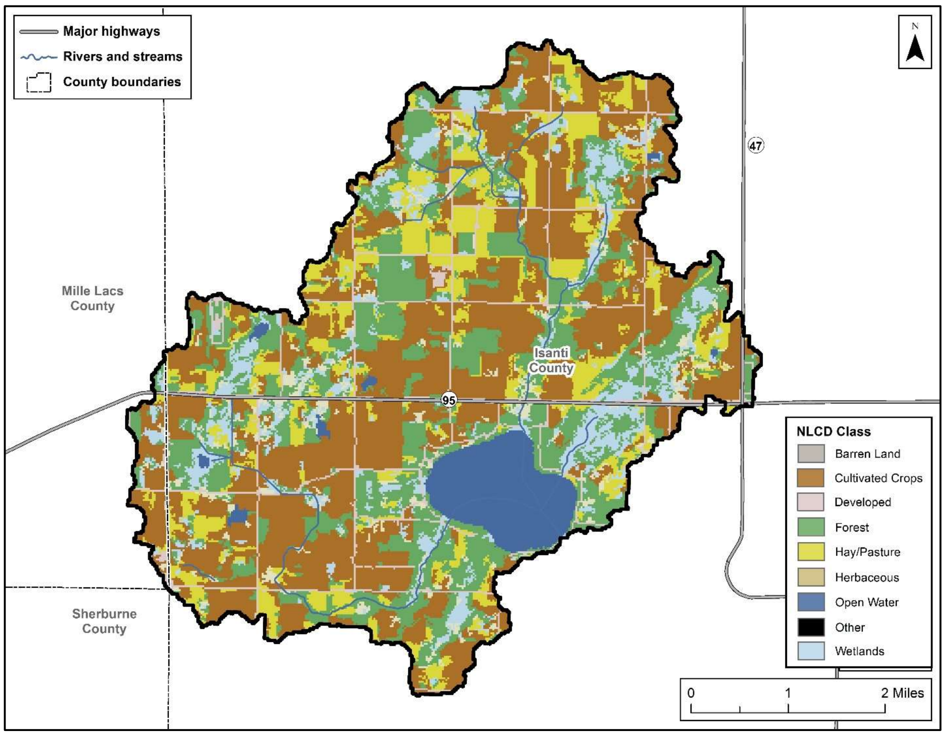


Figure 8. Green Lake Watershed land cover (NLCD 2011)

2.7 Feedlots and animal operations

There are five registered feedlots, with one being a Confined Animal Feeding Operation (CAFO) in the Green Lake Watershed (Table 9).

Table 9. Animals in the Green Lake Watershed

Animals	Number animals
Beef cattle	90
Dairy cattle	2,900
Horses	35

Animals	Number animals
Turkeys	73,000

2.8 Wastewater

Wastewater treatment and handling within the watershed is important as it may impact nutrient loading to waterways and waterbodies. There are no wastewater treatment plants present within the Green Lake watershed, however all residents are served by subsurface wastewater treatment systems (SSTS). Isanti County estimates that there are approximately 175 SSTSs located immediately surrounding Green Lake. Based on recent county-wide estimates, approximately 6% of those systems are considered failing. Nutrient loading from SSTSs to Green Lake was estimated to be 68 pounds per year (lbs/yr) based on this information (Wenck 2019).

2.9 Climate and precipitation

The Rum River TMDL report (MPCA 2017) noted subtle north-south gradients across the entire Rum River watershed, as defined by storm precipitation intensities and durations, annual precipitation, evaporation, and frost-free periods with higher levels tracking south in the basin. Growing-season runoff is expected to be affected by wide variations of month-to-month rainfall amounts, increasing average temperatures, and storm intensities. Storm-precipitation intensities for the typical 24-hour storm and multiday wet periods can be substantial with potential wide-ranging impacts that affect communities, agricultural producers, streams, lakes, wetlands, and associated aquatic habitats. Collectively, these basic climate and hydrologic cycle components vary considerably between years and seasonally, which potentially results in wide ranges of watershed runoff and the associated runoff-pollutant dynamics that should be factored into future restoration/protection and monitoring program design considerations.

Climate variability for the Rum River watershed was assessed by using available long-term data for sites from the Midwest Regional Climate Center, DNR gridded precipitation data, and National Oceanic and Atmospheric Administration's databases summarized for east-central Minnesota (Climate Division 6). Few monitoring stations with long-term climate data exist in the Rum River watershed; hence, interpolated data from the DNR's gridded precipitation network and the Climate Division data were evaluated. Annual precipitation at three gages in the Rum River watershed show an overall range in precipitation from approximately 14 inches per year in 1977 to 45 inches per year in 2004 (Figure 9).

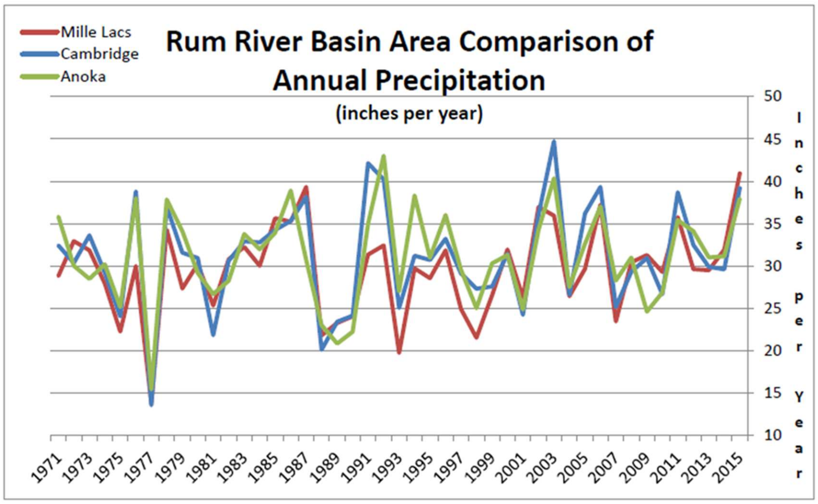


Figure 9. Comparison of Annual Precipitation for Representative Sites of the North (Mille Lacs), Central (Cambridge), and Lower (Anoka) Rum River Basin (MPCA 2017)

3. Water quality and quantity

3.1 Water quality standards

The federal Clean Water Act requires states to designate beneficial uses for all waters and develop water quality criteria 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 to protect the beneficial uses
- 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 Minnesota Rules chapter 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).

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 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 and state standards

Narrative and numeric water quality criteria for all uses are listed for four 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, also protected for drinking water: classes 1B or 1C; 2Bd, 2Bde, 2Bdg, or 2Bdm; 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 water bodies 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 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 E. coli in the water, which is used as an indicator species of potential waterborne pathogens. To determine if a lake supports aquatic recreational activities, its trophic status is evaluated using total phosphorus, Secchi depth, and chlorophyll-a as indicators. Lakes that are enriched with nutrients and have abundant algal growth are eutrophic and do not support aquatic recreation.

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

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 and 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.

Standards and criteria in Green Lake Watershed

The waterbodies in the Green Lake watershed are designated as class 2B waters. Green Lake is defined as a deep lake. The water quality standards and criteria used in assessing the streams and lakes include the following parameters:

- ***Escherichia (E.) coli*** – not to exceed 126 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies between April 1 and October 31.
- Dissolved oxygen (DO) – daily minimum of 5.0 mg/L.
- pH – to be between 6.5 and 9.0 standard units.
- Total suspended solids (TSS) – 30 mg/L not to be exceeded more than 10% of the time between April 1 and October 31.
- Stream eutrophication – based on summer average concentrations for the Central Nutrient Region
  - Total phosphorus concentration less than or equal to 100 µg/L and
  - Chlorophyll-a (seston) concentration less than or equal to 18 µg/L or
  - Diel dissolved oxygen flux less than or equal to 3.5 mg/L or
  - Five-day biochemical oxygen demand concentration less than or equal to 2.0 mg/L.

If the TP criterion is exceeded and no other variable is exceeded, the eutrophication standard is met.

- Lake eutrophication – based on summer average values for deep lakes in the North Central Hardwood Forest (NCHF) Ecoregion
  - Total phosphorus concentration less than or equal to 40 µg/L and
  - Chlorophyll-a concentration less than or equal to 14 µg/L or
  - Secchi disk transparency not less than 1.4 meters (4.59 feet).
- Biological indicators – The basis for assessing the biological community are the narrative water quality criteria and assessment factors in Minn. R. 7050.0150. Attainment of these standards is measured through sampling of the aquatic biota and is based on impairment thresholds for indices of biological integrity (IBI) that vary by use class. Appendix 4.2 and 4.3 in the Rum River Watershed Monitoring and Assessment Report (MPCA 2016b) provides the IBI numeric thresholds.
- Mercury – The standard for class 2 waters is based on the mercury concentration in edible fish tissue: 0.2 mg/kg fish mercury concentration.
- PCBs – A concentration of 0.22 mg/kg in fish tissue is used to determine if the fish meet the protection level goals for fish consumers. Concentrations above this amount result in a water body being listed as impaired.

3.2 Lake water levels

Lake water level elevation is measured for Green Lake, for which the average water elevation from 2007 to 2016 is approximately 922.7 feet (Figure 10). Lake-level fluctuations can be large and range from about one foot to four feet. Note that there are no monitored stream gages along any tributaries to Green Lake.

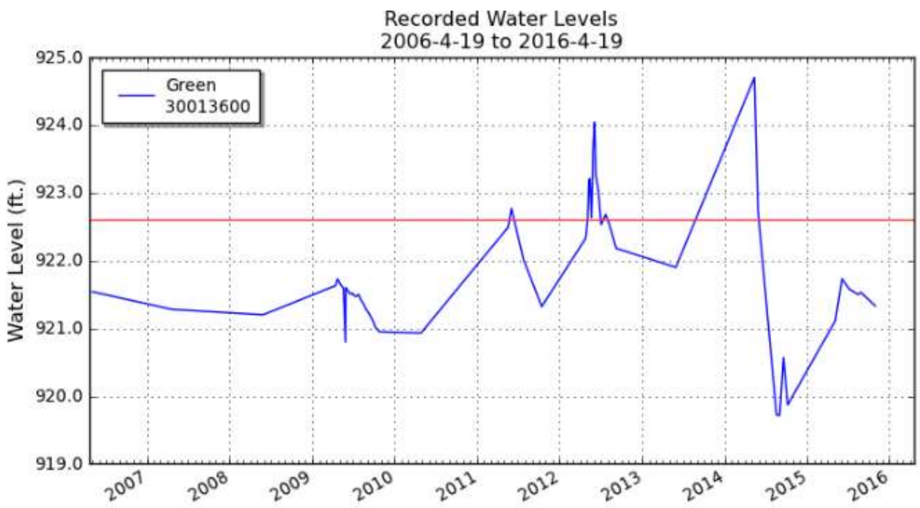


Figure 10. Green Lake Lake-Level Fluctuations (MPCA 2017; MN LakeFinder)

3.3 Water quality data summaries

Water quality monitoring has occurred at stations located at the downstream end of the four major tributaries to Green Lake (North Brook, Bratlin Creek, Old Judge's Ditch, Wyanett Creek), as well as in the lake itself (Figure 13). Water quality results at these sites are summarized in the following sections.

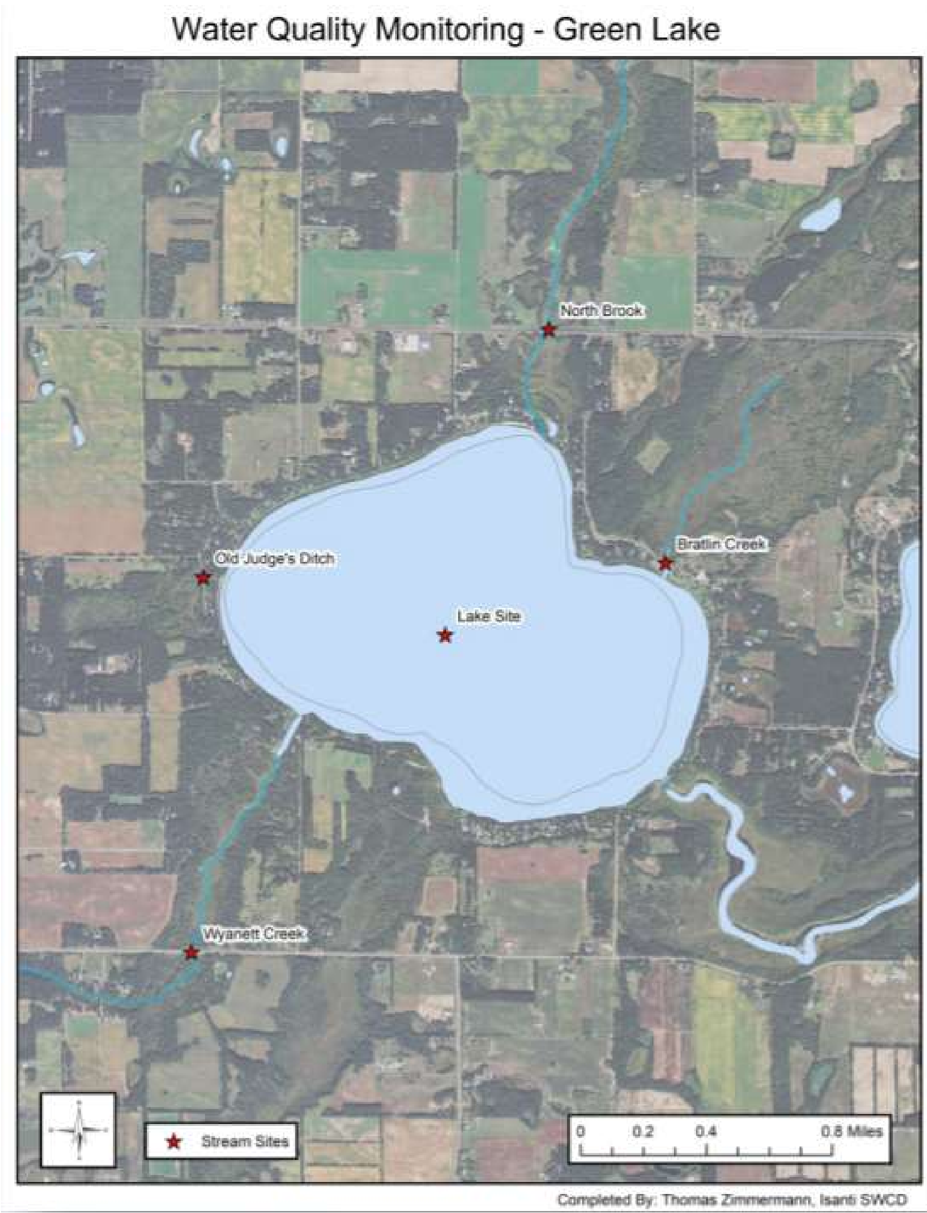


Figure 11. Water quality monitoring locations along stream sites and Green Lake (Isanti SWCD 2018b)

Lake water quality

Commented [DT-NCM1]: Why didn't use P. Diagnositc study or more recent data?

