RILEY
PURGATORY
BLUFF CREEK
WATERSHED DISTRICT

Water Resources Report

RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT
2018 ANNUAL REPORT

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Executive Summary

The Riley Purgatory Bluff Creek Watershed District (RPBCWD) had a successful water quality sampling season in 2018, completing a full year of sample collection and data analysis. This effort was made possible through multiple partnerships with municipalities and organizations based within the watershed. The results from the 2018 sampling effort are presented in this report.

2018 LAKE SUMMARY

During the 2018 monitoring season, 13 lakes and one high value wetland (Lake Idlewild) were monitored throughout the District. Regular water quality lake sampling was conducted on each lake approximately every two weeks throughout the growing season (June-September). In addition to regular lake sampling, the District monitored water levels on all waterbodies, assessed carp populations within the Riley and Purgatory Chain of Lakes, and assessed zooplankton and phytoplankton populations in five lakes. Staff were able to remove 1,901 common carp from the Purgatory Creek Recreation Area during the spring spawning run which reduced overall carp numbers in the system. The District also monitored public access points and analyzed water samples for the presence of zebra mussels in these 14 waterbodies. Unfortunately, zebra mussels were found on Lake Riley, which is the first lake within the District to become infested. Successful alum treatments occurred on Lotus Lake, Round Lake, and Rice Marsh Lake in 2018. Herbicide treatments for curly leaf pondweed were conducted on Lotus Lake, Lake Susan, Mitchell Lake, Red Rock Lake, Staring Lake, and Lake Riley.

Surface water samples were collected, analyzed, and compared to standards set by the Minnesota Pollution Control Agency (MPCA) to assess overall lake health. Figure 1 displays lakes sampled in 2018 that met or exceeded the MPCA lake water quality standards for Chlorophyll-a (Chl-a), Total Phosphorus (TP), and Secchi Disk depth during the growing season (June-September). The MPCA has specific standards for both ‘deep' lakes (Lake Ann, Lotus Lake, Lake Riley, and Round Lake) and ‘shallow' lakes (Duck Lake, Hyland Lake, Lake Idlewild, Lake Lucy, Mitchell Lake, Red Rock Lake, Rice Marsh Lake, Staring Lake, Lake Susan, and Silver Lake) (MPCA 2016). Lake Ann, Lake Idlewild, Lake Riley, Round Lake, Duck Lake, and Silver Lake met all three MPCA standards in 2018; Round (TP), Riley (Chl-a), Duck (TP), and Silver (Chl-a) did not previously meet all standards in 2017. This is the first time since data has been collected that Lake Riley and Silver Lake met all water quality standards. Lotus Lake, Red Rock, Rice Marsh, and Lake Susan all exceeded both the Chl-a and TP standards in 2018. Similar to 2017, Hyland did not meet all three standards in 2018. Mitchell Lake also did not meet all water quality standards due to the declined summer secchi disk average. Both Red Rock and Rice Marsh Lake declined in water quality as both

Chl-a and TP summer averages increased. All lakes met the nitrate/nitrite water quality standard and only Lake Idlewild did not meet the chloride standard.

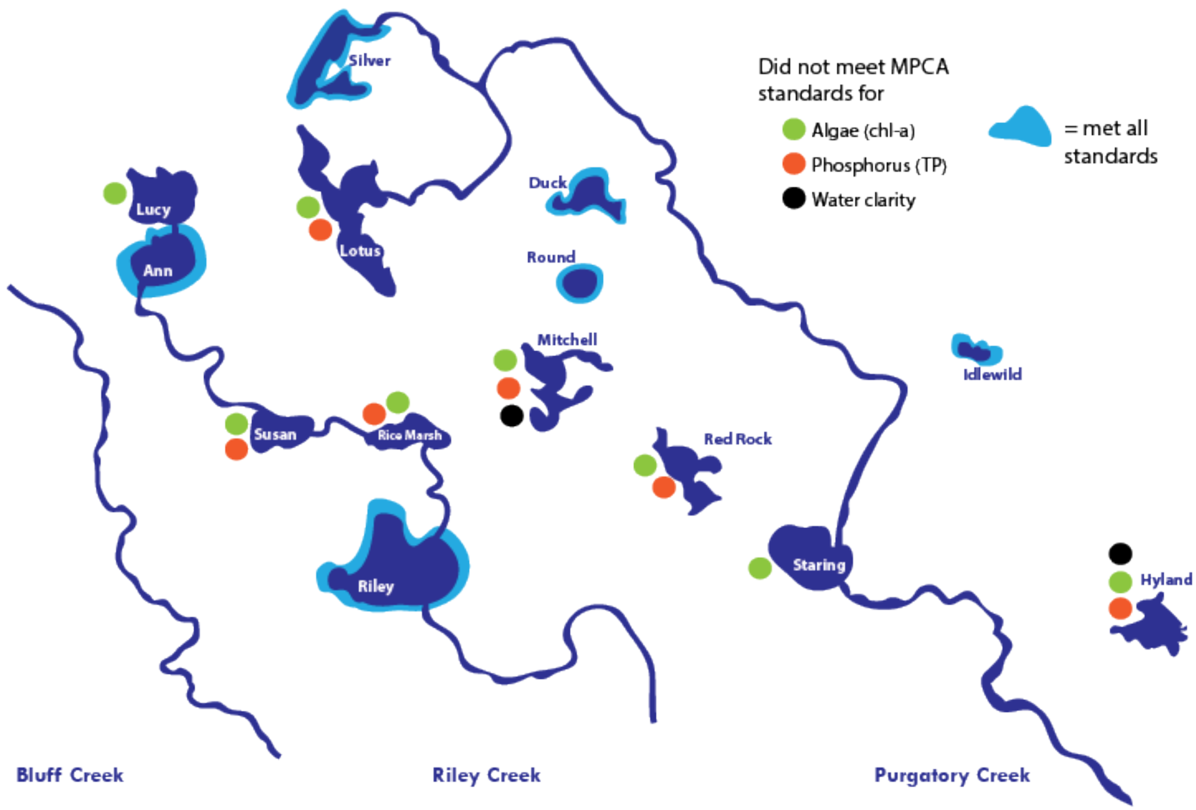


Figure 1   2018 Lake Water Quality

Summary of the lake water quality data collected in 2018 by the Riley Purgatory Bluff Creek Watershed District as compared to the Minnesota Pollution Control Agency Water Quality Standards. Chlorophyll-a (green), Total Phosphorus (orange), and Secchi Disk depth (black) were assessed during the growing season (June-September) for both 'deep' lakes or lakes >15 ft deep and < 80% littoral area (Lake Ann, Lotus Lake, Lake Riley, and Round Lake), and 'shallow' lakes or lakes <15 ft deep and >80% littoral area (Duck Lake, Hyland Lake, Lake Idlewild, Lake Lucy, Mitchell Lake, Red Rock Lake, Rice Marsh Lake, Staring Lake, Lake Susan, and Silver Lake). The corresponding dots next to each lake indicate which water quality standard was not met and lakes surrounded by blue met all water quality standards.

2018 STREAM SUMMARY

In 2018, the District collected water quality samples and performed data analysis on 21 different sampling sites along Riley Creek (six sites), Bluff Creek (five sites), and Purgatory Creek (ten sites). During the 2018 creek monitoring season (April-September) water chemistry and turbidity were regularly measured at the 18-regular water quality monitoring sites every two weeks. Water samples were collected to assess nutrient (TP and Chl-a) and total suspended sediment (TSS) concentrations. Creek flow was calculated from velocity measurements taken at consistent creek cross sections at each water quality monitoring location. The District collected macroinvertebrates at all five Riley Creek regular water quality sites in 2018. Sections of Purgatory Creek were walked and assessed using the Creek Restoration Action Strategy (CRAS) evaluation, which identifies stream reaches in the most need of restoration. Staff walked two new reaches during these evaluations. Overall, the 2018 CRAS scores of subreaches previously walked remained very similar to past scores. The two tributary streams not previously walked were determined to be in good to moderate condition. In 2018, the CRAS was published in the Water Science Bulletin of the Center for Watershed Protection.

The summary for all three creeks is based on water quality parameters developed by the MPCA in 2014 for Eutrophication and TSS. The parameters measured during the summer growing season (April-September) and the associated MPCA water quality limits for streams located in the Central River Region include: Dissolved Oxygen (DO) daily minimum > 4mg/L, summer season average TP < 0.1mg/L, TSS < 10% exceedance of 30mg/L limit during the summer season, summer season average Chl-a <18ug/L, and summer season average pH < 9su and >6su (MPCA, 2016).

P3 was the only regular creek sampling site to meet all MPCA water quality standards in 2018 (Figure 2). The overall number of water quality standard impairments increased from 2017 to 2018; Bluff had 10, Riley had seven, and Purgatory had nine (previously ten, two and seven, respectively). Bluff Creek remained the stream with the most impaired water quality, as previously seen in 2015, 2016, and 2017, with TP impairments at all sites, as well as TSS impairments at three sites, a DO impairment at B5, and a fish impairment at B1. Once again, TP was the water quality standard most impaired in 2018 with 10 of the 18 sites not meeting the standard (summer average <0.1 mg/L). TSS impairments increased from five impairments in 2017 to nine in 2018. The dissolved oxygen standard (daily minimum of 4mg/L) was impaired across five stream sites. All sites met the pH water quality standard (< 9su and >6su). Similar to 2016 and 2017, P2 was the only site which did not meet the Chl-a standard (summer average <18ug/L).

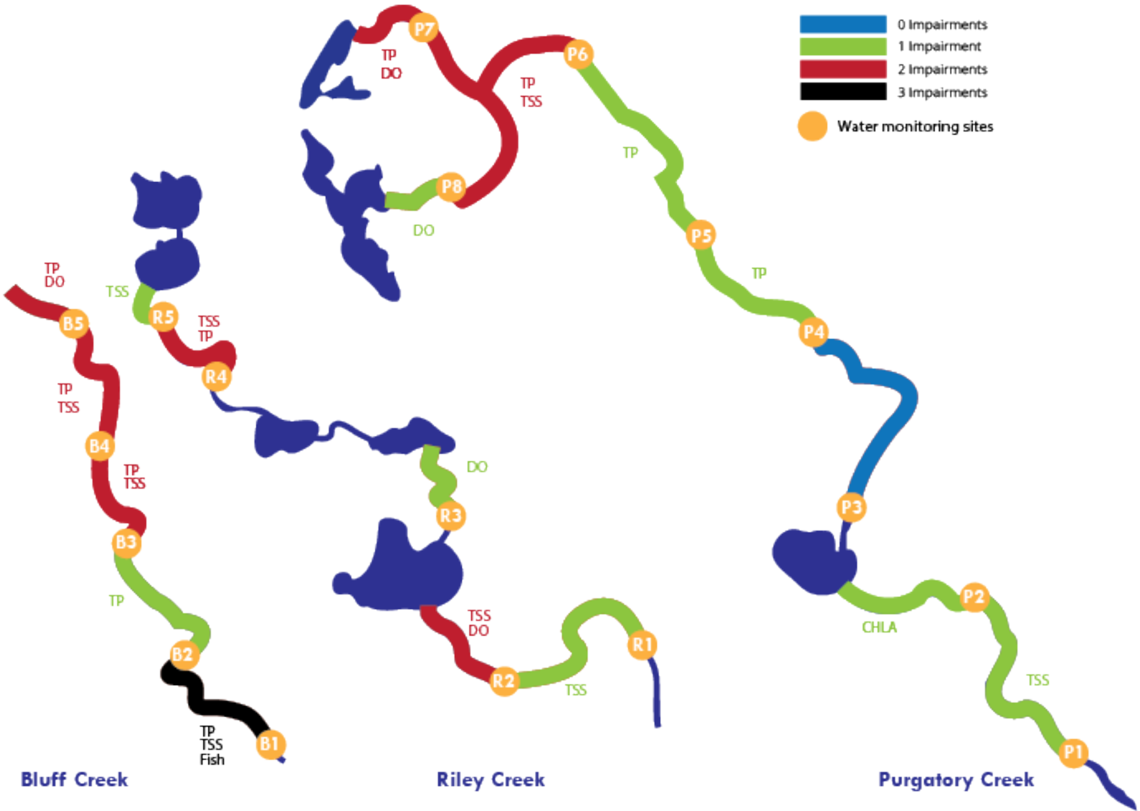


Figure 2   2018 Stream Water Quality

Summary of stream water quality data collected on Bluff Creek, Riley Creek, and Purgatory Creek in 2018 by the Riley Purgatory Bluff Creek Watershed District as compared to the Minnesota Pollution Control Agency (MPCA) Water Quality Standards. A total of 18 water monitoring locations (orange circles) were sampled and information gathered from the individual sites were applied upstream to the next monitoring location. The summer season (April-September) eutrophication and total suspended solids water quality standards used in this assessment included: Dissolved Oxygen (DO) daily minimum > 4mg/L, average Total Phosphorus (TP) < 0.1mg/L, Total Suspended Solids (TSS) < 10% exceedance of 30mg/L limit, average Chlorophyll-a (CHLA) <18ug/L, average pH < 9su and > 6su. The corresponding labels next to each stream section indicate which water quality standard were not met.

Table of Contents

Executive Summary i
List of Tables 3
List of Exhibits 3
Acronyms & Abbreviations 4
1 Introduction and Overview 6
2 Methods 8
2.1 Water Quality Sampling 9
2.2 Analytical Laboratory Methods 10
3 Water Quality Standards 11
3.1 Lakes 11
3.2 Streams 12
4 Water Quality Data Collection 14
4.1 2018 Lakes Water Quality Summary 14
4.2 Alum Treatments 16
4.3 Lake Water Levels 18
4.4 Powers Blvd Riley Creek Crossing 20
4.5 Creek Restoration Action Strategy 22
4.6 Chloride Monitoring 27
4.7 Nitrate Monitoring 29
4.8 Zooplankton and Phytoplankton 31
4.9 Winterkills and Fish Stocking 40
4.10 Lake Susan Spent-Lime Treatment System 42
4.11 Rice Marsh Lake Stormwater Inputs 44
4.12 EnviroDIY 47
4.13 Wetland Inventory 49
5 Aquatic Invasive Species 50
5.1 AIS Management 50
5.2 Aquatic Plant Management 51
5.3 Common Carp Management 56
5.4 Zebra Mussel Detection in Lake Riley 59
6 Lake and Creek Fact Sheets 63
7 References 64
8 Exhibits i

List of Figures

Figure 1 2018 Lake Water Quality ii
Figure 2 2018 Stream Water Quality iv
Figure 1-1 Riley Purgatory Bluff Creek Watershed District Boundary 6
Figure 4-1 2018 Lake Growing Season Mean Chlorophyll-a 14
Figure 4-2 2018 Lakes Growing Season Mean Total Phosphorus 15
Figure 4-3 2018 Lakes Growing Season Mean Secchi Disk Depth 16
Figure 4-4 Lake Riley Total Phosphorus Levels pre- and post- Alum Treatment 17
Figure 4-5 2017 and 2018 Upper Riley Creek Total Suspended Solids 21
Figure 4-6 2017 and 2018 Upper Riley Creek Phosphorus 21
Figure 4-7 2013-2018 Chloride Levels within the Purgatory Chain of Lakes 28
Figure 4-8 2013-2018 Chloride Levels within the Riley Chain of Lakes 28
Figure 4-9 2013-2018 Chloride Levels within Stormwater Ponds 28
Figure 4-10 2018 Lakes Summer Average Ammonia+ Ammonium 30
Figure 4-11 2018 Lake Riley Zooplankton Counts (#/m²) 32
Figure 4-12 2018 Lake Riley Epilimnetic Grazing Rates 32
Figure 4-13 2018 Lake Riley Phytoplankton Abundance (#/L) by Class. 33
Figure 4-14 2018 Lotus Lake Zooplankton Counts (#/m²) 33
Figure 4-15 2018 Lotus Lake Epilimnetic Grazing Rates 34
Figure 4-16 2018 Lotus Lake Phytoplankton Abundance (#/L) by Class. 34
Figure 4-17 2018 Lake Susan Zooplankton Counts (#/m²) 35
Figure 4-18 2018 Lake Susan Epilimnetic Grazing Rates 35
Figure 4-19 2018 Lake Susan Phytoplankton Abundance (#/L) by Class. 36
Figure 4-20 2018 Rice Marsh Lake Zooplankton Counts (#/m²) 36
Figure 4-21 2018 Rice Marsh Lake Epilimnetic Grazing Rates 37
Figure 4-22 2018 Rice Marsh Lake Phytoplankton Abundance (#/L) by Class. 37
Figure 4-23 2018 Staring Lake Zooplankton Counts (#/m²) 38
Figure 4-24 2018 Staring Lake Grazing Rates 38
Figure 4-25 2018 Staring Lake Phytoplankton Abundance (#/L) by Class. 39
Figure 4-26 Duck Lake and Rice Marsh Lake Dissolved Oxygen Levels in March 2018 40
Figure 4-27 2018 Bluegill Stocking Rates 41
Figure 4-28 Spent Lime Treatment System 42
Figure 4-29 2017 and 2018 Stormwater Phosphorus Inputs to Rice Marsh Lake 45
Figure 4-30 2017 and 2018 Stormwater Pond Phosphorus Inputs to Rice Marsh Lake 45
Figure 4-31 2017 and 2018 Stormwater Total Suspended Solids Input to Rice Marsh Lake 46
Figure 4-32 2017 and 2018 Stormwater Pond Total Suspended Solids Inputs to Rice Marsh Lake 46
Figure 4-33 EnviroDIY Water Monitoring Stations 48
Figure 4-34 Sundew plants found in local wetland. 49
Figure 5-1 2018 Aquatic Invasive Species Sampling 50
Figure 5-2 2018 Staring Lake Eurasian Watermilfoil Surveys and Removal Areas 52
Figure 5-3 2017 Lotus Lake Brittle Naiad Treatment Areas 53
Figure 5-4 2018 Lotus Lake brittle naiad map. 54
Figure 5-5 2017 Lake Ann Brittle Naiad Discovery and Treatment Map. 55
Figure 5-6 2018 Lake Ann Brittle Naiad Assessment Map. 56
Figure 5-7 Purgatory Chain of Lakes Common Carp Biomass Estimates 57
Figure 5-8 Large floating trap net deployed in Purgatory Creek. 58
Figure 5-9 2018 Size Structure of Common Carp Removed from the Purgatory Creek Rec Area. 58
Figure 5-10 Purgatory Creek Recreational Area Common Carp removal vs Environmental Variables 59
Figure 5-11 Zebra mussels found in Lake Riley. 60
Figure 5-12 Zebra Mussel Assessment Map on Lake Riley. 61

List of Tables

Table 1-1 District Water Resource Sampling Partnerships 6
Table 1-2 RPBCWD Monthly Field Data Collection Locations 7
Table 2-1 Sampling Parameters 8
Table 2-2 Basic Water Quality Monitoring Activities 9
Table 2-3 RMB Environmental Laboratories Parameters and Methods Used for Analyses 10
Table 3-1 MPCA Water Quality Standards for Shallow and Deep Lakes 12
Table 3-2 MPCA Water Quality Standards for Streams 12
Table 4-1 Lake Water Levels Summary 19
Table 4-2 2018 Powers Blvd Riley Creek Crossing Nutrient Summary 20
Table 4-3 Severe Reaches Identified by the Creek Restoration Action Strategy 22
Table 4-4 2018 Creek Restoration Action Strategy Updates 24
Table 4-5 2017-2018 Bank Pin Data 25
Table 4-6 2018 Lakes Summer Average Nitrate+Nitrite 29
Table 5-1 Aquatic Invasive Species Infested Lakes 51
Table 5-2 2018 Common Carp Biomass Estimates for the Purgatory Chain of Lakes 58
Table 5-3 Lake Riley Suitability for Zebra Mussels 61

List of Exhibits

Exhibit A Lake Water Levels
Exhibit B Fyke Net Data
Exhibit C Zooplankton Summary Data
Exhibit D Phytoplankton Summary Data
Exhibit E Creek Walk Summaries
Exhibit F Lake and Creek Fact Sheets

Acronyms & Abbreviations

ac	Acre
BMP	Best Management Practice
cBOD	5-day Carbonaceous Biochemical Oxygen Demand
cf	Cubic feet
cfs	Cubic feet per second
Chl-a	Chlorophyll-a
Cl	Chloride
CRAS	Creek Restoration Action Strategy
CS	Chronic Standard
DO	Dissolved Oxygen
E. coli	*Escherichia coli*
EPA	Environmental Protection Agency
EWM	Eurasian Watermilfoil
ft	Foot/Feet
FWSS	Freshwater Scientific Services
GPS	Global Positioning System
ha	Hectare
IBI	Index of Biological Integrity
in	Inch
kg	Kilogram
L	Liter
lb	Pound
m	Meter
MCWD	Minnehaha Creek Watershed District
METC	Metropolitan Council
mg	Milligram
mL	Milliliter
MNDNR	Minnesota Department of Natural Resources
MnDOT	Minnesota Department of Transportation
MPCA	Minnesota Pollution Control Agency
MS	Maximum Standard
MS4	Municipal Separate Storm Sewer System
NA	Not Available
NCHF	North Central Hardwood Forest
NH_3	Ammonia
NO_2	Nitrite
NO_3	Nitrate
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
OHWL	Ordinary High-Water Level
ORP	Oxidation Reduction Potential
Ortho-P	Ortho-Phosphate
PAR	Photosynthetic Active Radiation
PCL	Purgatory Chain of Lakes
RCL	Riley Chain of Lakes
RPBCWD/District	Riley Purgatory Bluff Creek Watershed District
sec	Second
SRP	Soluble Reactive Phosphorus
TDP	Total Dissolved Phosphorus
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TMDL	Total Maximum Daily Load
TPA	Total Phytoplankton Abundance
TP	Total Phosphorus
TSS	Total Suspended Solids

UAA	Use and Attainability Assessment
UMN	University of Minnesota-St. Paul Campus
WD	Watershed District
WIDNR	Wisconsin DNR
WMO	Watershed Management Organization
YOY	Young of Year

1 Introduction and Overview

The Riley Purgatory Bluff Creek Watershed District was established on July 31st, 1969, by the Minnesota Water Resources Board acting under the authority of the watershed law. The District is located in the southwestern portion of the Twin Cities Metropolitan Area. It consists of a largely developed urban landscape and encompasses portions of Bloomington, Chanhassen, Chaska, Deephaven, Eden Prairie, Minnetonka, and Shorewood (Figure 1-1). This total area for the watershed is close to 50 square miles located in both Hennepin and Carver Counties and includes three smaller subwatersheds: Riley Creek Watershed, Purgatory Creek Watershed, and Bluff Creek Watershed.

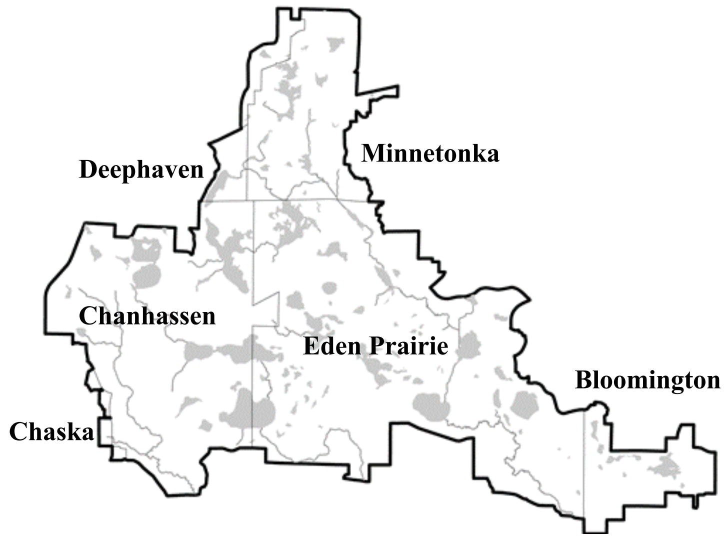


Figure 1-1 Riley Purgatory Bluff Creek Watershed District Boundary

Data collection and reporting are the foundation for the RPBCWD's work. Regular, detailed water quality monitoring provides the District with scientifically reliable information that is needed to decide if water improvement projects are needed and how effective they are in the watershed. Data collection remains a key component of the District's work as we strive to de-list, protect, and improve the water bodies within the watershed. The purpose of this report is to summarize the water quality and quantity results collected over the past year, which can be used to direct the District in managing our water resources.

Table 1-1 District Water Resource Sampling Partnerships

Water Resource	RPBCWD	Three Rivers Park District	EP	UMN	METC
Duck Lake	■				
Hyland Lake	■	■			
Lake Ann	■				
Lake Idlewild	■		■		
Lake Lucy	■				
Lake Riley	■			■	
Lake Susan	■			■	
Lotus Lake	■				
Mitchell Lake	■		■	■	
Red Rock Lake	■		■		
Rice Marsh Lake	■				
Round Lake	■		■		
Silver Lake	■				
Staring Lake	■			■	
Bluff Creek	■				■
Purgatory Creek	■				■
Riley Creek	■		■		■

Through partnerships with the cities of Chanhassen and Eden Prairie (EP), Three Rivers Park District, the University of Minnesota (UMN), and the Metropolitan Council (METC), water quality data was collected on 13 lakes, one high value wetland (Lake Idlewild), and 23 creek sites in the District. The 22 creek sites include six on Bluff Creek, six on Riley Creek, and eleven on Purgatory Creek. Lake McCoy and Neil Lake, which are within the watershed boundaries, have not been part of the District's sampling regime. Each partner was responsible for monitoring certain parameters of their respective lakes/streams and reporting their findings, allowing for more time and attention to be given to each individual water resource (Table 1-1).

Water quality and water quantity was monitored at each stream site during the field season (April-September) approximately twice a month. The METC also has continuous monitoring stations near the outlet of each creek as part of its long-term monitoring program which identifies pollutant loads entering the Minnesota River. In addition to water quality monitoring, creek walks were also conducted to gather more information about the current stream conditions in the District. This information was included in the Creek Restoration Action Strategy (CRAS), which was developed by the District to identify and prioritize future stream restoration sites (Section 4.5). Bank pin data was also collected near each of the water quality monitoring sites to measure generalized sedimentation and erosion rates across all three streams. Macroinvertebrates were collected at all Riley Creek water quality sites in September and will be rotating through each stream moving forward.

Lakes were also monitored bi-weekly during the summer growing season (June-September) for water quality. Lake levels were continuously recorded from ice out to ice in. Lake water samples were also collected in early summer and analyzed for the presence of zebra mussel veligers. Additionally, during every sampling event, boat launch areas and zebra mussel monitoring plates were scanned for adult zebra mussels. Zooplankton and phytoplankton samples were also collected on five lakes to assess the overall health of the population as it applies to fishery health and water quality. Plant surveys and herbicide treatments were also conducted to assess overall health of the plant community and to search/treat for invasive plants. Common Carp have also been identified as being detrimental to lake health and are continually monitored by the District. Winter monitoring occurred on the Riley Chain of Lakes (Lucy, Ann, Susan, Rice Marsh, and Riley), as well as four separate stormwater ponds in 2018. Extending the monitoring activities into the winter months can provide key insights into ways to improve water quality during the summer months. Winter monitoring also allows us to evaluate the influence of chloride levels in our lakes. The data collection and reporting events were tracked throughout the year and can be seen in Table 1-2. Data was not collected in November and December due to unsafe ice conditions. In addition to lakes and streams, multiple stormwater ponds and other specialty projects were monitored to evaluate their effectiveness or contributing pollutant loads to the watershed.

Table 1-2 RPBCWD Monthly Field Data Collection Locations

Water Resource	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lake Ann	■	■	■	■	■	■	■	■	■	■		
Duck Lake				■	■	■	■	■	■	■		
Hyland Lake												
Lake Idlewild				■	■	■	■	■	■	■		
Lotus Lake				■	■	■	■	■	■	■		
Lake Lucy	■	■	■	■	■	■	■	■	■	■		
Mitchell Lake				■	■	■	■	■	■	■		
Red Rock Lake				■	■	■	■	■	■	■		
Rice Marsh Lake	■	■	■	■	■	■	■	■	■	■		
Round Lake												
Lake Riley	■	■	■	■	■	■	■	■	■	■		
Staring Lake				■	■	■	■	■	■	■		
Lake Susan	■	■	■	■	■	■	■	■	■	■		
Silver Lake				■	■	■	■	■	■	■		
Bluff Creek **(5 sites)**				■	■	■	■	■	■	■		
Purgatory Creek **(8 sites)**				■	■	■	■	■	■	■		
Riley Creek **(5 sites)**				■	■	■	■	■	■	■		

*Water Level Sensors were placed on all lakes.

2 Methods

Water quality and quantity monitoring entails the collection of multi-probe sonde data readings, water samples, zooplankton samples, phytoplankton samples, macroinvertebrate samples, zebra mussel veliger samples, and physical readings, as well as recording the general site and climactic conditions at the time of sampling. Listed in the following sections are the methods and materials, for both lake and stream monitoring, used to gather the water quality and quantity data during the 2018 field-monitoring season. Table 2-1 identifies many of the different chemical, physical, and biological variables analyzed to assess overall water quality.

Table 2-1 Sampling Parameters

Parameter	Analysis	Summer Lakes	Winter Lakes	Streams	Reason for Monitoring
Total Phosphorus	Wet	■	■	■	Nutrient, phosphorus (P) controls algae growth
Orthophosphate	Wet	■	■	■	Nutrient, form of P available to algae
Chlorophyll-a, pheophytin	Wet	Surface	Surface	■	Measure of algae concentration
Ammonia as N	Wet	■	■		Nutrient, form of nitrogen (N) available to algae
Nitrate + Nitrite as N	Wet	■	■		Nutrient, also oxygen substitute for bacteria
Total Alkalinity, adjusted	Wet	Surface	Surface		Measure of ability to resist drop in pH
Total Suspended Solids	Wet			■	Measure of the solids in water (block light)
Chloride	Wet	■	■	■	Measure of chloride ions, salts in water
Temperature	Sonde	■	■	■	Impacts biological and chemical activity in water
pH	Sonde	■	■	■	Impact chemical reactions (acidic or basic)
Conductivity	Sonde	■	■	■	Ability to carry an electrical current (TSS & Cl)
Dissolved Oxygen	Sonde	■	■	■	Oxygen for aquatic organisms to live
Macroinvertebrates	Wet			■	Organisms fluctuate due to environmental variables
Oxidation Reduction Potential	Sonde	■	■	■	Tracks chemistry in low or no oxygen conditions
Phycocyanin	Sonde	■	■		Pigment, measures cyanobacteria concentration
Phytoplankton	Wet	■			Organisms fluctuate due to environmental variables
Photosynthetic Active Radiation	Sonde	■	■		Measure of light available for photosynthesis
Turbidity	Sonde			■	Measure of light penetration in shallow water
Secchi disk depth	Observation	■	■		Measure of light penetration in deeper water
Transparency Tube	Observation			■	Measure of light penetration into shallow water
Zooplankton	Wet	■			Organisms fluctuate due to environmental variables
Zebra Mussel Veligers	Wet	■			Larval form of zebra mussels/plate checks (AIS)

2.1 Water Quality Sampling

The monitoring program supports the District's 10-year water management plan to delist waters from the MPCA's 303d Impaired Waters list. The parameters monitored during the field season help determine the sources of water quality impairments and provide supporting data that is necessary to best design and install water quality improvement projects.

Multi-probe sondes (Hach Water Quality Sondes, Lakes DS-5/ Streams MS-5) were used for collecting water quality measurements across both streams and lakes. Sonde readings measured include temperature, pH, dissolved oxygen, conductivity, photosynthetic active radiation (PAR), oxidation reduction potential (ORP), and phycocyanin. Secchi disk depth readings were recorded at the same time as sonde readings were collected at all lake sampling locations. When monitoring stream locations, transparency, turbidity, and flow measurements (Flow Tracker) were collected as well. General site conditions related to weather and other observations were recorded as well. A list of the variety of parameters monitored during each sampling event can be seen in Table 2-2.

Table 2-2 Basic Water Quality Monitoring Activities

Pre-Field Work Activities	Calibrate Water Quality Sensors (sonde) Obtain Water Sample Bottles and Labels from Analytical Lab Prepare Other Equipment and Perform Safety Checks Coordinate Events with Other Projects and Other Entities
Summer Lake – Physical and Chemical	Navigate to Monitoring Location Read Secchi Disk Depth and Record Climatic Data Record Water Quality Sonde Readings at Meter Intervals Collect Water Samples from Top, Thermocline, and Bottom
Summer Lake – Biological	Collect Zooplankton Tow (pulling a net) from Lake Bottom to Top Collect Phytoplankton Tow (2m surface composite sample) Collect Zebra Mussel Veliger Tow (pulling a net) from Lake Bottom to Top at Multiple Sites
Winter Lakes	Navigate to Monitoring Location Record Ice Thickness Read Secchi Disk Depth and Record Climatic Data Record Water Quality Sonde Readings at one Meter Intervals Collect Water Samples from top and bottom
Streams – Physical, Chemical, and Biological	Navigate to Monitoring Location Measure Total Flow by Measuring Velocity at 0.3 to 1 Foot Increments across Stream Record Water Quality Sonde Measurements Upstream of Flow Measurement in Middle of Stream Read Transparency Tube and Perform Turbidity Test Collect Water Samples from Middle of Stream Collect macroinvertebrate samples (D-net collection across representative habitat types) Collect Climatic Data and Take Photos
Post-Field Work Activities	Ship Water Samples to Analytical Lab Enter Data, Perform Quality Control Checks, and Format Data for Database Clean and Repair Equipment Reporting and Summarizing Data for Managers, Citizens, Cities, and Others

At each lake monitoring location, multiple water samples are collected using a Van Dorn, or depth integration sampler, for analytical laboratory analysis. For Duck, Idlewild, Rice Marsh, Silver, and Staring Lakes, water samples were collected at the surface and bottom due to the shallow depths (2-3m). For all other lakes within the District, water samples were collected at the surface, middle, and bottom of the lake. Lakes are monitored at the same location on each sampling trip, typically at the deepest part of the lake. All samples are collected from whole meter depths except for the bottom sample, which is collected 0.5 meters from the lake bottom to prevent disrupting the sediment. The surface sample is a composite sample of the top two meters of the water column. The middle sample is collected from the approximate midpoint of the temperature/dissolved oxygen change (>1-degree Celsius change) or thermocline. Pictures and climatic data are collected at each monitoring site. Water quality information collected in the winter is collected using the same procedures as in the summer. Zooplankton samples were collected using a 63 micrometer Wisconsin style zooplankton net and Phytoplankton samples were collected using a 2m integrated water sampler on Lake Susan, Lotus Lake, Staring Lake, Lake Riley, and Rice Marsh Lake. Zooplankton are collected by lowering the net to a depth of 0.5 meters from the bottom at the deepest point in the lake and raised slowly. Zebra mussel veliger samples were collected on all lakes using the same zooplankton sampling procedures but collected at three sites and consolidated before being sent to a lab for analysis. A Zeiss Primo Star microscope with a Zeiss Axiocam 100 digital camera was used to monitor zooplankton populations, scan for invasive zooplankton, and to calculate Cladoceran-grazing rates on algae.

Water quality samples collected during stream monitoring events were collected from the approximate middle (width and depth) of the stream in ideal flow conditions or from along the bank when necessary. Both water quality samples and flow monitoring activities were performed in the same section of the creek during each sampling event. Stream velocity was calculated at 0.3 to 1-foot increments across the width of the stream using the FlowTracker Velocity Meter at each sampling location. If no water or flow was recorded, only pictures and climatic data were collected. Macroinvertebrate samples were collected on one stream per year on a rotating basis. A D-net was used to sample macroinvertebrates and each habitat type was sampled proportional to the amount of habitat in each reach. The activities associated with the monitoring program are described in Table 2-2.

2.2 Analytical Laboratory Methods

RMB Environmental Labs, located in Detroit Lakes, MN, is the third-party company that is responsible for conducting the analytical tests on the water samples that were collected by the District Staff. The methods used by the laboratory to analyze the water samples for the specified parameters are noted in Table 2-3. Zebra mussel veliger and phytoplankton samples were also sent to RMB Labs for analysis.

Additional samples were sent to the Metropolitan Council (METC), St. Paul, MN. These samples included quality control duplicate samples and special water quality monitoring project samples. METC allows staff to bring samples in on a Friday which is not possible with RMB because samples must be shipped. Additionally, macroinvertebrate samples were sent to Dean Hansen of the University of Minnesota for identification and 10% of zooplankton samples were Margaret Rattei at Barr Engineering for quality control duplicate samples.

Table 2-3 RMB Environmental Laboratories Parameters and Methods Used for Analyses

Parameter	Standard Method
Alkalinity	EPA 310.2
Ammonia	EPA 350.1 Rev 2.0
Nitrogen, Nitrate & Nitrite	EPA 353.2 Rev 2.0
Chlorophyll-a	SM 10200H
Total Phosphorus	EPA 365.3
Orthophosphate	EPA 365.3
Chloride	SM 10200H

3 Water Quality Standards

In 1974, the Federal Clean Water Act set forth the requirements for states to develop water quality standards for surface waters. In 2014, specific standards were developed for eutrophication and TSS for rivers and streams. In Minnesota, the agency in charge of regulating water quality is the Minnesota Pollution Control Agency (MPCA). Water quality monitoring and reporting is a priority for the District to determine the overall health of the water bodies within the watershed boundaries. The District's main objectives are to prevent a decline in the overall water quality within lakes and streams and to prevent water bodies from being added to the 303d Impaired Water Bodies list (MPCA). The District is also charged with the responsibility to take appropriate actions to improve the water quality in water bodies that are currently listed for impairments.

There are seven ecoregions within Minnesota; the RPBCWD is within the Northern Central Hardwood Forest (NCHF) ecoregion. Rural areas in the NCHF are dominated by agricultural land and fertile soils characterize the ecoregion. For most water resources in the region, phosphorus is the limiting (least available) nutrient within lakes and streams, meaning that the available concentration of phosphorus often controls the extent of algal growth. The accumulation of excess nutrients (i.e. TP and Chl-a) in a waterbody is called eutrophication. This relationship has a direct impact on the clarity and recreational potential of our lakes and streams. Water bodies with high phosphorus concentrations and increased levels of algal production have reduced water clarity and limited recreational potential.

All lakes sampled in the district are considered Class 2B surface waters. The MPCA states that this class of surface waters should support the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats. They should also be suitable for aquatic recreation of all kinds, including bathing. This class of surface water is not protected as a source of drinking water. For more detailed information regarding water quality standards in Minnesota, please see the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment, 305(b) Report, and 303 (d) List of Impaired Waters. These resources provide information to better understand the water quality assessment process and the reasoning behind their implementation.

3.1 Lakes

The MPCA has specific standards for both 'deep' lakes or lakes >15ft deep and < 80% of the total lake surface area able to support aquatic plants (littoral area), and 'shallow' lakes or lakes <15ft deep and >80% littoral area. Except for chlorides, summer growing season (June-September) averages of the parameters listed in Table 3-1 for each lake are compared to the MPCA standards to determine the overall state of the lake. The standards are set in place to address issues of eutrophication or excess nutrients in local water bodies. Water samples are collected and sent to an analytical lab to assess concentrations of TP, Chl-a, and chlorides. If result values are greater than the standards listed in Table 3-1, the lake is considered impaired. Secchi disk readings are collected to measure the transparency, or visibility, in each lake. A higher individual reading corresponds to increased clarity within the lake as the Secchi Disk was visible at a deeper depth in the water column.

Chlorides (Cl) are of increasing concern, especially during the winter when road salt is heavily used. Targeted sampling occurs both during the winter and during early spring melting periods when salts are being flushed through our waterbodies. The Cl standard is the same for both deep lakes and shallow lakes. The table includes both the Cl chronic standard (CS) and a maximum standard (MS). The CS is the highest water concentration of Cl to which aquatic life, humans, or wildlife can be exposed to indefinitely without causing chronic toxicity. The MS is the highest concentration of Cl in water to which aquatic organisms can be exposed for a brief time with zero to slight mortality.

Table 3-1 MPCA Water Quality Standards for Shallow and Deep Lakes

Parameter	Shallow Lakes Criteria	Deep Lakes Criteria
Total Phosphorus (mg/L)	≤ 0.060	≤ 0.040
Chlorophyll-a (ug/L)	≤ 20	≤ 14
Secchi Disk (m)	≥ 1	≥ 1.4
Chloride Chronic Standard (mg/L)	230	230
Chloride Maximum Standard (mg/L)	860	860

3.2 Streams

Table 3-2 displays water quality parameters developed by the MPCA in 2014 for eutrophication and TSS. The standards include some parameters the District has not yet incorporated into their monitoring procedures that may eventually be added in the future. All streams sampled in the district are considered Class 2B surface waters. The MPCA states that this class of surface waters should support the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats. They should also be suitable for aquatic recreation of all kinds, including bathing. This class of surface water is not protected as a source of drinking water. For more detailed information regarding water quality standards in Minnesota, please see the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment, 305(b) Report, and 303 (d) List of Impaired Waters. These resources provide information to better understand the water quality assessment process and the reasoning behind their implementation.

Eutrophication pollution is measured based upon the exceedance of the summer growing season average (May-September) of TP levels and Chl-a (seston), five-day biochemical oxygen demand (cBOD, amount of DO needed by organisms to breakdown organic material present in a given water sample at a certain temperature over a five-day period), diel DO flux (difference between the maximum DO concentration and the minimum daily DO concentration), or summer average pH levels. Streams that exceed phosphorus levels but do not exceed the Chl-a (seston), cBOD, diel DO flux, or pH levels meet the eutrophication standard. The District added Chl-a to its sampling regime in 2015 to account for the polluted condition when Chl-a (periphyton) concentration exceeds 18ug/L. The daily minimum DO concentration for all Class 2B Waters cannot dip below 4mg/L to achieve the MPCA standard, which was used in the analysis for the Annual Report.

TSS is a measure of the amount of particulate (soil particles, algae, etc.) in the water. Increased levels of TSS can be associated with many negative effects including nutrient transport, reduced aesthetic value, reduced aquatic biota, and decreased water clarity. For the MPCA standard, TSS concentrations are assessed from April through September and cannot exceed 30mg/L more than 10 percent of the time during that period.

Table 3-2 MPCA Water Quality Standards for Streams

MPCA Standard	Parameter	Criteria
Eutrophication	Phosphorus	≤ 100ug/L

	Chlorophyll-a (seston)	≤ 18ug/L
	Diel Dissolved Oxygen	≤ 3.5mg/L
	Biochemical Oxygen Demand	≥ 2mg/L
	pH Max	≤ 9su
	pH Min	≥ 6.5su
Total Suspended Solids	TSS	≤ 30mg/L

4 Water Quality Data Collection

To improve water quality within the watershed, the District conducts studies to root out key sources of pollution or other negative variables that impact our lakes and streams. Once identified, the District will often monitor these locations and eventually act to improve the water resource if the data confirms the suspicion. Below is a summary of each special project/monitoring and an overall summary of the water quality data the District has collected in 2018.

4.1 2018 Lakes Water Quality Summary

The 2018 growing season Chl-a mean concentrations for all lakes sampled within the District are shown in Figure 4-1. Four lakes sampled within the District are categorized as ‘deep’ by the MPCA (>15ft deep, < 80% littoral area): Lake Ann, Lotus Lake, Lake Riley, and Round Lake. The MPCA standard for Chl-a in deep lakes (< 14ug/L) was met by Lake Ann, Lake Riley and Round Lake. Although Lotus Lake did not meet the standard, Chl-a levels decreased (a decrease of 18.6 ug/L from 2017). The remainder of the lakes sampled in 2018 are categorized as ‘shallow’ by the MPCA (<15ft deep, >80% littoral area): Duck Lake, Hyland Lake, Lake Lucy, Mitchell Lake, Red Rock Lake, Rice Marsh Lake, Staring Lake, Lake Susan, and Silver Lake. Water quality metrics on Lake Idlewild, classified as a high-value wetland, were compared to MPCA shallow lake standards. The water quality standard for shallow lakes (< 20ug/L) was met by Duck Lake, Lake Idlewild, and Silver Lake in 2018. Lake Lucy, Mitchell Lake, Red Rock Lake, Rice Marsh Lake, and Staring Lake did not meet the standard, while Hyland Lake and Lake Susan more than doubled the MPCA standard. Chl-a levels increased from 2017 on Lucy, Red Rock, Rice Marsh, Susan, and Mitchell. The increases in Chl-a from 2017 in Red Rock and Rice Marsh were rather high (increases of 22.6ug/L and 12ug/L respectively). Hyland Lake and Staring Lake decreased in levels from 2017, with Staring just exceeding the MPCA standard (23.1ug/L) in 2018.

Overall, six of the 14 lakes sampled in 2018 met the MPCA Chl-a standards for their lake classification (six lakes also met standard in 2017, although not the same lakes): Lake Ann, Duck Lake, Lake Idlewild, Lake Riley, Round Lake, and Silver Lake.

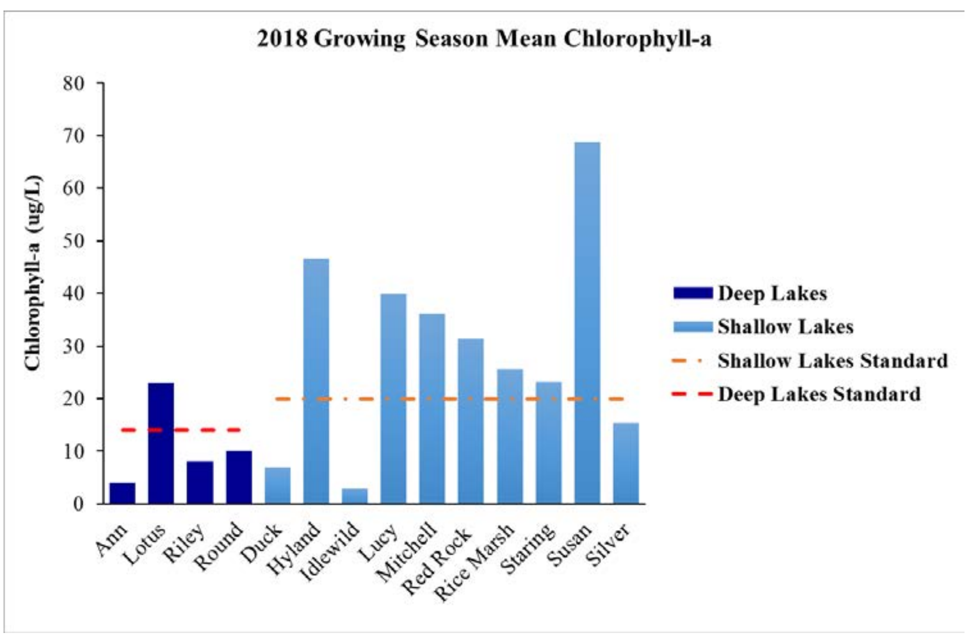


Figure 4-1 2018 Lake Growing Season Mean Chlorophyll-a

Lakes growing season (June-September) mean chlorophyll-a concentrations (ug/L) for shallow (lakes <15ft. deep, >80% littoral area-light blue bars) and deep lakes (lakes >15 ft. deep, <80% littoral area-dark blue bars) in the Riley Purgatory Bluff Creek Watershed District during 2018. The dashed lines represent the Minnesota Pollution Control Agency water quality standards for Chlorophyll-a for shallow (<20ug/L-orange dashed line) and deep lakes (<14ug/L-red dashed line).

The TP growing season averages for all lakes sampled within the District in 2018 are shown in Figure 4-2. The MPCA standard for TP in deep lakes (<0.040mg/L) was met by Lake Ann, Lake Riley, and Round Lake. TP levels were above the standard in Lotus; Round Lake's TP average decreased 0.015mg/L from 2017, putting it just under the standard. Lake Riley's TP levels continue to decrease year-to-year since the application of the aluminum sulfate treatment in 2016 (decrease of 0.003mg/L from 2017). For shallow lakes, the MPCA TP standard (<0.060mg/L) was met by Duck Lake, Lake Idlewild, Lake Lucy, Staring Lake, and Silver Lake in 2018. Despite having met the standard in 2017, both Red Rock and Rice Marsh did not meet the standard in 2018. Three of the shallow lakes decreased in overall TP levels, Hyland, Staring and Duck (Duck decreased TP by 0.022 mg/L, putting it below the standard).

Overall, eight of the 14 lakes sampled met the MPCA total phosphorus standard for their lake classification in 2018: Lake Ann, Duck Lake, Lake Idlewild, Lake Lucy, Lake Riley, Round Lake, Silver Lake, and Staring Lake.

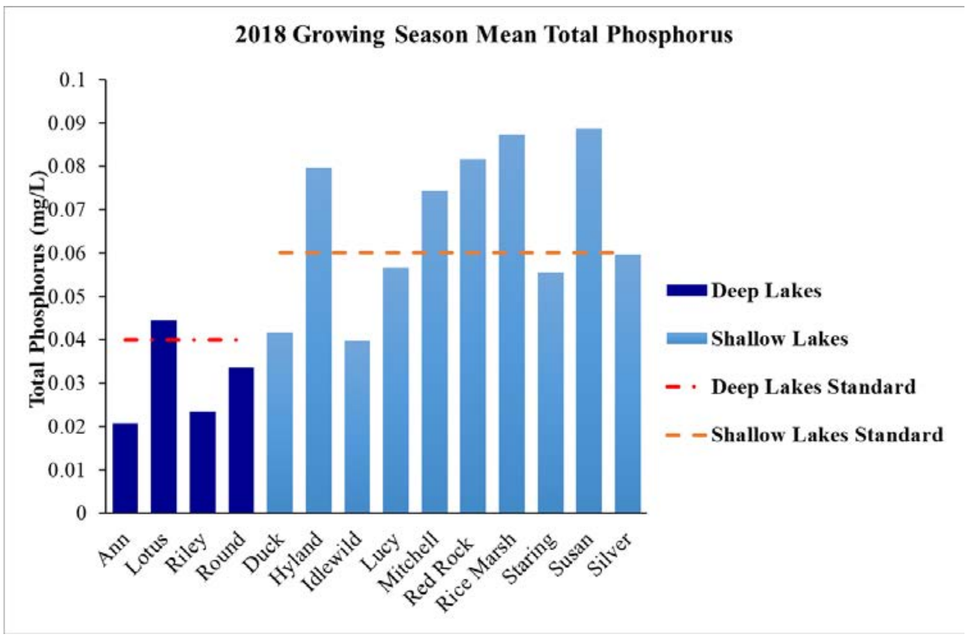


Figure 4-2 2018 Lakes Growing Season Mean Total Phosphorus

Lakes growing season (June-September) mean total phosphorus concentrations (mg/L) for shallow (lakes <15ft. deep, >80% littoral area-light blue bars) and deep lakes (lakes >15ft. deep, <80% littoral area-dark blue bars) in the Riley Purgatory Bluff Creek Watershed District during 2018. The dashed lines represent the Minnesota Pollution Control Agency water quality standards for Total Phosphorus for shallow (<0.060ug/L-orange dashed line) and deep lakes (<0.040ug/L-red dashed line).

The 2018 secchi disk growing season means for all District lakes sampled are shown in Figure 4-3. The MPCA standard for secchi disk depth/water clarity for deep lakes (> 1.4m) was met by all deep lakes in the District (Ann, Lotus, Riley, and Round). Ann, Lotus, and Riley all increased in clarity (1.04m, 0.006m, and 0.96m respectively). Round Lake only decreased 0.08m in average clarity. For shallow lakes, eight of ten lakes monitored achieved the MPCA secchi disk depth water quality standard (>1m). Hyland lake and Mitchell Lake were the only lakes which did meet the standard, although they were close, measuring an average clarity of 0.95m and 0.99m respectively. Hyland, Idlewild, Silver, and Staring all increased in water clarity.

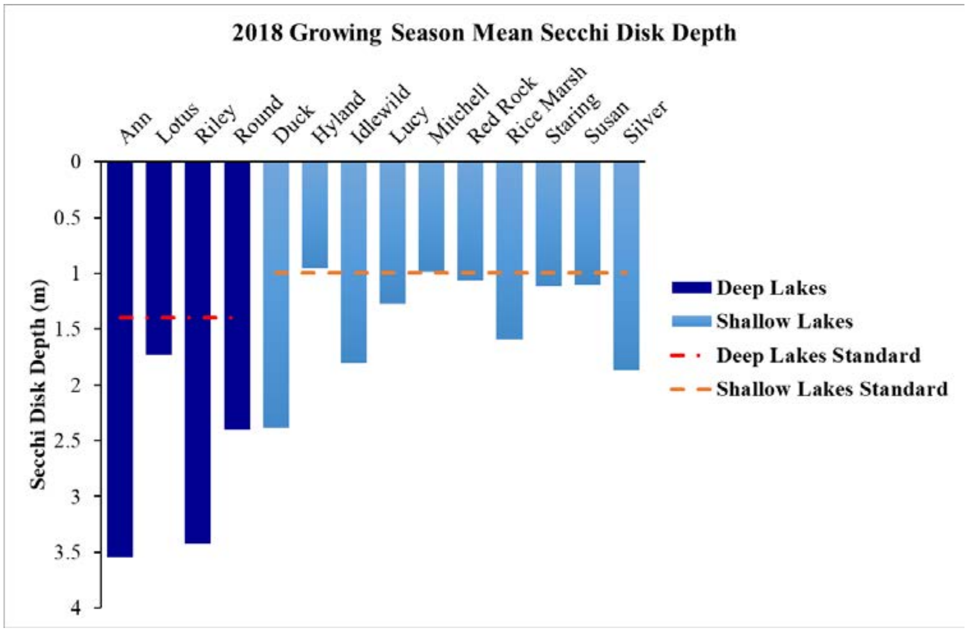


Figure 4-3 2018 Lakes Growing Season Mean Secchi Disk Depth

Lakes growing season (June-September) mean secchi disk depths (m) for shallow (lakes <15ft. deep, >80% littoral area-light blue bars) and deep lakes (lakes >15ft. deep, <80% littoral area-dark blue bars) in the Riley Purgatory Bluff Creek Watershed District during 2018. The dashed lines represent the Minnesota Pollution Control Agency water quality standards for secchi disk depths for shallow (>1m-orange dashed line) and deep lakes (>1.4m-red dashed line).

4.2 Alum Treatments

In May of 2016, the District treated Lake Riley with the first dose of aluminum sulfate (alum). In fall of 2018, the District treated both Lotus Lake and Rice Marsh Lake with the first round of alum. The City of Eden Prairie also treated Round Lake with a second dose of Alum in October of 2018. Alum is a compound which works to reduce the growth of algae by trapping the nutrient phosphorus (the main food source of algae) in the lake sediments. These treatments were applied by injecting the alum into water several feet below the surface of the lake. Upon contact with water, alum becomes aluminum hydroxide (also called floc), a fluffy precipitate. As floc settles to the bottom of the lake, it interacts with phosphorus, binding it, making it unusable by algae. This process also collects other particles suspended in the water column, helping to improve water clarity.

District staff have continued to monitor phosphorus levels on Lake Riley as a part of regular sampling, tracking the continued effectiveness of the treatment. Figure 4-4 illustrates total phosphorus (TP) levels two years prior to treatment, through the end of the 2018 growing season (29 months after the alum was applied). TP data was included from May 2014 to late September 2018 to highlight the abrupt changes in TP concentrations during that time. There was a large reduction in epilimnetic TP (upper layer of water in a thermally-stratified lake) after the treatment in May of 2016. This led to Lake Riley achieving the MPCA standard over the summer growing season (June-September) in 2016. During the 2018 growing season, TP levels continued meeting the MPCA standard in the epilimnion; only one sample this season did not meet the standard (Figure 4-4). The average TP level for the 2018 growing season was the lowest it has been since before the alum treatment (0.0235mg/L). TP levels sampled in the hypolimnion (the bottom layer of water in a thermally-stratified lake) rose almost 0.6mg/L from May through September in 2015. In 2016, TP levels in the hypolimnion were drastically reduced after treatment and increased about 0.06mg/L through September of that year. During the 2018 growing season, TP levels in the hypolimnion increased 0.19mg/L between June through September, which was 0.03mg/L more of an increase than in 2017 during those same months. Overall, this increase is still significantly less than what was observed in years before the alum treatment. In 2016, the decrease in TP led to reductions in summer averages of Chl-a (algae) concentrations, from 27.4ug/L in 2015 to 14.92ug/L. Additionally, secchi disk depth noticeably increased from 1.7m in 2015 to 2.89m in 2016. In 2018, the average secchi depth was the deepest recorded since before the alum treatment was applied (3.425 m, up from 2017 average of 2.46m). Chl-a level was also at its lowest recorded since before the treatment (7.98 ug/L, down from the 2017 average of 15.64 ug/L).

The District and its partners will continue monitoring water clarity and nutrient levels in 2019, as a part of regular monitoring, but also to track the continued effectiveness of the alum treatments on these lakes. Future monitoring will also indicate when a second dose of alum should be applied. More information about Lake Riley, Lotus Lake, and Rice Marsh Lake nutrient and water clarity data can be seen in the Fact Sheets located in Exhibits F.

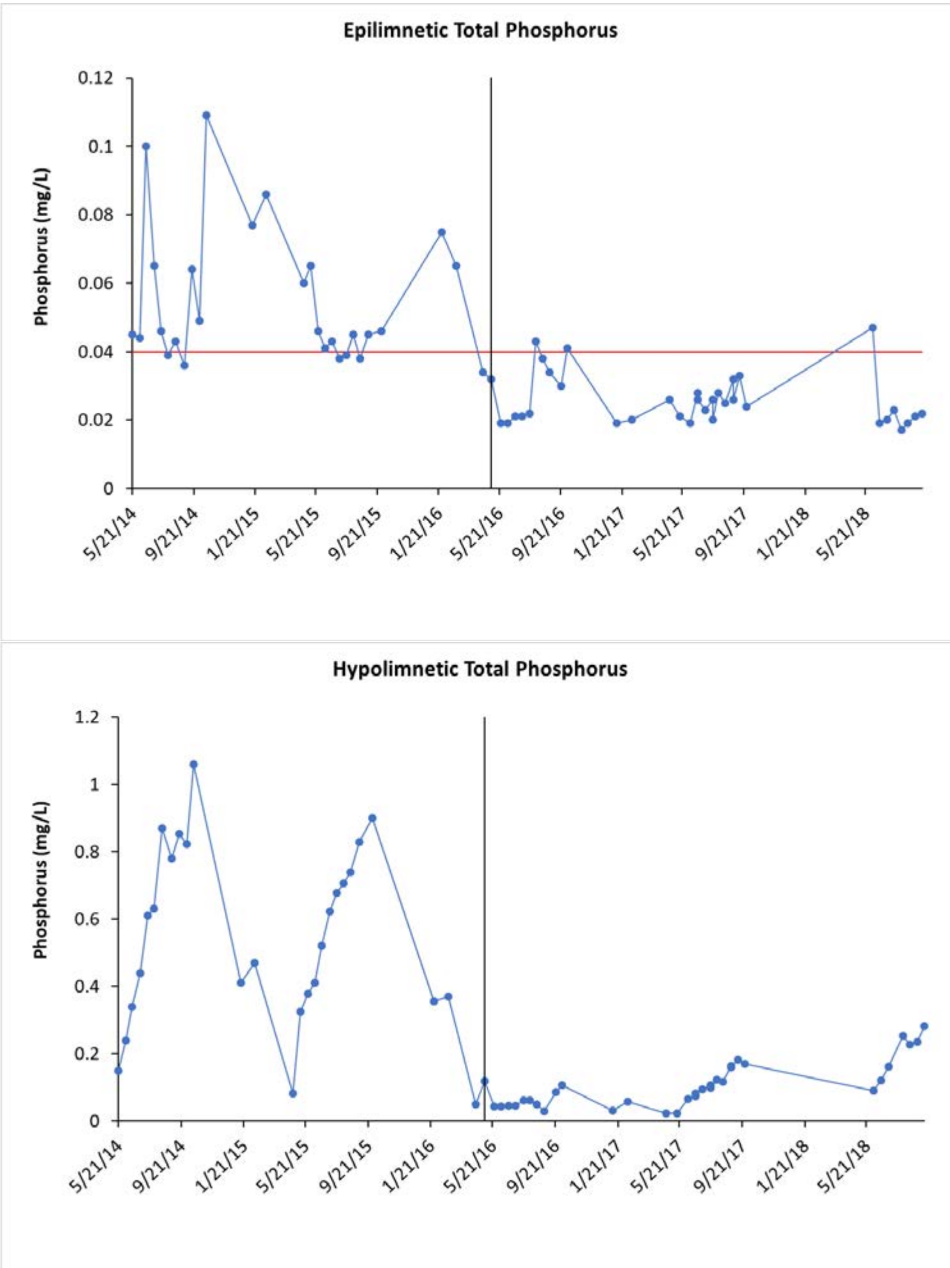


Figure 4-4 Lake Riley Total Phosphorus Levels pre- and post- Alum Treatment

Total phosphorus levels (TP) in Lake Riley between May 21, 2014 and September 11, 2018. The graphs reflect levels before and after the aluminum sulfate (Alum) treatment carried out in May of 2016 (indicated by vertical bar). The upper graph displays TP levels (mg/L) measured from 2m composite samples taken at the surface of the lake. The MPCA water quality standard for TP is represented in the upper graph by the horizontal red line (0.04mg/L). The lower graph displays the TP levels (mg/L) measured from samples taken 0.5-1m above the sediment in the deepest point of the lake.

4.3 Lake Water Levels

In-Situ Level Troll 500, 15-psig water level sensors, as well as METER Environment Hydros 21 water level sensors, have been placed on most lakes throughout the watershed district to monitor water quantity and assess yearly and historical water level fluctuations. These sensors are mounted inside a protective PVC pipe that are attached to a vertical post and placed in the water. A staff gauge, or measuring device, is also mounted to the vertical post, and surveyed by District staff to determine the elevation for each level sensor. Once the water elevation is established, the sensors record continuous water level monitoring data every 15 minutes from ice out until late fall. New to 2018, staff built and deployed two EnviroDIY stations run by EnviroDIY Mayfly circuit boards on Rice Marsh Lake and Lake Riley. These units were housed in a Pelican brand waterproof case which were mounted to one of the District's standard level sensor posts/staff gauges. These stations were outfitted with the Hydros 21 water level sensors, a solar panel, as well as a radio which allowed for remote communication with the station for real-time viewing of elevation/data.

Lake level data is used for developing and updating the District's models, which are used for stormwater and floodplain analysis. Monitoring the lake water levels can also help to determine the impact that climate change may have on lakes and land interactions in the watershed. Lake level data is also used to determine epilimnetic zooplankton grazing rates (located in section 4.8). Lake level data is submitted to the Minnesota Department of Natural Resources (MNDNR) at the end of each monitoring season and historical data specific to each lake can be found on MNDNR website using the Lakefinder database. See Exhibits A for 2018 level sensor results. Lake Levels for 2017 are also provided for a year-to-year comparison. In both the Lakefinder database and in Exhibits A, the Ordinary High-Water Level (OHWL) is displayed so water levels can be compared to what is considered the "normal" water level for each lake. The OHWL is used by governing bodies like the RPBCWD for regulating activities that occur above and below this zone. National Oceanic and Atmospheric Administration (NOAA) precipitation data collected from the area was also included in Exhibits A to evaluate how rain events influenced lake levels. Rain data recorded at the Flying Cloud Drive Airport, Eden Prairie, MN is included alongside lake level data from lakes in Hennepin County (including Lake Riley). A combination of rain data from Meteorological Station Chanhassen WSFO and Chanhassen 1.0 ESE is included alongside lake level data from lakes in Carver County.

In 2018, lake level measurements were collected on 13 lakes in the District and one high value wetland, Lake Idlewild (Table 4-1). Silver Lake experienced the greatest seasonal water level change over the 2018 season, increasing 0.402ft from ice-out to the last day of recording (Nov. 9). Round Lake had the largest range of fluctuation through 2018, having a low elevation of 878.671ft, and a high of 880.379ft (1.708ft difference). On average, lake levels decreased by 0.013ft over the 2018 season. The average fluctuation range across all lakes was 1.036ft.

Table 4-1 Lake Water Levels Summary

The 2018 (March-November) and historical recorded lake water levels (ft) for all monitored lakes within the Riley Purgatory Bluff Creek Watershed District. 2018 data includes the overall change in water level, the range of elevation fluctuation, and the highest and lowest recorded elevations. Historical data includes the highest and lowest historical recorded levels and the date they were taken.

	2018 Lake Water Level Data				Historical Lake Water Levels			
Lake	Seasonal Flux	Flux Range	High level	Low level	Highest Level	Date	Lowest Level	Date2
Ann	-0.139	0.864	956.437	955.573	957.93	2/18/1998	952.80	9/28/1970
Duck	0.007	0.704	914.623	913.919	916.12	6/20/2014	911.26	11/10/1988
Hyland	-0.265	1.078	816.300	815.222	818.68	8/11/1987	811.66	12/2/1977
Idlewild	0.160	1.282	854.507	853.225	860.78	3/29/1976	853.10	1/7/1985
Lotus	-0.104	0.830	895.943	895.113	897.08	7/2/1992	893.18	12/29/1976
Lucy	-0.090	0.830	956.567	955.737	957.67	6/20/2014	953.29	11/10/1988
Mitchell	0.332	1.050	871.951	870.901	874.21	6/25/2014	865.87	7/25/1977
Red Rock	-0.137	0.751	840.666	839.915	842.69	7/13/2014	835.69	9/28/1970
Rice Marsh	0.154	1.250	876.145	874.895	877.25	5/28/2012	872.04	8/27/1976
Riley	-0.177	0.505	865.137	864.632	866.74	7/6/1993	862.00	2/1/1990
Round	0.344	1.708	880.379	878.671	884.26	8/17/1987	875.29	7/25/1977
Silver	0.402	1.076	899.827	898.751	901.03	6/20/2012	894.78	6/6/1972
Staring	-0.373	1.401	815.206	813.805	820.00	7/24/1987	812.84	2/12/1977
Susan	-0.300	1.178	881.797	880.619	883.77	6/21/2014	879.42	12/29/1976
Average	-0.013	1.036						

4.4 Powers Blvd Riley Creek Crossing

In 2013, a Use and Attainability Analysis (UAA) identified Lake Susan Park Pond as a significant contributing source of nutrient pollution to Lake Susan. In 2015 and 2016, staff conducted sampling on Lake Susan Park Pond and at the Lake Susan Park Pond outlet to confirm the UAA findings. Results indicated the pond was contributing nutrient pollution, but at a lesser level then indicated by the UAA. In 2017, the District proposed actions to improve the water quality in Lake Susan through implementing the Lake Susan Park Pond Treatment and Stormwater Reuse Enhancement Project which was completed in 2018. As part of the project, staff placed an automated water-sampling unit on Riley Creek at the culvert passing under Powers Blvd, just upstream of Lake Susan and Lake Susan Park Pond. This was done to better quantify rain event nutrient loading from upstream sources. Analyzing the "first flush" of a storm event is important because these events are when water pollution entering storm drains in areas with high proportions of impervious surfaces is typically more concentrated compared to the remainder of the storm. Additionally, this information could potentially guide efforts to reduce nutrient loading from upstream sources. Water samples were collected and analyzed for total dissolved phosphorus (TDP), total phosphorus (TP), total suspended solids (TSS), and Chlorophyll-a (Chl-a) in 2017 and 2018. The automated water-sampling unit also estimated flow of the creek at that point.

In 2018, total phosphorus levels at the sampling site during storm events were high compared to the MPCA standard, but the first flush average TP level was down from 2017. As seen in Table 4-2, the average TP across 13 samples was 0.331mg/L (0.681mg/L in 2017). This level is still more than three times the MPCA eutrophication water quality standard for class 2B streams (≤ 0.1mg/L TP). The highest TP reading was 1.04mg/L (1.62mg/L was the highest sampled TP in 2017, Figure 4-6). The TDP average across the sampling events was 0.058mg/L (up from 0.034mg/L in 2017). The highest measurement was 0.076mg/L (0.066mg/L in 2017, Figure 4-6; Table 4-2). TSS concentrations at the sampling site were also high, but the average was less than half of the average in 2017. The average amount of TSS across the 13 samples taken was 310.61mg/L (down from 659.5mg/L in 2017, Table 4-2). To achieve the MPCA TSS stream water quality standard, a stream may not exceed 30mg/L TSS more than 10% of the time. Two of 13 samples taken in 2018 fell below 30mg/L TSS (Figure 4-5). Eleven Chl-a samples were taken from the site in 2018. Apart from one sample, which had 19ug/L Chl-a, all samples contained less than the MPCA eutrophication water quality standard of ≤ 18ug/L Chl-a (Table 4-2). It is important to remember that these samples are targeted samples, representative of the initial flush of water and pollutants that occurs during a rain event, and do not represent season-long pollutant levels in Riley Creek.

Table 4-2 2018 Powers Blvd Riley Creek Crossing Nutrient Summary

Powers Blvd Riley Creek Crossing Total Dissolved Phosphorus (mg/L), Total Phosphorus (mg/L), Chlorophyll-a (ug/L), and Total Suspended Solids (mg/L) concentrations (max, min, and average) from 2018 automated, flow-paced samples. The table also includes the Minnesota Pollution Control Agency water quality standards.

Parameter	# of samples	Minimum	Maximum	Average	MPCA Water Quality Standards
TP (mg/L)	13	0.072	1.04	0.331	≤ 0.1mg/L
TDP (mg/L)	13	0.04	0.076	0.058	-
Chl-a (ug/L)	11	1	19	6.00	≤ 18ug/L
TSS (mg/L)	13	9.6	969	310.61	≤ 30mg/L

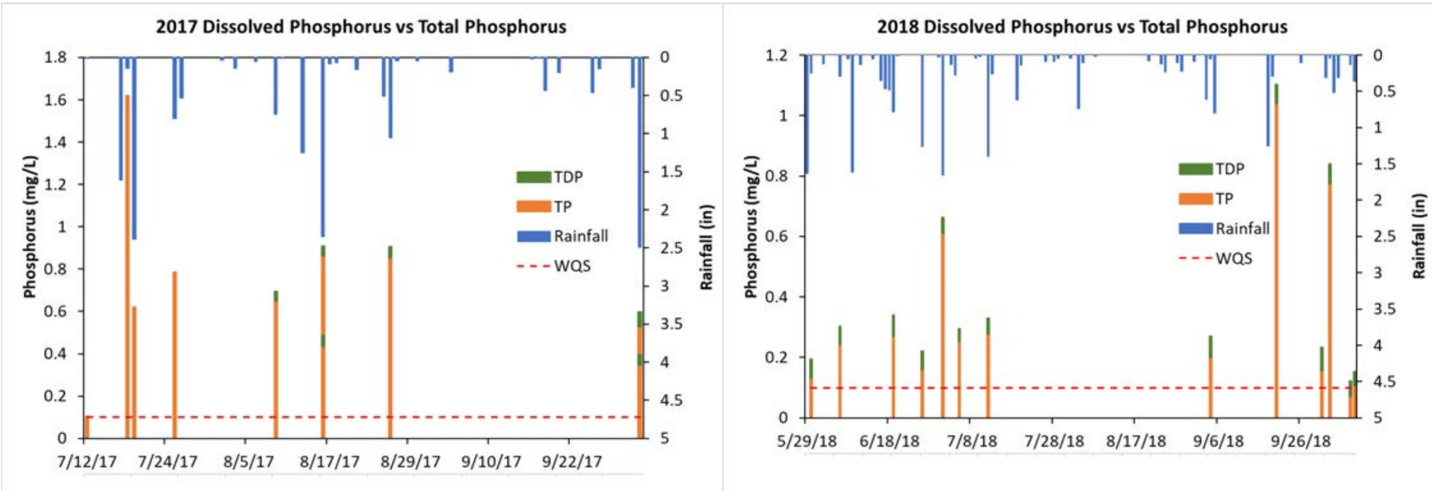


Figure 4-6 2017 and 2018 Upper Riley Creek Phosphorus

The Total Dissolved Phosphorus (TDP) and Total Phosphorus (TP) concentrations (mg/L) from Riley Creek under Powers Blvd from 2017 and 2018 automated, level triggered, flow-paced samples. Dashed line represents the Minnesota Pollution Control Agency standard for TP in class 2B creeks (≤ 0.1mg/L).

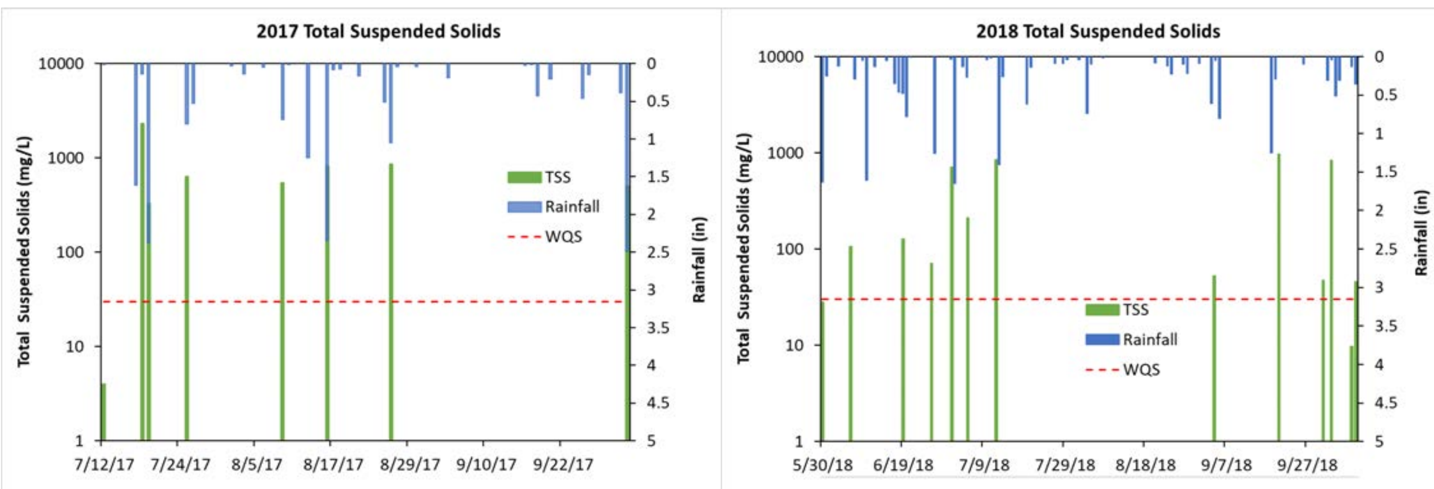


Figure 4-5 2017 and 2018 Upper Riley Creek Total Suspended Solids

Total Suspended Solids (TSS) concentrations (mg/L) from Riley Creek under Powers Blvd from 2017 and 2018 automated, level triggered, flow-paced samples. Dashed line represents the Minnesota Pollution Control Agency standard for TSS in class 2B creeks (≤ 30mg/L TSS no more than 10% of the time).