Total phosphorus, Chl-a, and Secchi data summary

Generally, the information in this section was excerpted from the Rum River TMDL report (MPCA 2017). Green Lake's monitoring data for the TMDL period included 17 paired samples of TP, chlorophyll-a (chl-a), and Secchi transparency data and 96 individual Secchi measurements collected between 2006 and 2015. Corresponding growing-season averages for TP, chl-a, and Secchi transparency with corresponding lake standards are summarized in Table 10, which illustrates that lake averages exceed the TP and chl-a standards. Average Secchi values do not exceed the standard threshold. Lake TP and chl-a averages remained above standards in recent years, which suggests persistent watershed sources. Secchi transparency, however, does not show a downward trend in clarity. This may reflect aquatic vegetation shifts. Annual average growing-season data are shown in Figure 12, Figure 13, and Figure 14. Monthly trends of data are shown in Figure 15, Figure 16, and Figure 17. P monthly means showed a progressive increase over the growing season from about 35 micrograms per liter (µg/L) to about 75 µg/L. The corresponding chl-a monthly mean values increase sequentially during the summer months to a peak of about 43 µg/L. Correspondingly, June to September average monthly Secchi transparencies vary from approximately 1.75 meters to about 1.5 meters.

Table 10. 2006-2015 total phosphorus, chl-a, and secchi transparency growing-season means for Green Lake (MPCA 2017)

Parameter	Minimum	Mean	Maximum	Standard deviation	Sample number	Lake standards
TP (ug/l)	26	50.6	90.0	20.6	17	=<40
Chl-a (ug/l	7	27.5	69	21	17	=<14
Secchi disk depth (m)	.5	1.6	4.6	.8	96	=> 1.4

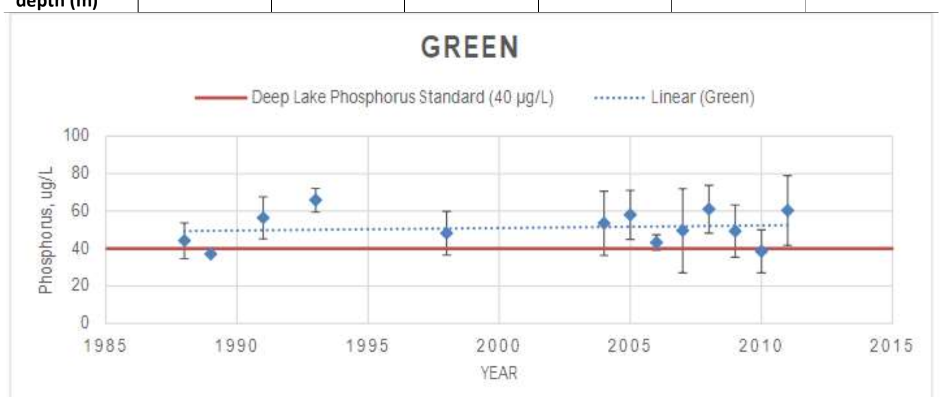


Figure 12. Annual growing-Season mean of TP concentrations for Green Lake (MPCA 2017)

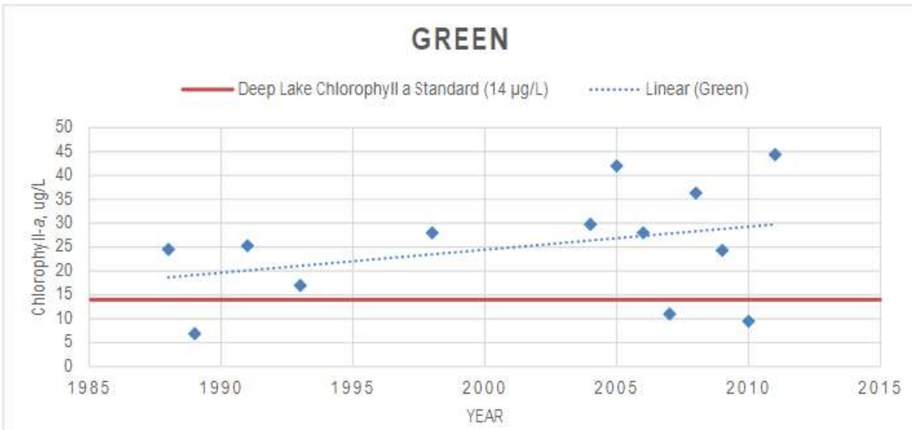


Figure 13. Annual growing-season mean of chlorophyll-a concentrations for Green Lake (MPCA 2017)

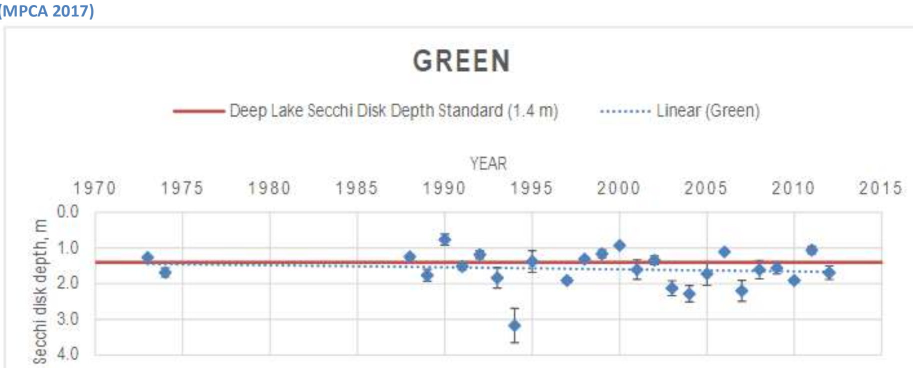


Figure 14. . Annual growing-season mean of secchi transparency for Green Lake (MPCA 2017)

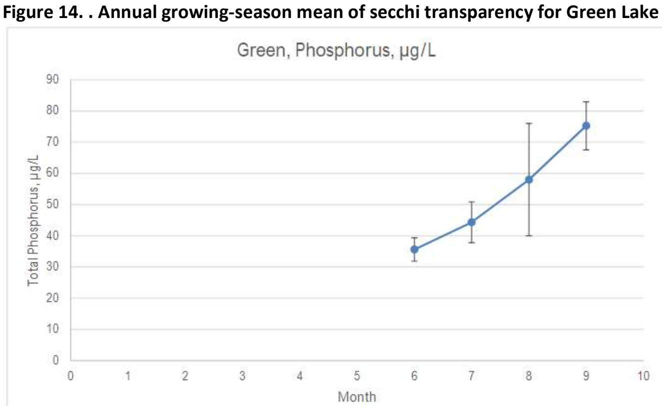


Figure 15. Growing-season monthly mean of TP for Green Lake (all available data between 2006-2015) (MPCA 2017)

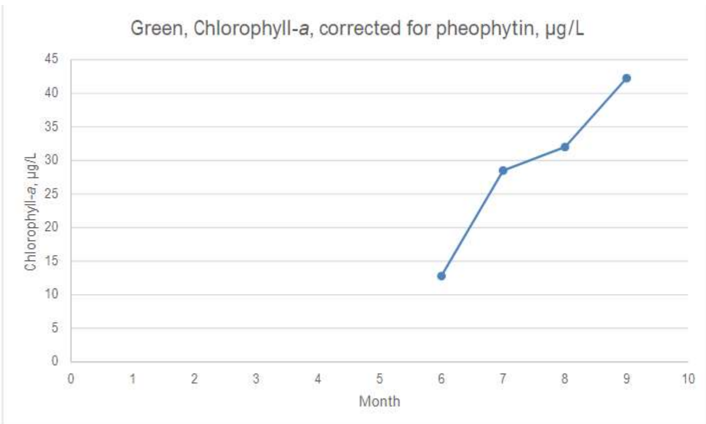


Figure 16. Growing-season monthly mean of chlorophyll-*a* for Green Lake (all available data between 2006-2015) (MPCA 2017).

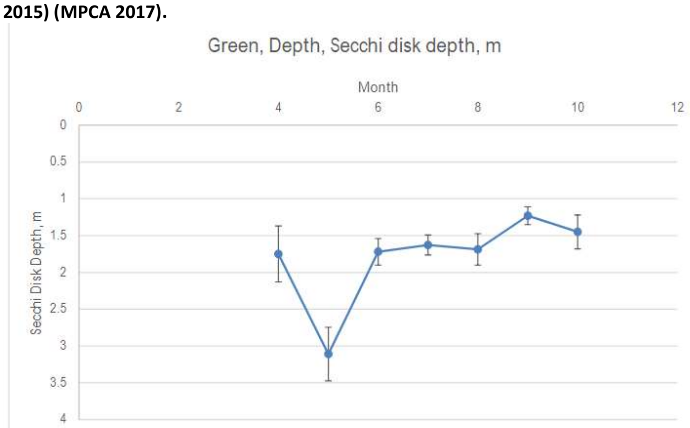


Figure 17. Growing-season monthly mean of secchi transparency for Green Lake (all available data between 2006-2015) (MPCA 2017).

Dissolved Oxygen and Temperature Data Summary

DO and temperature data monitored in depth profiles were examined to better define lake-mixing patterns that affect biological responses and lake TP dynamics (MPCA 2017). Available data from 1988 to 1991 are plotted in Figure 18 and Figure 19 for temperature and DO, respectively. As shown in Figure 20 and Figure 21, Green Lake is a deep lake in the Rum River watershed, which is noted to develop a thermocline and experience typical declining summer oxygen values in the hypolimnion to concentrations less than 2.0 mg/l.

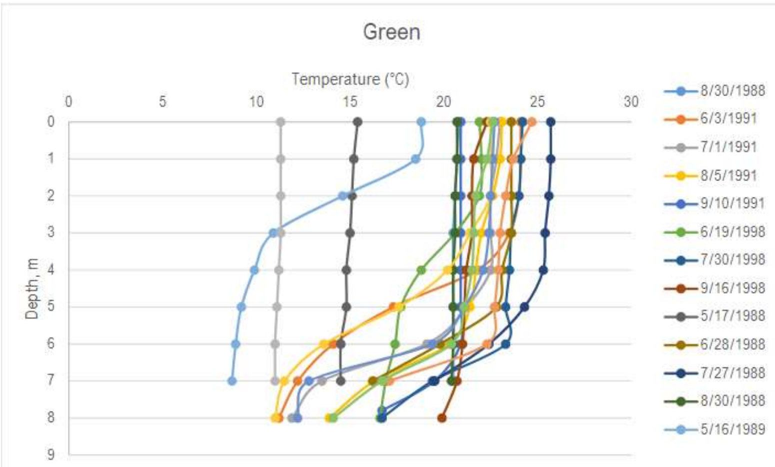


Figure 18. Lake temperature profiles for Green Lake (MPCA 2017).

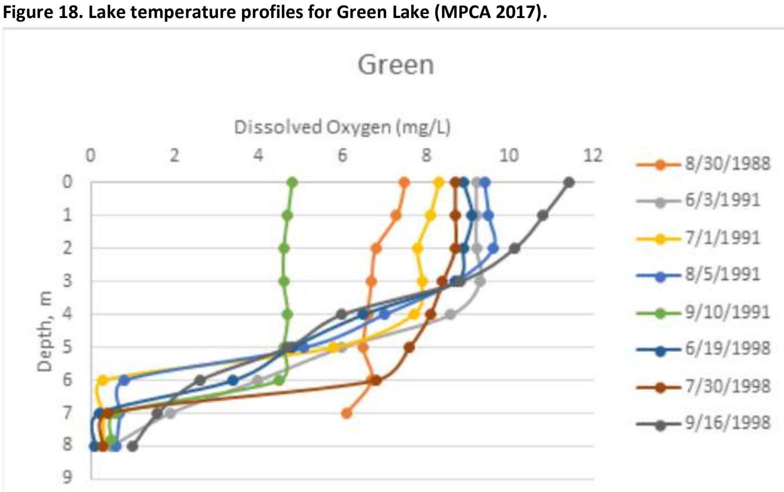


Figure 19. Dissolved oxygen profiles for Green Lake (MPCA 2017)

Fisheries data summary

Green Lake is primarily managed for walleye and northern pike, and the DNR's 2012 assessment found walleye size and abundance at historic highs. The walleye population is maintained through annual fingerling stocking. Common carp and black bullheads were found at the low end of the normal range for this type of lake.

The DNR has conducted surveys of fish relative abundance with standardized methods on a 5-year cycle in Green Lake since 1979. These survey methods allow inference of relative abundance by comparing catch rates over time and to normal ranges for lakes with similar characteristics. Lake survey catch per unit effort data from Green Lake suggest that overall fish abundance has varied significantly over time, has stayed mostly within normal ranges for similar lakes, and based on most recent survey in 2016 abundance is currently reaching the upper normal range in abundance. Benthivore (substrate feeding) fish populations exhibit similar trends over time in Green Lake, but account for small proportion of overall catch per unit effort (sampling bias may account for these differences) (Wenck 2019).

Inference about the effects of fish abundance on water quality in Green Lake is limited by the lack of data on planktivorous fish abundance and Common Carp biomass density. Available data suggests that currently the state of its piscivorous game fishery is favorable for high water clarity and a macrophyte dominated stable state. The predictable occurrence of Common Carp in DNR catch data over time is indicative of a reproducing population existing within the lake and/or subwatershed, warranting specific sampling to quantify biomass density of this benthivorous species. If Common Carp biomass density is higher than 100 kg/ha (Bajer et al 2009), suppressive management of this invasive/nuisance species would be a method to increase water quality in Green Lake that is commonly employed by water managers in the region (Wenck 2019).

Aquatic Vegetation Data Summary

Curlyleaf pondweed (CLP) and Eurasian water milfoil (EWM) are aquatic invasive species present in Green Lake. Limnopro Aquatic Science (2018) indicated that the range of CLP in the littoral zone of the lake has expanded from approximately 4% in 2005 to 35% in 2012 to 44% in 2018. EWM coverage of the lake in mid-June of 2005 and 2012 was 34% and 28%, respectively. The 2018 survey by Limnopro occurred in mid-May prior to the dominant growth of EWM, so coverage was underrepresented (Limnopro 2018). EWM generally is a problem for much of the summer; whereas, CLP naturally dies off at the beginning of July.

Stream water quality

Tributary monitoring is conducted at the outlets of the main tributaries to Green Lake, and the locations and frequency of sampling has increased over the past decade. In 2018, eight sampling events were targeted at the four major tributary outlets. Sampling events included four rain events and four baseflow periods that were sampled for TP, TSS, and transparency. Measurements in the field included DO, temperature, conductivity, pH, and flow. Water levels were also tracked continually in both North Brook and Wyanett Creek, measuring every four hours from early May through early November.

The Green Lake Tributary Monitoring Report (Isanti SWCD 2018b) details the following water quality data summaries about each main tributary to Green Lake:

- North Brook: TP concentrations observed in 2018 were lower than previous years (due in part to high volume of precipitation) but there is still plenty of opportunity for improvement in water quality.
- Wyanett Creek: TP levels were lower in 2018 than previous years (due to high precipitation) but plenty of opportunity for improvement.
- Bratlin Creek: This location typically has good water health (with the exception of the early season).
- Old Judge’s Ditch: In 2018 flow was lowest therefore TP contribution was lowest to lake.

3.4 Water quality impairment assessments

The MPCA assesses the use support of individual water bodies in Minnesota. A water body is defined as an individual stream reach, lake, or wetland and is identified as an assessment unit. Each assessment unit is assigned an assessment unit identification (AUID). Stream AUIDs are delineated using the 1:24,000 scale National Hydrography Dataset. Streams and rivers often contain more than one stream reach based on the presence of tributaries, lakes and wetlands, and other landscape changes. There are no MPCA assessed stream AUIDs in the Green Lake watershed. Lake and wetland AUIDs are based on the DNR's Protected Waters Inventory.

The assessment of aquatic recreation in lakes is based on total phosphorus, chl-a, and Secchi depth, and the assessment of aquatic life in lakes is based on chloride and fish data, where available. Where applicable and where sufficient data exist, other designated uses (e.g., limited resource value water, drinking water, and aquatic consumption) are assessed.

The Rum River Monitoring and Assessment Report (MPCA 2016b) concluded that Green Lake (30-0136-00) is eutrophic and not meeting the aquatic recreation standard due to excess nutrients. The poor water quality of Green Lake is reflected in the fish surveys and lack of complex nearshore habitat. Green Lake is also not meeting its aquatic life standard due to low fish bioassessment scores.

Mercury was analyzed in fish tissue samples collected from the Rum River and 11 lakes, including Green as part of the Fish Contaminant Monitoring Program. In addition, polychlorinated biphenyls (PCBs) were measured in fish in the Rum River and 7 lakes. Fish tissue from Green Lake was tested in both efforts and was found to be impaired for both pollutants (MPCA 2016b). No other waterbodies or applicable beneficial uses in the Green Lake watershed were assessed as part of that effort.

3.5 Impairments 303(d) listings

Water quality impairments are identified on Minnesota's 303(d) list. The most recent approved updates of the 303(d) list occurred in 2018; however, Green Lake watershed has listed impairments dating back to 1998. Figure 20 shows the impairments and Table 11 describes the criteria, date of listing and the status of total maximum daily load (TMDL) development.

Table 11. Impaired lakes in the Green Lake watershed

Lake name	Reach description	Classification	Year listed	Affected designated use	Pollutant or stressor	Status of TMDL
Green	8 MI E of Princeton	2B, 3C	1998	Aquatic Consumption	Mercury in fish tissue	Approved 2008
			1998	Aquatic Consumption	PCB in fish tissue	2020 Target completion
			2016	Aquatic Life	Fishes bioassessments	2027 Target completion
			2008	Aquatic Recreation	Nutrient/ eutrophication biological indicators	Approved 2017

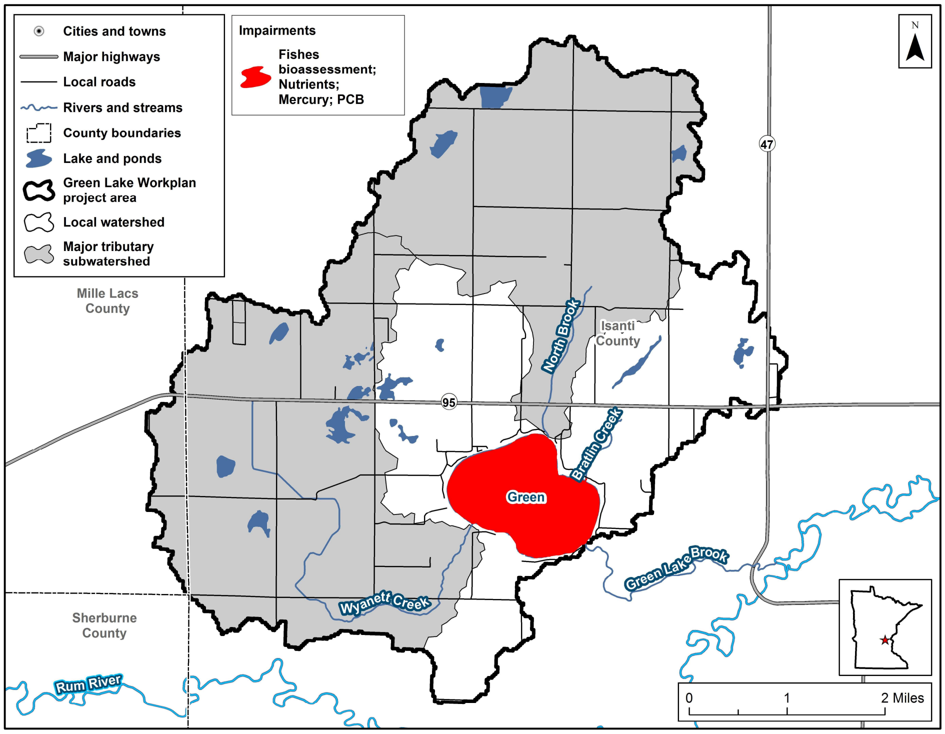


Figure 20. Impairments in the Green Lake watershed

3.6 Stressor identification for biological impairments

Biological stressor identification is the process of identifying the major factors causing harm to fish, macroinvertebrates and other aquatic organisms. The MPCA conducts a stressor identification process to identify the likely stressors causing either fish or macroinvertebrate biota impairments. This process encompasses both evaluation of pollutants and non-pollutant-related (e.g., altered hydrology, fish passage, habitat) factors as potential stressors. The Rum River Watershed Fish based Lake IBI Stressor Identification Report (Borgstrom 2016) evaluated the potential stressors of the fish bioassessment impairment in Green Lake. Borgstrom (2016) summarizes that "[t]he poor water quality and high disturbance (greater than 40%) within the watershed…would indicate that there is not one key cause of the reduced fish community, but rather a synergistic effect due to poor water quality, and lack of quality in-lake and nearshore habitat."

3.7 Watershed TMDLs

The Clean Water Act, Section 303(d) requires TMDLs to be completed 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 waterbody can assimilate while still achieving water quality standards and allocates allowable pollutant loads to various sources needed to meet water quality standards.

Green Lake was added to the Minnesota impaired waters list in 2008 for having high nutrients (too much phosphorus). The listing triggered the completion of a TMDL study in 2017 by the MPCA (Table 12). The TMDL study identified the need for a 39% overall phosphorus reduction or approximately 1,840 lbs/yr P.

Table 12. TMDL for Green Lake (MPCA 2017)

Green Lake Load Allocation		**Existing TP Load**		**Allowable TP Load**		**Estimated Load Reduction**	
		lbs/yr	**lbs/day**	**lbs/yr**	**lbs/day**	**lbs/yr**	**%**
Margin of Safety 10%				**319.17**	**0.87**		
Wasteload	Construction Stormwater	0.90	< 0.01	0.90	< 0.01	0.00	—
	Industrial Stormwater	5.04	0.01	5.04	0.01	0.00	—
	Total WLA	5.94	0.01	5.94	0.01	0.00	—
Load	Tributary 281	1,820.84	4.99	1,085.74	2.97	735.10	40
	Tributary 283	1,290.18	3.53	809.92	2.22	480.26	37
	Local Watershed	1,286.36	3.53	771.81	2.12	514.55	40
	SSTS	110.25	0.30	0.00	0.00	110.25	100
	Atmospheric Deposition	199.15	0.55	199.15	0.55	0.00	—
	Total LA	4,706.78	12.90	2,866.62	7.86	1,840.16	39
Total Load (WLA + LA)		4,712.72	12.91	2,872.56	7.87	1,840.16	39
Loading Capacity (WLA + LA + MOS)				**3,191.73**	**8.74**		

In addition, Green Lake has an aquatic consumption impairment due to high levels of mercury measured in fish tissue. Minnesota developed a statewide mercury TMDL that was approved by EPA in 2007. The MPCA updates information in the approved statewide mercury TMDL every two years. For more information on mercury impairments, see the statewide mercury TMDL at: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/special-projects/statewide-mercury-tmdl-pollutant-reduction-plan.html.

Following the completion of the TMDL, Isanti SWCD and the Green Lake Improvement District (LID) collected additional flow and water quality measurements from various ditches and streams that discharge to the lake. Wenck (2019) provided an updated diagnostic study using this data and an internal load component. The NKE plan is based on this diagnostic study. The study determined that a 54% reduction in P was needed, or an approximately 2,142 lbs/yr. The breakdown of reductions needed by watershed segment is described in Table 13.

Table 13. Load reductions by watershed segment for Green Lake (Wenck 2019)

Source Load	Existing TP Load	Allowable TP Load	Estimated Load Reduction	
	[lbs/yr]	[lbs/yr]	[lbs/yr]	[Percent]
Wyanett Creek	753	388	365	49%
North Brook	438	256	182	42%
Bratlin Creek	120	120	0	0%
Old Judge's Ditch	193	136	57	29%
Remaining Local Watershed	70	61	9	12%
SSTS	68	64	4	6%
Internal Load	2,064	539	1,525	74%
Curly-leaf pondweed	49	49	0	0%
Atmosphere	199	199	0	0%
TOTAL LOAD	**3,954**	**1,812**	**2,142**	**54%**

4. Pollutant source assessments

Pollutant source assessments are completed by MPCA for typical pollutant impairment listings and where a biological stressor ID process identifies a pollutant as a stressor. The pollutants of concern in the Green Lake watershed include phosphorus. Mercury and PCBs are also an issue from early monitoring and impairment assessment.

4.1 Phosphorus

The *Green Lake Diagnostic Study Technical Memo* (Wenck 2019) described phosphorus sources to Green Lake by subwatershed and other sources (Table 14). The HSPF model estimated P contributions by land use in the overall watershed, but did not include the internal loading components and did include atmospheric deposition. With these differences, the HSPF land use contribution estimates are assumed to be representative of the upland watershed contributions. Figure 21, Figure 22, figure 23, and Table 14 describe the HSPF estimate of pollutant source by land use in three segments.

The HSPF model broke out the watersheds by Wyanett Creek, North Brook Creek, and the remaining Green Lake Watershed. The Diagnostic Study broke out the watersheds by Wyanett Creek, North Brook Creek, Bratlin Creek, Old Judge's Ditch, and remaining watershed. The HSPF Green Lake Watershed includes the Diagnostic Study Bratlin, Old Judge's Ditch, and remaining watershed.

Phosphorus contributions from functioning SSTS are considered insignificant. Atmospheric deposition of phosphorus is a source of P that is largely not controllable. Internal loading is a significant source of P to the lake through P release from anoxic bottom sediment and aquatic vegetation uptake of P and release of P upon senescence.