4.5 Creek Restoration Action Strategy

The RPBCWD developed the Creek Restoration Action Strategy (CRAS) to prioritize creek reaches, sub-reaches, or sites, in need of stabilization and/or restoration. The District has identified eight categories of importance for project prioritization including: infrastructure risk, erosion and channel stability, public education, ecological benefits, water quality, project cost, partnerships, and watershed benefits. These categories were scored using methods developed for each category based on a combination of published studies and reports, erosion inventories, field visits, and scoring sheets from specific methodologies. Final tallies of scores for each category, using a two-tiered ranking system, were used to prioritize sites for restoration/remediation. More information on the CRAS can be found on the District's website: www.rpbcwd.org. The CRAS was finalized/adopted in 2015 and was updated in April of 2017. The CRAS was published in the Center for Watershed Protection Science Bulletin in 2018. A severe site list was developed which includes subreaches from all three creeks (Table 4-3).

Table 4-3 Severe Reaches Identified by the Creek Restoration Action Strategy

Stream	Tier II Rank	Tier I Rank	Reach	Subreach	Location
Purgatory	1	9	P7	P7E	Covington Road to Pond in Covington Park
Riley	2	2	R2	R2E	Middle 1/3 between Dell Road and Eden Prairie Road
Bluff	3	5	BT3	BT3A	Audubon Road to Pioneer Trail
Purgatory	4	4	P1	P1E	1,350 feet DS of Pioneer Trail to Burr Ridge Lane
Bluff	5	1	B1	B1D	475 feet US of Great Plains Blvd to Great Plains Blvd
Bluff	6	7	B3	B3A	750 feet DS of Railroad to 860 feet DS of Railroad
Bluff	7	10	B3	B3C	1,675 feet US of Audubon Road to Lyman Blvd
Bluff	8	6	R2	R2D	Upper 1/3 between Dell Road and Eden Prairie Road
Bluff	9	3	B5	B5C	Galpin Blvd to West 78th Street
Bluff	10	8	B5	B5B	985 feet US of Galpin Blvd to Galpin Blvd

Note: US = Upstream; DS = Downstream

As part of CRAS, stream reaches are walked on a rotational basis after the initial assessment was completed. This will allow staff to evaluate changes in the streams and update the CRAS accordingly. In 2018 staff walked Reach 8 of Purgatory Creek (including a tributary to this reach PT-4, that had not been assessed) and subreach P5A. Additionally, staff walked a northern tributary stream to P7 which began south of Highway 7 (PT-5). The tributary sites were especially in need of a full assessment as no previous scores had been calculated. Staff conducted Modified Pfankuch Stream Stability Assessments, MPCA Stream Habitat Assessments (MSHA), took photos, and recorded notes of each subreach to assess overall stream conditions. In addition to creek walks, staff also checked bank pins which were installed in 2015 and 2018 near all the regular water quality sites. The bank pins were installed in "representative" erosion sites to evaluate general erosion rates for each reach. Changes to the CRAS based upon 2018 creek walks can be seen in Table 4-4, Exhibits E, and in our Fact Sheets in Exhibits F. A summary of the 2018 creek walks can be seen below.

Purgatory Creek – PT-4A

This subreach is one that had not been previously walked and assessed by staff for the purpose of informing the CRAS. This reach begins in a ditch on the north side of Duck Lake Trail, at the intersect with Dell Road. It continues upstream (north/northeast) for about 0.2 stream miles, where it enters a wetland complex and eventually connects to the main channel of Purgatory Creek. The reach passes through deciduous forest and residential areas prior to the wetland. The riparian width for a majority of the subreach was approximately 50m along the left bank and 5m along the right bank. The substrate in this reach consisted mainly of sand, with several areas of sandy/silt. The immediate substrate north of Duck Lake Trail is cobble and gravel, mixed with placed riprap. Slope gradients in this reach were predominantly flat, 0% to 10%, with some steep slopes, over 60% for the first 10 meters of the subreach. Apart from the first 50 to 75 meters, the channel was not very sinuous. The channel development was fair to poor (riffle, run, pool). This subreach contained a great deal of woody debris jams and garbage. Several Eden Prairie park signs were encroaching on the channel or had fallen in the stream indicating the channel had shifted or high flows had occurred. Residential lawns were mowed close to the stream edge along the right bank. The immediate surrounding vegetation was dominated by thick brush, much of which consisted of buckthorn. There was moderate erosion throughout the subreach. The heavier areas of erosion and cutting occurred at the beginning of the subreach. As the reach continued, more of the lower areas of cutting were beginning to heal over, but there were several areas of bank that were bare. There was also considerable amount of sediment deposition in the beginning of the subreach. The exposed metal culvert within the stream has had the topsoil eroded away and could potentially be a risk if it moved at high flows in the future. Much of the subreach was littered with trash. For the full creek walk summary, see Exhibits E**.**

Purgatory Creek - PT-5A&B

This subreach is also one that had not been previously walked and assessed by staff for the purpose of informing the CRAS. This reach is made up of two subreaches, PT-5A and PT-5B. The tributary begins about 80 meters upstream of the recreational trail off Vine Hill Road. It continues downstream (south/southwest) for about 0.92 stream miles to where it meets Vine Hill Road. The stream starts at three locations, all draining the adjacent wetland area. The channel had little stream development (riffle, run, pool), and the channel was very shallow. The reach was surrounded by a mixture of wetland grasses/sedges and deciduous forests. In subreach A, the riparian widths were wide, but in subreach B, they were very narrow, less than five meters. A mixture of sand and silt made up the majority of the substrate. Slope gradients were very flat, allowing for connectivity to the floodplain. Staff observed a great deal of woody debris in the channel. It was fairly stable, although much of the stream was incised, about 0.1-0.5m. Infrastructure risks were low, excluding some erosion around the culvert under Del Ann Circle. For the full creek walk summary, see Exhibits E**.**

Purgatory Creek – P8

Scores for this reach remained relatively similar to the first assessment in 2015. This reach starts at Lotus Lake and passes through residential areas, deciduous forest, and wetlands, ending at Dell Road. The riparian width on the right bank averaged about 50m. The average width of riparian zone on the left bank was closer to 10m. There were several areas where the immediate upper bank was mowed to the channel on the left bank. The substrate in this reach consisted predominantly of sand/silt, with some areas exhibiting heavy mixtures of gravel/silt, gravel/sand, and silt/detritus. Slope gradients were low, between 0% and 10% for most of the reach. There were several stretches where the gradient was above 40%, and a few short areas that exceeded slopes of 60%. There were few areas where the channel was sinuous, but it was mostly fair at best. The channel development (riffle/run/pool) was fair-to-poor. Most of the channel was a run or glide. There was a built-up driveway/parking area with a wood retaining wall on the left bank in P8B and a partially filled culvert under Chanhassen Road that may pose some infrastructure risk. The bank slopes here were greater than 60%, mostly bare, and seemed to have had some continuous erosion occurring (there were several sediment deposits downstream of this bank).

Purgatory Creek – P5A

This subreach starts at Highway 62 and passes through a large wetland complex, ending at Eden Prairie Road. The riparian width was wide, averaging about 75m on both banks. The wide wetland floodplain was bordered by residential area on both sides. The channel banks were covered by wetland grasses, sedges and other herbaceous vegetation along the majority of the subreach. Sediment throughout the subreach was predominantly sand, with some sites containing mixtures of sand/silt, and some areas with cobble. The slope gradients throughout were very low, between 0% and 5%. There was a great deal of connectivity to the surrounding floodplain/wetland (water levels were a bit higher during the walk and the stream was connected to backwaters and small branches flowing to and from the wetland). Sinuosity of the channel was good at the start of the subreach but worsened moving downstream. The stream development (riffle/run/pool) was poor. There was a very low percent of riffles, runs, and pools; most of the stream was in a glide. In the beginning of the reach, the erosion along both banks was moderate and continuous. Cutting in the beginning stretch, measured around 1.5m high and didn't start to subside until about 150m into the subreach. Bank sloughing is occurring at several points. There is also quite a bit of sediment deposition and some deep scours along the bends in this section of the subreach.

Table 4-4 2018 Creek Restoration Action Strategy Updates

Tier I and Tier II scores for the Creek Restoration Action Strategy for 2017 and the corresponding updates from 2018 for subreaches within P8, PT-4, P5, and PT-5.

Reach	Subreach	Location	2017 Tier I Scores	2018 Tier I Scores	Tier II Scores
P8	P8A	Lotus Lake to Chanhassen Road	12	14	10
P8	P8B	Chanhassen Road to 120m West of Tartan Curve	16	16	10
P8	P8C	Wetland	n/a	n/a	n/a
P8	P8D	Tartan Curve to Duck Lake Trail	12	14	14
P8	P8E	Duck Lake Trail to Dell Road	18	18	12
PT-4	PT-4A	Duck Lake Trail to Main Channel	n/a	16	10
P5	P5A	Highway 62 to Eden Prairie Road	12	10	8
PT-5	PT-5A	Upper Silver Branch Tributary	n/a	14	12
PT-5	PT-5B	Middle Silver Branch Tributary	n/a	16	10

Note:
Red = Severe
Orange = Poor
Green = Moderate
Blue = Good

In 2019, staff will finish the second complete walk of Purgatory Creek and update accordingly. CRAS updates and potential additional monitoring for 2019:

- Placement of additional bank pins at sites that align with upcoming projects.
- Walk additional 1st order tributaries that have not been assessed.
- LRAS
- Assessing additional ravine erosion areas.
- Using the stream power index (SPI) to identify and assess potential areas of erosions upstream of wetland, creeks, and lakes.

- Installing EnviroDIY stations near areas of concern or where information is lacking.
- Utilize CRAS2 to advance creek stability assessments.
- Adding macroinvertebrates Index of Biotic Integrity to CRAS scoring methodology.

Bank Pins

In addition to creek walks, staff have also checked bank pins yearly since they were installed in 2015 near all the regular water quality sites. The bank pins were installed at "representative" erosion sites to evaluate erosion rates for each reach. Staff measured the amount of exposed bank pin or sediment accumulation if buried in 2016 through 2018 (2017 and 2018 measurements shown in Table 4-5). From this, staff can quantify estimates of lateral bank recession rates. Engineering firm Wenck Associates, Inc. also installed bank pins at 11 sites on lower Riley Creek (south of Lake Riley) and Purgatory Creek (south of Riverview Road) in 2008 and 2010, to monitor bank loss and quantify lateral recession rates (Wenck, 2017). From their monitoring results, Wenck was able to track the potential effectiveness of upstream bank repairs on bank-loss-reduction at the Purgatory Creek sites. Results from monitoring the Riley Creek bank pins informed Wenck's recommendation to the City of Eden Prairie to prioritize several reaches for stabilization. In 2018, staff added pins at representative erosion sites near the following regular creek monitoring sites (if pins were installed on the left bank, it is denoted here as LB; RB denotes pins installed on the right bank): 2 pins on LB at R4, 3 pins on RB and 3 pins on LB at R2, 3 pins on RB at B4, 3 pins on RB and 3 pins on LB at B3, 2 pins on RB at B2, and 1 pin on LB at P6. District staff will continue to monitor the bank pins/bank loss at our 18 regular monitoring sites, as well as replace any pins which were not found in 2018. In 2018, reach R5 had the highest estimated lateral loss (in/year) while reach three had the highest bank loss per one-yard stretch of creek (ft3).

Table 4-5 2017-2018 Bank Pin Data

Lateral creek bank loss per year as well as the estimated bank volume loss for a one-yard section of streambank at each of the 18 regular creek monitoring sites. Lateral loss was determined by taking the mean from each bank and then averaging the left and right bank means. Bank heights used to calculate the volume of bank loss were based off bank heights measured during installation in 2015. Negative values denote areas of bank where there was sediment deposition. Empty cells denote sites where pins were not found. Orange-highlighted cells denote sites where bank pins were added on one or both banks in 2018.

	Average Lateral Loss (in/year)	

Site			Estimated bank loss per one-yard stretch of creek (ft3)	
	2017	2018	2017	2018
R5	1.08	8.99	3.22	2.41
R4	1.08	0.42	1.15	0.25
R3	4.05	5.31	4.65	3.18
R2	-0.04	--	-0.01	--
R1	4.50	2.96	6.64	1.23
P8	-1.64	0.55	-0.12	0.12
P7	3.37	2.02	1.76	2.48
P6	1.23	0.73	0.85	0.35
P5	3.82	0.77	2.86	0.41
P4	2.79	0.83	1.40	0.27
P3	1.07	0.94	0.86	0.51
P2	0.75	0.50	0.56	0.24
P1	7.11	0.38	7.11	0.46
B5	0.49	-0.79	0.90	-0.23
B4	10.16	5.58	25.84	3.66
B3	2.79	--	5.38	--
B2	2.07	3.00	0.82	1.25
B1	4.43	-0.67	8.59	-0.25

4.6 Chloride Monitoring

Chloride (Cl) levels in our water bodies are becoming of greater concern within the state of Minnesota. It takes only one teaspoon of road salt to permanently pollute five gallons of water, as chlorides do not break down over time. At high concentrations, Cl can also be harmful to fish, aquatic plants, and other aquatic organisms. The MPCA Cl Chronic Standard (CS, highest water concentration of Cl to which aquatic life, humans, or wildlife can be exposed to indefinitely without causing chronic toxicity) is 230mg/L for class 2B surface waters (all waters sampled within the district, excluding storm water holding ponds). The MPCA Cl Maximum Standard (MS, highest concentration of Cl in water to which aquatic organisms can be exposed for a brief time with zero to slight mortality) is 860mg/L for class 2B surface waters.

The District has been monitoring salt concentrations in our lakes and ponds since 2013 and will continue monitoring efforts to identify high salt concentration areas and to assess temporal changes in salt concentrations. In 2018, staff carried out Cl sampling in lakes and streams every other week during the spring, switching to monthly sampling in summer/fall/winter. In 2018, winter monitoring included the Purgatory Chain of Lakes (Hyland, Lotus, Mitchell, Red Rock, Round, Silver and Staring), the Upper and Lower Purgatory Creek Recreation Area (UPCRA and LPCRA), Idlewild (a high value wetland) and a chain of ponds that drain the City of Eden Prairie Center to Purgatory Creek. During sampling, staff collected a surface 2m composite sample and a bottom water sample to be analyzed for Cl. Since 2013, except for some samples taken from Idlewild, every sample taken from the RCL and PCL, has fallen below the MPCA CS of 230mg/L (Figure 4-7; Figure 4-8). Cl levels have stayed relatively consistent within lakes year-to-year.

Figure 4-9 shows Cl levels within the four stormwater ponds, which includes all sampling events since 2013. In the spring of 2015, staff were no longer able to take accurate water samples on Pond A due to low water levels, so, sampling began on Pond B, directly upstream. In 2018, due to inconsistencies with getting samples without disturbing sediment, staff reverted to sampling Pond A in place of Pond B for several monitoring events. Most samples taken from Eden Pond greatly exceed the class 2B CS, some exceeding the class 2B MS. Except for two sampling events, all samples taken from Pond K exceed the class 2B MS, although, there has been a noticeable drop in Cl levels since sampling began in 2013. It is important to note that these stormwater ponds are not classified as class 2B surface waters by the MPCA; the CS is given in the figure to demonstrate how much higher Cl levels accumulating within these ponds are before water moves into Purgatory creek. Staff will continue the winter monitoring of Cl in the Purgatory Chain of Lakes in 2019 which will include: Lotus, Silver, Duck, Round, Mitchell, Red Rock, Staring, and Hyland Lake. Rice Marsh Lake will also be monitored for Cl in the 2019 winter, along with the stormwater ponds draining Eden Prairie Center, UPCRA, and LPCRA. Once-a-month Cl sampling will continue as part of sampling SOP's during the regular growing season on both lakes and streams.

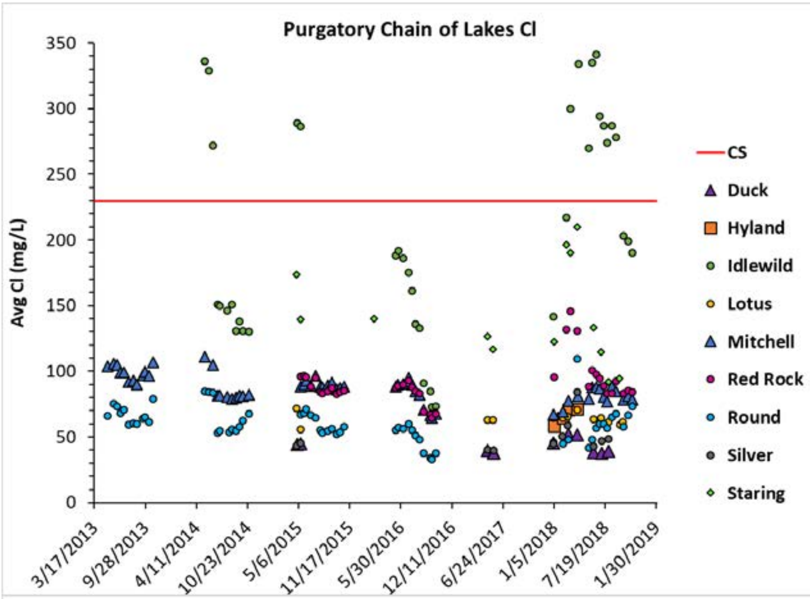


Figure 4-7 2013-2018 Chloride Levels within the Purgatory Chain of Lakes

All chloride sampling results (mg/L) on the Purgatory Chain of Lakes from 2013-2018. The MPCA chloride chronic standard for class 2B waters (230mg/L) is indicated by the red line.

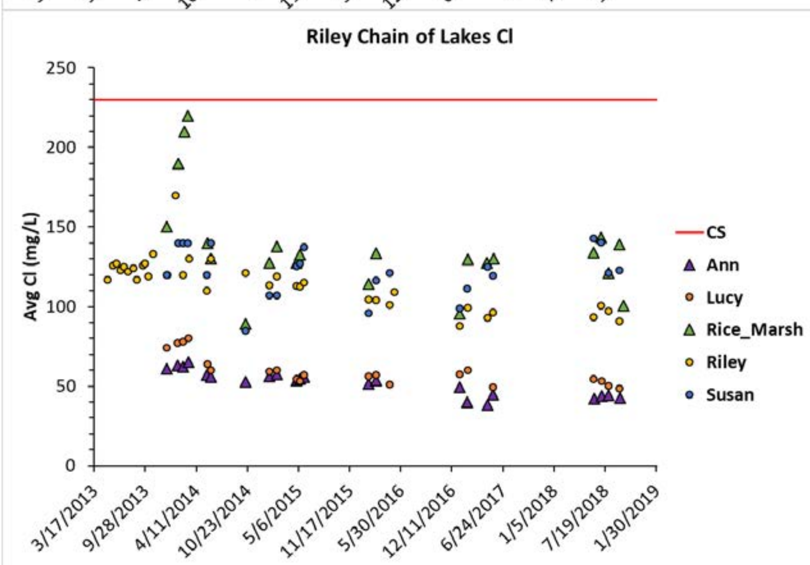


Figure 4-8 2013-2018 Chloride Levels within the Riley Chain of Lakes

All chloride sampling results (mg/L) on the Riley Chain of Lakes from 2013-2018. The MPCA chloride chronic standard for class 2B waters (230mg/L) is indicated by the red line.

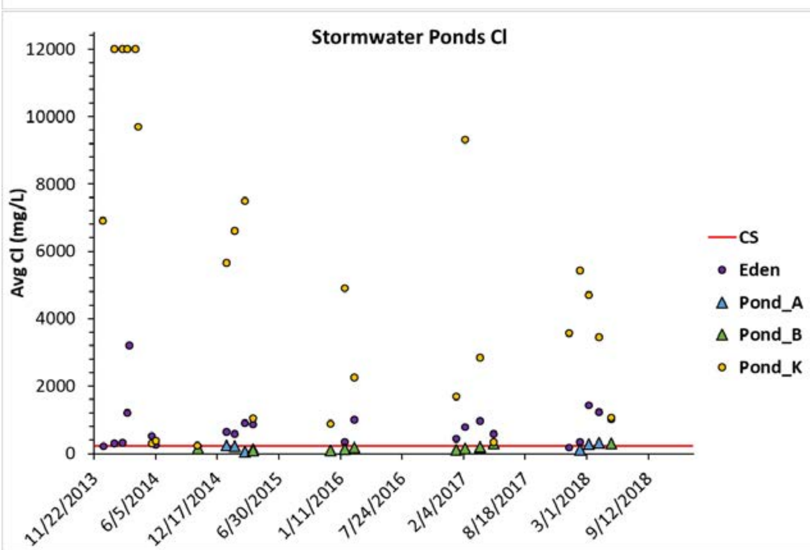


Figure 4-9 2013-2018 Chloride Levels within Stormwater Ponds

All chloride results (mg/L) on stormwater ponds draining the City of Eden Prairie Center to Purgatory Creek from 2013-2018. The MPCA chloride chronic standard (230mg/L) for class 2B waters indicated by the red line.

4.7 Nitrate Monitoring

The toxicity of nitrates to aquatic organisms has been a growing concern in MN over the last decade. Nitrate (NO_3), the most available form of nitrogen for use by plants, can accumulate in lakes and streams since aquatic plant growth is not limited by its abundance. While nitrate has not been found to directly contribute to eutrophication of surface waters (phosphorus is the main cause of eutrophication) and is not a MPCA water quality standard, studies have found that nitrate can cause toxicity in aquatic organisms. In 2010, the MPCA released the Aquatic Life Water Quality Standards Technical Support Document for Nitrate: Technical Water Quality Standard Amendments to Minn. R. chs. 7050 and 7052 (still in the draft stage for external review) to address concerns of the toxicity of nitrate in freshwater systems and develop nitrate standards for class 2B and 2A systems. Sources of excess nitrate in freshwater systems are linked to human activities that release nitrogen into water. The draft chronic standard (CS) of 4.9mg/L nitrate-N.

During sampling, staff collects a surface 2m composite, a sample at the thermocline of the lake, and a bottom water sample to be analyzed for nitrate+nitrite and ammonia+ammonium. Three Rivers Park District conducts water sampling on Hyland Lake and shares data with the District. Their lab tests do not specifically test for nitrogen as nitrate+nitrite or ammonia, therefore, nitrogen data on Hyland has been omitted. The District monitors for nitrates in lakes as a part of its regular sampling regime. The District tests for nitrates in the form of nitrate+nitrite (the combined total of nitrate and nitrite, Table 4-6). This lab also tests for ammonia in the form of ammonia+ammonium (Figure 4-10). As seen in Table 4-6, all the lakes in the District met the draft nitrate CS. It is also important to note that the lab equipment used to test for nitrate has a lower limit of 0.03mg/L. Therefore, it is possible that some of the samples contained less than 0.03mg/L nitrate; because of this, actual average nitrate levels in District lakes may be lower than what measured (Table 4-6).

Table 4-6 2018 Lakes Summer Average Nitrate+Nitrite

2018 growing season (June-September) average nitrate+nitrite levels for District lakes. The MPCA proposed chronic standard (CS) is included in the table (orange). Lower limit of lab analysis of nitrate+nitrite is 0.03mg/L, some of these averages may be lower than indicated.

Lake	Average Nitrate+Nitrite (mg/L)
CS	4.9
Ann	0.030
Duck	0.040
Lotus	0.230
Lucy	0.030
Rice Marsh	0.040
Riley	0.040
Silver	0.040
Staring	0.580
Susan	0.450
Idlewild	<0.05
Mitchell	<0.05
Red Rock	<0.05
Round	<0.05

Ammonia (NH_3), a more toxic nitrogen-based compound, is also of concern when discussing toxicity to aquatic organisms. It is commonly found in human and animal waste discharges, as well as agricultural fertilizers in the form of ammonium nitrate. When ammonia builds up in an aquatic system, it can accumulate in the tissues of aquatic organisms and eventually lead to death. The MPCA does have standards for assessing toxicity of ammonia; the CS of ammonia in class 2B is 0.04mg/L. RMB Environmental Lab water sample testing methods measures for ammonia in the form of ammonia+ammonium. The lab lower limit for these samples is 0.04mg/L. The lower limit for sample data provided by the City of Eden Prairie for Red Rock, Round, Idlewild, and Mitchell Lakes is 0.16mg/L. Due to these limits, some of the average levels of Ammonia+Ammonium provided in Figure 4-10 may actually be lower than what is given. In lakes and streams, ammonium (NH_{4+}) is usually much more predominant than ammonia (NH_3) under normalized pH ranges. Ammonium is less toxic than ammonia, and not until pH exceeds 9 will ammonia and ammonium be present in about equal quantities in a natural water system (as pH continues to rise beyond 9, ammonia becomes more predominant than ammonium). Figure 4-10 shows ammonia+ammonium average levels in each lake during the growing season. These numbers are not of concern at this point seeing that pH levels were normal throughout the 2018 growing season and because lab testing measures the combination of ammonia and ammonium. This suggesting that most of nitrogen found in these tests was from the less toxic compound ammonium.

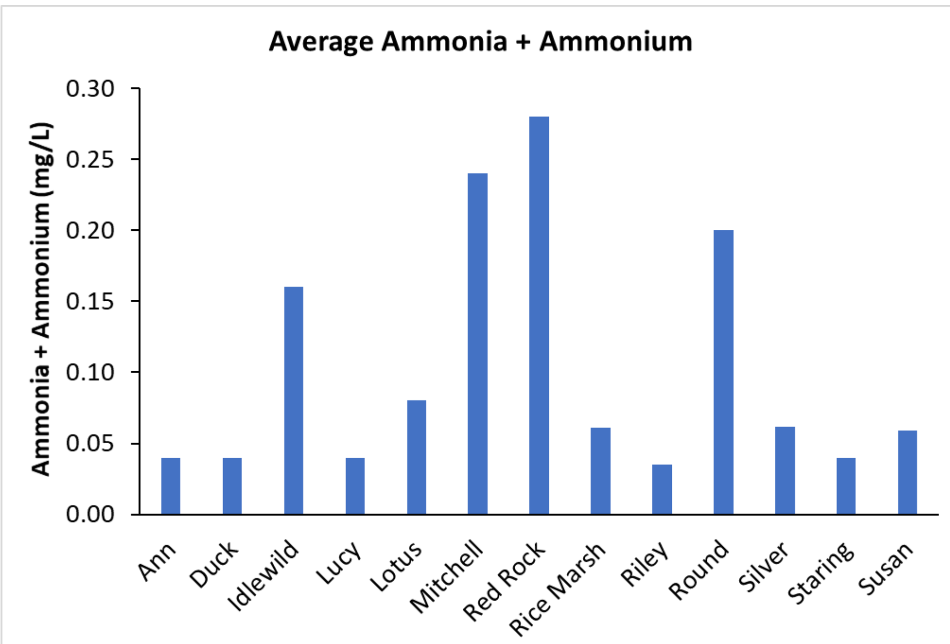


Figure 4-10 2018 Lakes Summer Average Ammonia+ Ammonium

The figure includes the average levels of ammonia+ammonium from samples taken on each lake during regular sampling within the growing season (June-September).

4.8 Zooplankton and Phytoplankton

In 2018, five lakes were sampled for both zooplankton and phytoplankton: Lake Riley, Rice Marsh Lake, Lake Susan, Lotus Lake, and Staring Lake. Zooplankton play an important role in a lake's ecosystem, specifically in fisheries and bio control of algae. Healthy zooplankton populations are characterized by having balanced densities (number per m^2) of three main groups of zooplankton: Rotifers, Cladocerans, and Copepods. The Sedgwick-Rafter Chamber (SRC) was used for zooplankton counting and species identification. A two mL sub-sample was prepared in which all zooplankton were counted and identified to the genus and/or species level. The sample was scanned at 10x magnification to identify and count zooplankton using a Zeiss Primo Star microscope. Cladocera images were taken using a Zeiss Axiocam 100 digital camera and lengths were calculated in Zen lite 2012. The District analyzed zooplankton populations for the following reasons:

1. Epilimnetic Grazing Rates (Burns 1969): The epilimnion is the uppermost portion of the lake during stratification where zooplankton feed. Zooplankton can be a form of bio control for algae that may otherwise grow to an out-of-control state and therefore influence water clarity.
2. Population Monitoring (APHA, 1992): Zooplankton are a valuable food source for planktivorous fish and other organisms. The presence or absence of healthy zooplankton populations can determine the quality of fish in a lake. Major changes in a lake (significant reduction in common carp, winter kills, large scale water quality improvement projects, etc.) can change zooplankton populations drastically. By insuring that the lower parts of the food chain are healthy, we can protect the higher ordered organisms.
3. Aquatic Invasive Species Monitoring: Early detection of water fleas is important to ensure these organisms are not spread throughout the District. These invasive species outcompete native zooplankton for food and grow large spines which make them difficult for fish to eat.

The Sedgwick-Rafter Chamber (SRC) was used for phytoplankton counting and species identification. A one mL aliquot of the sample was prepared using a Sedgewick Rafter cell. Phytoplankton were identified to genus level. The sample was scanned at 20x magnification to count and identify phytoplankton species using a Carl Zeiss Axio Observer Z1 inverted microscope equipped with phase contrast optics and digital camera. Higher magnification was used as necessary for identification and micrographs. The District analyzed phytoplankton populations for the following reasons:

1. Population Monitoring: Phytoplankton are the base of the food chain in freshwater systems and fluctuate throughout the year. By insuring that the lower parts of the food chain are healthy, we can protect the higher ordered organisms such as macroinvertebrates and fish.
2. Toxin Producers and Algae Blooms: Some phytoplankton produce toxins that can harm animals and humans, or cause water to have a fowl taste or odor (*Microcystis, Aphanizomenon, Dolichospermum, Planktothrix, and Cylindrospermopsis)*. Monitoring these organisms can help us take the proper precautions necessary and identify possible sources of pollution. Just because toxic algae are found in a lake does mean it could cause harm. Specific conditions must be met for the algae to become toxic.

Lake Riley

In 2018, all three groups of zooplankton were captured in Lake Riley (Exhibits C), however only 3.6% of the population was comprised of Cladocera. As expected, rotifers were the most abundant zooplankton sampled (Figure 4-11). Contrary to 2016 and 2017, the number of rotifers identified in 2018 steadily increased over sampling events with the highest number observed during the last fall sampling event at 1.4 million. Copepod numbers followed the opposite trend as seen with the rotifers with the last event having the lowest number of 158 thousand. Cladoceran numbers remained low across all sampling dates; the highest number was recorded in late July (106 thousand), followed by the lowest number in August (13 thousand). Total Cladoceran counts in 2018 were about half of what was seen in 2016 and 2017 (around 450 thousand). This reduction may be due to the continual increase in water clarity caused by the alum treatment, causing increased predation on zooplankton populations. Additionally, zebra mussels were discovered in 2018 which could also be contributing to the increased water clarity and therefore predation. The most predominant Cladocera found in Riley was *Daphnia pulex* which was found across all sample dates except the last and can be found across the North American continent.

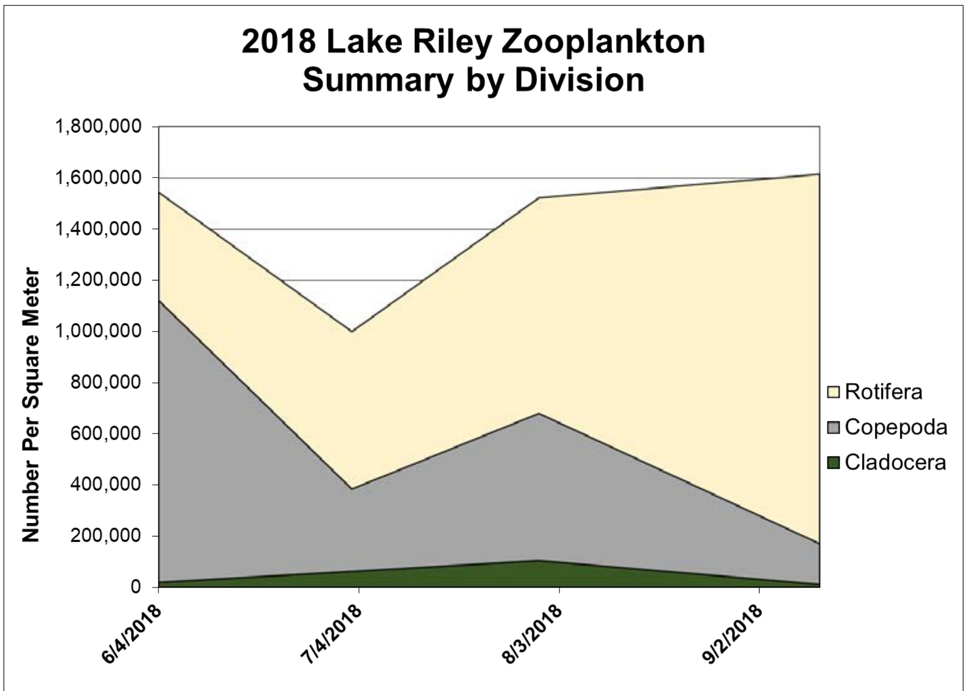


Figure 4-11 2018 Lake Riley Zooplankton Counts (#/m²)

Cladocera consume algae and have the potential to improve water quality if they are abundant in large numbers. The 2018 Cladocera seasonal trend of estimated epilimnetic grazing rates was very similar- to what was observed in 2016 and 2017. Due to the lower numbers of Cladocera as seen in the past, grazing rates were near half. The late June grazing rate was the highest at 13% in June and the lowest rate was near 0% in September (Figure 4-12). The highest June grazing rate was linked to the highest number of *Daphnia pulex* recorded for the year.

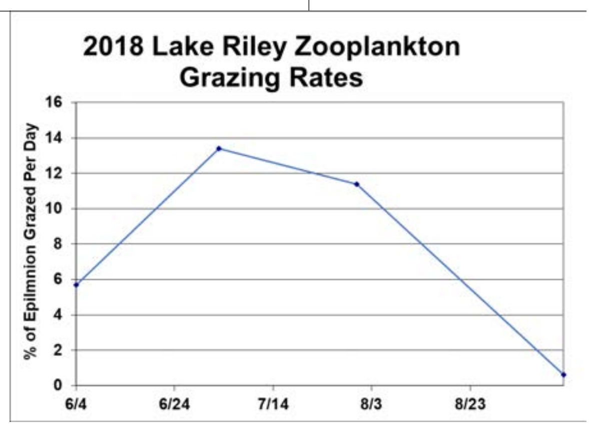


Figure 4-12 2018 Lake Riley Epilimnetic Grazing Rates

During the summer of 2018, staff collected four phytoplankton samples on Lake Riley (Exhibits D). The seasonal abundance of phytoplankton is presented in Figure 4-13. The early June phytoplankton population was comprised of primarily *Rhodomonas sp*. (Cryptophyceae) cells which made up 55% of the total phytoplankton abundance (TPA). Cryptophytes are motile unicellular algae that grow photosynthetically and are broadly distributed in lakes, usually preferring nutrient-rich environments. Cyanobacteria dominated the phytoplankton population for the remainder of the year at (97%, 91%, and 97% TPA). *Aphanizomenon sp*. was the predominant cyanobacteria found and is known as a possible toxin producer that may potentially produce cylindrospermopsin, anatoxins, and saxitoxins. These toxic compounds have the potential to pose serious threats to human and environmental health via contamination of drinking water, recreational exposure to waterborne toxins and possible accumulation of toxins in the food-web.

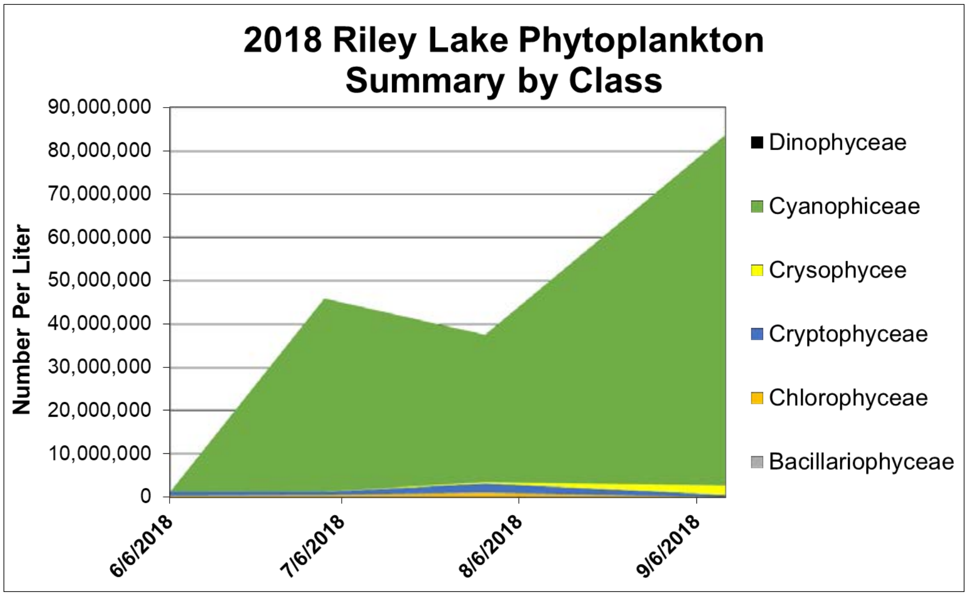


Figure 4-13 2018 Lake Riley Phytoplankton Abundance (#/L) by Class.