Table 14. Existing non-point phosphorus loads by source to Green Lake (adapted from Wenck 2019)

Source Load		Existing load (lbs/yr)
Major tributaries	Wyanett Creek	753
	North Brook Creek	438
Local watershed	Bratlin Creek	120
	Old Judge's Ditch	193
	Remaining watershed	70
SSTS		68
Atmospheric deposition		199
Internal loading		2,064
Curly leaf pondweed		49
Total existing load		**3,954**

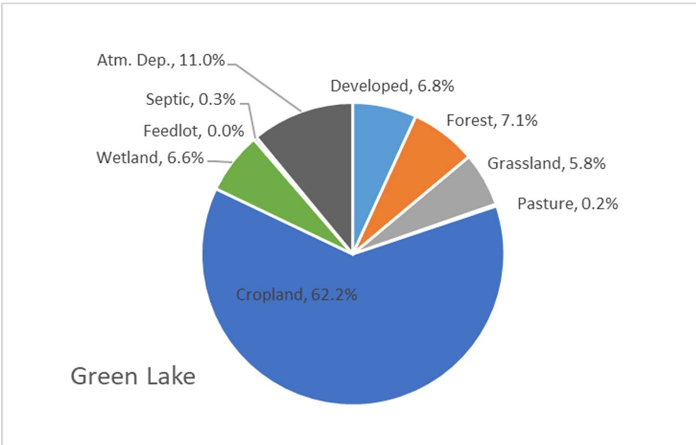


Figure 21. Upland watershed sources of P by land use to Green Lake Watershed as estimated by HSPF

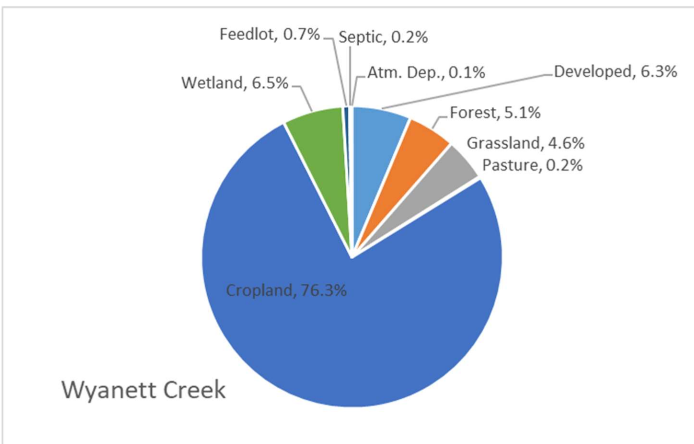


Figure 22. Upland watershed sources of P by land use to Wyanett Creek as estimated by HSPF

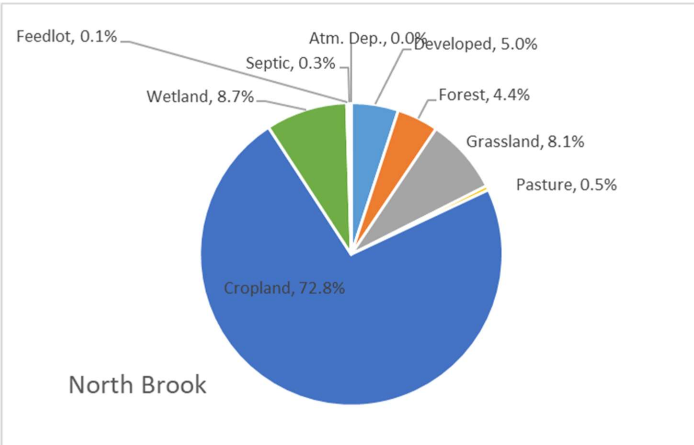


Figure 23. Upland watershed sources of P by land use to North Brook as estimated by HSPF

Table 15. Percent P loading by land use, SSTS, and atmospheric deposition for the three watershed segments in the HSPF model

Watershed	Developed	Forest	Grassland	Pasture	Cropland	Wetland	Feedlot	SSTS	Atm. Dep.
Wyanett Creek	6.3%	5.1%	4.6%	0.2%	76.3%	6.5%	0.7%	0.2%	0.1%
North Brook	5.0%	4.4%	8.1%	0.5%	72.8%	8.7%	0.1%	0.3%	0.0%
Green Lake	6.8%	7.1%	5.8%	0.2%	62.2%	6.6%	0.0%	0.3%	11.0%
Total	6.1%	5.5%	5.8%	0.3%	71.6%	7.1%	0.4%	0.3%	3.0%
Average	6.1%	5.5%	6.2%	0.3%	70.5%	7.3%	0.3%	0.3%	3.7%

4.2 Mercury

Almost all the mercury in Minnesota's lakes and rivers is delivered by the atmosphere. Mercury can be carried great distances on wind currents before it is brought down to earth in rain and snow. About 90% of the mercury deposited on Minnesota comes from other states and countries. Similarly, the vast majority of Minnesota's mercury emissions are carried by wind to other states and countries. It's impossible for Minnesota to solve this problem alone; the United States and other countries must greatly reduce mercury releases from all sources.

Atmospheric deposition of mercury is uniform across the state and supplies more than 99.5% of the mercury getting into fish. Agency research has demonstrated that 70% of current mercury deposition in Minnesota comes from human sources and 30% from natural sources, such as volcanoes. There are no known natural sources in the state that emit mercury directly to the atmosphere.

4.3 Polychlorinated biphenyls (PCBs)

An impairment for PCBs in fish tissue was added to the 303(d) list in 1998. There has been no TMDL completed for this impairment. The status of this pollutant is not known. The watershed partners will study fish tissue to determine whether this is still a concern.

5. Watershed prioritization

Priority watershed and critical areas are identified for the Green Lake NKE. These critical areas were identified using information in existing planning documents and represent the areas with the most potential to address the stressors and sources of impairment within the project area:

- **Priority Area #1:** Major tributary subwatersheds. In 2018, monitoring efforts conducted in the four inlets to Green Lake evaluated TP, TSS, and transparency during wet and dry events. Water quality results indicated that the subwatersheds to North Brook and Wyanett Creek contribute the highest levels of external pollutant loading to Green Lake and should be priority locations for restoration projects. Critical subwatersheds and catchments within the subwatersheds are identified in Figure 24.
- **Priority Area #2:** Nearshore areas (Figure 25). The Rum River Watershed Fish based Lake IBI Stressor Identification Report (Borgstrom 2016) identified poor riparian land use as a stressor to the fish bioassessment impairment and found that there was a high level of disturbed land use within 1,000 feet of the shoreline. As such, a nearshore critical area of a 2,000 foot buffer around Green Lake was created. This buffer accounts for the 1,000 feet identified by Borgstrom (2016) and any nearby areas of disturbance.
- **Priority Area #3:** Other tributaries to Green Lake. Runoff from agricultural land use was identified as a source of phosphorus in the Green Lake TMDL (MPCA 2017).
- **Priority Area #4:** Internal loading. The Diagnostic Study identified internal loading as a significant contributor to the P on the lake. To start addressing the internal loads, the Green Lake partners will act by removing curlyleaf pondweed annually. Once 50% of the upland loading has been addressed, the partners are planning a feasibility study for an alum treatment (Table 18).

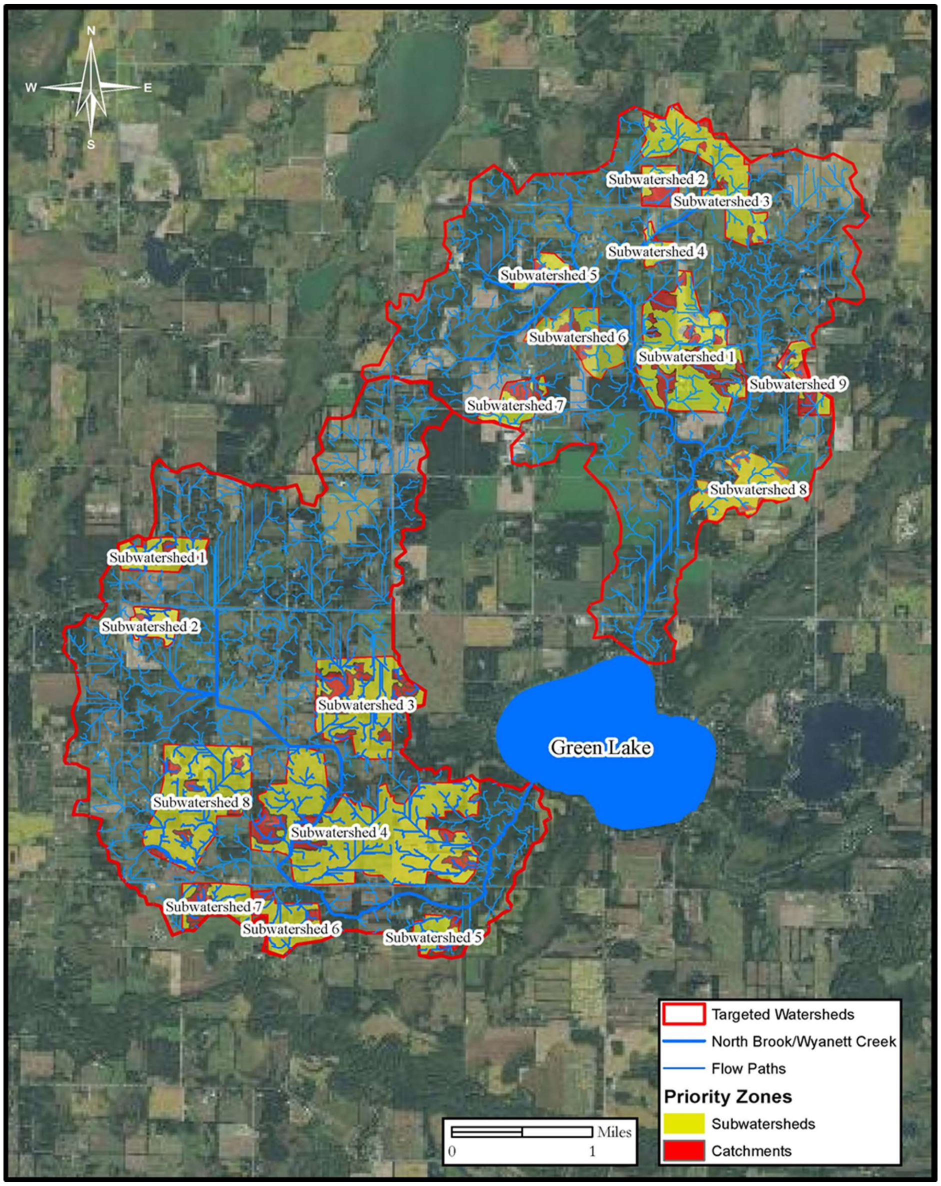


Figure 24. Critical (labeled as priority) zones in the North Brook and Wyanett Creek Watersheds

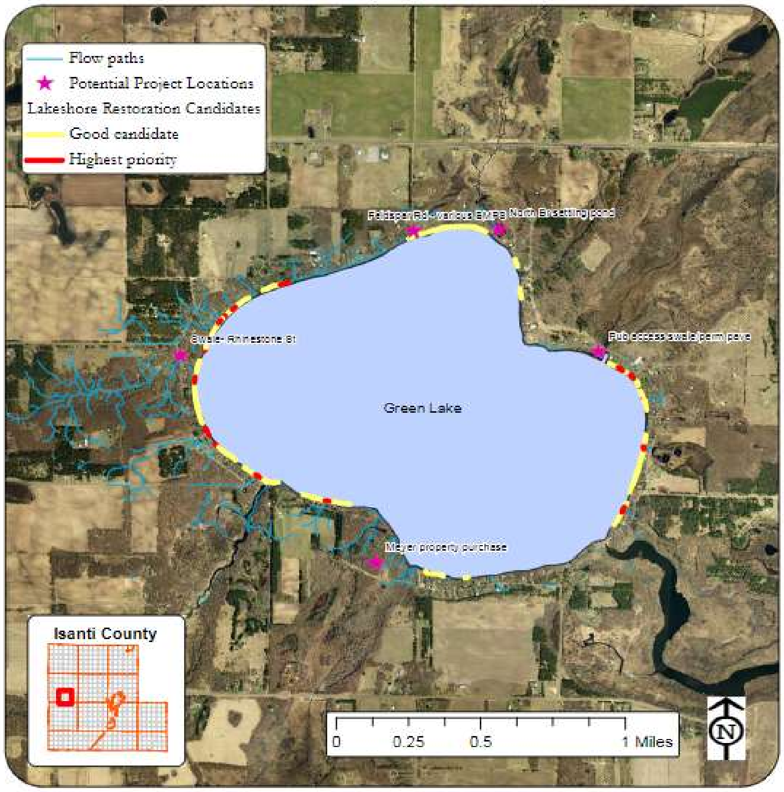


Figure 25. Critical locations for shoreline restoration projects on Green Lake

6. Watershed goals

Restoration goals are developed for impairments within the Green Lake watershed and are derived from existing TMDLs and planning documents. Protection goals are established for other pollutants or parameters of concern.

6.1 Restoration goals

- Phosphorus: Meet water quality standards for nutrients/eutrophication in Green Lake. The Green Lake TMDL requires an overall reduction of 39% or 1,840 lbs/yr of phosphorus loading to meet water quality standards. The Green Lake Diagnostic Study identified an overall needed reduction of 54% or 2,142 lbs/yr. This NKE plan exceeds the reductions identified in the Green Lake Diagnostic Study.
- Fish Community: Meet biological criteria for fish in Green Lake. The threshold for fish IBI in Green Lake is 45.
  - Reduce phosphorus loading to Green Lake
  - Improve nearshore/riparian habitat
  - Improve in-lake habitat
- Mercury: Meet goals of the Statewide Mercury TMDL. The long-term goal of the mercury TMDL is for the fish to meet water quality standards; the approach for Minnesota's share is mass reductions from state mercury sources. This mercury TMDL establishes that there needs to be a 93% reduction in state emissions from 1990 for the state to meet its share. Water point sources will be required to stay below 1% of the total load to the state and all but the smallest dischargers will be required to develop mercury minimization plans. Air sources of mercury will have a 93% emission reduction goal.
- PCBs: Determine current PCB concentrations in fish tissue below the water quality standard. No TMDL has been completed to address this impairment.

6.2 Protection goals

- Maintain water quality in Bratlin Creek. No further phosphorus reduction is needed in Bratlin Creek to achieve water quality standards for nutrients/eutrophication in Green Lake (Wenck 2019).
- Groundwater Protection: Protect groundwater quality in the Green Lake Watershed. Addressing nutrient loading will benefit the groundwater in the sandy soils of Green Lake Watershed.
- Aquatic Invasive Species. The Green Lake Improvement District (2016) identified preventing the spread of aquatic invasive species as a priority for Green Lake.

7. Implementation plan

Management strategies and activities to meet watershed goals have been described in many existing documents. This section summarizes those strategies and activities and expands upon them based on local input and priorities.

The following management practices and activities have been identified for the Green Lake Watershed. Implementation of all of these plans will achieve the water quality standards for Green Lake for nutrients. There are multiple benefits to each of the BMPs and they are expected to improve habitat conditions, ultimately increasing and diversifying the FIBI for Green Lake. Each of the sections include a ten-year timeline of activities and goals for this watershed, which should net the expected reductions for nutrients and improve habitat to meet state water quality standards. The Diagnostic Study identifies the current P loading as 3,954 lbs/yr. If this plan is implemented, it is estimated to reduce P loading by 2,510 lb/yr (63%).

7.1 Community partners

The SWCD is partnering with the Green Lake Improvement District to build a locally-led and funded shoreline restoration program that builds the capacity of the lake group such that they are able to fund, plan and install near-shore stormwater reduction projects on their own. The SWCD provides technical assistance but the lake group is responsible for getting the landowners on board, projects designed, contracts signed and projects installed. This program is based off a similar successful program on another local lake and it results in more efficiency of limited SWCD time and resources. Activities for community ordinances and other activities are described in Table 16.

Table 16. Protection actions via regulatory activities, goals, milestones, and assessment

	Milestones/schedule					Goals	Cost		Assessment criteria
Practice	**2-year**	**4-year**	**6-year**	**8-year**	**10-year**			**per unit**	
Update local ordinances to adopt Minimal Impact Design Standards (MIDS)			Two presentations to LGU staff and policy makers on MIDS options and strategies	Begin working on policy updates.	Update County ordinance and regulations	MIDS used as standard	$1,500	yr	County Ordinance updated
County shoreline ordinance update	Shoreline ordinances reviewed.	Shoreline ordinances updated				Stricter and/or more clearly defined shoreland regulations required by state to be enforced at the local level continue to be supported.	$1,500	yr	Rules and regulations enforced
Host workshop to help landowners and builders understand rules and stormwater mitigation methods		Host workshop- a minimum of 10 participants	Host workshop- a minimum of 10 participants	Host workshop- a minimum of 10 participants	Host workshop- a minimum of 10 participants	Landowners and contractors aware of County ordinances/rules and stormwater practices.	$1,000	yr	#participants at workshops

7.2 Agricultural BMPs

Runoff from cropland was identified as a source of phosphorus to Green Lake in the Rum River TMDL (MPCA 2017). Water and sediment control basins (WASCOBS), cover crops, and filter strips were selected to address phosphorus loading using an agricultural best management practices (BMP) scenario based on a review of existing planning documents. The implementation modeling scenario assumed 50% of agricultural land treated with an equal distribution of the three BMPs (1/3 of the acres treated with WASCOBs, 1/3 with cover crops, and 1/3 filter strips) in the North Brook and Wyanett Creek watersheds. A 44% implementation level was used for the local watershed as it achieved the required reductions for that area. These BMPs can be used in combination as a treatment train, which would yield additional benefits. Water retention practices also address habitat concerns.

Wetland restoration acts to slow surface water runoff and provide P treatment. Wetlands in the watershed have been affected by efforts to drain the land for crop production. Opportunities to restore wetlands will be pursued in conjunction with implementation of the ditch maintenance plan. Priority areas for wetland restorations include the North Brook and Wyanett Creek subwatersheds.

Agricultural BMP activities are described in Table 17 include practices specified in the Green Lake Subwatershed Retrofit Analysis for Areas Draining Directly to the Lake and Green Lake Rural Stormwater Retrofit Analysis of North Brook and Wyanett Creek (See Appendices B and C). A summary of the practices specific to these retrofit analyses by watershed can be found in Appendix F. For the purposes of this NKE plan, Table 16 includes those practices and the additional practices required to meet the estimated reductions to meet water quality standards, along with milestones and assessment criteria needed to evaluate the progress of the NKE plan implementation. Each of the analyses include maps to illustrate the targeting of the BMPs.

The estimated P reductions in Table 17 total 1,090 lbs/yr, which is greater than the 613 lbs/yr reduction in P needed for upland watershed P loading as identified in the *Green Lake Diagnostic Study (Wenck 2019)*.

Table 17. Agricultural practices, milestones, reductions, goals, and assessment criteria

Practice	Milestones/schedule					Goals	Estimated phosphorus reductions (lbs/yr)	Cost		Assessment criteria
	2-year	**4-year**	**6-year**	**8-year**	**10-year**				**per unit**	
Water Retention: Increasing water quantity on the land and reducing water quantity and rate into surface water (i.e. wetland restorations, in-line or off-line settling ponds, basins, and/or filters; alterations to improve or restore hydrology; alterations to increase storage; alterations to improve habitat and other wetland functions; stream/ditch channel restoration and/or maintenance		Install 2 BMPs	Install 2 BMPs	Install 2 BMPs	Install 2 BMPs	Continue project identification and install 8 projects	250	$10,000	project	Volume of water held on the land.

Practice	Milestones/schedule					Goals	Estimated phosphorus reductions (lbs/yr)	Cost		Assessment criteria
	2-year	**4-year**	**6-year**	**8-year**	**10-year**				**per unit**	
Identify areas w/in stream/ditch corridor for potential projects	North Brook: Establish and implement process a process to evaluate sites and identify potential improvements where necessary. Process could include: desktop analysis, upstream/downstream paired water quality monitoring, walking survey of channel to assess sedimentation, channel conditions, hydrology; wetland vegetation assessment such as rapid floristic quality assessment.	Continue with North Brook evaluations	Wyanette: Establish and implement process a process to evaluate sites and identify potential improvements where necessary. Process could include: desktop analysis, upstream/downstream paired water quality monitoring, walking survey of channel to assess sedimentation, channel conditions, hydrology; wetland vegetation assessment such as rapid floristic quality assessment.	Continue with North Brook evaluations	Continue evaluation process	Database of wetland restoration locations identified.	NA	$11,000	year	#locations for wetland restorations identified

Practice	Milestones/schedule					Goals	Estimated phosphorus reductions (lbs/yr)	Cost		Assessment criteria
	2-year	**4-year**	**6-year**	**8-year**	**10-year**				**per unit**	
Direct Contact Outreach		Landowner contacts (phone, knock, flyer, newsletter, etc.) to landowners w/identified potential locations- 5 contacts made.	Landowner contacts (phone, knock, flyer, newsletter, etc.) to landowners w/identified potential locations- 5 contacts made.	Landowner contacts (phone, knock, flyer, newsletter, etc.) to landowners w/identified potential locations- 5 contacts made.	Landowner contacts (phone, knock, flyer, newsletter, etc.) to landowners w/identified potential locations- 5 contacts made.	Develop partnership with Isanti community and gain buy in. Market SWCD as a resource for landowners wanting to implement conservation.	NA	$1,000	year	# of landowners contacted # of interested landowners
Education	Attend 1 Township and County Board Meeting to propose protection opportunities	Attend 1 Township and County Board Meeting to propose protection opportunities	Attend 1 Township and County Board Meeting to propose protection opportunities		Attend 1 Township and County Board Meeting and propose protection opportunities		NA	$2,000	year	Volume of water held on the land.
Social Media	Social media outreach program: 24 social media posts.		Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Develop partnership with Isanti community and gain buy in. Market SWCD as a resource for landowners wanting to implement conservation.	NA	$5,000	year	# of social media posts # of followers. # of landowners that contact the SWCD because of this platform.
WASCOBs		Design/ implement 3 WASCOBs	Design/ implementation of 3 WASCOBs	Design/ implementation of 5 WASCOBs	Assess effectiveness of WASCOBs	Total of 11 WASCOBs installed	66	$20,000	project	# of acres

Practice	Milestones/schedule					Goals	Estimated phosphorus reductions (lbs/yr)	Cost		Assessment criteria
	2-year	**4-year**	**6-year**	**8-year**	**10-year**				**per unit**	
Agricultural Technician to conduct outreach and implement programs	5 site visits, outreach as identified below	5 site visits, outreach as identified below	5 site visits, outreach as identified below	5 site visits, outreach as identified below	5 site visits, outreach as identified below	ISWCD is a credible source of implementation and information to landowners		$15,000	.25 staff person	.25 staff position funded
Direct Contact Outreach	Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10 landowner of contacted annually)	Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10 landowner of contacted annually)	Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10 landowner of contacted annually)	Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10 landowner of contacted annually)	Evaluate the effectiveness of outreach design	Increase interest in installing WASCOBs and develop a list of producers willing to partner.	NA	$1,000	year	# of landowners contacted # of sites identified # of interested landowners
Education	host 1 educational workshop with minimum 8 attendees	host 1 educational workshop with minimum 10 attendees	host 1 educational/demonstration workshop with minimum 12 attendees	host 1 Demonstration workshop with minimum 114 attendees	Assess effectiveness of workshop	Develop partnership with our agriculture community and gain buy in. Host by annual educational workshops	NA	$4,000	year	# of attendees, # of WASCOBs installed as a result of the workshops/demonstration

Practice	Milestones/schedule					Goals	Estimated phosphorus reductions (lbs/yr)	Cost		Assessment criteria
	2-year	4-year	6-year	8-year	10-year				per unit	
Social Media	Create social media outreach program: 24 social media posts	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Develop partnership with our agriculture community and gain landowner buy in. Increase landowner office contact.	NA	$5,000	year	# of social media posts # of followers. Number of landowners that contact the SWCD because of this platform
Landowner Discussion Group	Organize landowner discussion group (quarterly meetings)	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Create an opportunity for landowners to discuss current ag practices, conservation obstacles, conservation implementation.	NA	$4,000	Year	# of participating landowners
Cover Crops	Implement cover crops into 5% (173 acres) of Wyanett/North Brook row crow land	Implement cover crops into 5% (173 acres) of Wyanett/North Brook row crow land	Implement cover crops into 10% (343 acres) of Wyanett/North Brook row crow land	Implement cover crops into 10% (343 acres) of Wyanett/North Brook row crow land	Implement cover crops into 10% (343 acres) of Wyanett/North Brook row crow land	Total of 75% of row crop acres in cover crops	321	$50	acre	# of acres with where cover crops have been used or are currently being used.
Agricultural Technician to conduct outreach and implement programs	5 site visits, outreach as identified below	5 site visits, outreach as identified below	5 site visits, outreach as identified below	5 site visits, outreach as identified below	5 site visits, outreach as identified below	ISWCD is a credible source of implementation and information to landowners		$15,000	.25 staff person	.25 staff position funded

Practice	Milestones/schedule					Goals	Estimated phosphorus reductions (lbs/yr)	Cost		Assessment criteria
	2-year	4-year	6-year	8-year	10-year				per unit	
Direct Contact Outreach	Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10 landowner of contacted annually)	Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10 landowner of contacted annually)	Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10 landowner of contacted annually)	Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10 landowner of contacted annually)	Evaluate the effectiveness of outreach design	Develop partnership with our agriculture community and gain landowner buy in. Increase landowner office contact.	NA	$1,000	year	# of landowners contacted # of interested landowners
Education	host 1 educational workshop with minimum 8 attendees	host 1 educational workshop with minimum 10 attendees	host 1 educational/demonstration workshop with minimum 12 attendees	host 1 Demonstration workshop with minimum 114 attendees	Assess effectiveness of workshop	Develop partnership with our agriculture community and gain buy in. Host by annual educational workshops	NA	$4,000	year	# of attendees, acres of cover crops installed as a result of the workshops/demonstration
Cover Crop Field Day	Annual Field day with 10 participants (others held outside watershed)			Annual Field day with 10 participants (others held outside watershed)		Facilitate 10 new cover crop implementations	NA	$500	year	# of field day participants

Practice	Milestones/schedule					Goals	Estimated phosphorus reductions (lbs/yr)	Cost		Assessment criteria
	2-year	**4-year**	**6-year**	**8-year**	**10-year**				**per unit**	
Social Media	Create social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Develop partnership with our agriculture community and gain landowner buy in. Increase landowner office contact.	NA	$5,000	year	# of social media posts # of followers. Number of landowners that contact the SWCD because of this platform.
Landowner Discussion Group	Organize landowner discussion group (quarterly meetings)	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Create an opportunity for landowners to discuss current ag practices, conservation obstacles, conservation implementation.	NA	$4,000	Year	# of participating landowners
Conservation tillage/no till		Develop Conservation Tillage Program. Invest into minimal tillage equipment and develop rental program	Implement conservation tillage program. Convert 10% conventional tillage operations to minimal tillage operations. (346 acres of want/North Brook row crop land)	Implement conservation tillage program. Convert 15% conventional tillage operations to minimal tillage operations. (346 acres of Wyanett/North Brook row crop land)	Implement conservation tillage program. Convert 20% conventional tillage operations to minimal tillage operations. (346 acres of Wyanett/North Brook row crop land)	Total of 75% of row crop acres using conservation tillage	213	$150	acre	# of acres converted to minimal till

Practice	Milestones/schedule					Goals	Estimated phosphorus reductions (lbs/yr)	Cost		Assessment criteria
	2-year	**4-year**	**6-year**	**8-year**	**10-year**				**per unit**	
Agricultural Technician to conduct outreach and implement programs	5 site visits, outreach as identified below	5 site visits, outreach as identified below	5 site visits, outreach as identified below	5 site visits, outreach as identified below	5 site visits, outreach as identified below	ISWCD is a credible source of implementation and information to landowners		$15,000	.25 staff person	.25 staff position funded
Direct Contact Outreach	Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10 landowner of contacted annually)	Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10 landowner of contacted annually)	Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10 landowner of contacted annually)	Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10 landowner of contacted annually)	Evaluate the effectiveness of outreach tool.	Develop partnership with our agriculture community and gain buy in. Market SWCD as a resource for landowners wanting to implement conservation.	NA	$1,000	year	# of landowners contacted # of interested landowners
Education		host 1 educational workshop with minimum 10 attendees	host 1 educational/demonstration workshop with minimum 12 attendees	host 1 Demonstration workshop with minimum 114 attendees	Assess effectiveness of workshop	Develop partnership with our agriculture community and gain buy in. Host by annual educational workshops	NA	$5,000	year	# of attendees, acres of converted tillage practices as a result of the workshops/demonstration