Lotus Lake

In 2018, all three groups of zooplankton were present in Lotus Lake (Exhibits C). Rotifers were the most abundant zooplankton sampled (Figure 4-14). June rotifer numbers were high (3 million) before declining to 511 thousand in early July and less 176 thousand for the remainder of the year. Copepod numbers remained relatively level throughout the year averaging 600 thousand across all sample dates. Cladoceran numbers began at 246 thousand in June before decreasing to an average of 100 thousand for the remainder of the year. The highest spring Cladocera numbers can be attributed to largest abundance of *Daphnia retrocurva* sampled in 2018. *Daphnia retrocurva* is known for its large curved helmet it develops in late spring-to-summer to reduce predation by planktivorous fish and invertebrates.

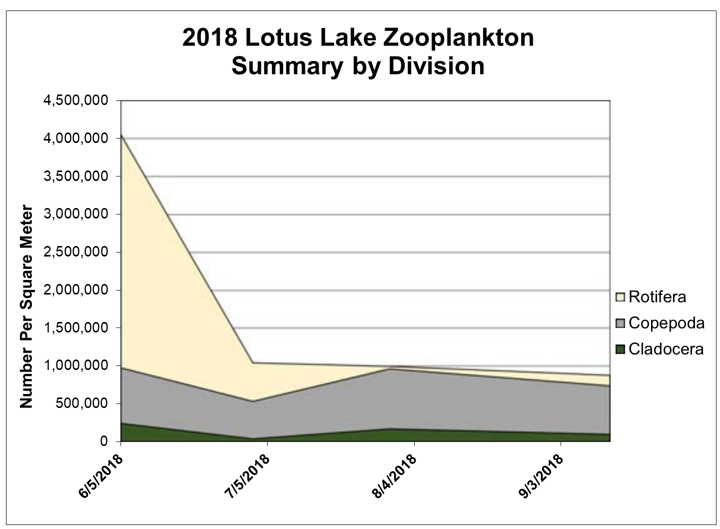


Figure 4-14 2018 Lotus Lake Zooplankton Counts (#/m²)

Large Cladocera consume algae and, if enough are present in a lake, they have the potential to improve water quality. The estimated epilimnetic grazing rates observed in 2018 ranged from 6% to 19% (Figure 4-15). As expected, grazing rates followed a similar trend to what was seen in the population fluctuations; the largest grazing rate occurred on June 5th when the spike in *Daphnia retrocurva* numbers occurred.

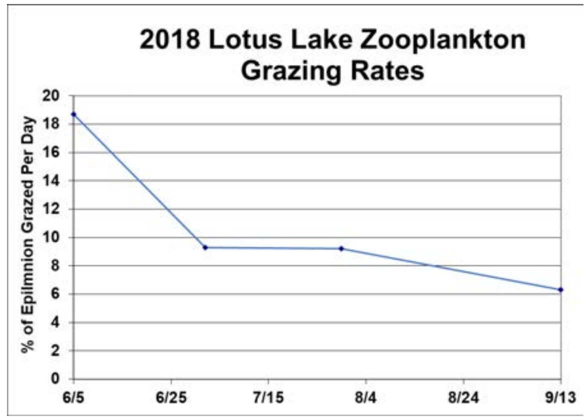


Figure 4-15 2018 Lotus Lake Epilimnetic Grazing Rates

During the summer of 2018, staff collected four phytoplankton samples on Lotus Lake (Exhibits D). The abundance of phytoplankton across all sampling dates is presented in Figure 4-16. Cyanobacteria was the dominant species across all sampling dates (96%, 58%, 99%, and 96% total phytoplankton abundance by sampling event). The June cyanobacteria population was dominated by *Aphanothece sp.* which may produce toxic compounds. *Aphanizomenon sp.* was the dominant species of cyanobacteria for the remainder of the year with a massive spike occurring in late July. *Aphanizomenon* are a potential cylindrospermopsin, anatoxins, and saxitoxins producer.

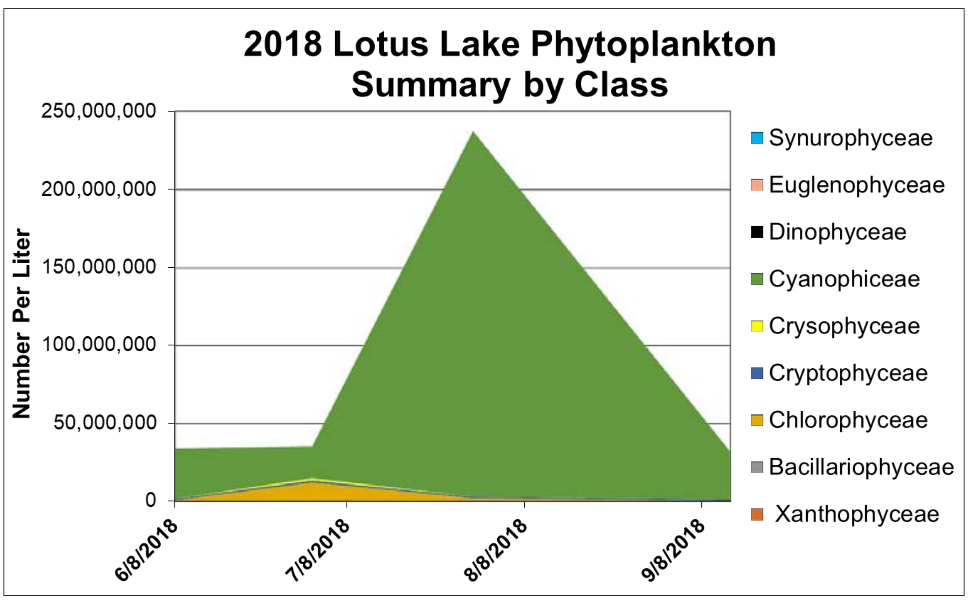


Figure 4-16 2018 Lotus Lake Phytoplankton Abundance (#/L) by Class.

Lake Susan

Rotifers were the most abundant zooplankton captured in 2018 in Lake Susan (Exhibits C). Both rotifer and cladocera numbers were overall significantly lower in 2018 than in 2017, while copepoda numbers remained similar. The rotifer population was variable over the sampling events with a spike in rotifers occurring in early July (2 million organisms). Copepod numbers were highest during the first sampling event (557 thousand) but remained stable across the remainder of the year, averaging around 270 thousand (Figure 4-17). Overall, Cladocera numbers were low, under 20 thousand individuals per sampling event, except for the spring sample which had 182 thousand organisms. The lowest Cladocera population was recorded in late July when only 8 thousand individuals were captured. The most abundant Cladocera captured in Lake Susan was *Daphnia galeata mendotae*.

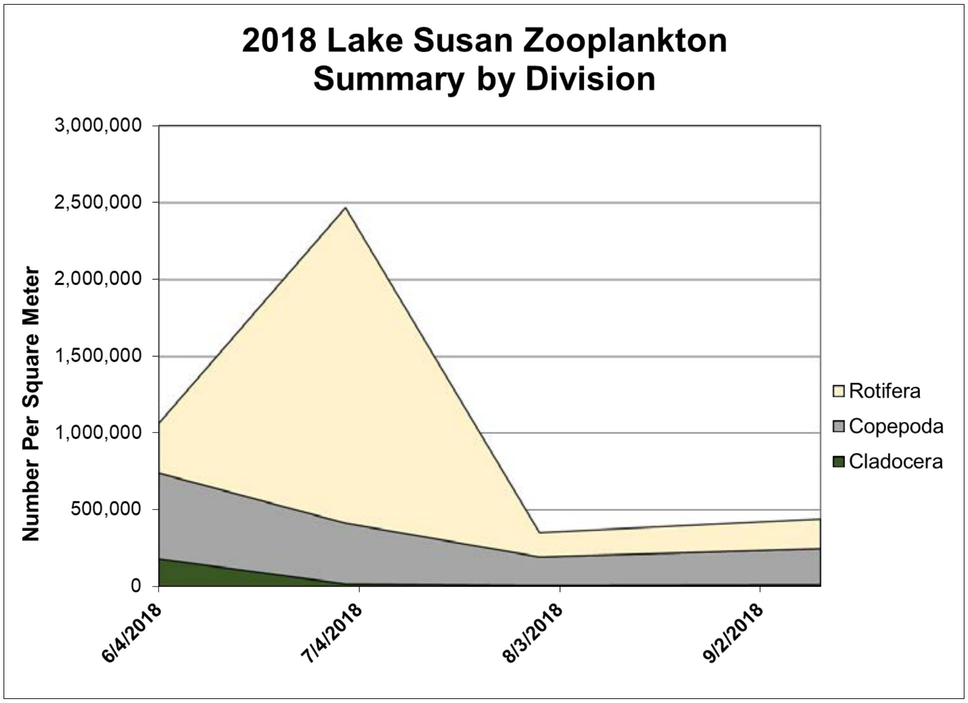


Figure 4-17 2018 Lake Susan Zooplankton Counts (#/m²)

The estimated epilimnetic grazing rates upon algae observed in 2018 were very low, ranging from 0.1% to 11% (Figure 4-18). This is mainly due to the very limited number of Cladocera present in all the samples collected. The highest grazing rate was observed in early June when *Daphnia galeata mendotae* were more numerous in the zooplankton community.

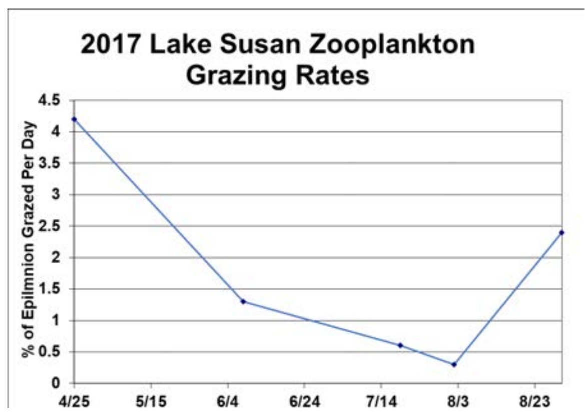


Figure 4-18 2018 Lake Susan Epilimnetic Grazing Rates

During the summer of 2018, staff collected four phytoplankton samples on Lake Susan (Exhibits D). Abundance of phytoplankton by Class are presented in Figure 4-19. During the spring sample, *Rhodomonas sp.* (Cryptophyceae) cells were 48% of the total phytoplankton abundance (TPA) found. Cryptophytes are motile unicellular algae that grow photosynthetically and are broadly distributed in lakes, usually preferring nutrient-rich environments. Cyanobacteria was the dominant phytoplankton species for the remainder of the year with TPA values at 93%, 98%, and 97% respectively. *Aphanizomenoon sp.* and *Lyngbia sp*. of cyanobacteria were the most common species present in the early July sample. *Aphanizomenon* may produce cylindrospermopsin, anatoxins, and saxitoxins. Near the end of July and in the September sample, *Cylindrospermopsis sp*. was the dominant species present. *Cylindrospermopsis* is a well-studied species due to the production of toxins like cylindrospermopsin and anatoxin; it was also shown to produce paralytic shellfish poisoning (PSP) toxins. These toxic compounds can pose serious threats to human and environmental health via contamination of drinking water, recreational exposure to waterborne toxins and possible accumulation of toxins in the food-web.

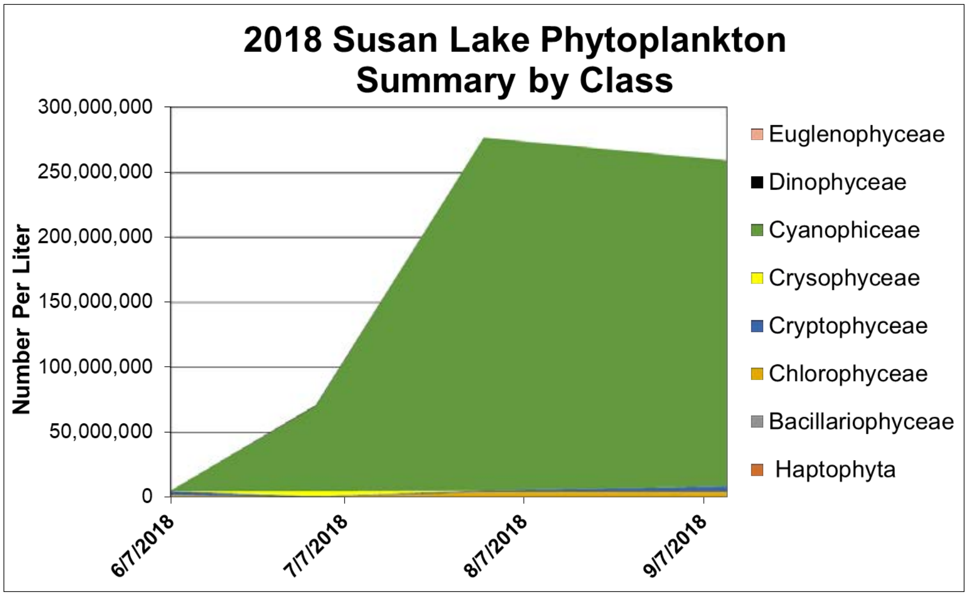


Figure 4-19 2018 Lake Susan Phytoplankton Abundance (#/L) by Class.

Rice Marsh Lake

In 2018, all three groups of zooplankton were captured in Rice Marsh Lake (Exhibits C), in which 13% of the population was comprised of Cladocerans, down from 27% in 2017. As expected, rotifers were the most abundant zooplankton sampled in 2018, however Copepod abundance was similar (Figure 4-20). Rotifer densities were highest during the first sampling event in July, while Copepod densities were highest in August. Cladoceran numbers began at its highest density of 173 thousand before declining to just under 23 thousand in early October. Across all sampling dates the Cladoceran community was dominated by small-bodied zooplankton, consisting of mainly *Bosmina longirostris, Ceriodaphnia sp*., and *Chydorus sphaericus.*

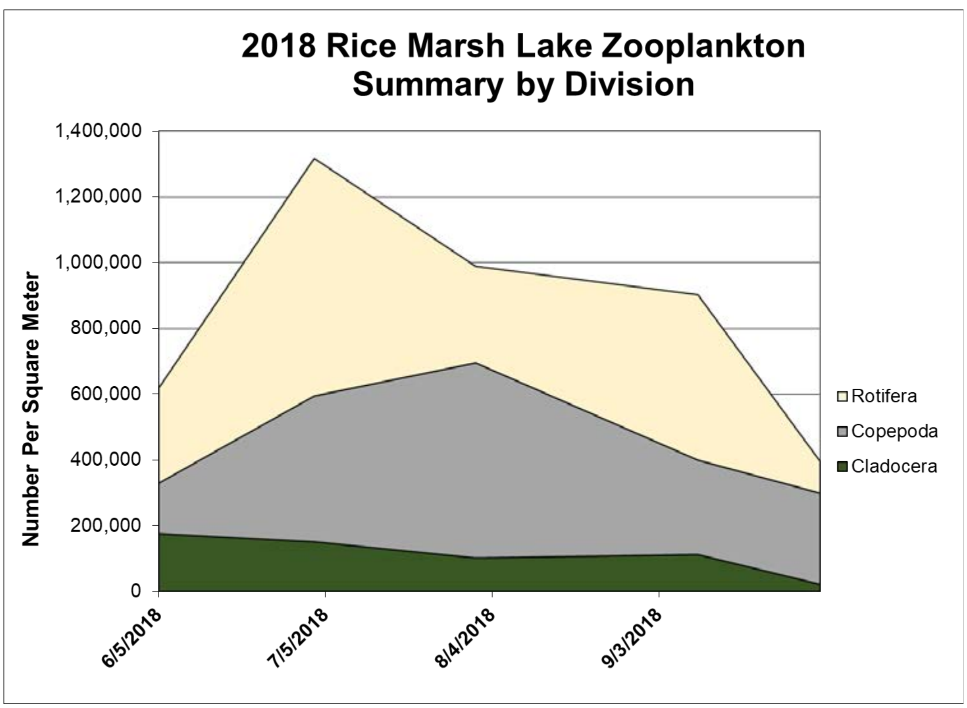


Figure 4-20 2018 Rice Marsh Lake Zooplankton Counts (#/m²)

The estimated epilimnetic grazing rates of Cladocera observed in 2018 ranged from near 0% to 23% on Rice Marsh Lake (Figure 4-21). The early June grazing rate was the highest, before averaging near 3% for the remainder of the year. The highest June grazing rate was linked with the presence of the larger bodied Cladocera *Daphnia galeata mendotae*. The most common Cladocera present was *Bosmina longirostris* which are commonly found in bog lakes such as Rice Marsh Lake.

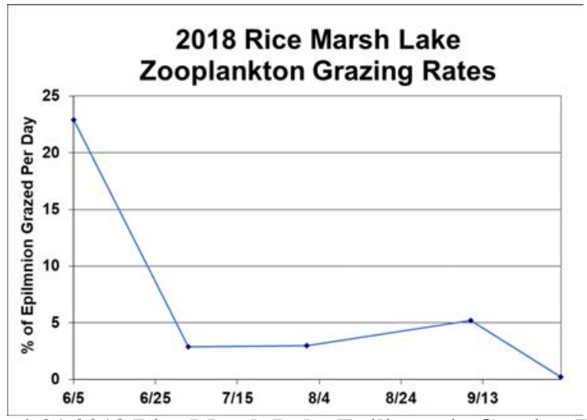


Figure 4-21 2018 Rice Marsh Lake Epilimnetic Grazing Rates

During the summer of 2018, staff collected five phytoplankton samples on Rice Marsh Lake (Exhibits D). Abundance of phytoplankton by Class for Rice Marsh Lake is presented in Figure 4-22. During the first June sampling event, *Uroglena sp.* (Crysophyceae) cells were 50% of the total phytoplankton abundance (TPA). *Uroglena sp.* may be a source of taste and odor problems. *Aphanizomenon sp.* was the dominant species in the sample and is a potentially toxic species. *Lyngbya sp.* was the dominant species during the late July sample, comprising 83% of TPA in the sample, and is potentially toxic. In August, *Rhodomonas sp.* (Cryptophyte) was the dominant species in the sample, comprising 65% of the TPA. Cryptophytes are motile unicellular algae that grow photosynthetically and are broadly distributed in lakes, usually preferring nutrient-rich environments. In October the dominant species in the sample was *Aphanizomenon sp.* which comprised 90% of the TPA. *Aphanizomenon* are a potential cylindrospermopsin, anatoxins, and saxitoxins producer.

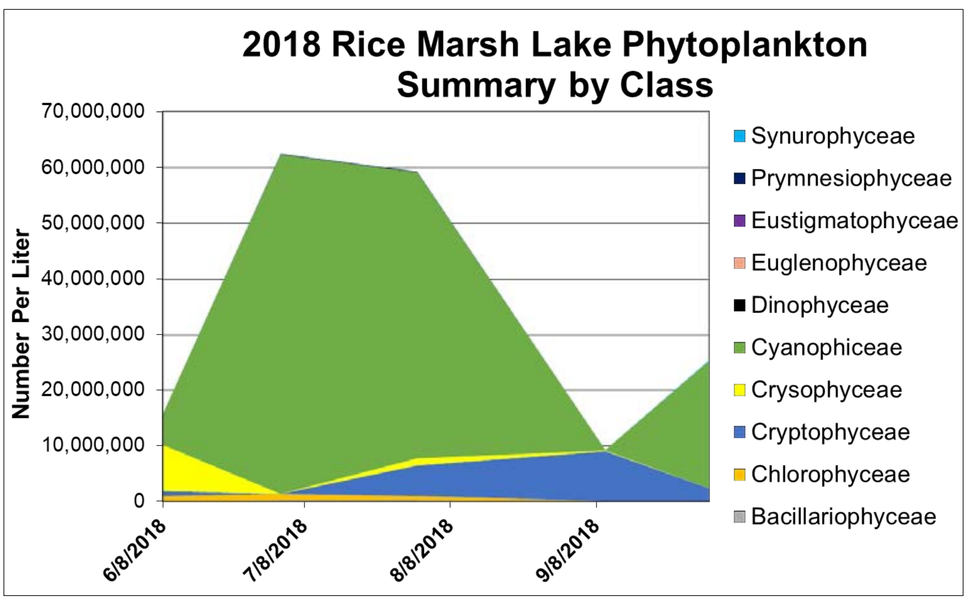


Figure 4-22 2018 Rice Marsh Lake Phytoplankton Abundance (#/L) by Class.

Staring

In 2018, all three groups of zooplankton were present and equally distributed across the year in Staring Lake (Exhibits C). The first June sampling event had the highest number organisms across all groups (Figure 4-23). Early June rotifer numbers were near 507 thousand before a decline to 47 thousand in June, and an average of 167 thousand for the remainder of the for the remainder of the year. Copepod numbers began the year around 1.7 million before declining to an average of 212 thousand. Cladoceran numbers remained relatively stable across all sampling dates except for the early July sample which bottomed out at 87 thousand. The most abundant Cladocera were *Bosmina longirostris* which are common in lakes and ponds across the United States.

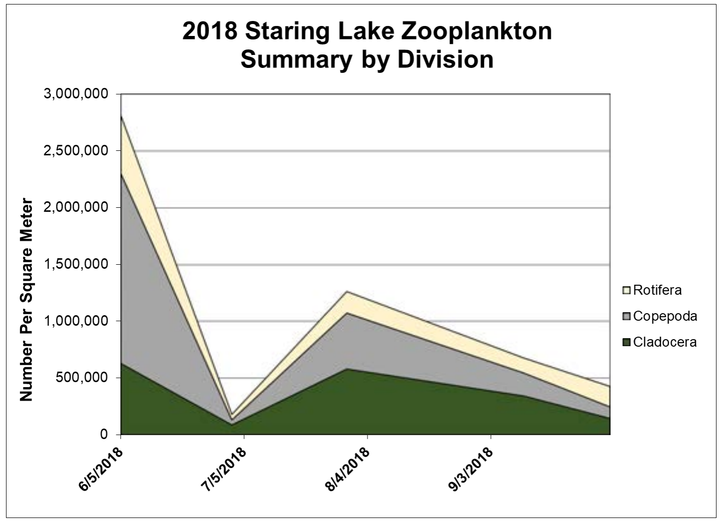


Figure 4-23 2018 Staring Lake Zooplankton Counts (#/m²)

Large Cladocera consume algae and may have the potential to improve water quality when present in large densities. The estimated epilimnetic grazing rates observed in 2018 ranged from 2% to 24% (Figure 4-24). The max grazing rate in June corresponded with the highest population of cladocera and optimal feeding temperatures near 21 degrees Celsius. Grazing rates were variable across the remaining sampling dates.

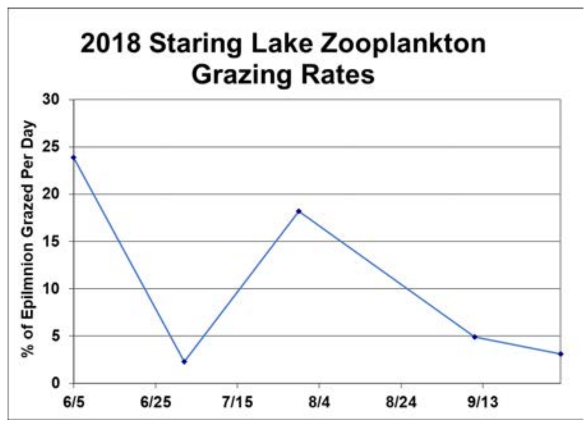


Figure 4-24 2018 Staring Lake Grazing Rates

During the summer of 2018, staff collected five phytoplankton samples on Staring Lake (Exhibits D). Abundance of phytoplankton by Class are presented in Figure 4-25. Cyanobacteria concentrations were extremely high across all sampling dates and comprised 95%, 98%, 99%, 99%, and 99% of the total phytoplankton abundance (TPA) respectively. *Aphanozomenon sp.*, *Microcystis wesenbergii*, and *Aphanocapsa sp.* were the most common. All mentioned species have the potential to produce harmful toxins which can pose serious threats to human and environmental health via contamination of drinking water, recreational exposure to waterborne toxins, and possible accumulation of toxins in the food-web.

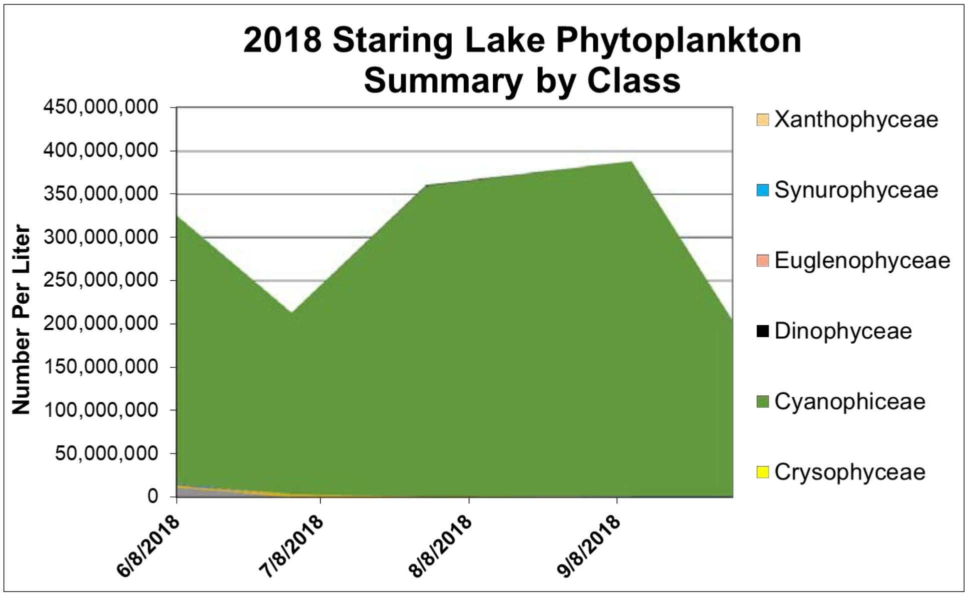


Figure 4-25 2018 Staring Lake Phytoplankton Abundance (#/L) by Class.

4.9 Winterkills and Fish Stocking

Winterkills are common across the state of Minnesota, especially in shallow eutrophic (nutrient-rich) lakes with muck bottoms and an abundance of aquatic plants. Many shallow lakes within the Riley Purgatory Bluff Creek Watershed District have had a history of winterkills. A winterkill occurs when dissolved oxygen (DO) levels within a lake drop below 4 mg/L for an extended period, causing fish to suffocate and perish. During the summer season, oxygen is added to lakes through wind action and photosynthesis by phytoplankton and macrophytes. In the winter, if there is limited snow to block sunlight, phytoplankton and some macrophytes may continue to photosynthesize and help prevent a winterkill from occurring. Microorganisms near the lake bottom and in the sediment of a lake are continuously decomposing material and consume DO in that process. If a large snow event occurs or snow coverage has been present for an extended period, it becomes too dark for photosynthesis to occur. The high organic content in shallow lakes provide an abundance of food for the decomposers which can cause DO levels to become depleted and a fish kill can occur.

In late March of 2018, RPBCWD staff were notified about a possible winterkill on Rice Marsh Lake by a resident who contacted the City of Chanhassen. Staff went out and conducted a regular water quality sampling event on the lake to observe if a fish kill occurred. Upon arriving at the lake, staff noticed many eagles and osprey sitting around the edge of the open water caused by the aeration unit and hypothesized that they were feeding. Immediately after drilling an ice hole, staff observed small bluegills floating to the top of the hole, deteriorated water clarity, and a smell was present, all of which confirmed a winterkill had occurred. DO levels in Rice Marsh Lake across all depths were less than 2 mg/l. After sampling Rice Marsh Lake, staff also sampled Duck Lake where similar conditions were observed, indicating a winterkill had occurred. The surface DO level was at 8 mg/L, while the remaining levels were below 2 mg/L. The high surface DO in Duck was likely caused by the power auger agitating the surface water. Lake residents attempted to prevent a winterkill by plowing away strips of snow totaling four to five acres to increase photosynthesis but were unsuccessful.

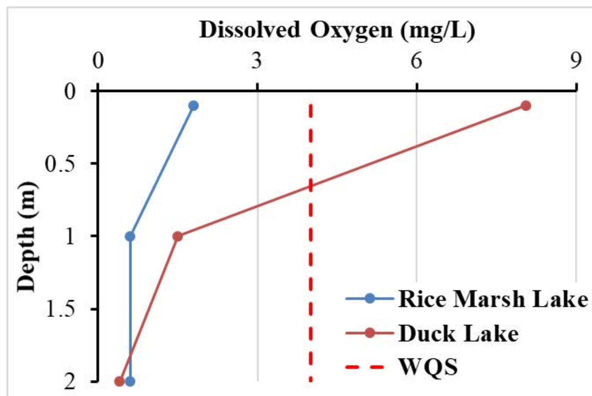


Figure 4-26 Duck Lake and Rice Marsh Lake Dissolved Oxygen Levels in March 2018

Staff had been operating an aeration unit on Rice Marsh Lake successfully and a large open water area was present all winter in 2018. No winterkills had previously occurred on Rice Marsh Lake since the aeration unit was installed in 2010. Preventing a winterkill in Rice Marsh Lake is a critical part of the Common Carp Management Plan for the Riley Chain of Lakes. Common carp have been known to move from various lakes in the Riley Chain into Rice Marsh Lake to spawn. Before the aeration unit was operational, Rice Marsh Lake would winterkill every few years which would eliminate all predators of common carp in the system and allow carp to successfully spawn. These successful spawning events caused large carp populations to form in all lakes within the Riley Chain. Since operation of the unit in 2010, no winterkills, and subsequently no major recruitment events of common carp occurred within the Riley Creek system until this winterkill.

Fish stocking following a winterkill is a common practice to reestablish a fish population. Due to the importance of Rice Marsh Lake in combating carp within the Riley Chain of Lakes, it was decided that bluegill sunfish would be stocked into the lake. Bluegill sunfish can suppress a carp population by consuming carp eggs during the spawn. A well-established bluegill population in a lake can completely control a carp population and prevent it from becoming a problem. Since the certified private hatchery was delivering bluegill to Rice Marsh Lake, staff also directed the stocking of bluegills in the Upper Purgatory Creek Recreational Area and Staring Lake. These two water bodies have variable carp populations that are not under full control and stocking bluegill has been used in the past to aid in common carp control. The stocking was used to bolster bluegill populations within the system with the hope of eliminating carp recruitment. Bluegill stocking rates can be seen in Figure 4-27.

Figure 4-27 2018 Bluegill Stocking Rates

Lake	Number of Bluegill Stocked
Rice Marsh Lake	1000
Staring	300
UPCRA	200
LPCRA	500

No spring fish kills were identified in 2018 as a result of the bacterial infection *Flexibacter columnaris* which in the past has occurred on Lotus Lake and Lake Susan.

4.10 Lake Susan Spent-Lime Treatment System

Figure 4-28 Spent Lime Treatment System

Lake Susan is an 88-acre lake next to Lake Susan Park. It is an important resource in the city of Chanhassen and the Riley Purgatory Bluff Creek Watershed District. The lake is a popular recreational water body used for boating and fishing. Lake Susan is connected to four other lakes by Riley Creek. It receives stormwater runoff from 66 acres of land around it, and from two upstream lakes (Lake Ann and Lake Lucy). The stormwater entering the lake carries debris and pollutants, including the nutrient phosphorus. Phosphorus is a nutrient that comes from sources such as erosion, fertilizers, and decaying leaves and grass clippings. Excess phosphorus can cause cloudy water and algal blooms in lakes. Removing phosphorus from stormwater is a proven way to improve the water quality of lakes and streams.

In 2016, an innovative spent-lime filtration system was constructed along a tributary stream draining a wetland on the south-west corner of Lake Susan (Figure 4-28). Based on system performance of the one other experimental spent lime filter site in the eastern Twin Cities area, modeling simulations based on available water quality measurements suggested the Lake Susan system had the potential to remove up to 45 pounds of phosphorus annually from water entering the lake. This would result in improved water quality and recreational opportunities. Spent-lime is calcium carbonate that comes from drinking-water treatment plants as a byproduct of treating water. Instead of disposing of it, spent-lime can be used to treat stormwater runoff. When nutrient-rich water flows through the spent-lime system, the phosphorus binds to the calcium. The water flows out of the spent-lime system, leaving the phosphorus behind.

Observation and monitoring data collected by District staff in 2016, suggested the system was underperforming and inundated for extended periods, which deviated from the original design parameters. In the spring of 2017, Barr completed additional field investigations, and laboratory testing for the Lake Susan spent lime system. Utilizing spent lime from the system, it was found that soluble reactive phosphorus (SRP) removals were on the order of 80-90%; within column tests which simulate the contact time within the Lake Susan system, removals were 30-40%. Additional testing led to modifications to attempt to improve system performance and address observed short-circuiting of flow through the system at no cost to the District. These modifications included the replacement of the cleanout pipes to eliminate leaky joints, modification of the header pipe so that pipe joints have welded connections, filling holes at the bottom of splash basin at the entrance to the system and of the monitoring hole in the side of the chamber, adding additional spent lime to the system, and removal of one stoplog in the manhole with the intention of promoting water level fluctuation in the spent lime system. Following the modifications, the system was put online for the summer of 2017 and was sampled weekly during the summer and into the fall. Similar to 2016, the system continued to underperform in 2017.

In 2018, sampling ports were installed at various locations within the spent-lime and monitored to allow the District and Barr to see removals throughout the spent lime layers. Monitoring results within the spent lime were again highly variable and did not indicate the consistent removal of nutrients. Due to the observed differences in water levels between the water on the surface of the media and the underdrain system, the reduced ability to extract water from the sampling port within the spent lime by mid-summer, the observation of no flow through the media during bucket tests at the site, and limited shifts in pH, it is hypothesized that the water is unable to contact or filter through the spent lime. Therefore, the material has significantly limited opportunity to form the calcium precipitates and remove phosphorus.

District staff and Barr Engineering will be meeting in 2019 to discuss possible next steps to improve removal efficiencies of the spent lime unit. Possible modifications include:

- Mixing spent lime with sand to increase filtering capacity.
- Replace two clean outs with perforated pipe to increase flow through the system.
- Modify the inlet so that inflow can be more precisely controlled to limit inundation duration.
- Modify the underdrains so water flows upward through the filter media to an overflow to increase water contact time with the spent lime.
- Adding baffles within the filter to create a longer flow path and extend residence time to increase phosphorus reductions.

4.11 Rice Marsh Lake Stormwater Inputs

Based on the Use and Attainability (UAA) assessment in 2016, 44% of the load of phosphorus entering Rice Marsh Lake was attributed to watershed runoff (Barr 2016). The District wanted to better capture and understand rain event nutrient loading into Rice Marsh Lake from the residential and business area northwest of the lake. This area was identified as a potential site for a water quality improvement project in the UAA. However, more information on nutrient loading at this site was needed. In August of 2016, District staff deployed an automated water-sampling unit at a storm drain pipe access point on Dakota Lane. They redeployed this unit again at this point in 2017 and 2018. This pipe drains to a stormwater pond which then drains into Rice Marsh Lake. Analyzing the "first flush" of a storm event is important because these events are when water pollution entering storm drains in areas with high proportions of impervious surfaces is typically more concentrated compared to the remainder of the storm. Water samples were analyzed for TDP, TP, TSS, and Chl-a. The automated water-sampling unit also tracked flow of water in the storm drain pipe at that point. In conjunction with the unit samples taken during/after a rain event, staff collected post-rain samples from the receiving stormwater pond. TP results were compared to MPCA TP standards for stormwater ponds.

In 2018, the amount of TP moving through the culvert after rain events was high, as seen in Figure 4-29. Five of the total nine samples taken had TP levels exceeding the ceiling of the MPCA standard for stormwater ponds (0.1mg/L – 0.25mg/L), the highest being 0.558mg/L. Three of remaining samples exceeded the floor of the standard (Figure 4-29). TP levels in the pond were lower, none exceeding the ceiling of the MPCA TP water quality standard (Figure 4-30); all but one sample exceeded the floor of the standard. Relative to TP measurements, TDP readings were low, the highest in-drain reading measuring 0.112mg/L, and the highest pond reading measuring 0.068mg/L (Figure 4-29, Figure 4-30).TSS was also quite high in samples taken from the stormwater drain pipe. Six of the nine samples had TSS levels higher than 30mg/L (MPCA standard for TSS in District creeks is <10% of the time exceedance of 30mg/L TSS, Figure 4-31). There is no water quality standard for TSS in a stormwater pond, but all samples collected from the pond had TSS levels below 30mg/L (Figure 4-32). These results indicate the stormwater pond is continuing to reduce the amount of nutrients entering Rice Marsh Lake from these inputs. However, removing more nutrients from the water before it enters the pond via a treatment system or BMP could potentially lead to a greater increase in water quality of the lake.

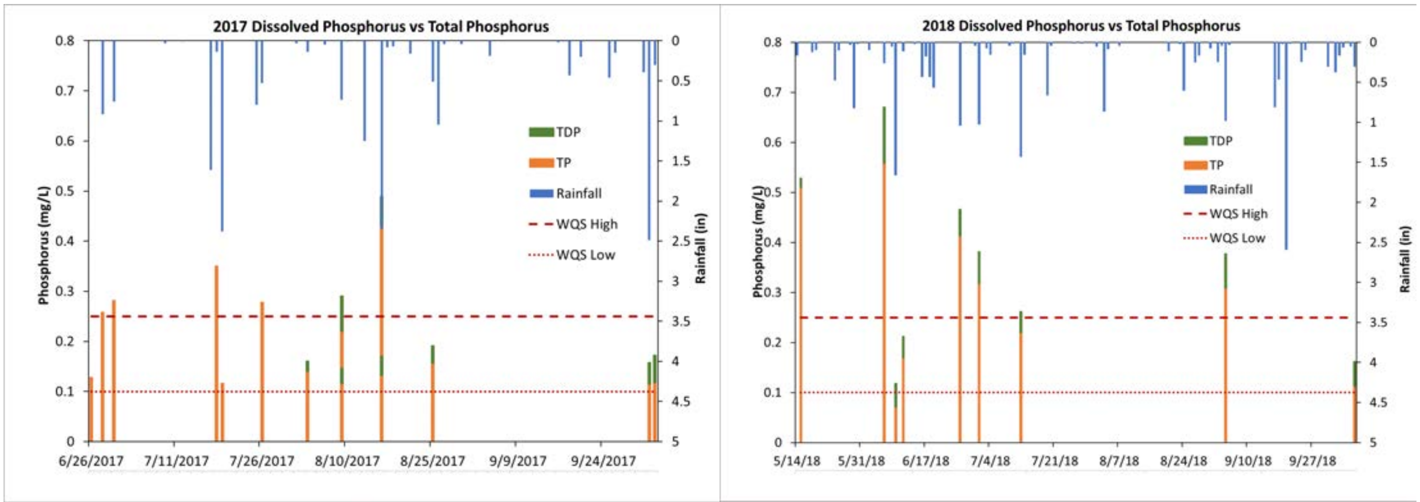


Figure 4-29 2017 and 2018 Stormwater Phosphorus Inputs to Rice Marsh Lake

Total Dissolved Phosphorus (TDP) and Total Phosphorus (TP) concentrations (mg/L) from the stormwater draining into the pond at the northwest end of Rice Marsh Lake. Dashed lines represent the Minnesota Pollution Control Agency TP Standards for stormwater ponds (0.1mg/L-0.25mg/L).

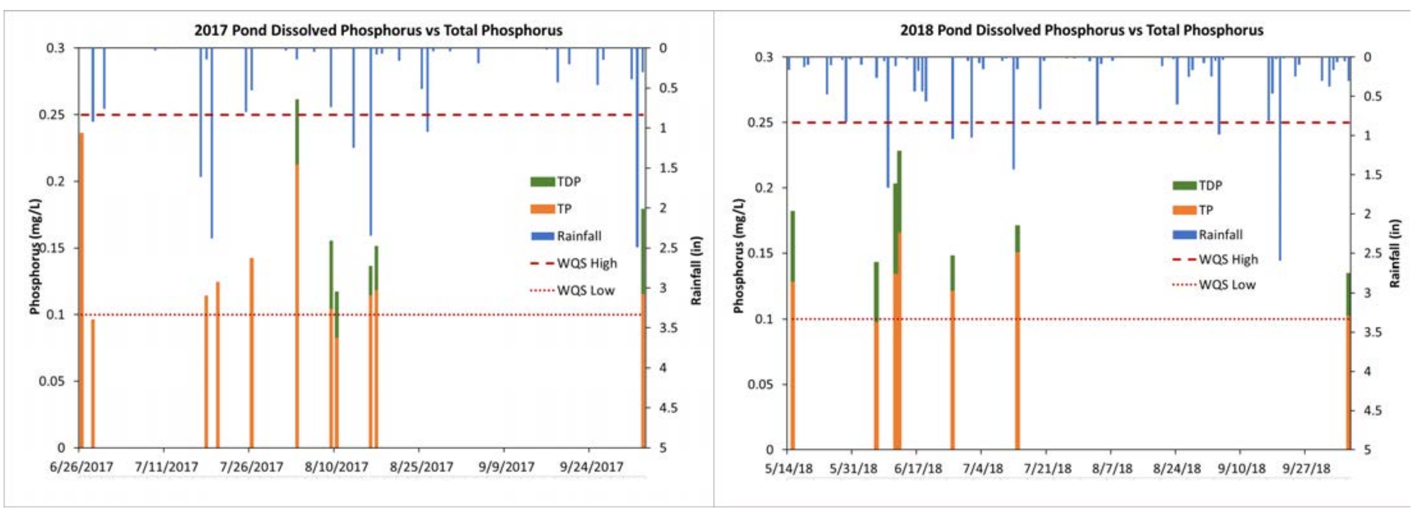


Figure 4-30 2017 and 2018 Stormwater Pond Phosphorus Inputs to Rice Marsh Lake

Total Dissolved Phosphorus (TDP) and Total Phosphorus (TP) concentrations (mg/L) from the stormwater pond draining into the northwest corner of Rice Marsh Lake. Dashed lines represent the Minnesota Pollution Control Agency TP standards for stormwater ponds (0.1mg/L-0.25mg/L).

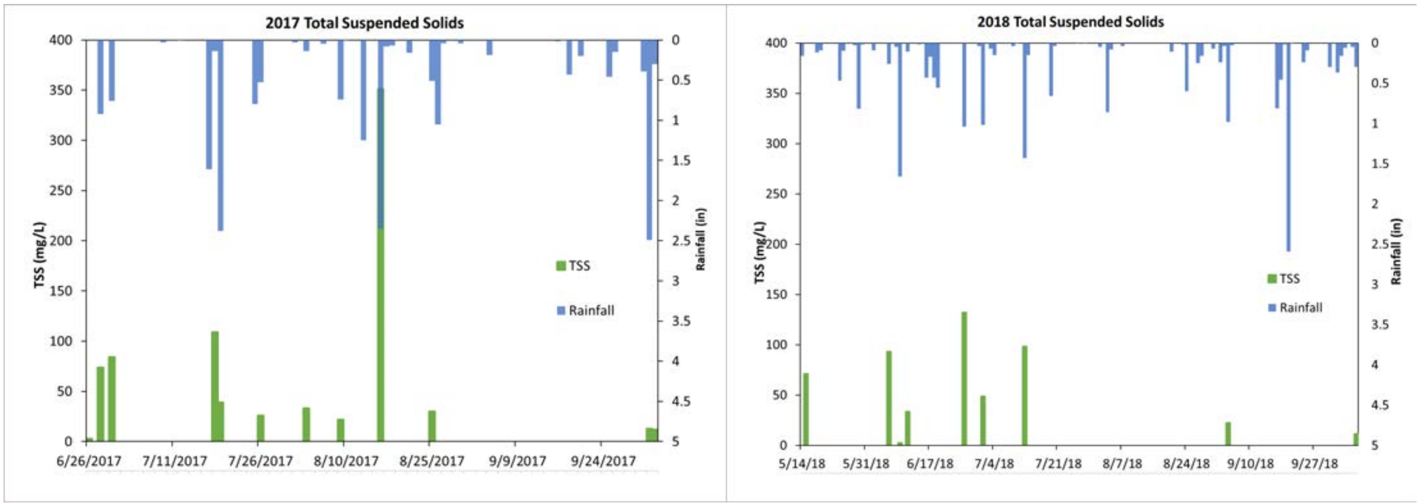


Figure 4-31 2017 and 2018 Stormwater Total Suspended Solids Input to Rice Marsh Lake

Total Suspended Solids (TSS) concentrations (mg/L) from the stormwater draining into the pond at the northwest corner of Rice Marsh Lake.

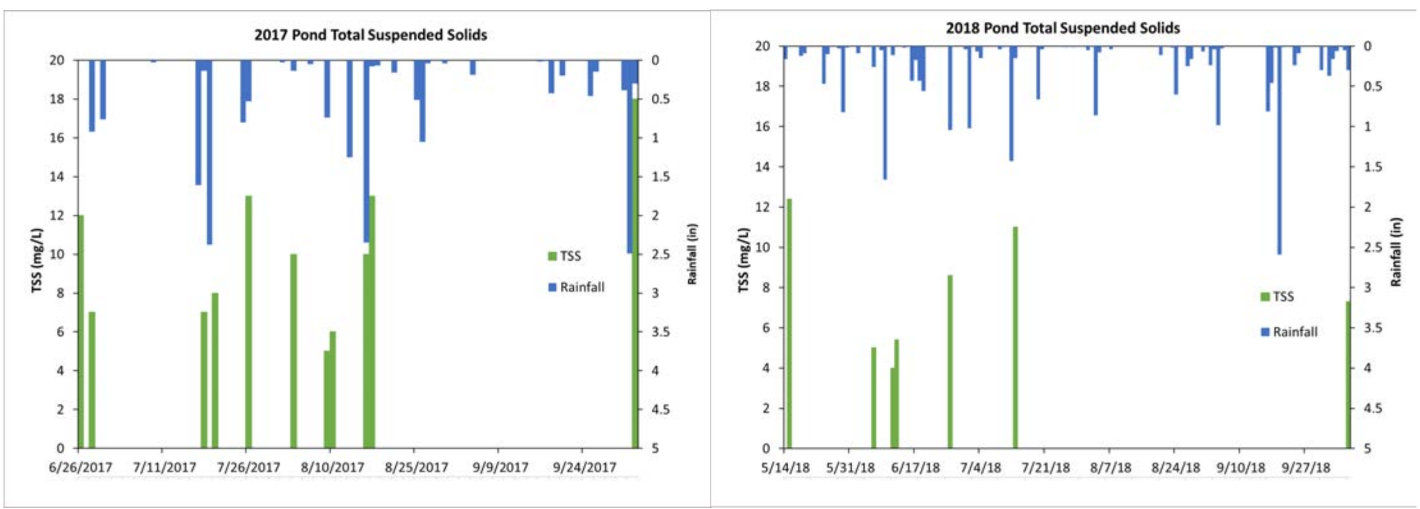


Figure 4-32 2017 and 2018 Stormwater Pond Total Suspended Solids Inputs to Rice Marsh Lake

Total Suspended Solids (TSS) concentrations (mg/L) from the stormwater pond draining into the northwest end of Rice Marsh Lake.

4.12 EnviroDIY

Over the course of 2018, staff has been working with staff from the environmental engineering/science consultant firm LimnoTech to implement EnviroDIY technology into everyday District water monitoring and data collection. EnviroDIY is a part of WikiWatershed, a web toolkit designed to help citizens, conservation practitioners, municipal decision-makers, researchers, educators, and students advance knowledge and stewardship of fresh water (EnviroDIY 2019). Staff learned how to build monitoring stations from the ground up, how to pair them with professional grade water sensors, and how to deploy them in the field. They also learned how to program the stations with the assistance of LimnoTech and UMN scientists, utilizing open-source code developed by researchers/scientists from the EnviroDIY community. These stations are a reliable, cost-efficient alternative to monitoring stations used by the District in the past. Not only is there the added benefit of staff being able to edit and troubleshoot sensor/station programming on their own, but these stations are set up to allow for staff, and eventually the public, to access and review real-time data remotely. Additionally, staff can deploy these for Education and Outreach Programming, so kids can instantly compare water quality they collected with the logger data.

On January 11th, 2018, the District hosted a day-long workshop led by LimnoTech staff on choosing parts for, and the construction of a general EnviroDIY water quality monitoring station. During the workshop, staff and attendees built six monitoring stations to be used in the District for monitoring. These stations utilize an EnviroDIY Mayfly Data Logger microprocessor board connected to an external 3.7 v battery and 3.5-watt solar panel. Each station was outfitted with an air temperature sensor, a MaxSonar WRMT ultrasonic range finder, a Yosemitech Y520-A 4-electrode conductivity sensor, and a Yosemitech Y511-A optical turbidity sensor. Data collected was stored on an on-board SD card connected to the board, as well as uploaded to an online repository via a Hologram global SIM card and a GPRSbee rev.6 antenna. The Mayfly boards, along with the battery and other components were housed inside of a Pelican Case 1120 waterproof box which was set up to be able to attach to a post or structure in/around the creek/lake/pond site. Over the course of 2018, staff purchased materials for, assembled and deployed two more EnviroDIY stations to be used as lake level sensors (these were deployed in 2018 on Rice Marsh Lake and Lake Riley after ice-out). All eight of these stations were programmed by LimnoTech staff, and any troubleshooting that occurred on these units during 2018 was also carried out by LimnoTech staff.

On December 13th, the District hosted another day-long workshop, led by LimnoTech staff, on programming, setup/connecting to, and troubleshooting/changing code of the EnviroDIY stations. In the week prior to this workshop, staff worked through a series of online tutorials on setting up and connecting instruments and devices to microprocessor boards, as well as tutorials on introduction to programming and accessing online repositories and resources. During the workshop, staff learned how to use existing, open-source code (found via code libraries provided by the EnviroDIY online community) to digitally locate and activate station sensors, as well as change and write code in order to make the sensors collect and log data. After completing this training, staff purchased parts to build two more general water monitoring sensors for the 2019 season. In total, the District has 10 EnviroDIY stations: eight built and programmed, and two which staff will assemble and program in 2019. Of these stations, four were installed at different sites around the District as a test deployment in 2018 (two general stations and two lake level stations). After some troubleshooting of sensor programming, these stations all measured and logged data continuously until they were removed for the winter (each station was programmed to collect sensor readings at a set interval, e.g. every 15 min). Staff plans on deploying all 10 in 2019.

On June 29th, 2018, staff installed one of the general water monitoring EnviroDIY stations (station RPB 3) in Purgatory Creek on the west side of Vine Hill Road. On July 13th, 2018, another was installed in Bluff Creek just upstream of the culvert running under Pioneer Trail (station RPB 4, installed just upstream of regular stream monitoring site B2). These units were each attached to an eight-foot section of metal fence post which was driven into the sediment (RPB 3 was placed in the pooling part of the stream just below the discharging culvert, and RPB 4 was placed in the pool just upstream of B2). These units measured water level, water temperature, air temperature, conductivity, and turbidity. They were both pulled from their sites on November 11th, 2018.

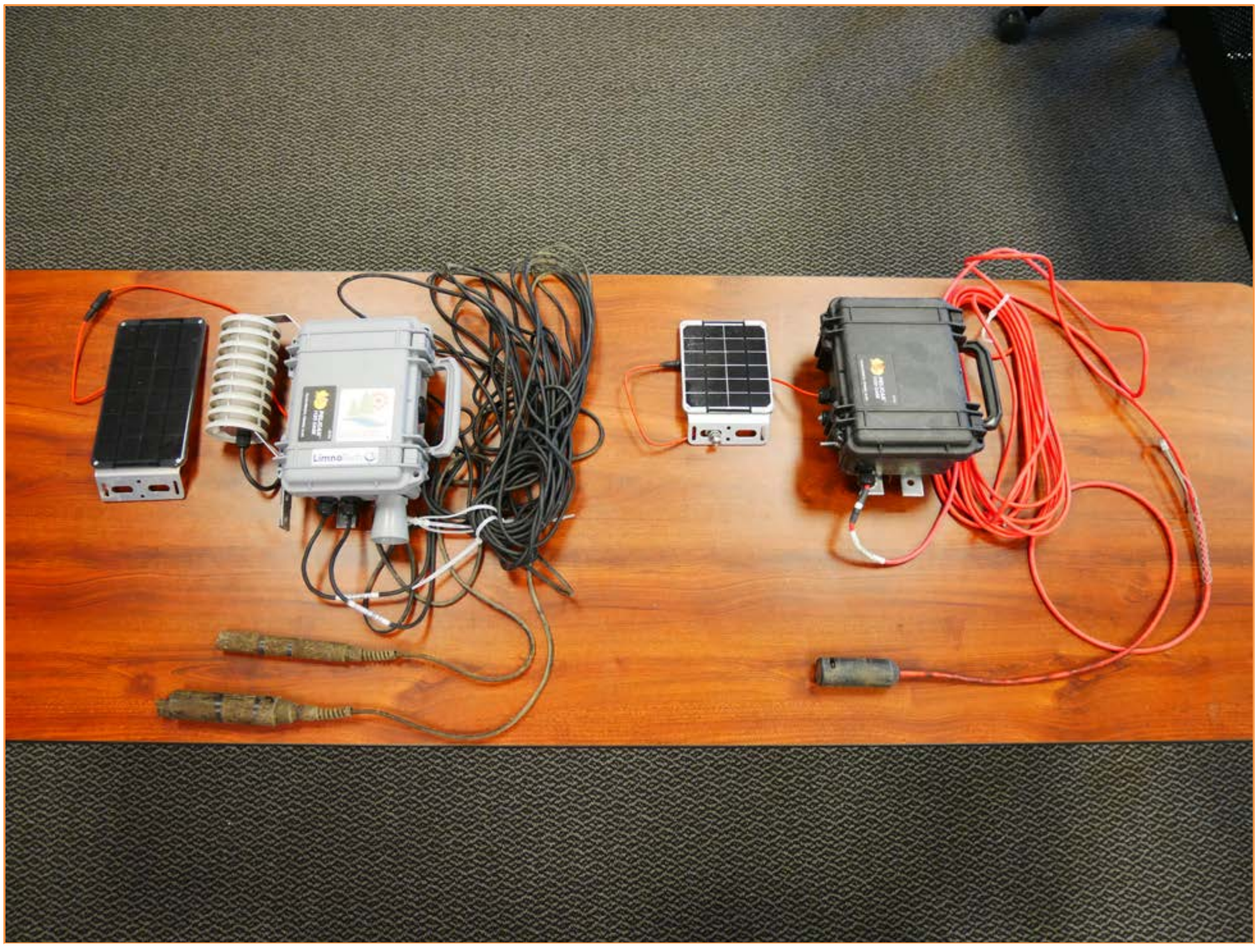


Figure 4-33 EnviroDIY Water Monitoring Stations
One of the District's EnviroDIY general monitoring stations (Left), equipped with air temperature, ultrasonic range, water temperature, conductivity, and turbidity sensors. The EnviroDIY water level monitoring station (Right) is equipped with sensor which measures water level, conductivity, and water temperature.

4.13 Wetland Inventory

As part of the Riley-Purgatory-Bluff Creek Watershed District Wetland inventory program, field assessments began June 2018 and ended November 2018. During this period, staff conducted wetland assessments to be recorded in the District database. Wetland assessments started at the west end of the district. A total of 102 wetlands were assessed and recorded using MnRAM 3.2 digital/manual worksheet. Notable flora and fauna were also documented to further assess the ecological integrity of each wetland being scored. Other documentation, such as directional photographs and GIS mapping were added to the documentation of each wetland. To gain a deeper understanding of the wetlands being assessed, historic and current county mapping data was used to identify possible disturbances of wetland ecology, municipal drainage, and stormwater management systems. Web Soil Survey was also used in the assessments to classify hydric soil type within wetland bounds to help in the scoring process. Each wetland assessed was given a name for future identification based on their mapped location section, township, and range, followed by a specific number (e.g. a group of wetlands located in T116 R23 S04 would be identified as 04-116-23-001, 04-116-23-002, and so on). The ultimate goals of the wetland assessment program are as follows: The District will have an as-complete-as-possible inventory of wetlands in the watershed; the District will have an objective measure of the wetland quality based upon functions and values provided by the wetland for the implementation of the District's regulatory program; the District will be able to identify wetlands that are degraded and well suited for ecological enhancement, or relic wetlands that are fully drained but candidates for hydrologic restoration.

Figure 4-34 Sundew plants found in local wetland.

In July 2018, staff lead a wetland walk aimed toward community outreach to educate the public. Thirteen individuals attended the event. They were introduced to some of the basics in the assessment and scoring process of wetland ecology. Board of Water and Soil Resources (BWSR) MnRAM scoring systems, along with Circular 39 and Cowardin Wetland Classification Systems were part of the information presented, along with a pamphlet of wetland types and the flora found within each. Site visits to wetlands in the vicinity of Rice Marsh Lake were also a part of this event. This in-the-field observation provided an opportunity for people to see firsthand the different type of wetland ecology found within the district boundary.

5 Aquatic Invasive Species

5.1 AIS Management

Due to the increase in spread of Aquatic Invasive Species (AIS) throughout the state of Minnesota, staff completed an AIS early detection and management plan in 2015. As part of the plan, an AIS inventory for all waterbodies within the District was completed and a foundation was set up to monitor invasive species that are currently established within District waters (Table 5-1). Early detection is critical to reduce the negative impacts of AIS and to potentially eliminate an invasive species before it becomes fully established within a waterbody. Effective AIS management of established AIS populations will also reduce negative impacts and control their further spread. The RPBCWD AIS plan is adapted from the Wisconsin Department of Natural Resources (WIDNR, 2015), Minnehaha Creek Watershed District (MCWD, 2013), and the Minnesota Department of Natural Resources (MNDNR, 2015a) Aquatic Invasive Species Early Detection Monitoring Strategy. The goal is to not only assess AIS that currently exist in RPBCWD waterbodies, but to be an early detection tool for new infestations of AIS. Figure 5-1 identifies what AIS monitoring/management occurred in 2018 excluding common carp management.

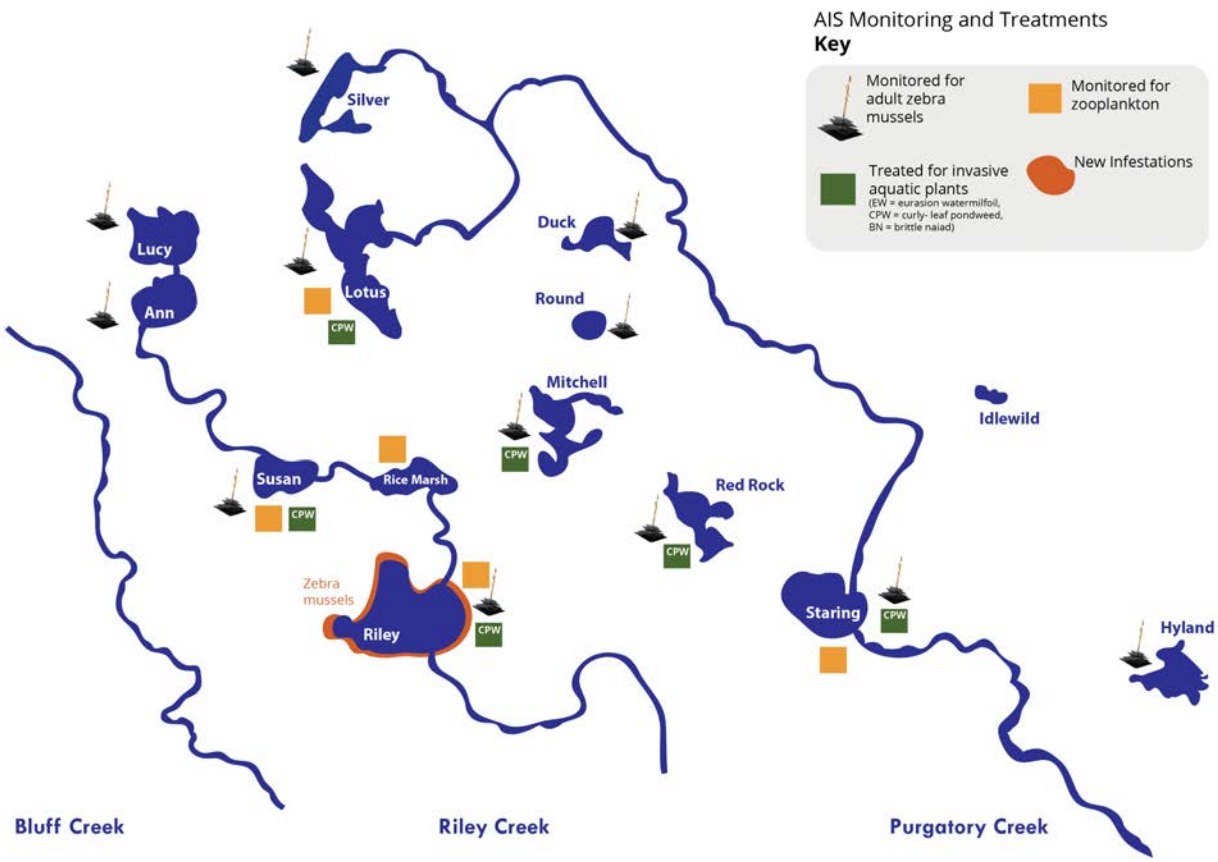


Figure 5-1 2018 Aquatic Invasive Species Sampling

Aquatic Invasive Species work conducted in 2018 within the Riley-Purgatory-Bluff Creek Watershed District. Zebra mussel plate symbol indicates some the installation of monitoring plates and bi-weekly public boat launch scans. Lakes that received zooplankton and phytoplankton sampling are identified by orange squares and lakes that received herbicide treatments are identified by green squares (CPW=curly-leaf pondweed; BN=Brittle Naiad; EW=Eurasian watermilfoil). The orange outline around Lake Riley indicates the new infestation of zebra mussels found in 2018. All lakes received juvenile mussel sampling; none were found. This map excludes carp management.

Table 5-1 Aquatic Invasive Species Infested Lakes

Lake Names	Infested Waters	Brittle Naiad	Eurasian Watermilfoil	Curlyleaf Pondweed	Purple Loosestrife	Common Carp	Zebra Mussels
Ann	x	x	x	x	x	x	
Lotus	x	x	x	x		x	
Lucy	x		x	x	x	x	
Red Rock	x		x	x	x		
Rice Marsh	x			x	x	x	
Riley	x		x	x	x	x	x
Silver	x			x	x		
Staring	x	x	x	x		x	
Susan	x		x	x	x	x	
Duck	x			x	x		
Mitchell	x		x	x	x		
Round	x	x	x	x			
Hyland	x			x			

X – Indicates new infestation.

5.2 Aquatic Plant Management

Aquatic plant surveys are important because they allow the District to map out invasive plant species for treatment, locate rare plants for possible protection, create plant community/density maps which evaluate temporal changes in vegetation community, identify the presence of new AIS within water bodies, and they can assess the effectiveness of herbicide treatments. Aquatic plant surveys have been conducted on a rotational basis within RPBCWD to ensure all lakes have received adequate assessments. As projects arise, or issues occur, additional plant surveys are conducted to aid in the decision-making process. Herbicide treatments have been shown to reduce and control aquatic invasive plants to a manageable level, which may in turn allow for native plants to increase in abundance. The District will continue to monitor the aquatic plant communities within our lakes and use herbicide treatments to manage aquatic invasive plants to sustain healthy aquatic communities into the future. In early the spring of 2018, herbicide treatments were carried out on Lotus Lake, Mitchell Lake, Red Rock Lake, Lake Riley, Staring Lake, and Lake Susan for curly leaf pondweed. No Eurasian watermilfoil or brittle naiad treatments occurred.

Staring Lake Eurasian Watermilfoil

Eurasian watermilfoil (EWM) is a species native to Europe and Asia that has been introduced to the United States. The concern with this species is that it can form dense mats that outcompete native species and interfere with recreational activities such as boating, swimming, and fishing. Since the infestation of EWM in Staring Lake in 2015, the District has been working with James Johnson from the Freshwater Scientific Services (FWSS) and has developed a mechanical and chemical rapid response strategy to potentially eliminate the plant from the lake. The strategy of hand-pulling followed by a fall herbicide treatment has been successfully used to control new infestations of EWM on Weaver Lake (Hennepin Co.) and Lake Charlotte (Wright Co.). In 2018, Johnson, the District, and the University of Minnesota (UMN) all surveyed Staring for EWM. Only one removal event took place in which District staff mechanically pulled 80 plants from the northwest end of the lake and another 30 plants from the northeast end (just northwest of the Staring Outdoor Center, Figure 5-2). No herbicide was applied to Staring in 2018.

On June 20th, Johnson located about 15 individuals/small clusters of EWM across the lake (Figure 5-2). As the summer went on, EWM infested areas and density of stands increased. The UMN and District staff located several more areas of infestation in August, October and November (Figure 5-2). During two of the UMN scans, June 28th and August 15th, UMN researchers identified possible hybrid watermilfoil growing at two points during each date, but genetic testing will be done to determine strain (Figure 5-2). Hybrid watermilfoil is a hybrid of EWM and the native northern watermilfoil. It is similar to EWM in that it spreads and forms dense stands that choke out native plants. During the November 6th partial lake survey, District staff located about 147 individuals (as seen in Figure 5-2, stands of EWM on this date were dense and some of these points may include a small cluster of plants). These points will help guide removal and treatment actions in 2019. If stands continue to grow in such densities, mechanical removal may end, making herbicide treatment the singular control practice in 2019. Staff will continue to monitor for EWM in 2019 to determine how extensive herbicide treatments will need to be, as well as their effectiveness.

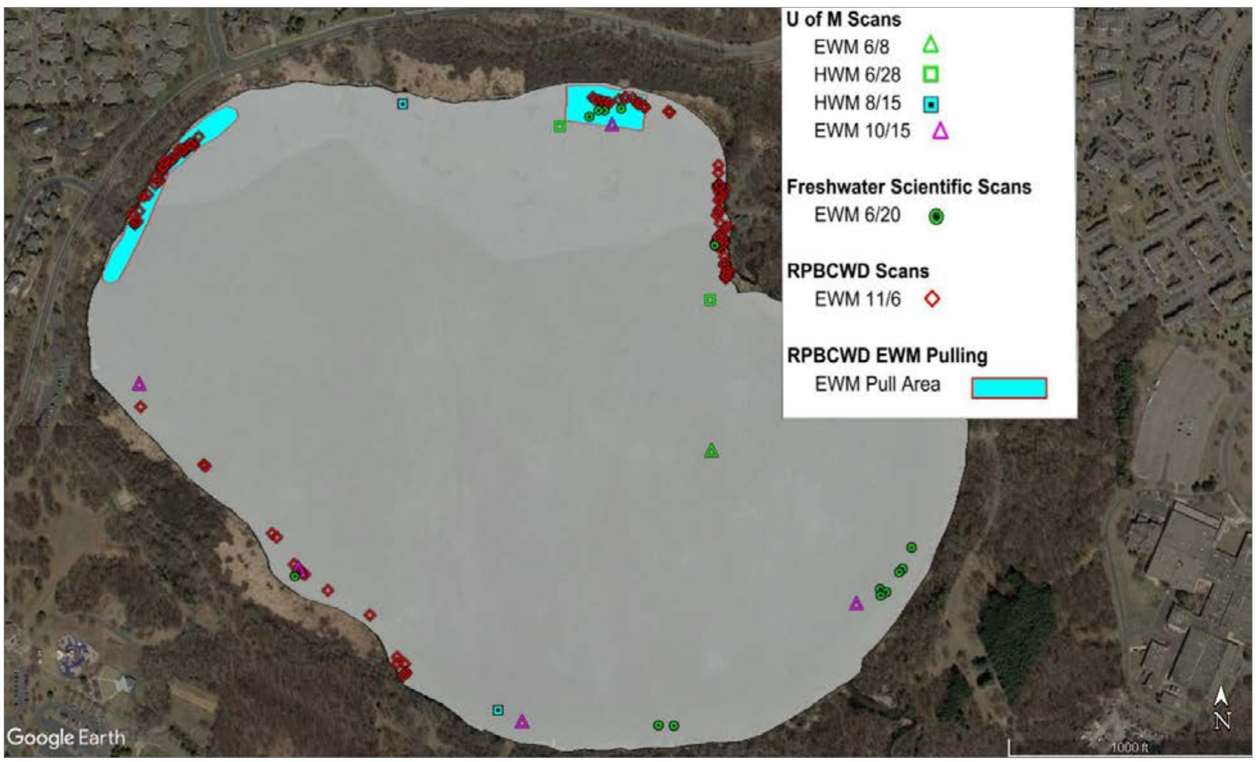


Figure 5-2 2018 Staring Lake Eurasian Watermilfoil Surveys and Removal Areas

The points represent Eurasian watermilfoil plants (individuals or small clumps of plants), as well as plants that were possibly hybrid watermilfoil species, observed during several EWM surveys carried out during summer/fall of 2018. District staff, the UMN, and Freshwater Scientific all carried out scans at different times. District staff pulled about 110 total plants within the two areas represented by the blue polygons.

Brittle Naiad

Brittle Naiad is a species native to Europe, western Asia, and northern Africa that has been introduced to the United States. The concern with Brittle Naiad is that it can form dense mats that can outcompete native plants. These dense communities can disrupt fish and waterfowl habitat, choking out plants which animals depend on for survival and potentially decreasing dissolved oxygen levels upon its decomposition. Brittle naiad is a fairly resilient plant; it can survive in some polluted and eutrophic waters and can reproduce by fragmentation. With that said, brittle naiad is a very new AIS and not much is known about its effects especially in Minnesota.

Lotus Lake Brittle Naiad

On September 26, 2017, Riley Purgatory Bluff Creek Watershed District staff found brittle naiad (Najas minor) located on both sides of the public boat access on the south side of Lotus Lake. The plants were found during a routine boat launch aquatic invasive species (AIS) inspection. These inspections, conducted bimonthly, consist of staff searching around the boat launch for various types of aquatic invasive species for 5-10 minutes after the regular water quality sampling event. Since most AIS enter a lake through the public access this is the most likely location to find AIS. Staff immediately reported the occurrence of brittle naiad to Aquatic Invasive Species Specialist Keegan Lund of the Minnesota Department of Natural Resources. Staff extended the inspection to a full scan of the lake, mapping the position of every observed brittle naiad occurrence with a handheld GPS device. An effective treatment area was determined from the GPS points (Figure 5-3). That fall, an herbicide was applied to the lake in an area totaling 2.42 acres across all areas where brittle naiad was found.

Figure 5-3 2017 Lotus Lake Brittle Naiad Treatment Areas

The red polygons indicate the areas treated with herbicide during the fall of 2017 for brittle naiad. The total area treated was 2.42ac.

On September 24th and 26th of 2018, RPBCWD staff conducted brittle naiad surveys to determine the effectiveness of the herbicide and to see if the plant had spread throughout the lake. During the scan staff drove a lap around the lake and every brittle naiad plant found was marked with a handheld GPS device. Results of the survey can be seen in Figure 5-4.