Practice	Milestones/schedule					Goals	Estimated phosphorus reductions (lbs/yr)	Cost		Assessment criteria
	2-year	**4-year**	**6-year**	**8-year**	**10-year**				**per unit**	
Social Media	Create social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Develop partnership with our agriculture community and gain landowner buy in. Increase landowner office contact.	NA	$5,000	year	# of social media posts # of followers. Number of landowners that contact the SWCD because of this platform.
Landowner Discussion Group	Organize landowner discussion group (quarterly meetings)	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Create an opportunity for landowners to discuss current ag practices, conservation obstacles, conservation implementation.	NA	$4,000	Year	# of participating landowners
Grassed waterways			5 grassed waterways (Identified in rural assessment)	10 grassed waterways (Identified in rural assessment)	15 grassed waterways (Identified in rural assessment)	59 grassed waterways installed	232	$60	ln ft	# of linear feet of grassed waterways
Agricultural Technician to conduct outreach and implement programs	5 site visits, outreach as identified below	5 site visits, outreach as identified below	5 site visits, outreach as identified below	5 site visits, outreach as identified below	5 site visits, outreach as identified below	ISWCD is a credible source of implementation and information to landowners		$15,000	.25 staff person	.25 staff position funded

Practice	Milestones/schedule					Goals	Estimated phosphorus reductions (lbs/yr)	Cost		Assessment criteria
	2-year	**4-year**	**6-year**	**8-year**	**10-year**				**per unit**	
Direct Contact Outreach		Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10 landowner of contacted annually)	Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10 landowner of contacted annually)	Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10 landowner of contacted annually)	Evaluate the effectiveness of outreach tool.	Develop partnership with our agriculture community and gain buy in. Market SWCD as a resource for landowners wanting to implement conservation.	NA	$1,000	year	# of landowners contacted # of interested landowners
Education		host 1 educational workshop with minimum 10 attendees	host 1 educational/demonstration workshop with minimum 12 attendees	host 1 Demonstration workshop with minimum 114 attendees	Assess effectiveness of workshop	Develop partnership with our agriculture community and gain buy in. Host by annual educational workshops	NA	$5,000	year	# of attendees, # of waterways installed as a result of the workshops/demonstration
Social Media		Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Develop partnership with our agriculture community and gain landowner buy in. Increase landowner office contact.	NA	$5,000	year	# of social media posts # of followers. #of landowners that contact the SWCD because of this platform.

Practice	Milestones/schedule					Goals	Estimated phosphorus reductions (lbs/yr)	Cost		Assessment criteria
	2-year	**4-year**	**6-year**	**8-year**	**10-year**				**per unit**	
Landowner Discussion Group	Organize landowner discussion group (quarterly meetings)	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Create an opportunity for landowners to discuss current ag practices, conservation obstacles, conservation implementation.	NA	$4,000	Year	# of participating landowners
Filter Strips			3 grassed waterways (Identified in rural assessment)	3 grassed waterways (Identified in rural assessment)	5 grassed waterways (Identified in rural assessment)	Identify 25 more areas where filter strips would be beneficial	8.88	$100	acre	# acres treated
Agricultural Technician to conduct outreach and implement programs	5 site visits, outreach as identified below	5 site visits, outreach as identified below	5 site visits, outreach as identified below	5 site visits, outreach as identified below	5 site visits, outreach as identified below	ISWCD is a credible source of implementation and information to landowners		$15,000	.25 staff person	.25 staff position funded
Direct Contact Outreach		Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10 landowner of	Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10 landowner of	Kitchen table discussions and landowner contacts (phone, knock, flyer, newsletter, etc.) in ag producers in the area (Minimum 10	Evaluate the effectiveness of outreach tool.	Develop partnership with our agriculture community and gain buy in. Market SWCD as a resource for landowners wanting to implement conservation.	NA	$1,000	year	# of landowners contacted # of interested landowners

Practice	Milestones/schedule					Goals	Estimated phosphorus reductions (lbs/yr)	Cost		Assessment criteria
	2-year	4-year	6-year	8-year	10-year				per unit	
		contacted annually)	contacted annually)	landowner of contacted annually)						
Education		host 1 educational workshop with minimum 10 attendees	host 1 educational/demonstration workshop with minimum 12 attendees	host 1 Demonstration workshop with minimum 14 attendees	Assess effectiveness of workshop	Develop partnership with our agriculture community and gain buy in. Host by annual educational workshops	NA	$5,000	year	# of attendees, # of filter strips installed as a result of the workshops/demonstration
Social Media		Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Develop partnership with our agriculture community and gain landowner buy in. Increase landowner office contact.	NA	$5,000	year	# of social media posts # of followers. #of landowners that contact the SWCD because of this platform.
Landowner Discussion Group/Farmer Led Council	Organize landowner discussion group (quarterly meetings)	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Continue landowner discussion group (quarterly meetings). Assess effectiveness.	Create an opportunity for landowners to discuss current ag practices, conservation obstacles, conservation implementation.	NA	$4,000	Year	# of participating landowners

7.3 Internal load management

Internal P load controls include an alum treatment, carp management, and curly-leaf pondweed controls to seal P in bottom sediments, reduce bottom sediment suspension by carp, and reduce P release early in the summer from curly-leaf pondweed growth and senescence, respectively.

Chemical treatment of a lake with alum is a common practice in Minnesota to address internal loading. Costs of alum treatment can range from $750,000 to $2 million. A sediment internal load feasibility study is needed to determine feasibility, P reduction effectiveness, and cost prior to an alum treatment. Estimated cost for the feasibility study, including core sampling, laboratory analysis, and a final memo, is approximately $17,000. Part of the analysis of the feasibility study for a chemical treatment such as alum, will include assess the external loading reductions to ensure the best use of the application.

A carp abundance and density study was recommended to determine the extent carp population control would reduce sediment P release. However, locals do not feel that excessive carp populations are an issue. As such, this item was moved to a “last resort” item in the implementation plan. A general cost estimate for three carp density surveys is $15,000. Research suggests that P reductions with decreased carp densities are variable. Research does suggest that carp management aids the control of aquatic invasive plant species by encouraging the growth of native aquatic plant species. A 20 percent reduction in P release in shallow areas of the lake is estimated.

Controlling aquatic invasive plant species, especially curly leaf pondweed, has been demonstrated to improve Secchi disk clarity significantly. Control has been identified as a means of reducing the internal load by preventing the associated loading with the mid-June dieback (James et al. 2007). Control is estimated to reduce P loading by 10 lbs/yr.

The Isanti SWCD has worked with the Lake Improvement District to generate interest and engagement. The LID will be continuing the aquatic invasive species control. This work will continue to contribute toward pollutant reductions and is described here; however, it should be noted that the LID will be taking the lead on this work.

Internal loading BMP activities are described in Table 18. The estimated reductions for internal P loading are 1,582 lbs/yr. The *Green Lake Diagnostic Study (Wenck 2019)* estimates that a 1,525 lb/yr reduction is needed. In year five, partners will assess the effectiveness of internal and external reduction efforts and adapt the plan accordingly.

Table 18. Internal load activities, milestones, goals, reductions, and assessment criteria for Green Lake

Practice	Milestones/schedule					Goals	Estimated phosphorus reductions	Cost		Assessment criteria
	2-year	4-year	6-year	8-year	10-year		(lb/yr)		per unit	
Alum treatment			Sediment internal load feasibility study to identify potential for alum		Alum treatment	90% reduction in P	1572.5	$.75-2M		pounds of P reduced
Sediment internal load feasibility study to identify potential for alum				Outreach and education surrounding alum treatment		Assess effectiveness in reducing internal loading	NA	$17,000	survey	Study complete
Carp management					Common Carp density assessment, develop common carp mitigation plan.			$15,000	survey	Study complete

Practice	Milestones/schedule					Goals	Estimated phosphorus reductions	Cost		Assessment criteria
	2-year	**4-year**	**6-year**	**8-year**	**10-year**		**(lb/yr)**		**per unit**	
Curlyleaf pondweed treatment	Herbicide treatments to reduce amount of curly-leaf pondweed	Evaluate effectiveness of herbicide treatments	Herbicide treatments to reduce amount of curly-leaf pondweed	Evaluate effectiveness of herbicide treatments	Herbicide treatments to reduce amount of curly-leaf pondweed	Determine most effective curly-leaf pond weed treatment	10	$4,000	yr	# of acres of CLPW treated
Evaluate the effectiveness of upland and internal load management and analyze data		Analyze the effectiveness of internal and external load management and make appropriate changes				Determine the effectiveness of the internal and external load management activities		$500	ea	Analysis applied

7.4 SSTS compliance

SSTS were identified as a source of phosphorus to Green Lake in the Rum River TMDL. Regular pumping of SSTS and the upgrade of failing systems is important for both nutrient and human health reasons. Annual inspections, in addition to regular maintenance, ensure that systems are functioning properly. It is estimated there are 175 SSTS including 11 failing systems in the watershed.

SSTS activities are described in Table 19. Planned SSTS replacement/upgrading will yield an estimated 4 lbs/yr P reduction, which is the recommended reduction identified by the *Green Lake Diagnostic Study (2019)*.

Table 19. SSTS practices, milestones, reductions, and assessment criteria for Green Lake

	Milestones/schedule					Goals	Estimated phosphorus reductions	Cost		Assessment criteria
Practice	**2-year**	**4-year**	**6-year**	**8-year**	**10-year**		**(lb/yr)**		**per unit**	
SSTS compliance			Conduct review of SSTS information: Compile database of existing information to verify SSTS non-compliance. Should include: year home built, lot size, most recent point of sale, age of SSTS, SSTS inspection records, review of pump maintenance records. See diagnostic study for details.	Determine compliance of SSTS-voluntary inspections	Update non-compliant SSTS	Upgrade 10 SSTS	4	10000 to 20000	SSTS	# of SSTS upgraded/replaced
Education/ Outreach		Provide educational materials regarding proper function and		Provide educational materials regarding proper function and		Provide educational materials regarding proper function and	NA	$1,000	yr	# of landowners reached

Commented [DT-NCM2]:
Commented [DT-NCM3R2]: Would county be willing to do this?

	Milestones/schedule					Goals	Estimated phosphorus reductions	Cost		Assessment criteria
Practice	**2-year**	**4-year**	**6-year**	**8-year**	**10-year**		**(lb/yr)**		**per unit**	
		maintenance of SSTS		maintenance of SSTS		maintenance of SSTS				

7.5 Near-shore restoration

Runoff from impervious, urban areas was identified as a source of phosphorus to Green Lake in the Rum River TMDL (MPCA 2017). Urban retrofit opportunities were identified in the Green Lake Subwatershed Retrofit Analysis (Isanti SWCD 2014). Reduction estimates and modeling scenarios were completed using WinSLAMM. Area described as urban is primarily lakeshore development, with some residential development outside that area. There is no MS4 permit in this area.

Poor lake shore habitat was identified as a stressor to the fish community in Green Lake (Borgstrom 2016). Locations along the Green Lake lakeshore were identified as candidates for restoration projects. Figure 25 identifies the good and highest priority locations for restoration based on a survey of shoreline conditions. The following activities were included in the Green Lake management plan (Green Lake Improvement District 2012):

- Fund and restore native vegetation to eroded and mowed sites around Green Lake
- Pursue surface water zoning in areas that are sensitive to shoreline erosion and/or habitat destruction.

It is expected that lake shore restoration activities will reduce the P loading to the lake and improve the aquatic habitat of the lake and improve the fishes bioassessments impairment.

Restoration of native vegetation will occur along the lakeshore and in the near-shore waters. Terrestrial native vegetation reduces runoff and P loading from lakeshore homes and lawns. It also improves bird and wildlife habitat. Aquatic native vegetation can provide some P uptake, but provides improved aquatic life habitat. The presence of native vegetation is a significant change in public perceptions prioritizing manicured green lawns to the shore and beaches without weeds. Restoration to native vegetation will require aquatic invasive species control. The partners will assess the improvement of the habitat at least twice over the next ten years (Table 22).

Near shore restoration activities are described in Table 20. Near shore estimated P reductions are 34 lbs/yr. The *Green Lake Diagnostic Study* does not provide a specific reduction for near shore lake activities.