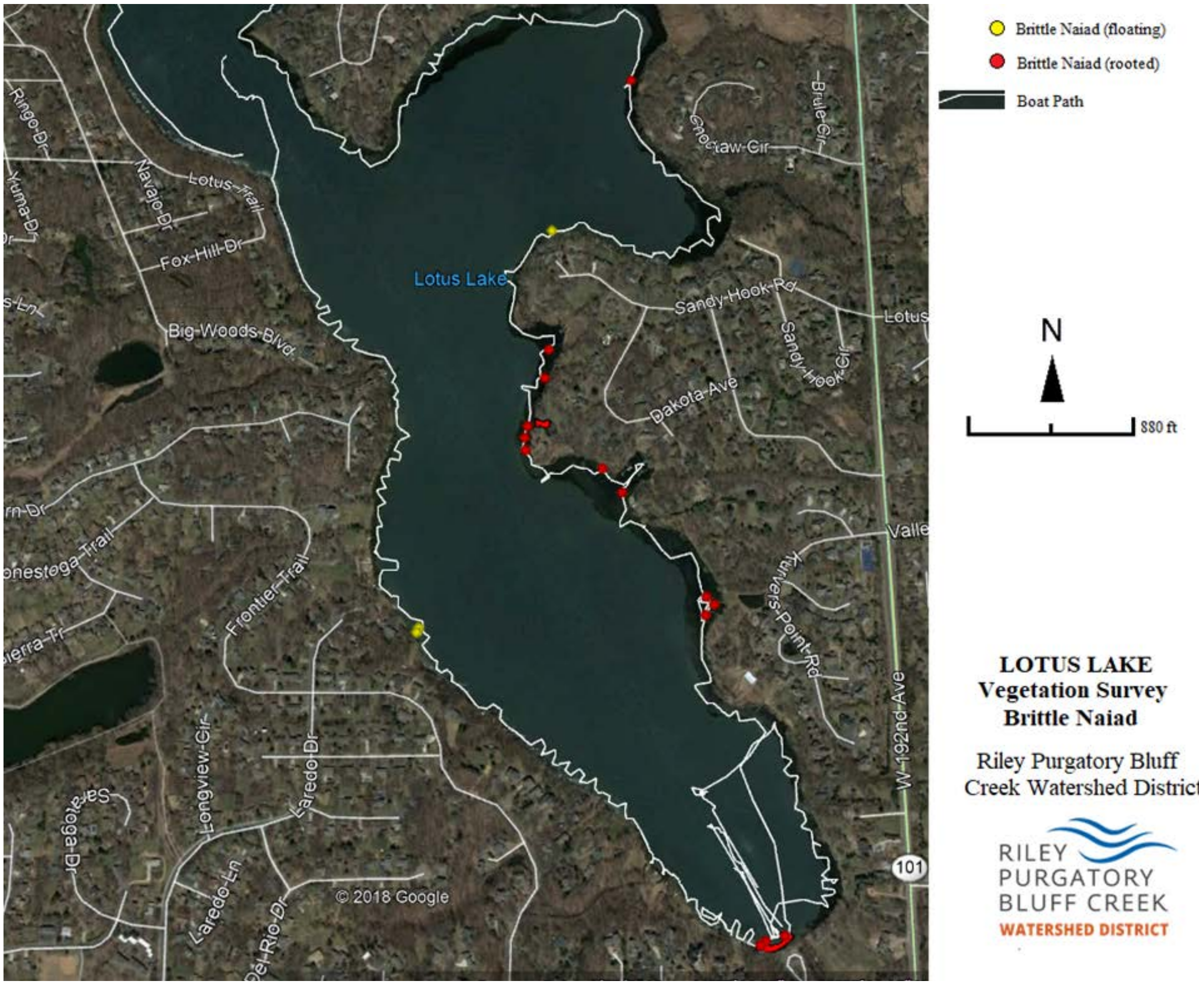


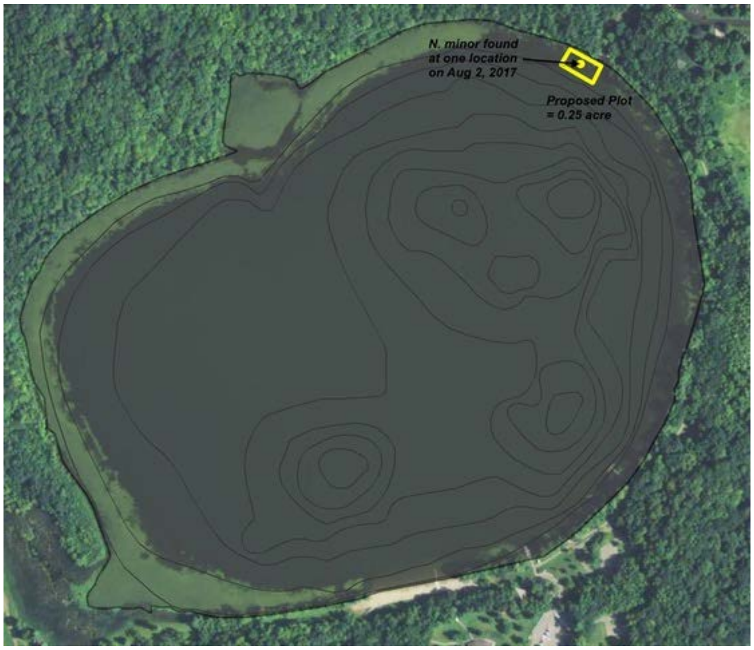
Figure 5-4 2018 Lotus Lake brittle naiad map.

Based on the 2018 brittle naiad scan, it appears the overall plant distribution has been reduced in the treatment areas. Plants were found on both sides of the public access, similar to where stands of plants were most dense in 2017, however the number and area occupied by the plants was reduced considerably. Additionally, no rooted plants were found on the southwest side of the lake. More plants were found scattered along the south east shoreline and into the east bay which may have been missed during the 2017 survey. Due to the limited water clarity of Lotus Lake, brittle naiad was observed growing between 0.5 to three feet of water. The plant growing depth may increase due to the alum treatment that occurred during the fall of 2018 which should increase water clarity in 2019. Additional vegetation scans will occur in 2019 to see if the plant distribution expands.

Lake Ann Brittle Naiad

Freshwater Scientific Services, LLC surveyed the aquatic plant community of Lake Ann (Carver County, MN) on August 2, 2017 using the point-intercept survey method described. This survey was based upon 366 sample points arranged in a uniform grid (50m spacing) across the entire lake. At each designated sample location, plants were collected using a double-headed, 14-tine rake on a rope. For each rake sample, the rake was dragged over the lake bottom for approximately 5 ft before retrieving.

During the 2017 survey Brittle Naiad (*najas minor*) was discovered at one location in the northeast corner of the lake near the public swimming beach and dock (Figure 5-5). The immediate area surrounding where the plants were found was surveyed intensively to identify if there were more plants present, however none were found. The District immediately treated the 0.25ac area as part of the rapid response plan in attempt to slow or stop the plant from spreading.



Freshwater Scientific Services LLC

Lake Ann
Brittle Naiad Survey
8/2/2017

Brittle Naiad location and treatment area.

N

Figure 5-5 2017 Lake Ann Brittle Naiad Discovery and Treatment Map.

On September 28th, 2018 RPBCWD staff conducted another brittle naiad scan to assess treatment results (Figure 5-6). During the scan staff drove a shallow and deep lap around the lake and searched for the presence of the plant. The survey was conducted on a sunny day to aid visibility of the plant, however strong north winds did decrease visibility along the south side of the lake. Plants were found near the location of the swimming dock and beach, similar to where they were found in 2017, however multiple extensive stands were present. Additionally, plants were found along the west shoreline and near the public access, equipment rental dock, and public beach (southeast). The results of the assessment suggest that brittle naiad was more widely distributed than it was in the 2017 survey. As part of the continuation of the rapid response plan, the district will be in discussion with the Minnesota Department of Natural Resources and Herbicide Applicator to discuss options for treatment on Lake Ann to prevent further spread of the invasive plant.

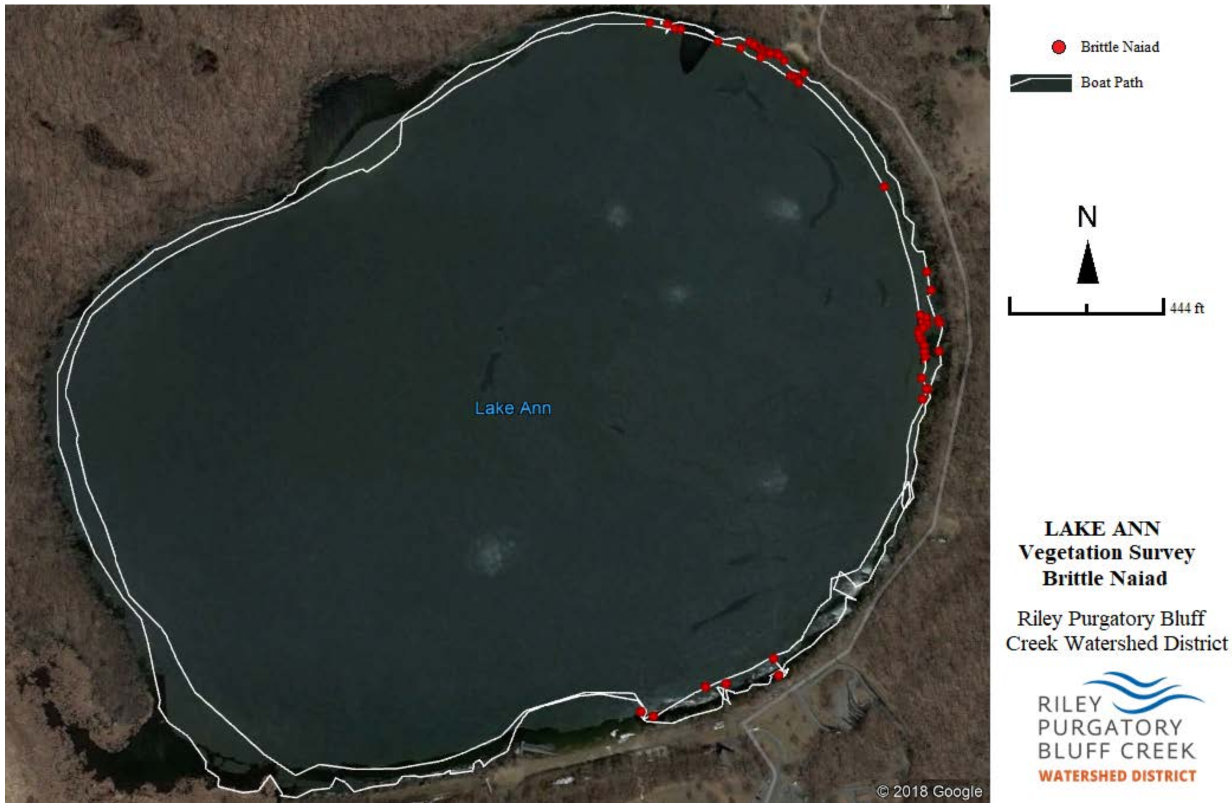


Figure 5-6 2018 Lake Ann Brittle Naiad Assessment Map.

5.3 Common Carp Management

The RPBCWD, in cooperation with the University of Minnesota (UMN), has been a key leader in the development of successful carp management strategy for lakes within the state of Minnesota. Following the completion of the Riley Chain of Lakes (RCL) Carp Management Plan drafted by the UMN in 2014 (Bajer et al., 2014), and the Purgatory Creek Carp Management Plan drafted in 2015 (Sorensen et al., 2015), the District took over monitoring duties from the University. Carp can be detrimental to lake water quality. They feed on the bottom of the lake, uprooting aquatic plants and resuspending nutrients in the sediment. Adult carp are monitored within RPBCWD by conducting, three, 20-minute electrofishing transects on each lake, three times between late July and early October (totaling nine transects per lake). If the total biomass estimate of carp is above 100kg/h, the population is considered harmful to lake water quality and the District would need to consider removing carp. Young of the year (YOY) carp are monitored by conducting five, 24-hour small mesh fyke net sets between August and September. If YOY carp are captured during this sampling, it suggests successful recruitment has occurred, and monitoring efforts should be increased on that water body. At that point, the District would also consider the removal of excess carp.

District staff completed fyke net surveys on all lakes within the RCL, as well as lakes within the Purgatory Chain of Lakes (PCL), including Lotus Lake, Staring Lake, the Upper Purgatory Creek Recreational Area (UPCRA), and the Lower Purgatory Recreation Area (LPCRA). As is true with many lakes during late summer located within the twin cities metro area, the RCL and PCL inshore fish community was dominated by bluegill sunfish and bullhead species. Similar to 2017, Lake Riley had the highest number of bluegills captured in 2018 averaging 107 fish per net, while an average of only 19 bluegills/net were captured on Staring Lake. Many other Centrarchid species, including pumpkinseed sunfish and black crappie, were also very common across all lakes. Larger predator fish including northern pike and largemouth bass were also captured via fyke netting. The most diverse fish population was observed in LPCRA where 14 different species were captured. A full summary table of the fish captured for each lake can be found in Exhibits B. Similar to 2017, no YOY carp were captured in any of the lakes during fyke net surveys in 2018. The lack of young individuals captured in lakes indicates that 2018 was a very poor recruitment year for common carp overall One YOY carp was captured during fyke netting on the UPCRA and nine YOY carp were captured in the LPCRA indicating some recruitment occurred. Reviewing past sampling data, this appears to be the first recruitment event since 2015.

The PCL lakes (Staring and Lotus) and the Purgatory Recreation Area were surveyed via electrofishing in 2018. The RCL will be sampled via electrofishing in 2019. In 2018, the common carp biomass estimate was 95.1 kg/h on Lotus Lake, which is up from the 2017 estimate of 68.8 kg/h (Table 5-2). This number is still under the carp biomass threshold (100 kg/ha). Comparing the past four years of electrofishing data (Figure 5-7) the carp population has remained stable, with slight year to year variability. With no YOY carp captured, combined with a lower adult carp biomass estimate, the resident carp population in Lotus Lake is of limited concern in relation to the degradation water quality. As seen in Figure 5-7, the adult common carp biomass estimates have been decreasing in Staring Lake over the past four years. In 2017 the carp biomass estimate was below the threshold at 61.7 kg/ha. In 2018, it was lower still at 41.1 kg/h (Table 5-2). These fish consisted of individuals from the 2014/2015-year class, which was the last successful recruitment year for common carp in the system.

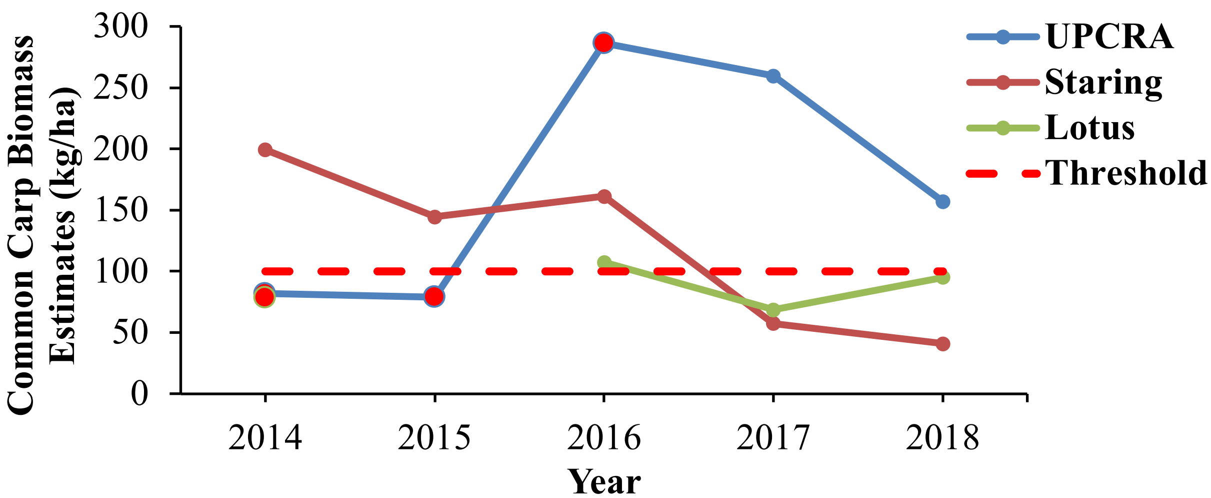


Figure 5-7 Purgatory Chain of Lakes Common Carp Biomass Estimates
Common carp biomass estimates (kg/ha) for the Purgatory Creek Chain of Lakes from 2014-2018 as compared to the 100 kg/h threshold. Red markers indicate only one sampling event occurred as opposed to the suggested three.

The LPCRA was not electrofished in 2018 due to access issues and the amount of brittle naiad present in the system. In 2018 the UPCRA again had a carp biomass estimate that exceeded the biomass threshold at 157.6 kg/h (Table 5-2). This number is down significantly from the 245.2 kg/ha estimate in 2017. Since the UPCRA area is essentially the top of the system (fish cannot get to Silver Lake and Lotus Lake), and has a deep-water refuge, fish move to this location. Due to the shallowness of the system, winter seining would have limited effectiveness at capturing carp. Additionally, winter seining may yield limited success in Staring Lake due to the low number of carp captured. The reduction in biomass estimates in both Staring and Purgatory Creek Recreational Area suggest that spring removals utilizing the Purgatory Creek Trap Net and backpack electrofishing may have been able to reduce carp populations in the Purgatory Creek System, specifically in 2018 (more information in next section). Even though the carp biomass estimate was lower in UPCRA, levels still exceeded the threshold and carp could reduce water quality in the system. Additionally, fyke nets captured nine YOY carp which suggests some level of recruitment occurred in the recreation area. Staff will continue to monitor the carp population in 2019. Overall, 14 carp were tagged with implant-style VHF transmitters, twelve fish in Staring and four in the UPCRA. This will allow staff to locate when and where in the lake the carp are schooling and moving.

Table 5-2 2018 Common Carp Biomass Estimates for the Purgatory Chain of Lakes

	Lake	Fish per Hour	Density per Hectare	Average Weight (kg)	Carp Biomass (kg/ha)
Purgatory Chain	Lotus	5.3	28.2	3.4	95.1
	Staring	5.6	29.2	1.4	41.1
	Upper Purgatory Wetland	31.4	151.2	1.1	157.1
	Lower Purgatory Wetland	-	-	-	-

*Lower Purgatory Creek Recreational Area not sampled.

Floating Trap Net and Backpack Electrofishing

Figure 5-8 Large floating trap net deployed in Purgatory Creek.

In the spring of 2018, staff placed a large floating trap net below the barrier in Purgatory Creek during peak spawning runs to capture common carp as an experimental gear (Figure 5-8). This net was checked daily; staff sorted fish, releasing natives and removing carp. In 2018, the barrier was closed on May 4th after northern pike were allowed to move upstream into the recreational area to spawn and return to Staring Lake. Because of the extended winter season and the abrupt end due too rapidly warming water temperatures, it appeared that northern pike and common carp spawning runs overlapped more than normal (as suggested by Chizinski et al., 2016). The floating trap net was deployed May 7th. The City of Eden Prairie opened, cleaned, and closed the fish barrier multiple times during the spring and late summer due to high water levels in the Purgatory Creek Recreational Area. During this time, fish could potentially move freely throughout the system when the trap net wasn't present. Fish species found in the floating trap net included northern pike, black crappie, freshwater drum, bigmouth buffalo, bluegills, largemouth bass, and black bullheads. The first carp was captured on May 8th. The total number of carp removed via floating trap net was 48 (139 were removed in 2017). Staff hoped a larger number of fish would have been captured by the trap net, but this net is an experimental gear and it was unsure how many would be captured.

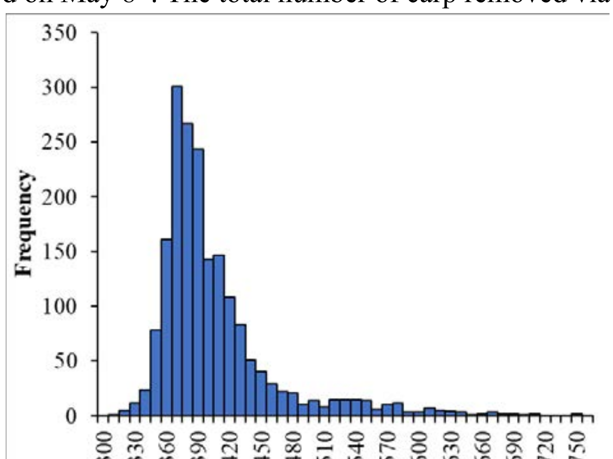


Figure 5-9 2018 Size Structure of Common Carp Removed from the Purgatory Creek Rec Area.

In 2018 staff also utilized a backpack electrofishing unit and block nets to remove common carp during the spring spawning run. These two gears were deployed in the channel upstream of the barrier to trap carp between the net and barrier, and at the breach in the berm that separates the Upper and Lower Purgatory Creek Recreational Area. Most of the fish captured via backpack electrofishing were captured at the breached berm site which allowed water to short circuit the overflow structure. Water was always flowing at this location which led to carp concentrating in the shallow water near the breach before they tried to move upstream. The sheet piling, combined with the consistent flow, eroded the downstream side of the berm, causing a drop that impeded carp movement. A block net was anchored on one side of the flow at the breach and then stretched around the congregating carp, trapping them against the berm and net. Staff used an electrofishing backpack to easily remove the trapped fish. During the heavy spawning run, staff repeated the process up to three times a day, taking about an hour each time from installation of the net to completion of sampling. Utilizing both the trap net and backpack electrofishing, a total of 1,901 carp were captured and removed from the LPCRA. In late October 2015, approximately 3000 YOY carp had entered Lake Staring from LPCRA and started to grow rapidly (Sorensen et al., 2015). This year class was a result of the last major recruitment event that occurred in the system and made up the majority of the fish captured from LPCRA as seen in Figure 5-9. Most of the carp were removed when water levels at the barrier were between 29-31 inches in depth (based on the installed staff gauge), and when temperatures ranged between 18 to 25 degrees Celsius (Figure 5-10). District staff have been working with the City of Eden Prairie to stabilize the berm while still allowing staff to utilize the location for future carp removal events. Staff will hopefully be placing an automated monitoring station at the barrier in 2019 to maximize removal efforts in the future.

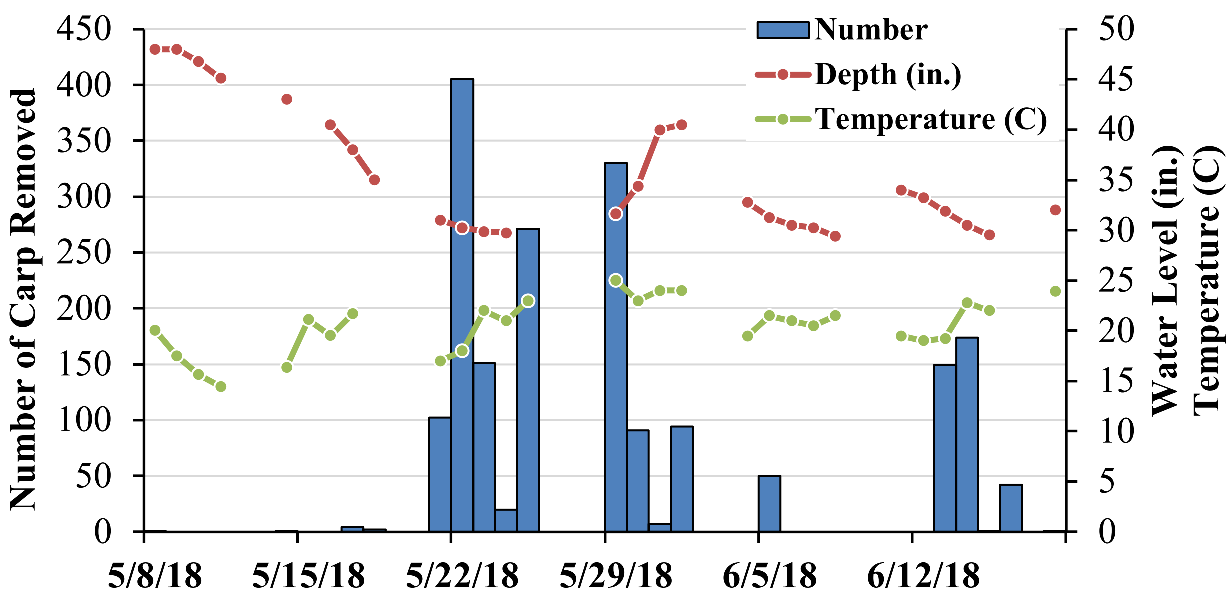


Figure 5-10 Purgatory Creek Recreational Area Common Carp removal vs Environmental Variables

5.4 Zebra Mussel Detection in Lake Riley

Zebra mussels are native to Eastern Europe and Western Russia and were introduced to the United States. Zebra mussels can cover equipment in the water, clog water intakes, cause cuts in bare feet, smother native mussels by covering them, and they can fundamentally change the food web of a lake by extensively filtering out phytoplankton to which many aquatic animals need (MNDNRb 2015). Treatment methods available to date are considered experimental and have not been effective in eradicating zebra mussels from a lake once they are introduced.

The District continued to monitor for adult and veliger zebra mussels in 2018. The District conducted veliger sampling from June to July on 13 lakes and a high-value wetland to detect the presence of zebra mussels. Each lake was sampled once, apart from Lake Riley and Lotus Lake, each of which were sampled twice due to the amount of summer traffic on these lakes. RMB Environmental Labs processed the samples and found no zebra mussel veligers across all lakes. Adult zebra mussel presence was assessed using monitoring plates that were hung from all public access docks and private docks of residents participating in the Adopt-a-Dock program. Monitoring plates were checked monthly and no mussels were found across all lakes during the 2018 open water season. Additionally, public accesses were scanned for approximately ten minutes during each regular water quality sampling period (bi-weekly). Staff visually searched rocks, docks, sticks, and vegetation for adult zebra mussels. No adult zebra mussels were found utilizing this technique in 2018.

On October 22, 2018, RPBCWD staff conducted a more intensive zebra mussel scan on Lake Riley after a lake service provider discovered some zebra mussels while pulling docks and lifts. Previously, no zebra mussels had been found in the lake during the regular monitoring season, which included all the monitoring efforts mentioned above. Staff conducted five scans, varying in distance from 175ft to 900 ft, across the lake. Scans were conducted from shore out to waste deep water, most of which occurred between one to three feet of water. Staff utilized a handheld GPS device to track the scan route and mark points where zebra mussels were found. Structures and items checked for mussels included woody debris, rocks, aquatic vegetation, inlet pipes, bricks, and garbage.

Figure 5-11 Zebra mussels found in Lake Riley.

Zebra mussels were found at all five scan locations during the assessment, however only a single individual was found near the boat launch and in the northeast bay (). A total of 91 individual zebra mussels were found across all scans. The zebra mussels appeared to be widespread across the lake at low densities. Mussels were found of varying sizes suggesting that reproduction in Lake Riley had occurred (Figure 5-11). Most zebra mussels were found on rock, wood, and items placed in the water, including pvc pipes and bricks. In discussion with our AIS specialist, it was determined that a rapid response would not be effective and was not recommended.

Following the confirmation of zebra mussels in Lake Riley staff distributed MN DNR zebra mussel fact sheets to all lakeshore owners (MNDNRb, 2015) and hosted an informational zebra mussel workshop in December. Additionally, staff conducted more extensive zebra mussel scans on all lakes within the District that had public accesses after mussels were found on Riley. The scans followed all the same procedures described in our normal boat launch scans but included three scans of varying distances across each lake in addition to a boat launch scan. No zebra mussels were found during these additional scans.

Figure 5-12 Zebra Mussel Assessment Map on Lake Riley.

The chemical and physical makeup of a lake determines the suitability of that lake to support zebra mussels. Like many organisms, there is a wide range of suitable conditions in which zebra mussels can survive. Optimal conditions are conditions in which there are no limiting variables that are controlling an organism's ability to grow and reproduce within a system. In Table 5-3, the different variables associated with zebra mussels that the District currently measured in 2018 are presented for Lake Riley and compared to the criteria used to determine the level of infestation by zebra mussels in North America (Mackie and Claudi 2010). In Table 5-3, variables are arranged from greatest to least importance for determining suitability for zebra mussels. For consistency, all variables included in the analysis were measured during the summer growing season (June-September) and include only the top two meters for Lake Riley. The different variables can be grouped into three categories:

- Chalk variables which are needed for shell formation.
- Trophic (nutrient) variables which are associated with growth and reproductive success.
- Physical variables or basic lake variables that limit where zebra mussels can live in a lake.

Table 5-3 Lake Riley Suitability for Zebra Mussels

	Parameter	Mean Value	Risk Potential
Chalk Variables	Calcium (mg/L)	48.7	High
	Alkalinity (mg/L)	121.75	High
	pH	8.69	High
Trophic Variables	TP (mg/L)	0.024	Moderate
	Chl-a (ug/L)	7.98	Moderate
	Secchi (m)	3.43	High
Physical Variables	Temp (deg C)	24.69	High
	DO (% saturation)	104.56	High
	DO (mg/L)	8.79	High
	Cond (uS/cm)	483.7	High
	Hard Structure	n/a	High

Calcium concentrations in Lake Riley were estimated based on average monthly alkalinity samples. The estimated calcium concentrations in Lake Riley were similar to actual calcium concentrations collected from all other lakes in the Riley Chain. Comparing all lakes in the District with the calcium threshold established by Mackie and Claudi 2010, only Round and Hyland have less than optimal calcium concentrations (>30mg/L) for zebra mussels. Alkalinity and pH are associated with calcium concentrations and were both highly suitable for sustaining zebra mussels in Lake Riley. The nutrient variables, overall, were at moderate levels for zebra mussel suitability, however both TP and Chl-a concentrations were near the upper end of the moderate infestation threshold. Steve McComas found Chlorophyll concentrations directly impacted zebra mussel populations in Lake Minnetonka bays. Areas of the lake with optimal chlorophyll conditions experienced significant reductions in chlorophyll concentrations after infestation. This was followed by a zebra mussel dieback, occurring three to four years after the first mussels were found (McComas 2018). Physical variables all scored high for zebra mussel suitability in Riley. These variables all change with depth, however optimal conditions for each were present in Lake Riley. Hard structure suitability was estimated as highly suitable for zebra mussels. In 2016, it was found that 98% of the zebra mussel population in Lake Minnetonka were mostly juveniles and were found on submerged aquatic plants (McComas 2018). That said, it was hypothesized that many of those individuals died off and the main source of zebra mussel year to year recruitment may be from smaller, but dense groups of adults spread on isolated hard structure in slightly deeper portions of the lake. Hard structure in Lake Riley included predominantly rock and woody debris and is hypothesized to not be limiting for zebra mussels.

Based on the results in Table 5-3, the suitability of Lake Riley to support a robust and expansive zebra mussel population is high. Once large zebra mussel populations become established, it is hypothesized that Chl-a and TP will decrease, and water clarity will increase due to zebra mussel filtering rates. The District will look at suitability for zebra mussels across all lakes in the district in 2019.

6 Lake and Creek Fact Sheets

The Riley Purgatory Bluff Creek Watershed District has included in this report informational fact sheets for the lakes and creeks that were monitored during the 2018 sampling season (See Exhibits F). The lake fact sheets include: Lake Ann, Duck Lake, Hyland Lake, Lake Idlewild (high value wetland), Lotus Lake, Lake Lucy, Mitchell Lake, Red Rock Lake, Rice Marsh Lake, Lake Riley, Round Lake, Silver Lake, Staring Lake, and Lake Susan. The creek fact sheets include: Bluff Creek, Purgatory Creek, and Riley Creek.

Each lake fact sheet includes a summary of the historical water quality data collected as related to the MPCA water quality parameters: Secchi Disk depth, Total Phosphorus, and Chlorophyll-a. Each creek fact sheet includes a summary of the most current Creek Restoration Acton Strategy assessment, which includes the analysis of infrastructure risk, water quality, stream stability/erosion, and habitat. Lake or creek characteristics, stewardship opportunities, and information about what the District is doing in and around local water bodies is also described in each fact sheet.

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8 Exhibits

Exhibit A	2017 & 2018 Lake Level Sensor Graphs
Exhibit B	2018 Fyke Net Summary Data
Exhibit C	2018 Zooplankton Summary Data
Exhibit D	2018 Phytoplankton Summary Data
Exhibit E	2018 Creek Assessments
Exhibit F	2018 Lake and Creek Fact Sheets

Exhibit A

2017 & 2018 Lake Level Sensor Graphs

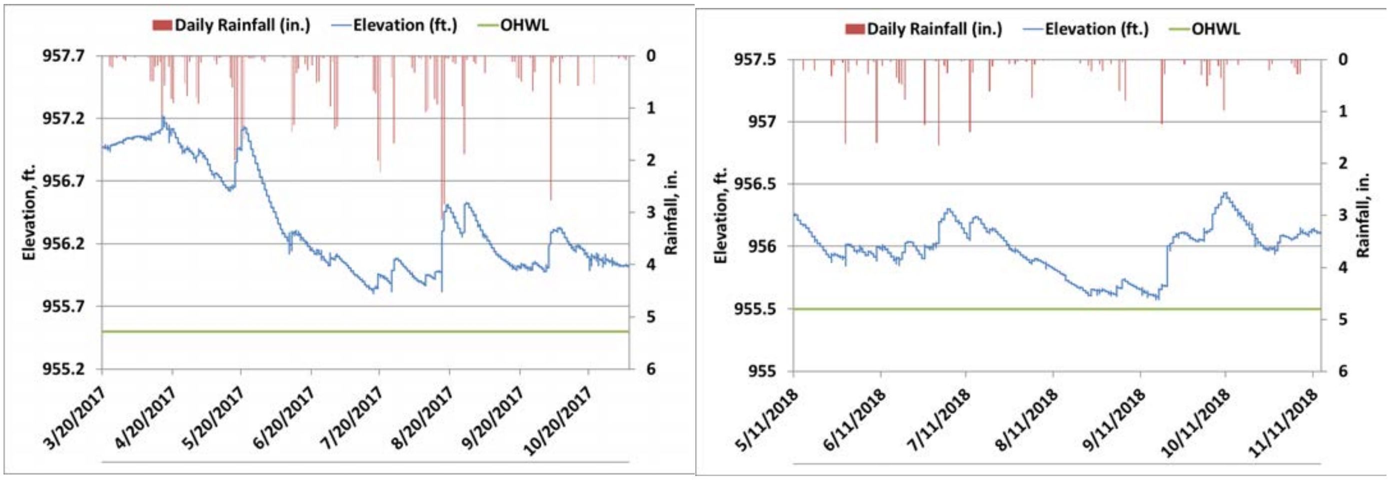


Figure A-1. **Lake Ann** level elevation data (ft.) for 2017 and 2018 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

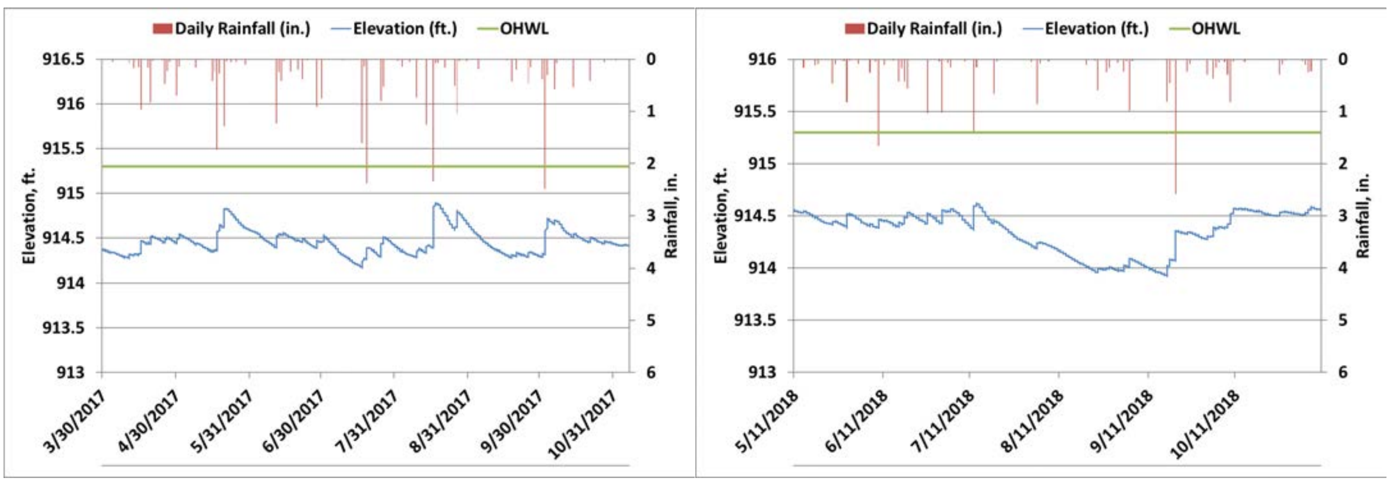


Figure A-2**. Duck Lake** level elevation data (ft.) for 2017 and 2018 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

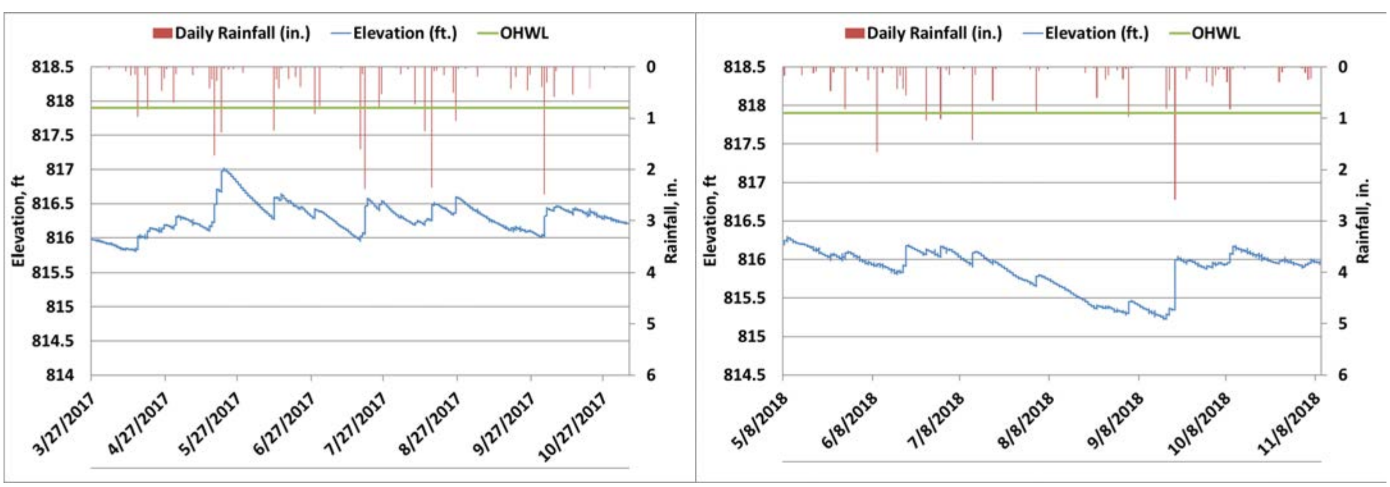


Figure A-3. **Hyland Lake** level elevation data (ft.) for 2017 and 2018 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

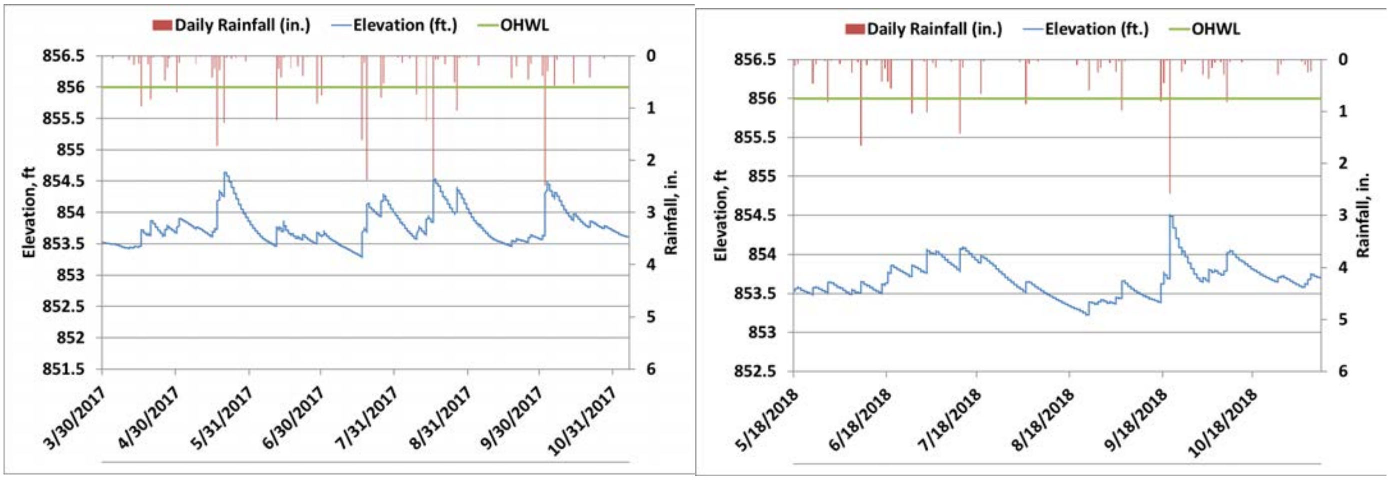


Figure A-4. **Lake Idlewild** level elevation data (ft.) for 2017 and 2018 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

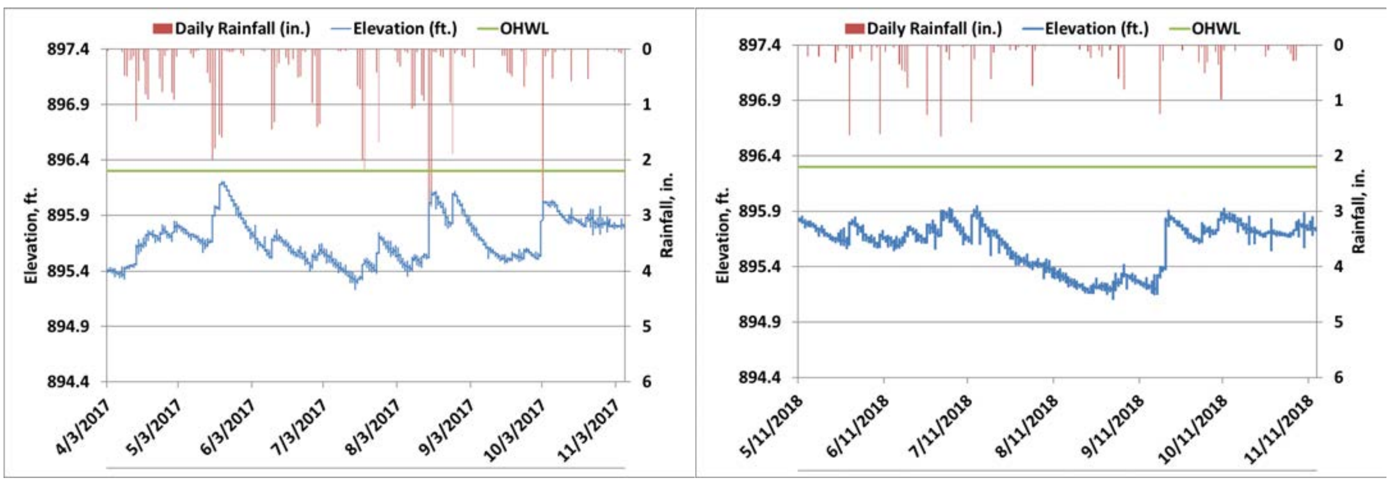


Figure A-5. **Lotus Lake** level elevation data (ft.) for 2017 and 2018 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

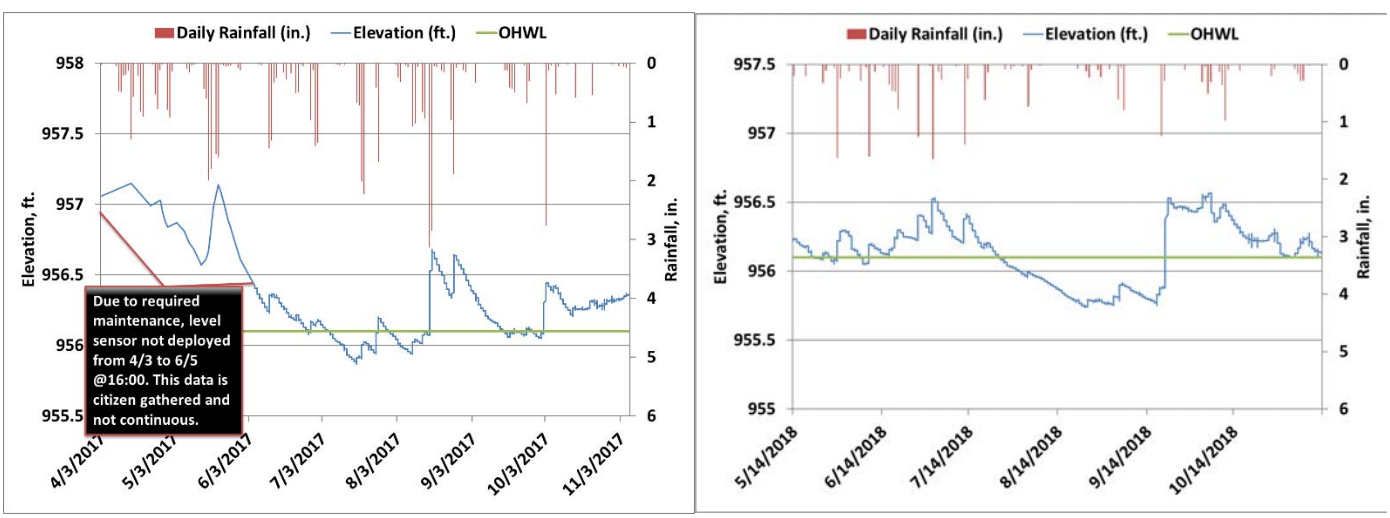


Figure A-6. **Lake Lucy** level elevation data (ft.) for 2017 and 2018 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

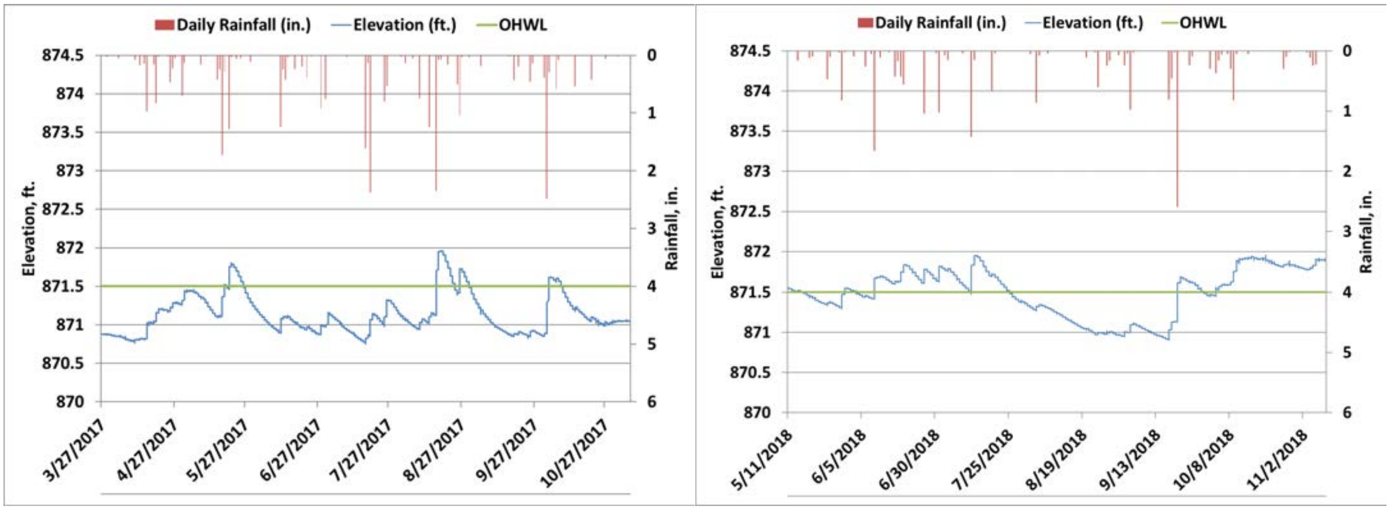


Figure A-7. **Mitchell Lake** level elevation data (ft.) for 2017 and 2018 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

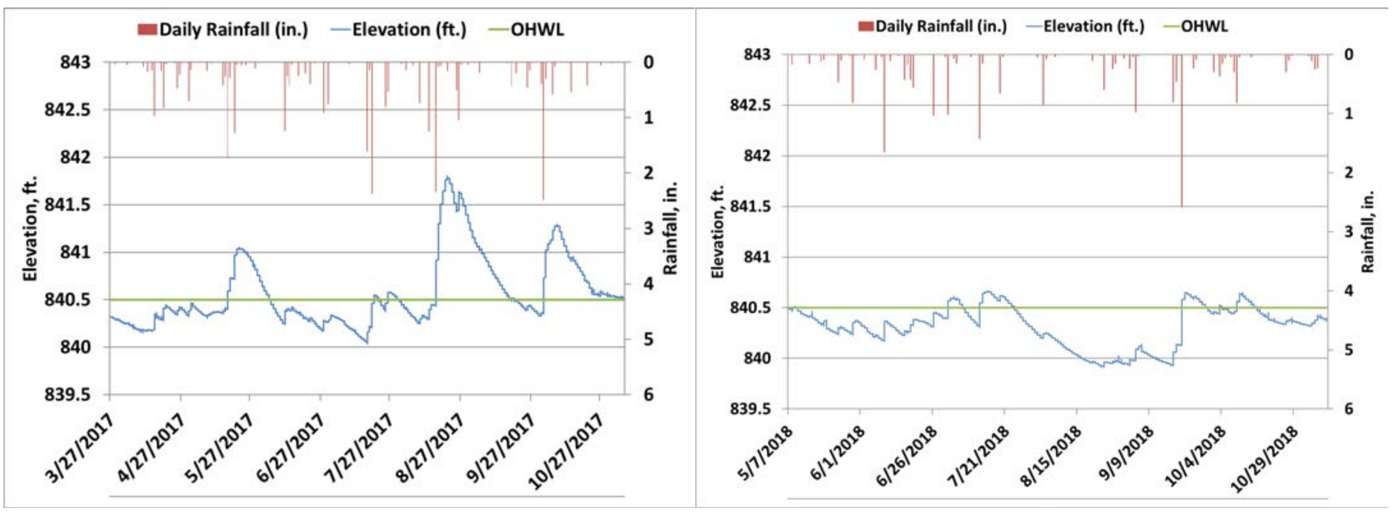


Figure A-8. **Red Rock Lake** level elevation data (ft.) for 2017 and 2018 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

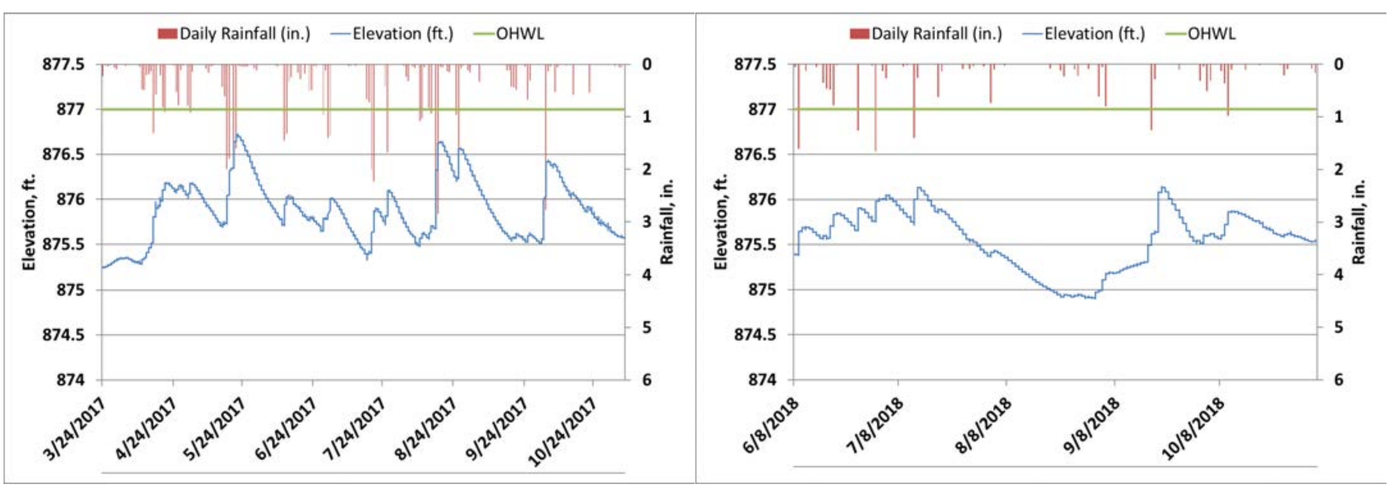


Figure A-9. **Rice Marsh Lake** level elevation data (ft.) for 2017 and 2018 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

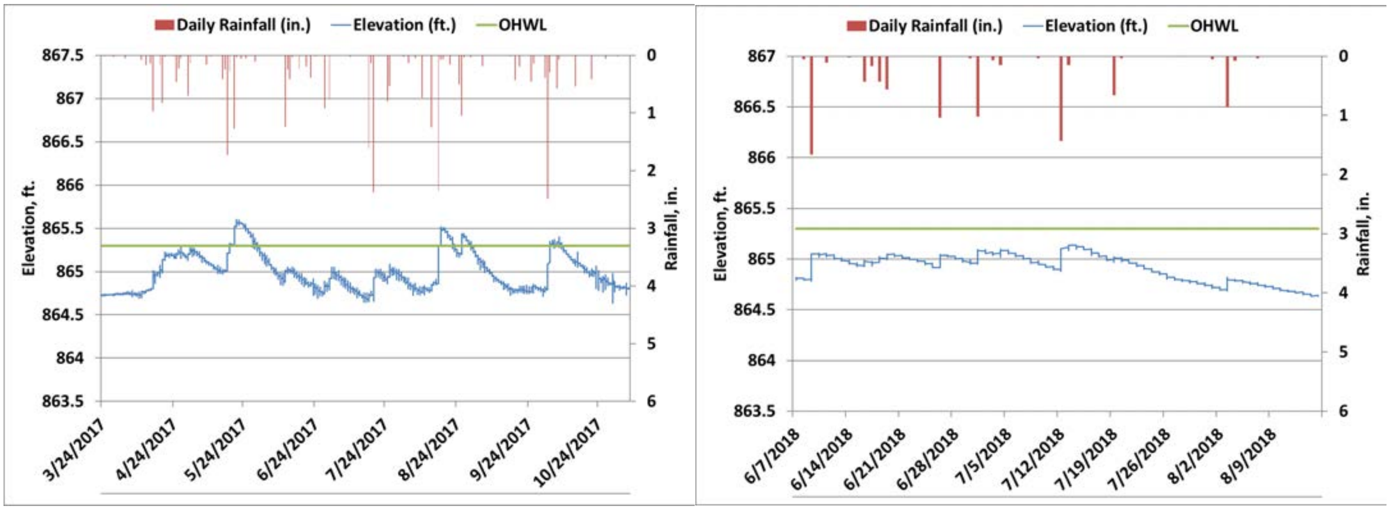


Figure A-10. **Lake Riley** level elevation data (ft.) for 2017 and 2018 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

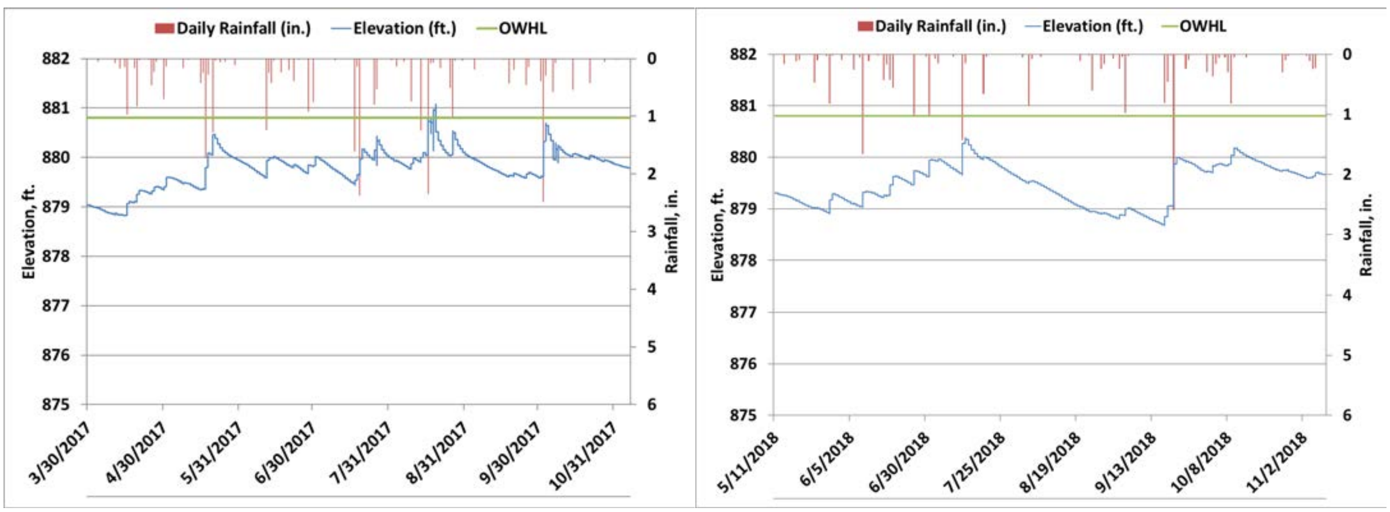


Figure A-11. **Round Lake** level elevation data (ft.) for 2017 and 2018 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

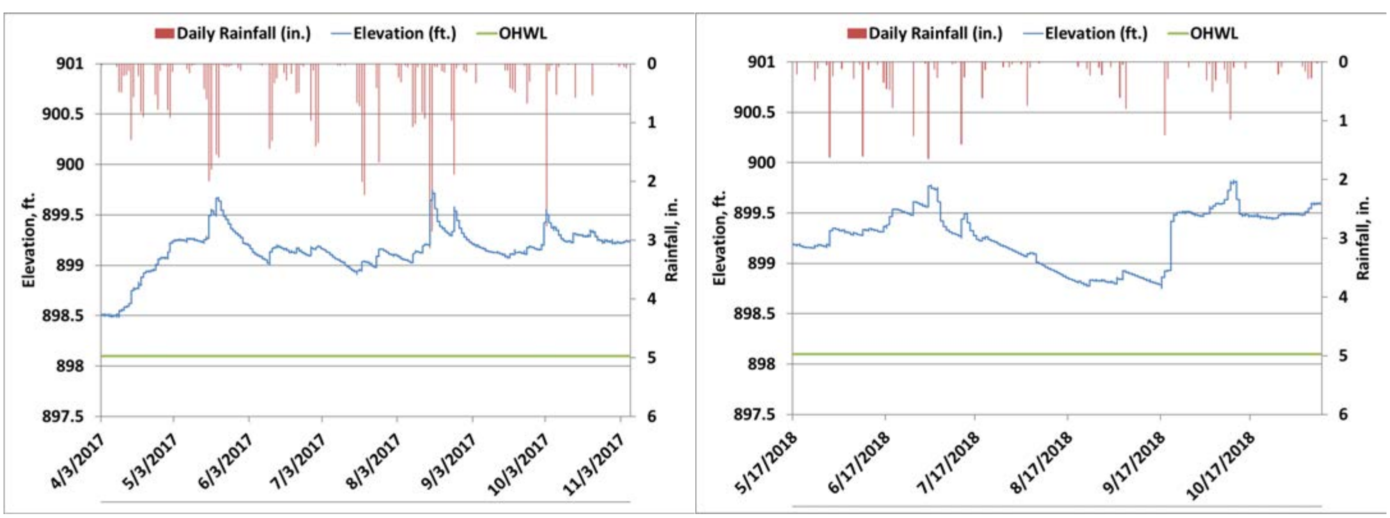


Figure A-12. **Silver Lake** level elevation data (ft.) for 2017 and 2018 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

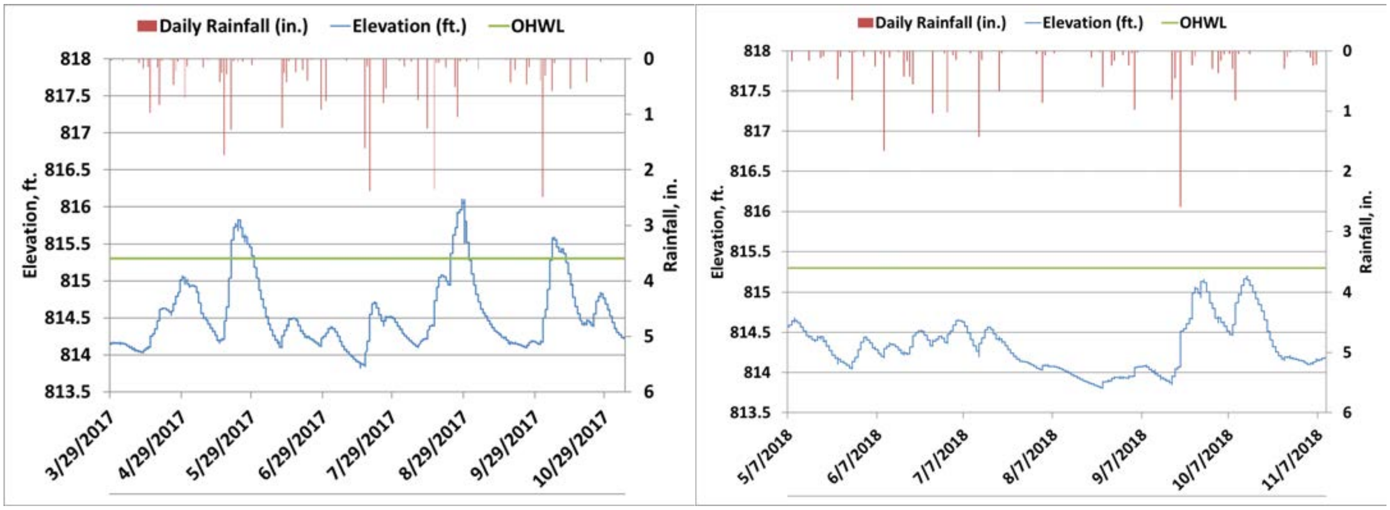


Figure A-13. **Staring Lake** level elevation data (ft.) for 2017 and 2018 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

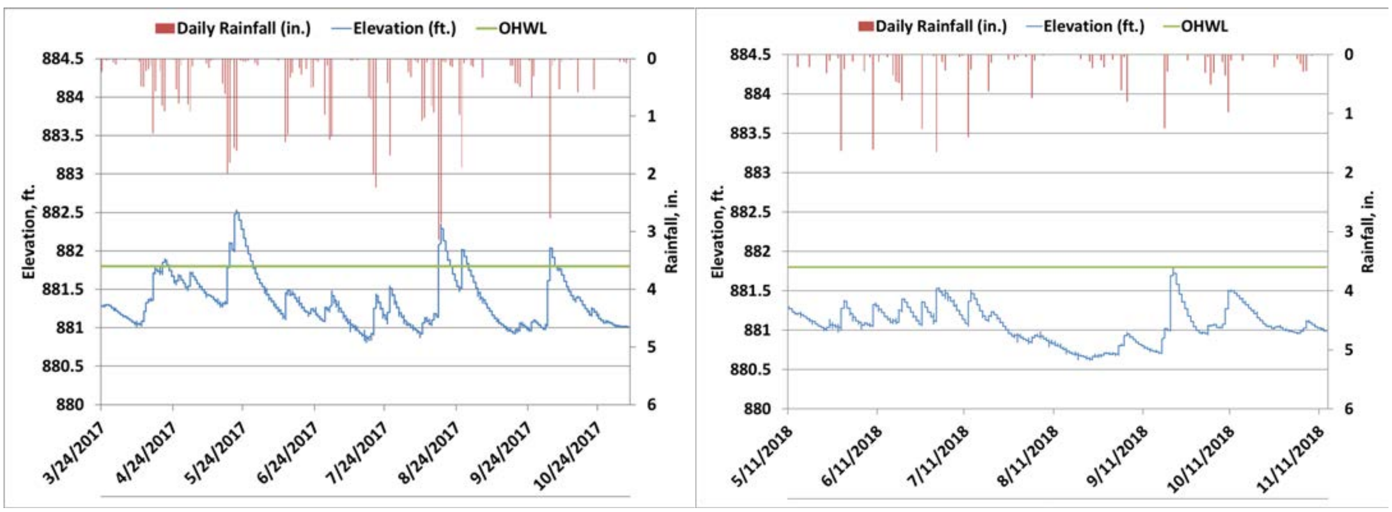


Figure A-14**. Lake Susan** level elevation data (ft.) for 2017 and 2018 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

Exhibit B

2018 Fyke Net Summary Data

Table B1: 2018 **Lake Ann** fyke net data

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black crappie	2								2	0.4
bluegill	229	37							266	53.2
common carp		1							1	0.2
green sunfish	5	6							11	2.2
hybrid sunfish	3								3	0.6
largemouth bass	1								1	0.2
northern pike			1		1	1	1		4	0.8
pumpkinseed	254	33							287	57.4
yellow bullhead			15						15	3
yellow perch	1								1	0.2
painted turtle									9	1.8
snapping turtle									1	0.2

Table B2: 2018 **Lake Lotus** fyke net data

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black crappie		36	3						39	7.8
bluegill sunfish	223	206							452	90.4
common carp							2		2	0.4
hybrid sunfish	1	2							3	0.6
largemouth	3			1					4	0.8
pumpkinseed		1							1	0.2
walleye					4	3			7	1.4
yellow bullhead		1	13	12					26	5.2
painted turtle									31	6.2
snapping turtle									4	0.8

Table B3: 2018 **Lake Lucy** fyke net data

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead		1							1	0.2
black crappie		33	4						37	7.4
bluegill	282	108							446	89.2
hybrid sunfish	13	6							19	3.8
largemouth bass						1			1	0.2
northern pike						1		1	2	0.4
pumpkinseed	38	6							44	8.8
yellow bullhead	1	17	31	7					56	11.2
painted turtle									30	6
snapping turtle									5	1

Table B4: 2018 **Lower Purgatory Creek Recreational Area** fyke net data

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead	59	210	2						437	109.25
black crappie	75	72							147	36.75
bluegill	126	18							144	36
common carp	9	5		21	37	2	1		75	18.75
freshwater drum					1				1	0.25
green sunfish	44								44	11
golden shiner	24	5							29	7.25
hybrid sunfish	39	2							41	10.25
largemouth bass	19	2	1	1					23	5.75
northern pike						1	1		2	0.5
pumpkinseed	104	1							105	26.25
white sucker			1	3	3				7	1.75
yellow bullhead	50	43	11	1					105	26.25
yellow perch	13	45							58	14.5
painted turtle									6	1.5
snapping turtle									2	0.5

Table B5: 2018 **Upper Purgatory Creek Recreational Area** fyke net data

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead	26	373							837	209.25
black crappie	84	118							202	50.5
bluegill	267	12							383	95.75
common carp	1		1	1	1	1			5	1.25
green sunfish	69								69	17.25
golden shiner	1								1	0.25
hybrid sunfish	98								98	24.5
largemouth bass	14	1							15	3.75
northern pike						1	1	1	3	0.75
pumpkinseed	230								297	74.25
yellow bullhead	4	22	7						33	8.25
yellow perch	130	12							142	35.5
painted turtle									16	4
snapping turtle									1	0.25

Table B6: 2018 **Rice Marsh Lake** fyke net data

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black crappie		2							2	0.4
bluegill	108	123							303	60.6
hybrid sunfish	1								1	0.2
largemouth bass	5								5	1
northern pike		1						1	2	0.4
pumpkinseed	1								1	0.2
yellow bullhead		3	5						8	1.6
painted turtle									22	4.4
snapping turtle									12	2.4

Table B7: 2018 **Lake Riley** fyke net data

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead		1							1	0.2
black crappie	1	2	2						5	1
bluegill	318	62							536	107.2
largemouth bass	2								2	0.4
northern pike							1		1	0.2
pumpkinseed	7	7							14	2.8
walleye		1				1			2	0.4
yellow bullhead	1	7	15	2					25	5
yellow perch	1								1	0.2
painted turtle									35	7
snapping turtle									4	0.8

Table B8: 2018 **Staring Lake** fyke net data

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead		56	9	1					66	13.2
black crappie		1							1	0.2
bluegill	92	3							95	19
common carp					3				3	0.6
green sunfish	1								1	0.2
golden shiner		1							1	0.2
largemouth bass	8								8	1.6
pumpkinseed	6								6	1.2
white sucker				2	8				10	2
yellow bullhead		9	6	1					16	3.2
yellow perch	9	1							10	2

Table B9: 2018 **Lake Susan** fyke net data

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead				1					1	0.2
black crappie	6	41	18						65	13
bluegill	168	143	1						492	98.4
common carp					2	2			4	0.8
freshwater drum			1						1	0.2
hybrid sunfish	4								4	0.8
largemouth bass	3	1			2				6	1.2
northern pike					1	3	1		5	1
pumpkinseed	3	1							4	0.8
white sucker					2	2			4	0.8
yellow bullhead		8	38	9					55	11
painted turtle									25	5
snapping turtle									3	0.6

Exhibit C

2018 Zooplankton Summary Data

Table C1: 2018 **Lake Riley** Zooplankton Counts (#/m²)

LAKE RILEY

DIVISION	TAXON	6/4/2018 #/m2	7/3/2018 #/m2	7/31/2018 #/m2	9/11/2018 #/m2
CLADOCERA	*Bosmina longirostris*	7,534	0	4,426	0
	Ceriodaphnia sp.	0	0	4,426	0
	Chydorus sphaericus	0	7,873	0	0
	Daphnia ambigua/parvula	0	0	0	0
	Daphnia galeata mendotae	0	15,746	17,705	0
	Daphnia pulex	15,068	39,365	35,410	0
	Daphnia retrocurva	0	0	35,410	13,184
	Diaphanosoma leuchtenbergianum	0	0	8,852	0
	Immature Cladocera	0	0	0	0
	Kindtti	0	0	0	0
	CLADOCERA TOTAL	**22,602**	**62,984**	**106,229**	**13,184**
COPEPODA	*Cyclops sp. / Mesocyclops sp.*	248,621	70,857	61,967	46,146
	Diaptomus sp.	120,544	78,730	79,672	52,738
	Nauplii	730,795	173,206	433,768	59,330
	Copepodid	0	0	0	0
	COPEPODA TOTAL	**1,099,960**	**322,793**	**575,407**	**158,213**
ROTIFERA	*Asplanchna priodonta*	60,272	23,619	278,851	0
	Brachionus sp.	7,534	0	8,852	0
	Filinia longiseta	0	7,873	4,426	0
	Lecane sp.	0	0	0	0
	Monostyla sp.	0	0	0	0
	Keratella cochlearis	105,476	133,841	278,851	876,766
	Keratella quadrata	45,204	39,365	8,852	19,777
	Kellicottia sp.	0	0	0	0
	Polyarthra vulgaris	195,883	70,857	44,262	283,466
	Trichocerca cylindrica	0	0	0	19,777
	Trichocera similis	0	7,873	4,426	0
	Trichocerca multicrinis	0	15,746	17,705	13,184
	Conochilus sp.	0	283,428	181,475	19,777
	Noltholca	7,534	0	0	0
	UID Rotifer	0	31,492	13,279	210,951
	ROTIFERA TOTAL	**421,902**	**614,094**	**840,980**	**1,443,697**
	TOTALS	**1,544,464**	**999,871**	**1,522,616**	**1,615,095**

Table C2: 2018 **Staring Lake** Zooplankton Counts (#/m²)

STARING

DIVISION	TAXON	6/5/2018 #/m2	7/2/2018 #/m2	7/30/2018 #/m2	9/11/2018 #/m2	10/2/2018 #/m2
CLADOCERA	*Bosmina longirostris*	373,384	23,732	226,999	91,199	58,162
	Ceriodaphnia sp.	26,670	0	108,565	111,465	36,351
	Chydorus sphaericus	8,890	39,553	98,695	111,465	36,351
	Daphnia ambigua/parvula	0	0	0	0	0
	Daphnia galeata mendotae	151,131	23,732	98,695	0	7,270
	Daphnia pulex	53,341	0	0	0	0
	Daphnia retrocurva	0	0	0	0	0
	Diaphanosoma leuchtenbergianum	17,780	0	49,348	30,400	7,270
	Immature Cladocera	0	0	0	0	0
	Kindtti	0	0	0	0	0
	CLADOCERA TOTAL	631,196	87,017	582,301	344,529	145,406
COPEPODA	*Cyclops sp. / Mesocyclops sp.*	595,636	7,911	118,434	81,066	36,351
	Diaptomus sp.	231,142	23,732	98,695	40,533	7,270
	Nauplii	844,558	15,821	256,607	81,066	58,162
	Copepodid	0	0	19,739	0	0
	COPEPODA TOTAL	1,671,336	47,464	493,475	202,664	101,784
ROTIFERA	*Asplanchna priodonta*	26,670	15,821	19,739	10,133	7,270
	Brachionus sp.	0	0	0	0	0
	Filinia longiseta	0	0	9,870	0	0
	Lecane sp.	0	0	0	0	0
	Monostyla sp.	0	0	0	0	0
	Keratella cochlearis	426,724	23,732	29,609	81,066	94,514
	Keratella quadrata	35,560	0	0	0	0
	Kellicottia sp.	0	0	39,478	0	0
	Polyarthra vulgaris	17,780	7,911	39,478	40,533	79,973
	Trichocerca cylindrica	0	0	9,870	0	0
	Trichocera similis	0	0	0	0	0
	Trichocerca multicrinis	0	0	39,478	0	0
	Conochilus sp.	0	0	0	0	0
	UID Rotifer	0	0	0	0	0
	ROTIFERA TOTAL	**506,735**	**47,464**	**187,521**	**131,732**	**181,757**

TOTALS	**2,809,268**	**181,945**	**1,263,297**	**678,924**	**428,947**

Table C3: 2018 **Lotus Lake** Zooplankton Counts (#/m²)

LOTUS LAKE

DIVISION	TAXON	6/5/2018 #/m2	7/2/2018 #/m2	7/30/2018 #/m2	9/13/2018 #/m2
CLADOCERA	*Bosmina longirostris*	68,371	0	45,656	0
	Ceriodaphnia sp.	0	0	0	0
	Chydorus sphaericus	4,558	0	0	0
	Daphnia ambigua/parvula	0	0	0	0
	Daphnia galeata mendotae	41,022	0	0	0
	Daphnia pulex	4,558	0	0	0
	Daphnia retrocurva	127,625	43,546	98,921	43,772
	Diaphanosoma leuchtenbergianum	0	0	30,437	56,279
	Immature Cladocera	0	0	0	0
	Kindtti	0	0	0	0
	CLADOCERA TOTAL	**246,135**	**43,546**	**175,014**	**100,051**
COPEPODA	*Cyclops sp. / Mesocyclops sp.*	350,970	10,887	167,405	93,798
	Diaptomus sp.	173,206	152,412	114,140	75,038
	Nauplii	200,554	326,598	509,824	456,483
	Copepodid	4,558	0	0	12,506
	COPEPODA TOTAL	**729,289**	**489,897**	**791,368**	**637,826**
ROTIFERA	*Asplanchna priodonta*	154,974	0	0	0
	Brachionus sp.	0	0	0	0
	Filinia longiseta	4,558	0	0	0
	Lecane sp.	0	0	0	0
	Monostyla sp.	0	0	0	0
	Keratella cochlearis	2,629,997	10,887	15,219	87,545
	Keratella quadrata	287,157	0	0	0
	Kellicottia sp.	0	304,825	15,219	0
	Polyarthra vulgaris	0	65,320	0	0
	Trichocerca cylindrica	0	0	0	0
	Trichocera similis	0	0	0	0
	Trichocerca multicrinis	0	0	0	0
	Conochilus sp.	0	130,639	0	50,026
	UID Rotifer	0	0	0	0
	ROTIFERA TOTAL	**3,076,686**	**511,670**	**30,437**	**137,570**

TOTALS	**4,052,109**	**1,045,113**	**996,820**	**875,448**

Table C4: 2018 **Lake Susan** Zooplankton Counts (#/m²)