Table 20. Nearshore projects with activities, milestones, goals, reductions, and assessment criteria

	Milestones/schedule					Long term goals greater than ten years	Estimated phosphorus reductions	Cost		Assessment criteria
Practice	**2-year**	**4-year**	**6-year**	**8-year**	**10-year**		**(lb/yr)**		**per unit**	
Nearshore Stormwater Retrofits: Bioretention, filtration, infiltration, erosion control, diversion, etc.	Identify appropriate BMPs and develop Design	Install Projects	Identify appropriate BMPs and develop Design	Install Projects	Identify appropriate BMPs and develop Design	Address all project options within the lakeshed.	23.4	$800,000	All Projects	# acres treated
Direct Contact Outreach	Landowner contacts (phone, knock, flyer, newsletter, etc.) to landowners within areas directly connected to Green Lake or tributaries	Landowner contacts (phone, knock, flyer, newsletter, etc.) to landowners within areas directly connected to Green Lake or tributaries	Landowner contacts (phone, knock, flyer, newsletter, etc.) to landowners within areas directly connected to Green Lake or tributaries	Landowner contacts (phone, knock, flyer, newsletter, etc.) to landowners within areas directly connected to Green Lake or tributaries	Landowner contacts (phone, knock, flyer, newsletter, etc.) to all landowners within the lakeshed	Develop partnership with our lake community and gain buy in. Market SWCD as a resource for landowners wanting to implement conservation.	NA	$1,000	year	# of landowners contacted # of interested landowners

	Milestones/schedule					Long term goals greater than ten years	Estimated phosphorus reductions	Cost		Assessment criteria
Practice	**2-year**	**4-year**	**6-year**	**8-year**	**10-year**		**(lb/yr)**		**per unit**	
Education	host 1 educational workshop with minimum 10 attendees	host 1 educational/Demonstration workshop with minimum 10 attendees	host 1 educational/Demonstration workshop with minimum 10 attendees	host 1 educational/Demonstration workshop with minimum 10 attendees	Assess effectiveness of workshop	Develop partnership with our lake community and gain buy in. Market SWCD as a resource for landowners wanting to implement conservation.	NA	$5,000	year	# of attendees, # of projects installed as a result of the workshops/demonstration
Social Media		Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Develop partnership with our lake community and gain buy in. Market SWCD as a resource for landowners wanting to implement conservation.	NA	$5,000	year	# of social media posts # of followers. # of landowners that contact the SWCD because of this platform.

	Milestones/schedule					Long term goals greater than ten years	Estimated phosphorus reductions	Cost		Assessment criteria
Practice	**2-year**	**4-year**	**6-year**	**8-year**	**10-year**		**(lb/yr)**		**per unit**	
Land Protection: Easements/ Purchases		Identify sensitive/high priority lands using: Metro Wildlife Corridor Focus areas, DNR Wildlife Action Network, Rum River Landscape Stewardship Plan RAQ Scores		Easements/Purchase Land (32 acres)	Easements/Purchase Land (32 acres)	Protect 250 acres.	8.9	$10,000	acre	# acres protected
Direct Contact Outreach		Landowner contacts (phone, knock, flyer, newsletter, etc.) to parcels using prioritization tools such as: Metro Wildlife Corridor Focus areas, DNR Wildlife Action Network Landscape Stewardship Plan RAQ scores,	Landowner contacts (phone, knock, flyer, newsletter, etc.) to parcels using prioritization tools such as: Metro Wildlife Corridor Focus areas, DNR Wildlife Action Network Landscape Stewardship Plan RAQ scores,	Landowner contacts (phone, knock, flyer, newsletter, etc.) to parcels using prioritization tools such as: Metro Wildlife Corridor Focus areas, DNR Wildlife Action Network Landscape Stewardship Plan RAQ scores,	Landowner contacts (phone, knock, flyer, newsletter, etc.) to parcels using prioritization tools such as: Metro Wildlife Corridor Focus areas, DNR Wildlife Action Network Landscape Stewardship Plan RAQ scores,	Develop partnership with Isanti community and gain buy in. Market SWCD as a resource for landowners wanting to implement conservation.	NA	$1,000	year	# of landowners contacted # of interested landowners
Education		Attend 1 Township and County Board Meeting to propose protection opportunities	Attend 1 Township and County Board Meeting to propose protection opportunities		Attend 1 Township and County Board Meeting and propose protection opportunities		NA	$2,000	year	# of acres put into easements or purchased

	Milestones/schedule					Long term goals greater than ten years	Estimated phosphorus reductions	Cost		Assessment criteria
Practice	2-year	4-year	6-year	8-year	10-year		(lb/yr)		per unit	
Social Media		Social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Continue social media outreach program: 24 social media posts.	Develop partnership with Isanti community and gain buy in. Market SWCD as a resource for landowners wanting to implement conservation.	NA	$5,000	year	# of social media posts # of followers. # of landowners that contact the SWCD because of this platform.

7.6 Statewide Mercury TMDL Implementation

Atmospheric deposition of mercury is uniform across the state and supplies more than 99.5% of the mercury getting into fish. Agency research has demonstrated that 70% of current mercury deposition in Minnesota comes from human sources and 30% from natural sources, such as volcanoes. There are no known natural sources in the state that emit mercury directly to the atmosphere.

The long-term goal of the mercury TMDL is for the fish to meet water quality standards; the approach for Minnesota's share is mass reductions from state mercury sources. This mercury TMDL establishes that there needs to be a 93% reduction in state emissions from 1990 for the state to meet its share. Water point sources will be required to stay below 1 percent of the total load to the state and all but the smallest dischargers will be required to develop mercury minimization plans. Air sources of mercury will have a 93% emission reduction goal.

Almost all the mercury in Minnesota's lakes and rivers is delivered by the atmosphere. Mercury can be carried great distances on wind currents before it is brought down to earth in rain and snow. About 90% of the mercury deposited on Minnesota comes from other states and countries. Similarly, the vast majority of Minnesota's mercury emissions are carried by wind to other states and countries. It's impossible for Minnesota to solve this problem alone; the United States and other countries must greatly reduce mercury releases from all sources.

Because mercury in runoff is derived from atmospheric deposition, mercury in stormwater is accounted for in the calculation of the atmospheric load. Separate strategies for reducing nonpoint sources are not included in this plan because implementation of the strategies in section 4 to reduce air deposition will ultimately reduce stormwater loading.

Any efforts to reduce soil erosion will tend to reduce mercury entering a lake or river from nonpoint water sources. Many of these practices are already employed for control of sediment and nutrient loading and will result in reducing mercury loading to surface waters.

7.7 PCB Remediation

In Minnesota, PCBs are subject to the Federal Toxic Substance Control Act Regulations administered by the EPA and the Minnesota Hazardous Waste Rules administered by the MPCA (MPCA 2013). This pollutant understanding is limited. The strategy for this pollutant will be to confirm the continued presence of PCBs in fish tissue, conduct source assessment, and develop a mitigation plan, if necessary.

Table 21 describes the expected costs, milestones, goals and assessment criteria for PCB remediation practices and activities.

Table 21. PCB activities

Management strategy or activity		Milestones/schedule					Goals	Estimated phosphorus reductions	Cost		Assessment criteria
	Practice	**2-year**	**4-year**	**6-year**	**8-year**	**10-year**		**(lb/yr)**		**per unit**	
PCBs	Tissue analysis				Redo tissue analysis and confirm PCB levels in fish		Fish tissue remains below maximum threshold		$5,000		# samples
	Remediation of source(s) of PCBs	Feasibility study on PCB removal/ containment	Plan developed for PCB removal/ containment	Implement plan (update milestones)	Implement plan (update milestones)	Plan completed and implementation milestones set for years 4, 6, and 8	< 0.22 mg/kg PCBs in fish tissue		$10,000		# samples

7.8 Reduction estimates

The combined P reductions for the practices described in Section 7 is 2,520 lb/yr. This exceeds the reduction required by the Green Lake TMDL and the recommended reductions of the Green Lake Diagnostic study. It is expected that if implemented fully, this plan will achieve the necessary reductions to achieve the P water quality standards for Green Lake in 10 years. The IBI impairment will improve based on the decreased nutrient loading and improved habitat via AIS control and shoreline restoration. The removal and management of aquatic invasive species will provide native plants a chance to thrive, thus increasing habitat. The stabilization of the shoreline with native vegetation and bioengineering stabilization practices.

8. Education and outreach

Information and education activities recommended for Green Lake in existing reports include:

- Develop an intensive education program for all property owners in the Green Lake watershed to learn about the potential impacts of their land use activities on the lake. Develop a mailing list and send a newsletter and other promotional materials.
- Provide information to property owners on the benefits of native vegetation to water quality of the lake and habitat.
- Educate Green Lake property owners on the impacts of altered shoreline and boat motors to aquatic vegetation in Green Lake.
- Provide information on workshops for design and management of rain gardens and benefits of no-mow lawns. Encourage attendance of lakeshore property owners.
- Provide information to property owners on proper care and maintenance of SSTS.
- State and other agencies should work with townships and others to coordinate educational and outreach activities.
- DNR review of the Low Impact Development management plan and coordinate DNR activities where applicable.
- Implemented the SWCDs Agricultural Outreach Plan.

9. Monitoring

Green Lake water quality monitoring by Isanti SWCD and the Green Lake Improvement District began in 2016 to monitor the health of Green Lake. The monitoring data collected through this effort helps get a better understanding of the factors driving high phosphorus levels in Green Lake and tracks trends and effectiveness of practices installed to reduce phosphorus loading to the lake. The lake and stream monitoring is described below.

Lake

Volunteers from the Green Lake Improvement District collect TP, chl-a, and transparency (Secchi disk) data every two weeks during the months of May through September. SWCD staff conduct profiles for dissolved oxygen, pH, conductivity and temperature data once a month in Green Lake from June through September. SWCD staff provide training, equipment, and coordinated lab testing for this effort. The monitoring data collected through this effort helps get a better understanding of the factors driving high phosphorus levels in Green Lake and tracks trends and effectiveness of practices installed to reduce phosphorus loading to the lake.

- In lake monitoring site (Figure 26) based on current schedule: three years monitoring and three years break or as deemed necessary. Sampling should occur once every two weeks May through October. Measurements should include Secchi transparency, TP and chl-*a*.
- Investigate internal load to the lake thought sediment core sampling
- Continue bi-weekly Citizen's Lake Monitoring Program Secchi transparency readings on Green Lake.

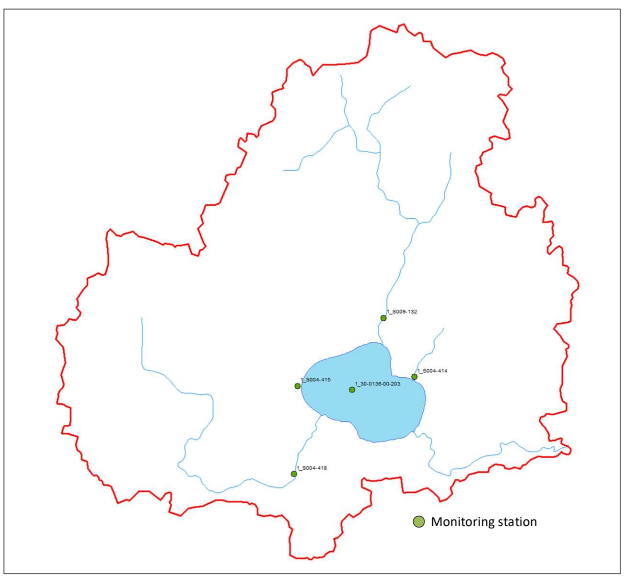


Figure 26. Monitoring sites in Green Lake Watershed

Streams

SWCD staff collected data from North Brook, Wyanett Creek, Bratlin Creek, and Old Judge's Ditch into Green Lake from 2015-2017 (Figure 26). Sampling was targeted to rain events and base flow. The samples were tested for TP, TSS, and transparency. Dissolved oxygen, temperature, conductivity, pH and water flow were also measured in the field. The data helped determine which tributary should be a higher priority for water quality projects.

Future monitoring plans include:

- Expand existing monitoring efforts along tributaries to include ortho-P and dissolved phosphorus parameters.
- Conduct longitudinal surveys (4-5 events) along North Brook and Wyanett Creek to evaluate changes in water quality from upstream to downstream and pinpoint potential problem areas. Surveys should target different times of year and flow conditions and include the following parameters: TSS, TP, ortho-P, DO, temperature, pH, and flow.
- Conduct outlet monitoring for North Brook and Wyanett Creek to measure pollutant loads entering Green Lake. Establish an upstream monitoring site on each stream to provide upstream/downstream paired water quality monitoring to evaluate the change in water quality due to BMP implementation. Parameters to be measured include TSS, TP, ortho-P, DO, temperature, pH, and flow.
- Conduct a walking survey of channel to assess sedimentation, channel conditions, hydrology, etc.
- Conduct a wetland vegetation assessment such as the rapid floristic quality assessment.

BMP implementation is tracked by the Board of Water and Soil Resources (BWSR) in its eLINK database for state-funded implementation and the United States Department of Agriculture for federally-funded implementation. Both agencies track the locations of BMP installations; however, reporting is generally limited to individual watersheds due to data privacy limits.

The estimated cost of the lake and stream monitoring is shown in Table 22.

Table 22. Estimated monitoring costs

Monitoring type	Description	Unit cost (annual)	Total (10-years)
Stream flow and water quality sampling and analysis	0.05 FTE for 4 sites	$5,000	$280,000
	0.05 FTE for data analysis	$5,000	
	Lab costs/4 site	$8,000	
	Equipment/2 outlet sites	$5,000/site	
Lake monitoring	0.01 FTE for 1 site	$1,000	$30,000
	Lab costs/1 site	$2,000	
Stream and lake habitat and vegetation surveys	0.05 FTE (2 times per 10-year period)	$5,000	$10,000
Total			**$320,000**

10. Financial and technical resources

Implementation of the Green Lake NKE will require additional financial and technical resources.

A list of existing funding sources available to support implementation is provided in Table 23.