LAKE SUSAN

DIVISION	TAXON	6/4/2018 #/m2	7/2/2018 #/m2	7/31/2018 #/m2	9/11/2018 #/m2
CLADOCERA	*Bosmina longirostris*	14,842	0	0	7,120
	Ceriodaphnia sp.	0	0	0	0
	Chydorus sphaericus	0	0	0	0
	Daphnia ambigua/parvula	0	0	0	0
	Daphnia galeata mendotae	103,893	19,212	0	0
	Daphnia pulex	63,078	0	0	0
	Daphnia retrocurva	0	0	0	0
	Diaphanosoma leuchtenbergianum	0	0	7,534	7,120
	Immature Cladocera	0	0	0	0
	Kindtti	0	0	0	0
	CLADOCERA TOTAL	**181,814**	**19,212**	**7,534**	**14,239**
COPEPODA	*Cyclops sp. / Mesocyclops sp.*	237,471	76,847	82,874	85,435
	Diaptomus sp.	148,419	86,452	0	7,120
	Nauplii	170,682	230,540	105,476	135,272
	Copepodid	0	0	0	7,120
	COPEPODA TOTAL	**556,572**	**393,838**	**188,349**	**234,947**
ROTIFERA	*Asplanchna priodonta*	0	0	0	0
	Brachionus sp.	0	0	0	0
	Filinia longiseta	0	288,174	0	0
	Lecane sp.	0	0	0	0
	Monostyla sp.	0	0	0	0
	Keratella cochlearis	126,156	1,709,835	158,213	192,229
	Keratella quadrata	115,025	9,606	0	0
	Kellicottia sp.	81,631	0	0	0
	Polyarthra vulgaris	3,710	0	0	0
	Trichocerca cylindrica	0	0	0	0
	Trichocera similis	0	48,029	0	0
	Trichocerca multicrinis	0	0	0	0
	Conochilus sp.	0	0	0	0
	UID Rotifer	0	0	0	0
	ROTIFERA TOTAL	**326,522**	**2,055,644**	**158,213**	**192,229**
	TOTALS	**1,064,908**	**2,468,694**	**354,097**	**441,416**

Table C5: 2018 **Rice Marsh Lake** Zooplankton Counts (#/m²)

RICE MARSH

DIVISION	TAXON	6/5/2018 #/m2	7/3/2018 #/m2	8/1/2018 #/m2	9/10/2018 #/m2	10/2/2018 #/m2
CLADOCERA	*Bosmina longirostris*	48,368	109,205	28,252	108,301	22,602
	Ceriodaphnia sp.	24,184	25,201	18,835	0	0
	Chydorus sphaericus	16,123	0	47,087	4,709	0
	Daphnia ambigua/parvula	0	0	0	0	0
	Daphnia galeata mendotae	88,675	0	0	0	0
	Daphnia pulex	0	0	0	0	0
	Daphnia retrocurva	0	0	0	0	0
	Diaphanosoma leuchtenbergianum	0	16,801	9,417	0	0
	Immature Cladocera	0	0	0	0	0
	Kindtti	0	0	0	0	0
	CLADOCERA TOTAL	**177,350**	**151,207**	**103,592**	**113,010**	**22,602**
COPEPODA	*Cyclops sp. / Mesocyclops sp.*	24,184	58,803	197,767	28,252	56,505
	Diaptomus sp.	0	0	0	0	0
	Nauplii	128,982	386,417	395,534	258,980	220,369
	Copepodid	0	0	0	0	0
	COPEPODA TOTAL	**153,166**	**445,220**	**593,300**	**287,233**	**276,873**
ROTIFERA	*Asplanchna priodonta*	0	268,812	197,767	0	0
	Brachionus sp.	0	0	0	0	0
	Filinia longiseta	0	16,801	0	0	0
	Lecane sp.	0	0	0	4,709	0
	Monostyla sp.	0	0	0	0	0
	Keratella cochlearis	290,209	159,607	37,670	56,505	16,951
	Keratella quadrata	0	0	0	0	0
	Kellicottia sp.	0	0	0	0	0
	Polyarthra vulgaris	0	92,404	56,505	442,621	79,107
	Trichocerca cylindrica	0	0	0	0	0
	Trichocera similis	0	0	0	0	0
	Trichocerca multicrinis	0	0	0	0	0
	Conochilus sp.	0	184,808	0	0	0
	Euchlaris sp.	0	0	0	0	0
	UID Rotifer	0	0	0	0	0
	ROTIFERA TOTAL	**290,209**	**722,433**	**291,941**	**503,834**	**96,058**

TOTALS	**620,724**	**1,318,860**	**988,834**	**904,077**	**395,534**

Exhibit D

2018 Phytoplankton Summary Data

Table D1: 2018 **Lotus Lake** Phytoplankton #/L

	6/8/2018	7/2/2018	7/30/2018	9/13/2018
Class	**#/L**	**#/L**	**#/L**	**#/L**
Xanthophyceae			283	
Bacillariophyceae	23730	18931.03	565737	4924
Chlorophyceae	665268	12033594.11	1674299	238154
Cryptophyceae	722222	1449042	678885	1092307
Crysophyceae		1308812	84861	
Cyanophiceae	32515683	20427093.74	234818196	30533432
Dinophyceae	5777	3272.0309	1980	616
Euglenophyceae			283	308
Synurophyceae			283	1231
Total	**33932680**	**35240744.91**	**237824807**	**31870972**

Table D2: 2018 **Staring Lake** Phytoplankton #/L

	6/8/2018	7/2/2018	7/30/2018	9/11/2018	10/2/2018
Class	**#/L**	**#/L**	**#/L**	**#/L**	**#/L**
Eustigmatophyceae			1239		
Bacillariophyceae	12097812	535586.2261	39965	6155	380410
Chlorophyceae	1489951	2803609.114	375173	114769	162835
Cryptophyceae	1252846	177011.5	325294	738461	636886
Crysophyceae	2057	25287.36			
Cyanophiceae	310776419	209538717.3	359139319	387411843	203039782
Dinophyceae	187	3540.23	311353	1846	1033
Euglenophyceae			310		
Synurophyceae	374			615	1033
Xanthophyceae	187				
Total	**325619833**	**213083751.7**	**360192653**	**388273689**	**204221979**

Table D3: 2018 **Lake Riley** Phytoplankton #/L

	6/6/2018	7/3/2018	7/31/2018	9/11/2018
Class	**#/L**	**#/L**	**#/L**	**#/L**
Bacillariophyceae	111692	36556	26736	3316
Chlorophyceae	296308	554554	1114566	15978
Cryptophyceae	784615	725926	1986792	587868
Crysophycee	8000		380189	2080147
Cyanophiceae	34088	44663630	33992751	81034089
Dinophyceae	1692	2333	36792	16882
Total	**1236395**	**45982999**	**37537826**	**83738280**

Table D4: 2018 **Rice Marsh** Lake Phytoplankton #/L

Class	6/8/2018 #/L	7/3/2018 #/L	8/1/2018 #/L	9/10/2018 #/L	10/2/2018 #/L
Bacillariophyceae	6000	221074	188701	918	730
Chlorophyceae	1009600	1095530	803146	36756	34287
Cryptophyceae	810000	32340	5528205	8982433	2425615
Crysophyceae	8350000		1196581	114865	
Cyanophiceae	5485000	60986132	51449572	147487	22870082
Dinophyceae	400	103359	1795	13324	5836
Euglenophyceae		4511	6821	919	365
Eustigmatophyceae		2051	2154		
Prymnesiophyceae		61523	119658		
Synurophyceae					72951
Bacillariophyceae	6000	221074	188701	918	730
Total	**15661000**	**62506520**	**59296633**	**9296702**	**25409866**

Table D5: 2018 **Lake Susan** Phytoplankton #/L

Class	6/7/2018 #/L	7/2/2018 #/L	7/31/2018 #/L	9/11/2018 #/L
Haptophyta	11382			
Bacillariophyceae	2049	8988	76000	90677
Chlorophyceae	1837072	61334	3753260	4045366
Cryptophyceae	2492683	704981	1463000	4370626
Crysophyceae	11382	3877395		
Cyanophiceae	905431	65814599	271549379	250903930
Dinophyceae	4325	476214	342000	60663
Euglenophyceae		176	38000	5984
Grand Total	**5264324**	**70943687**	**277221639**	**259477246**

Exhibit E

2018 Creek Assessments

Purgatory Creek Assessment

Duck Lake Trail to Purgatory Creek Main Channel

Conducted by: RPBCWD staff [Zach Dickhausen] and University of MN volunteer
Conducted on: 15 October 2018

Summary

Site/Scope

On the 15th of October at 10:48, 2018, Riley Purgatory Bluff Creek Watershed District (RPBCWD) staff conducted a stream corridor assessment of the tributary Reach PT-4 of Purgatory Creek. Staff started at Duck Lake Trail and walked downstream into the wetland complex where the tributary connects to the main channel. Staff walked both sides of the creek to assess overall stream conditions and to discover and prioritize possible restoration locations (walked approximately 0.20 stream miles). Staff conducted a Modified Pfankuch Channel Stability Assessment and a Minnesota Pollution Control Agency (MPCA) Stream Habitat Assessment (MSHA) on each subreach to better characterize the stream. A GPS, and a GPS-enabled camera were used to mark points and take photos.

- All pictures were taken <u>Facing Downstream</u> unless noted otherwise.
- <u>Right</u> and <u>Left</u> bank are defined by looking downstream.
- Erosion was defined as <u>Slight</u>, <u>Moderate</u>, or <u>Severe</u>.
- <u>Stream bank Erosion</u> was measured from the streambed to the top of the eroding bank.
- Vegetation was defined as <u>Sparse</u>, <u>Patchy</u>, or <u>Dense</u>.
- All measurements were recorded in <u>Meters</u>.
- All major erosion sites were labeled on the GPS by the erosion site number and reach

Weather Conditions

10/15/2018
Wind: 2.4 mph
Temp: 5.3 °C
Cloud Cover: 25 %

Stream Features

This subreach passes through deciduous forest surrounded by residential area, ending at its confluence with the main channel within a wetland area just north of Duck Lake Trail. The riparian width for a majority of the subreach was approximately 50m along the left bank and 5m along the right bank. The substrate in this reach consisted mainly of sand, with several areas of sandy/silt. The immediate substrate north of Duck Lake Trail is cobble and gravel, mixed with placed riprap. Slope gradients in this reach were predominantly flat, 0% to 10%, with the initial slope gradient of 60% for about 10 meters at the very start of the subreach. Apart from the first 50 to 75m, the channel was not sinuous and channel development was fair to poor (riffle, run, pool). The majority of the few riffles occurred towards the beginning of the subreach and there were very few pools.

Areas of Concern

This subreach contained a great deal of woody debris jams and garbage. Several Eden Prairie park signs were encroaching on the channel or had fallen in the stream indicating the channel had shifted or high flows had occurred. Residential lawns were mowed close to the stream edge along the right bank. The immediate surrounding vegetation was dominated by thick brush, much of which consisted of buckthorn. There was moderate erosion throughout the subreach. The heavier areas of erosion and cutting occurred at the beginning of the subreach. As the reach continued, more of the lower areas of cutting were beginning to heal over, but there were several areas of bank that were bare. There was also considerable amount of sediment deposition in the beginning of the subreach. There were no major erosion/mass wasting sites or infrastructure risks. The exposed metal culvert within the stream has had the topsoil eroded away and could potentially be a risk if it moved at high flows in the future. Much of the subreach was littered with trash.

Subreach PT-4A- Duck Lake Trail to Main Channel

ROSGEN: E5; MSHA: 46.75 (Fair); **Pfankuch:** 86 (Fair)

Staff began this creek walk at Duck Lake Trail where the tributary's surface flow begins in the steep ditch on the north side of the road. The start of the reach was full of placed boulders/riprap, some of which were partially covered with moss and duckweed (IMG_3573, IMG_3577). The immediate slopes were quite steep, grades greater than 60% on the left bank, but as staff continued out of the roadside ditch area, grades lessened quickly to 5%. There was lots of woody canopy cover, consisting of a mixture of buckthorn (which was very dense in areas) and large deciduous trees. The substrate at the beginning was a mixture of cobble and gravel within the boulders (IMG_3574). Throughout the subreach there was considerable leaf litter accumulation, but it was heaviest in the first quarter. Staff observed a great deal of woody debris and small downed trees within the channel throughout the subreach (IMG_358, IMG_3581). The channel was quite sinuous for the first 50 to 75m. All of this, along with the thick growth of the understory of buckthorn slowed the navigation of this section. Within the first 20m of the beginning of the stream, staff observed cutting on both banks. On the right bank, the cutting measured about 0.6m high (IMG_3581); on the left bank the cutting measured about 0.15m to 1.2m high (IMG_3582). The cutting on both banks continued through the sinuous part of the subreach. Staff noticed a considerable amount of trash and dumped items such as tires in the stream throughout the subreach (IMG_3584, IMG_3585).

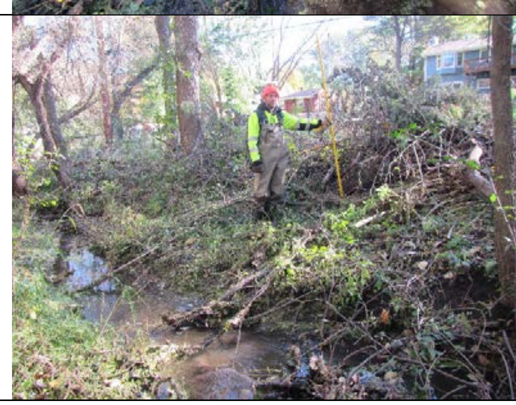
Continuing downstream, staff started noticing sediment deposition; there was a bar near the right bank (IMG_3586) and a great deal of deposition along the left bank just after that (IMG_3588). Staff continued to encounter heavy amounts of woody debris (IMG_3589 – IMG_3592), but the frequency did decrease. The canopy soon opened and the amount of buckthorn decreased, although the left bank still was rather dense with buckthorn through many parts of the subreach. Staff also observed an Eden Prairie park boundary sign in the stream (IMG_3592) and several others in and along the channel throughout the reach (IMG_ 3598, IMG_3601, IMG_3606, IMG_3619). Staff observed another sediment deposition bar along the left bank (IMG_3594). Just downstream was a pile of woody debris that was causing the stream to pool (IMG_3595).
About 100m into the walk, the woody vegetation thinned out along the right bank and the lawns of the residential area were set back about 5 to 7m. The channel soon straightened, and staff observed a wood/brush pile on the right bank measuring about 2m tall and 6m long (IMG_3596).

<table>
<tr>
<td></td>
<td>IMG_3573

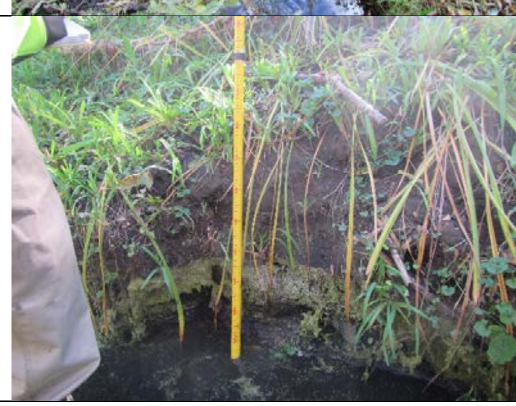
Start of tributary under Duck Lake Trail; boulders/riprap.</td>
<td></td>
<td>IMG_3574

Gravel/cobble substrate at start of tributary.</td>
</tr>
</table>

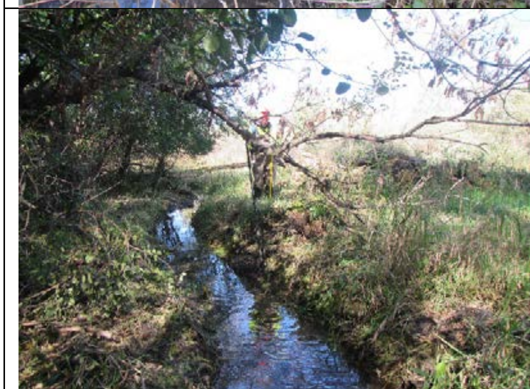
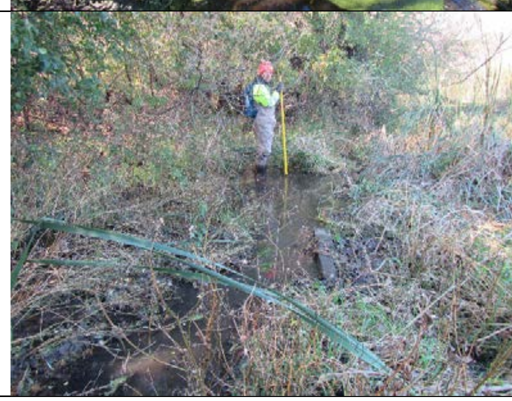
	**IMG_3576** Woody Debris and boulder riffle.		**IMG_3577** General Stream photo; lots of boulders in-stream and on banks.
	**IMG_3580** Multiple downed trees and heavy woody debris.		**IMG_3581** Erosion on RB, 0.6m high.
	**IMG_3582** Erosion on left bank, 0.15 – 1.2m high.		**IMG_3584** Tire in channel.
	**IMG_3585** Garbage in channel.		**IMG_3586** Sediment bar near RB.

	**IMG_3588** Large sediment deposition bar and woody debris, LB; visible mattress coils.		**IMG_3589** General stream photo; heavy woody debris.
	**IMG_3590** Sediment deposit and woody debris.		**IMG_3591** Rebar and woody debris.
	**IMG_3592** Eden Prairie park marker sign in stream.		**IMG_3594** Deposition bar, LB.
	**IMG_3595** Woody debris; tire and some garbage in stream.		**IMG_3596** Brush pile on RB, 2m high by 6m long.

The cutting along both banks decreased; much of which was healing over and had grass growing on it. Continuing downstream, there were several more occurrences of heavy woody debris, some of it causing water to pool (IMG_3597 – IMG_3600). Staff did still observe some erosion that wasn't quite fully healed; there was an occurrence on the right bank that measured 0.8m and stretched for about 8m (IMG_3603). Here the channel narrowed, and the banks were very low (IMG_3604). Staff saw more trash/scrap in the channel (IMG_3606). Just downstream the stream started to wind for a few meters and there was some deposition along the right bank and cutting along the opposite bank (IMG_3608). As the stream straightened again, there was a stretch of creek that had thick grass and herbaceous vegetation growing on both upper banks (IMG_3609). Within the grass was some lumber spanning the creek channel (IMG_3609). Staff observed more deposition along the right bank (IMG_3614) and another small tree across the channel (IMG_3615). By this point, the lawns of the residential area were within 2m of the right bank, and the slope grade was close to 0%. Staff observed another brush pile on the right bank (IMG_3616). The canopy on the right bank was made up of a tree every 10–20m. Just after the brush pile, there was a large, metal culvert in the channel through which the stream flowed through (IMG_3616, IMG_3617). It appeared to be an old stream crossing that which the topsoil had eroded away. There were also some railroad ties laid across the top of the pipe. Continuing downstream, there were several railroad ties laid along the top of the right bank (IMG_3618). Downstream was a log pile on the right bank (IMG_3619), followed by two more sites of heavy debris (IMG_3620, IMG_3621). At this point, the vegetation along the right bank started to get thicker, consisting of grasses, sedges and other herbaceous wetland plants (IMG_3622). Staff finally came to the end of the reach where the subreach entered a wetland which eventually met up with the main channel (IMG_3623).

	**IMG_3597** Woody debris dam causing water to pool.		**IMG_3598** Eden Prairie park marker sign on left bank LB.
	**IMG_3599** Woody debris; deposition along LB.		**IMG_3600** Heavy woody debris.
	**IMG_3601** Eden Prairie park marker sign across stream; some trash in stream.		**IMG_3603** Some erosion starting to heal over with grass cover, 0.8m high by 8m on RB.

	**IMG_3604** General stream photo.		**IMG_3605** Erosion on LB healing, 0.6m high by 7m long.
	**IMG_3606** Metal pole, tire and railroad tie in stream; Eden Prairie park marker sign (not in photo).		**IMG_3608** Deposition along RB; metal marker pin with pink flagging.
	**IMG_3609** General stream photo; lumber across channel.		**IMG_3614** Soil deposition along RB.
	**IMG_3615** Fallen tree across channel.		**IMG_3616** Wood pile on RB.

	**IMG_3617** Metal pipe in channel; stream flows through it.		**IMG_3618** Eden Prairie park marker sign and railroad ties on RB.
	**IMG_3619** Log pile and Eden Prairie park marker sign on RB.		**IMG_3620** Heavy woody debris.
	**IMG_3621** Woody debris.		**IMG_3622** General stream photo.
	**IMG_3623** Tributary disappearing into wetland; end of subreach before connecting with channel.		

Purgatory Creek Assessment

Silver Branch North Tributary

Conducted by: RPBCWD staff [Josh Maxwell] and University of MN volunteer
Conducted on: 10 October 2018

Summary

Site/Scope

On the 10th of October 2018, Riley Purgatory Bluff Creek Watershed District (RPBCWD) staff and a University of Minnesota student conducted a stream corridor assessment of two subreaches of the north tributary stream that enters Reach P7 of Purgatory Creek. Staff started eighty meters upstream of the recreational trail off Vine Hill Road and walked downstream to Vine Hill Road (approximately 0.92 stream miles). Staff walked both sides of the creek to assess overall stream conditions and to discover and prioritize possible restoration locations. Staff conducted a Modified Pfankuch Channel Stability Assessment and a Minnesota Pollution Control Agency (MPCA) Stream Habitat Assessment (MSHA) on the subreach to better characterize the stream. A GPS, and a GPS-enabled camera were used to mark points and take photos.

- All pictures were taken Facing Downstream unless noted otherwise.
- Right and Left bank are defined by looking downstream.
- Erosion was defined as Slight, Moderate, or Severe.
- Stream bank Erosion was measured from the streambed to the top of the eroding bank.
- Vegetation was defined as Sparse, Patchy, or Dense.
- All measurements were recorded in Meters.
- All major erosion sites were labeled on the GPS by the erosion site number and reach (E#R2).

Weather Conditions

Wind: 7 mph
Temp: 7.8°C
Cloud Cover: 100%
Rain Total: 1.04 inches

Stream Features

This tributary stream section begins at three locations, all of which drain from wetlands. The channel was relatively shallow and was considered a glide/run for most of the tributary. There was very little stream development (riffle, run, pool) across both subreaches. The surrounding vegetation was a mix of deciduous forests and wetland grasses and sedges. The riparian widths were very wide in subreach A but were only 5m wide in subreach B. Residential housing bordered most of subreach B along both banks. All subreaches had similar substrates with fine sand and silt being predominant. Near the wetland origins the substrate was primarily muck. Slope gradients within the upper reaches were very flat, which would allow the stream to easily access the floodplain if needed during highwater conditions. The stream was not sinuous; there were long, straight stretches within each subreach. Woody debris and overhanging vegetation were the most common instream habitat in this tributary.

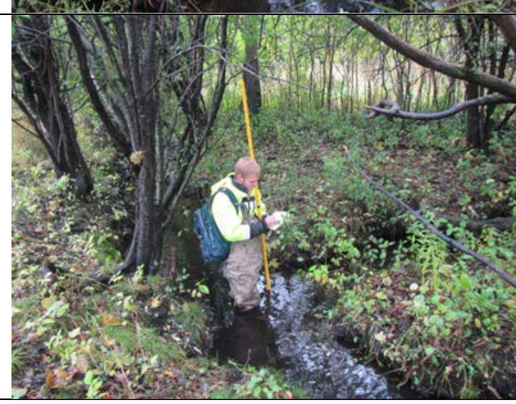
Areas of Concern

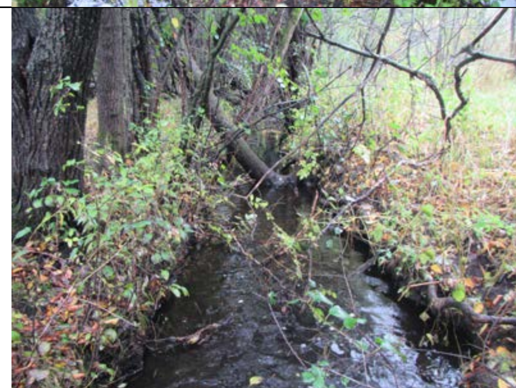
Overall the tributary was considered fairly stable. Pfankuch scores indicated moderately stable conditions across all subreaches. The stream did appear to be incised for much of the reach by about 0.1-0.5m. Infrastructure risks were relatively low, however the culvert under Del Ann Circle was experiencing some erosion. Additionally, the very flat slopes and residential housing proximity to the stream were of concern if high water conditions occur. In subreach B, bank vegetation had been cleared and grass was mowed to the stream edge which was causing some larger erosion sites. MSHA scores were fair much like what is seen throughout the district. The culvert under Vine Hill Road was also clogged.

Subreach PT-5A–Upper Subreach of the Silver Branch Tributary

Rosgen: E5; **MSHA:** 42 (Fair); **Pfankuch:** 72 (Moderately Stable)

The PT-5A subreach begins 80m upstream of the recreational trail off Vine Hill Road and includes an additional tributary branch that joins from the east (IMG_3492). The stream begins from the drainage of an upstream wetland (IMG_3493). The channel bankfull width at the start of the subreach was 0.9m wide and 0.3m deep. The depth of the stream on the day of the assessment was 0.1m. The substrate was predominantly muck and the stream was continuously incised between 0.1-0.2m (IMG_3494). Shortly downstream, a small tributary entered on the right bank (IMG_3495) and stretched 15m west from the mainstem (IMG_3497). The main stream depth after the confluence increased to 0.3m (IMG_3498). The bankfull width increased to 1m and the bankfull depth increased to 0.7m. The stream was considered a glide with very limited channel development and sinuosity. The surrounding slopes were flat. The surrounding vegetation was comprised of wetland grasses and sedges. The stream, under high water conditions, could access the large surrounding floodplain. Brush, shrubs, and small trees increased in density as staff moved downstream. Consequently, woody debris also increased moving downstream (IMG_3499). Due to the recent rains, the wetland was draining into the channel at multiple points as seen in IMG_3501 and IMG_3502. Also, a fallen tree on the left bank which roots exposed raw soil can be seen in those images.

	**IMG – 3492** Tributary start; wetland draining to creek; US.		**IMG – 3493** Stream start; US.
	**IMG – 3494** Stream start; DS photo.		**IMG – 3495** Tributary entering RB.

	**IMG – 3497** RB tributary start 15m from main stem.		**IMG – 3498** DS of confluence; width increase to 1m.
	**IMG – 3499** Woody debris increasing.		**IMG – 3500** General stream photo; straight stream channel.
	**IMG – 3501** Exposed soil from tree fell; wetland drainage on LB and RB.		**IMG – 3502** Exposed soil from tree fell; wetland drainage on LB and RB.

The stream then crossed under the recreational trail off Vine Hill Road via metal culvert (IMG_3503 and IMG_3504). In IMG_3504 another fallen tree had exposed soil and was causing erosion measuring approximately 0.8m x 1m. The substrate immediately downstream of the culvert was gravel due to the channel confinement causing increased velocities, but soon substrate transitioned to sand/silt. About 6m downstream of the recreational trail, another small tributary stream entered on the right bank (IMG_3505) and stretched approximately 15m to the west (IMG_3506). The surrounding vegetation shifted to small trees and shrubs, depositing increased woody debris into the stream (IMG_3507). The channel also widened and was shallow in depth. Cutting occurred sporadically along both banks measuring up to 0.5m high (IMG_3508). Moving downstream, staff found another fallen tree which exposed approximately 1.3m x 4m of raw soil (IMG_3509). After the root exposure, the stream became continuously incised by 0.5m. An additional drainage channel entered on the right bank which stretched to the west about 5m (IMG_3511). Woody debris became more intense and caused multiple woody debris dams (IMG_3510 and IMG_3512). Continuing downstream, staff came across a brick riffle (IMG_3513) followed by an old culvert blocking the channel and causing a debris dam (IMG_3514). Staff then moved downstream a distance and came across a depositional island close to the left bank (IMG_3517). Then, a wooden bridge was found across the stream (IMG_3518). Near the confluence of the east tributary (IMG_3520), staff observed a sediment deposition island (IMG_3519).

	**IMG – 3503** Metal culvert under recreational trail.		**IMG – 3504** Metal culvert under recreational trail; US view.
	**IMG – 3505** Tributary confluence on RB.		**IMG – 3506** Tributary confluence on RB; start 15m from main stem.
	**IMG – 3507** General stream photo; increased woody debris.		**IMG – 3508** Stream incised 0.5m.
	**IMG – 3509** Exposed root system with 1.3m of erosion.		**IMG – 3510** General stream photo; woody debris dam.

	**IMG – 3511** Confluence of small drainage tributary on LB.		**IMG – 3512** Thick woody debris dam; US.
	**IMG – 3513** Brick riffle; US		**IMG – 3514** Rusted metal culvert in debris dam.
	**IMG – 3515** Instream brushpile.		**IMG – 3516** General stream photo.
	**IMG – 3517** General stream photo; deposition island.		**IMG – 3518** Wooden bridge.

IMG – 3519

Sediment island.

IMG – 3520

Confluence with additional tributary branch on left bank.

Immediately at the confluence, instream sediment was extremely soft, and staff had extreme difficulty walking. Staff walked upstream from the confluence on the east tributary branch. Characteristics of the east tributary channel matched the mainstream channel characteristics (IMG_3521). Moving upstream, along the left bank, was a woody debris and yard waste dump site in a shallow intermittent wetland (IMG_3522 and IMG_3523). Bordering the pond was residential housing, set back approximately 20m from the stream edge. Staff than came to an additional channel split and walked up the northern branch (IMG_3525). Near the confluence, the stream was incised about 0.3m, but this cutting reduced moving upstream as the stream became smaller (IMG_3526). Staff soon came to the recreational trail off Vine Hill Road, about 350m east on the trail from the mainstream intersection (IMG_3528). North of the trail was a large wetland that had a water control structure regulating water flow into the tributary channel (IMG_3530).

Staff then went back to the east channel split and walked up the east tributary (IMG_3531). Again, this tributary shared many of the same characteristics before ending at a wetland (IMG_3532). Residential housing was set back 15m from the left bank with multiple yard waste dump sites near the stream. Near the wetland the sediment was muck and very soft. Staff then returned to the main channel before it ended about 100m upstream of the De Ann Circle.

IMG – 3521

Upstream view of RB, tributary.

IMG – 3522

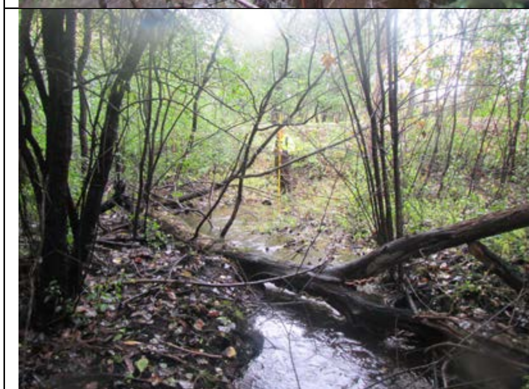
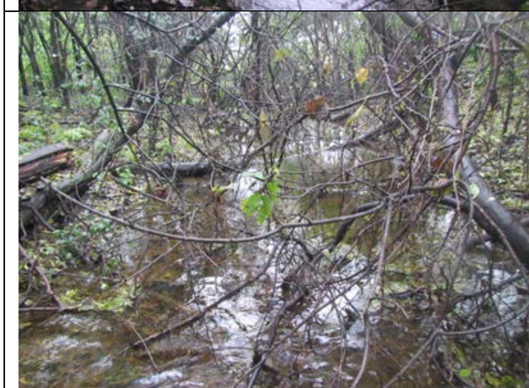
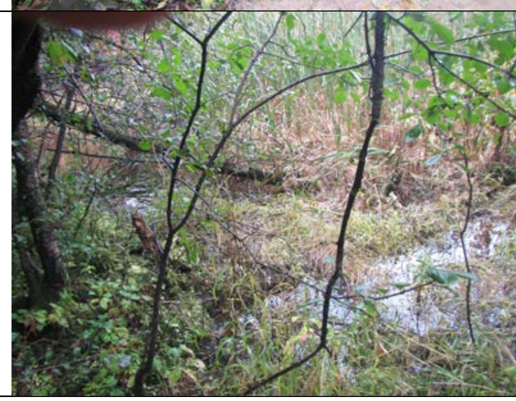
Tree and yard dumpsite along RB.

IMG – 3523

Tree and yard dumpsite in shallow intermittent wetland along RB.

IMG – 3524

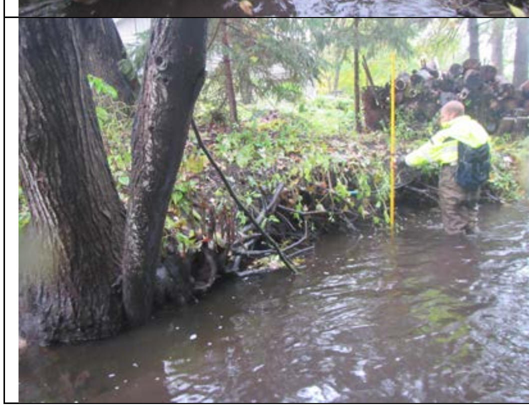
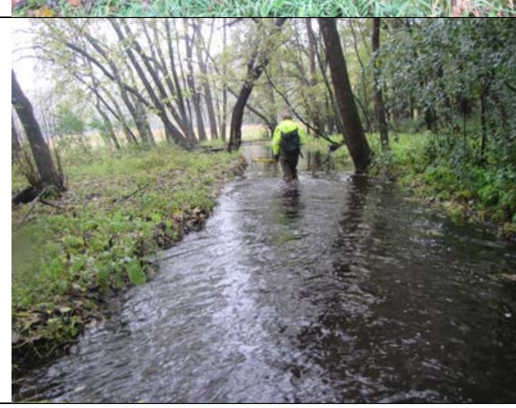
General stream photo; US.

	**IMG – 3525** Stream split; US.		**IMG – 3526** US view up north channel.
	**IMG – 3528** North channel start at recreational trail; US.		**IMG – 3530** Water control structure draining wetland to north channel.
	**IMG – 3531** East channel view upstream from confluence.		**IMG – 3532** East channel start from wetland.
	**IMG – 3533** Back to mainstream channel below confluence; general photo.		

Subreach PT-5B –100m Upstream of the De Ann Circle Road to Vine Hill Road

Rosgen: E5; **MSHA:** 43.3 (Fair); **Pfankuch:** 73 (Moderately Stable)

Staff began subreach PT-5B 100m upstream of Dell Ann Circle. The sediment was primarily comprised of sand. The left bank had erosion measuring 1m in height for approximately 30m (IMG_3534). The riparian zone was reduced in this transect, measuring between 1-5m, with residential housing along both banks (IMG_3535 and IMG_3536). The vegetation was completely cleared along the right bank. Continuing downstream staff came to a constructed boulder riffle (IMG_3536) before reaching the metal culvert under Del Ann Circle (IMG_3537). Behind the culvert on the right side was a smaller bank failure with erosion occurring (IMG_3538). After Del Ann circle was a large and deep pool that had a rock riffle controlling the water level (IMG_3539). Residents had placed a wooden bridge over the stream which can also be seen in IMG_3539. Both banks had lawns mowed to the stream edge, causing cutting. Bank cutting increased up to 1m on stream bends as seen on the left bank in IMG_3540. Sediment near the culvert was predominantly gravel before shifting back to sand/silt with clay, as it returned to a glide (IMG_3541) before entering the wetland (IMG_3542).

	**IMG – 3534** LB 1m erosion.		**IMG – 3535** General stream photo; residential housing close.
	**IMG – 3536** Boulder riffle.		**IMG – 3537** Metal culvert under Del Ann Circle.
	**IMG – 3538** Erosion behind metal culvert under Del Ann Circle.		**IMG – 3539** DS of Del Ann Circle; resident bridge; mowed yards to stream edge.
	**IMG – 3540** LB erosion 0.9m tall.		**IMG – 3541** General stream photo.

The channel split when it reached the wetland, however, most of the flow was leaving to the left (IMG_3543). The flow in the right channel was very slow and it appeared to disperse into the wetland. Following the left channel, sinuosity increased, and overhanging wetland grasses and sedges were dense. Continuing downstream, residential housing was present on the left bank. Staff observed a deck-like, wooden platform near the stream edge (IMG_3544). Further downstream, the upper right bank had a plastic erosion tarp covering it (IMG_3545). Staff then discovered another channel, located north of the left channel, which was draining the wetland (IMG_3547). Eventually, the two channels merged (IMG_3548) before flowing to Vine Hill Road (IMG_3549 and IMG_3550). At Vine Hill Road, the culvert was very clogged which staff partially cleared (IMG_3551 and IMG_3552).

IMG – 3542

Stream enters wetland; main flow to the left.

IMG – 3543

View of left channel from confluence.

IMG – 3544

Wooden platform and mowed grass to stream edge on LB

IMG – 3545

Plastic erosion control tarp covering high LB.

IMG – 3546

Genral stream photo.

IMG – 3547

Upstream view of channel forming out of wetland.

	**IMG – 3548** Wetland channel and left channel confluence.		**IMG – 3549** View downstream after wetland channel and left channel confluence.
	**IMG – 3550** General stream photo.		**IMG – 3551** Clogged metal culvert under Vine Hill Road.
	**IMG – 3552** Clogged metal culvert under Vine Hill Road.		

Exhibit F

2018 Lake and Creek Fact Sheets