Table 23. Partial list of funding sources for restoration and protection strategies

Sponsor or Information Source	Program Description
MPCA	**Section 319 Grants:** Federal grant funding from the EPA as part of the Clean Water Act, Section 319. Grants awarded by MPCA to local governmental units and other groups are to address NPS pollution through implementation projects. **Clean Water Partnership Loan**: The state funded Clean Water Partnership Program awards no-interest loans to local governmental units for work on projects that address nonpoint source pollution. **Clean Water State Revolving Fund:** The state revolving fund provides loans to for both point source (wastewater and stormwater) and nonpoint source water pollution control projects.
BWSR	**Clean Water Fund Competitive Grants:** These grants are to restore, protect, and enhance water quality. Eligible activities must be consistent with a comprehensive watershed management plan, county comprehensive local water management plan, soil and water conservation district comprehensive plan, metropolitan local water plan or metropolitan groundwater plan that has been State approved and locally adopted or an approved TMDL, WRAPS document, surface water intake plan, or well head protection plan. **The Erosion Control and Water Management Program**: commonly known as the State Cost-Share Program: This program provides funds to Soil and Water Conservation Districts to share the cost of systems or practices for erosion control, sedimentation control, or water quality improvements that are designed to protect and improve soil and water resources. Through this program, land occupiers can request financial and technical assistance from their local District for the implementation of conservation practices. **Watershed-based funding (1W1P):** Watershed-based funding is provided to watershed partnerships that have completed comprehensive watershed management plans under the 1W1P program or the Metropolitan Surface Water or Groundwater Management framework. The funding is an alternative to the traditional competitive grant processes often used to fund water quality improvement projects.
Minnesota Department of Agriculture (MDA)	**AgBMP Loan Program:** This program encourages implementation of BMPs that prevent or reduce pollution problems, such as runoff from feedlots, erosion from farm fields and shoreline, and noncompliant septic systems and wells. MDA provides a wide array of other information from their agency as well as other state and federal agencies on conservation programs addressing agriculture and other land uses. In addition, Clean Water Research Projects are available for funding.
Minnesota DNR	**DNR grants** are available for a variety of programs relating to land preservation, wildlife and habitat, native prairie, forestry and wetlands.
USDA NRCS	**Environmental Quality Incentives Program (EQIP):** EQIP is a voluntary program to implement conservation practices, or activities, such as conservation planning, that address natural resource concerns for agricultural producers. **Conservation Reserve Program – Continuous Signup:** This program is a USDA Farm Service Agency-funded voluntary program designed to help farmers restore and protect environmentally sensitive land—particularly wetlands, wildlife habitat and water quality buffers.

Sponsor or Information Source	Program Description
	Conservation Stewardship Program: Conservation Stewardship Program is a voluntary program to improve resource conditions such as soil quality, water quality, water quantity, air quality, habitat quality, and energy.

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Appendix A
WINSLAMM model assumptions

[insert pages of appendix B]

Appendix B.
Green Lake Subwatershed Retrofit Analysis for Areas Draining Directly to the Lake

[Insert PDF]

Appendix C
Green Lake Rural Stormwater Retrofit Analysis of North Brook and Wyanett Creek

[Insert PDF]

Appendix D
Green Lake Diagnostic Study October 2019

[Insert PDF]

Appendix E

Green Lake: Lake Status Report, Isanti County 2018

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Appendix F
Projects planned by subwatershed

The watershed partners have developed two subwatershed analysis that are attached in Appendices B and C. These projects are included in the implementation plan in Section 7; however, the following tables describe more precise targeting for the projects.

Table 24 describes the projects planned in the *Green Lake Subwatershed Retrofit Analysis for Areas Draining Directly to the Lake* report that can be referenced in its entirety in Appendix B.

Table 24. Summary of preferred stormwater opportunities, ranked by cost-effectiveness (*Green Lake Subwatershed Retrofit Analysis for Areas Draining Directly to the Lake*)

Retrofit Type (refer to catchment profile pages for additional detail)	Projects Identified	TP Reduction (lb/yr)	Total Project Cost	Estimated cost/ lb-TP (30-year)	Notes/Description
Rain gardens - Feldspar St	2	0.7	$29,550	$2,050	Pave gravel road that washes out into the lake, install 2 rain gardens.
Swale - public boat parking	1	0.3	$15,541	$2,060	Redirect boat landing runoff into the lakeshore swale.
Grass swale at bottom of Feldspar St (road not paved)	1	0.6	$22,472	$2,648	A grass swale at the water's edge of Feldspar St, which currently runs into the lake.
Land protection - 62 acres	1	8.9	$611,910	$2,966	Purchase fee title or an easement for property on SW side of the lake, currently for sale.
Lakeshore restoration - All 95 Candidate Sites	95	10.7	$437,770	$3,352	Restore all candidate lakeshore restoration sites, or some lesser amount. Offers habitat benefits in addition to water quality.
Lakeshore restoration - 15 High Priority Sites	15	1.6	$70,129	$3,505	Restore the 15 candidate lakeshores where active erosion and concentrated flow occur.
Permeable asphalt - 20% of Fedlspar St	1	0.7	$59,334	$4,254	Pave gravel road that washes out into the lake, including 20% permeable pavement.
Diversion to swale - Rhinestone St	1	0.1	$11,509	$4,836	Divert street runoff to roadside swale. Some diversion already occurs due to road crowning.
Permeable asphalt - 20% public boat parking	1	0.6	$61,884	$5,438	Install permeable asphalt on 20% of public boat landing parking.

Retrofit Type (refer to catchment profile pages for additional detail)	Projects Identified	TP Reduction (lb/yr)	Total Project Cost	Estimated cost/ lb-TP (30-year)	Notes/Description
Trench grate sediment traps - Feldspar St	1	0.4	$35,415	$5,535	Pave gravel road that washes out into the lake, including trench grate sediment traps.
Hydrodynamic device - Feldspar St	1	0.4	$41,014	$7,168	Pave gravel road that washes out into the lake, including commercial hydrodynamic separator.

Table 25 and Table 26 describes the projects planned in the *Green Lake Rural Stormwater Retrofit Analysis of North Brook and Wyanett Creek* report that can be referenced in its entirety in Appendix C. These projects are ranked by the cost per pound of TP removal. The projects and maps can be

Table 25. North Brook Watershed BMP ranking based on dollars per pound of TP removed

BMP characteristics				Cost-benefit		
Project Ranking	**Priority Zone**	**Sub-Basin**	**Applicable Practice**	**Practice Cost**	**P reduction (lb/yr)**	**$/lb TP**
1	4	2	Filter Strip	$ 173.55	$ 2.71	$ 64.04
2	4	1	Filter Strip	$ 224.91	$ 1.99	$ 113.02
3	1	2	Grassed Waterway	$ 3,148.83	$ 24.84	$ 126.76
4	1	1	Grassed Waterway	$ 1,666.33	$ 13.14	$ 126.81
5	6	2	Grassed Waterway	$ 895.43	$ 3.51	$ 255.11
6	1	14	Grassed Waterway	$ 539.63	$ 1.54	$ 350.41
7	3	2	Grassed Waterway	$ 978.45	$ 2.74	$ 357.10
8	7	3	Grassed Waterway	$ 1,476.57	$ 3.98	$ 371.00
9	3	3	Grassed Waterway	$ 806.48	$ 2.02	$ 399.25
10	1	5	Grassed Waterway	$ 824.27	$ 1.86	$ 443.16
11	1	4	Grassed Waterway	$ 1,197.86	$ 2.69	$ 445.30
12	1	8	Grassed Waterway	$ 1,891.67	$ 4.12	$ 459.14
13	2	2	Grassed Waterway	$ 2,223.75	$ 4.79	$ 464.25

BMP characteristics				Cost-benefit		
Project Ranking	Priority Zone	Sub-Basin	Applicable Practice	Practice Cost	P reduction (lb/yr)	$/lb TP
14	8	1	Grassed Waterway	$ 1,043.68	$ 2.23	$ 468.02
15	9	1	Grassed Waterway	$ 1,043.68	$ 2.23	$ 468.02
16	8	5	Grassed Waterway	$ 1,191.93	$ 2.51	$ 474.87
17	1	9	Grassed Waterway	$ 1,553.66	$ 3.19	$ 487.04
18	7	4	Grassed Waterway	$ 1,571.45	$ 2.58	$ 609.09
19	1	12	Grassed Waterway	$ 1,476.57	$ 2.42	$ 610.15
20	7	1	Grassed Waterway	$ 646.37	$ 1.05	$ 615.59
21	7	5	Grassed Waterway	$ 2,496.53	$ 4.02	$ 621.03
22	9	3	Grassed Waterway	$ 1,856.09	$ 2.97	$ 624.95
23	9	2	Grassed Waterway	$ 2,069.57	$ 3.31	$ 625.25
24	8	6	Grassed Waterway	$ 604.86	$ 0.96	$ 630.06
25	7	2	Grassed Waterway	$ 978.45	$ 1.53	$ 639.51
26	9	4	Grassed Waterway	$ 2,336.42	$ 3.62	$ 645.42
27	3	1	Grassed Waterway	$ 907.29	$ 1.29	$ 703.33
28	3	6	Grassed Waterway	$ 1,387.62	$ 1.97	$ 704.38
29	3	5	Grassed Waterway	$ 670.09	$ 0.95	$ 705.36
30	3	4	Grassed Waterway	$ 2,621.06	$ 3.48	$ 753.18
31	8	4	WASCOB	$ 17,548.62	$ 7.69	$ 2,282.01
32	8	2	WASCOB	$ 26,469.99	$ 9.18	$ 2,883.44
33	4	3	Grassed Waterway	$ 1,601.10	$ 0.52	$ 3,079.04
34	1	13	WASCOB	$ 17,058.44	$ 4.92	$ 3,467.16
35	8	3	WASCOB	$ 31,567.91	$ 6.53	$ 4,834.29

BMP characteristics				Cost-benefit		
Project Ranking	Priority Zone	Sub-Basin	Applicable Practice	Practice Cost	P reduction (lb/yr)	$/lb TP
36	6	3	WASCOB	$ 35,097.25	$ 3.86	$ 9,092.55
37	1	3	WASCOB	$ 46,763.65	$ 5.00	$ 9,352.73
38	9	5	WASCOB	$ 50,391.02	$ 3.80	$ 13,260.79

Table 26. Wyanett Creek Watershed BMP ranking based on dollars per pound of TP removed

Project Ranking	Priority Zone	Sub-Basin	Applicable Practice	Practice Cost	P reduction (lb/yr)	$ per lb TP Removed
24	4	6	Grassed Waterway	$ 2,217.82	$ 10.86	$ 204.22
30	5	2	Grassed Waterway	$ 2,140.73	$ 8.09	$ 264.61
37	7	3	Grassed Waterway	$ 1,310.53	$ 4.46	$ 293.84
42	8	4	Grassed Waterway	$ 1,719.70	$ 5.81	$ 295.99
20	4	3	Grassed Waterway	$ 990.31	$ 3.16	$ 313.39
44	8	6	Grassed Waterway	$ 1,701.91	$ 5.32	$ 319.91
41	8	3	Grassed Waterway	$ 2,057.71	$ 6.08	$ 338.44
39	8	1	Grassed Waterway	$ 1,856.09	$ 5.39	$ 344.36
11	3	6	Grassed Waterway	$ 1,061.47	$ 2.81	$ 377.75
29	5	1	Grassed Waterway	$ 776.83	$ 2.03	$ 382.67
45	8	7	Grassed Waterway	$ 2,158.52	$ 5.45	$ 396.06
8	3	3	Grassed Waterway	$ 889.50	$ 2.23	$ 398.88
40	8	2	Grassed Waterway	$ 2,235.61	$ 5.45	$ 410.20
17	3	12	Grassed Waterway	$ 2,793.03	$ 6.57	$ 425.12
18	4	1	Grassed Waterway	$ 2,567.69	$ 5.95	$ 431.54

Project Ranking	Priority Zone	Sub-Basin	Applicable Practice	Practice Cost	P reduction (lb/yr)	$ per lb TP Removed
14	3	9	Filter Strip	$ 135.60	$ 0.31	$ 437.42
13	3	8	Filter Strip	$ 447.48	$ 1.02	$ 438.71
12	3	7	Filter Strip	$ 440.70	$ 1.00	$ 440.70
36	7	2	Grassed Waterway	$ 2,235.61	$ 4.96	$ 450.73
28	4	10	Grassed Waterway	$ 1,743.42	$ 3.80	$ 458.79
26	4	8	Grassed Waterway	$ 1,950.97	$ 4.25	$ 459.05
27	4	9	Grassed Waterway	$ 1,915.39	$ 4.17	$ 459.33
31	6	1	Grassed Waterway	$ 1,197.86	$ 2.51	$ 477.24
35	7	1	Grassed Waterway	$ 1,197.86	$ 2.51	$ 477.24
15	3	10	Grassed Waterway	$ 1,802.72	$ 3.48	$ 518.02
33	6	3	Grassed Waterway	$ 1,310.53	$ 2.49	$ 526.32
10	3	5	Grassed Waterway	$ 1,014.03	$ 1.76	$ 576.15
2	1	2	Grassed Waterway	$ 1,535.87	$ 2.56	$ 599.95
1	1	1	Grassed Waterway	$ 1,862.02	$ 3.10	$ 600.65
25	4	7	Grassed Waterway	$ 1,209.72	$ 2.00	$ 604.86
4	2	1	Grassed Waterway	$ 2,318.63	$ 3.66	$ 633.51
32	6	2	Grassed Waterway	$ 2,235.61	$ 3.51	$ 636.93
3	1	3	Grassed Waterway	$ 1,470.64	$ 2.28	$ 645.02
43	8	5	Filter Strip	$ 716.76	$ 0.67	$ 1,069.79
9	3	4	Filter Strip	$ 484.06	$ 0.45	$ 1,075.70
46	8	8	Filter Strip	$ 350.98	$ 0.28	$ 1,253.52
21	4	3	Filter Strip	$ 207.79	$ 0.16	$ 1,298.68

Project Ranking	Priority Zone	Sub-Basin	Applicable Practice	Practice Cost	P reduction (lb/yr)	$ per lb TP Removed
23	4	5	Filter Strip	$ 211.68	$ 0.16	$ 1,323.00
22	4	4	Filter Strip	$ 174.33	$ 0.13	$ 1,340.96
7	3	2	WASCOB	$ 12,646.77	$ 8.99	$ 1,406.76
6	3	1	WASCOB	$ 37,254.06	$ 7.93	$ 4,697.86
16	3	11	WASCOB	$ 57,743.79	$ 4.75	$ 12,156.59
19	4	2	WASCOB	$ 68,625.90	$ 4.69	$ 14,632.39