CLFLWD

WATERSHED DISTRICT

D.I.Y & C.A.T Diagnostic Monitoring Report

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2023

Table of Contents

List of Figures:

List of Tables:

1. Introduction

The Comfort Lake–Forest Lake Watershed District (CLFLWD) has a robust annual monitoring program with the purpose of evaluating the water quality condition of its water resources. The program includes lake and stream water quality monitoring, watershed-wide diagnostic monitoring, and post-construction project effectiveness monitoring. This data is used to establish baseline water quality trends, to identify waterbodies thar are impaired and in need of restoration, and to evaluate the success of completed projects.

The District uses an intensive and systematic diagnostic monitoring approach to identify sources of pollutants – whether that be an agricultural area, tributary, wetland sink releasing nutrients, or other source. This approach is effective but can be an expensive and lengthy endeavor. The average annual monitoring budget for the District is in excess of $180,000, a substantial proportion of the District's total annual operational budget. In its never-ending quest for improvement and efficiency, CLFLWD is exploring new technologies and strategies to streamline and improve the diagnostic monitoring process, save taxpayer dollars, and reach similar conclusions to full-scale traditional diagnostic monitoring.

In 2023, the District continued its implementation and evaluation of two monitoring strategies developed in 2020 to supplement and inform its current diagnostic monitoring program:

- The staff-led Do-it-Yourself (DIY) diagnostic monitoring program, and
- The volunteer-led Citizen Scientist Assisted Tributary (CAT) monitoring program.

2. Methods

2.1 Monitoring Equipment

A head-to-head comparison of several inexpensive diagnostic colorimeters in 2020 concluded that the HACH colorimeter (Figure 1) was the preferred option for the CLFLWD CAT and DIY efforts. The comparison found that this technology was user friendly, cost effective, and delivered consistent results. As such, the HACH colorimeter has been used for the 2020 -2023 DIY and CAT water quality analysis.

Figure 1. The Hach colorimeter, chemical reagent, and other equipment used by the CLFLWD for the CAT and DIY monitoring programs.

2.2 Monitoring Approach

The same monitoring approaches developed in 2020 were again used in 2021 -2023: the staff lead "Do-it-Yourself" (DIY) diagnostic monitoring approach and the volunteer conducted "Citizen Assisted Tributary Monitoring" (CAT) approach. The monitoring procedure for both efforts was essentially the same (described below in section 2.3) with the only distinction being whether District staff or volunteers collected the water samples. The DIY diagnostic program was conducted fully with District staff, whereas the CAT program used volunteers to collect, preserve / store, and sometimes analyze the water samples.

Both approaches have advantages and disadvantages. The DIY program offers more control over the monitoring effort, though it is also constrained by staff workload, the work week, and business hours. The CAT program was set up to allow local volunteers to collect water samples in their neighborhood in their off time, allowing more flexibility to conceivably collect water samples during the peak of a precipitation event, during non-office hours, and/or on the weekend. The use of volunteers could allow the collection of a great deal of data at a rather low expense to the district. However, the tradeoff for this flexibility and cost savings is the data collection effort is less controlled and certain storm events could be missed when volunteers are out of town or otherwise predisposed.

2.3 Data Collection

Water grab samples were taken at both baseflow and during highwater conditions, with the primary goal of sampling during or shortly after storm events. Staff and volunteers tried to collect water samples at each monitoring location after a rain event predicted to be around 0.75 inches or greater- as indicated on several websites (weather.com, Noaa.gov, CoCoRaHS.org). Staff or volunteers collected a 100 ml water grab sample at each monitoring location, labeled the sample, and then recorded the date, time, and any additional notes on a provided datasheet. No flow measurements were taken, but flow observations were noted (dry channel, trickle, swift flow) on the data sheet. Samples were kept on ice or filtered and frozen for future analysis. DIY diagnostic samples were analyzed within 2 hours of collection back at CLFLWD offices, and CAT samples were delivered in batches to the CLFLWD office for analysis by staff. All water samples were analyzed with the Hach colorimeter and PhosVer 3 reagent for orthophosphate. All data was entered into an Excel workbook and saved on the CLFLWD network.

2.4 Monitoring Sites

The 2023 DIY diagnostic and CAT monitoring efforts monitored three subwatersheds from May through September. The DIY diagnostic program focused on the direct drainages to Comfort Lake as well as the Sunrise River County Line subwatershed. The CAT monitoring program again studied the many direct drainages to Forest Lake and was expanded in 2023 to include all basins of Forest Lake, whereas in previous years, only the second and third basins were monitored.

Fifty-six potential sites within these three subwatersheds were identified through a desktop effort (GIS). Of those, 42 sites were field verified to be appropriate for the 2023 monitoring effort and were visited during five or more monitoring events throughout the spring, summer, and fall. Of the 42 viable monitoring locations, only 29 "primary" sites allowed for continued monitoring throughout the 2023

field season (three or more water quality samples collected). Drought conditions during the monitoring period dramatically limited the number of monitoring events and as such, the number total water quality samples collected. During a more normally distributed precipitation year, it may be possible to sample more of the 56 locations initially identified by GIS or monitor more of the 42 viable sites on a more consistent basis.

3. Results and Discussion

A total of 103 water grab samples were collected and analyzed in 2023: 34 samples through the DIY diagnostic program, and 69 samples through the CAT program. Despite the drought conditions, this is a considerable increase from the total number of samples collected in 2022 (72 samples). The increase is primarily due to the expansion of the CAT program into all basins of Forest Lake (14 new monitoring sites) and the onboarding of additional CAT volunteers. Thanks go out to both Jess Hall (Green Corps Member) and Victoria D'Amico (CLFLWD Water Resource Technician) for the growth seen with this program in 2023. They did an excellent job organizing and streamlining the program, as well as recruiting and training new volunteers.

While the CAT program saw an increase in the number of water quality samples collected, the DIY program had a decrease in the number of water quality samples collected as compared to previous years. This can be attributed to the below average precipitation totals or drought conditions for much of the 2023 monitoring season (May – October, Figure 2). Although the total amount of precipitation in 2023 is considered "normal," much of the precipitation occurred during sporadic events clustered in the early spring and fall. Except for a few larger precipitation events in August, much of the summer would be considered relatively dry. The larger events that did occur during the monitoring season failed to activate the drainage networks (creeks, ditches, etc.) as the depleted wetlands and lakes absorbed or retained much of this precipitation. As such, staff collected samples where they could during 0.75-inch rain events and also targeted lesser rain events to help supplement the dataset. As such, the results of the 2023 monitoring effort should be considered with a grain of salt as they may not be fully representative of nutrient loads seen during a monitoring season with more normally distributed precipitation events.

The results from these monitoring efforts, as well as interpretation and discussion of the results are presented below by subwatershed.

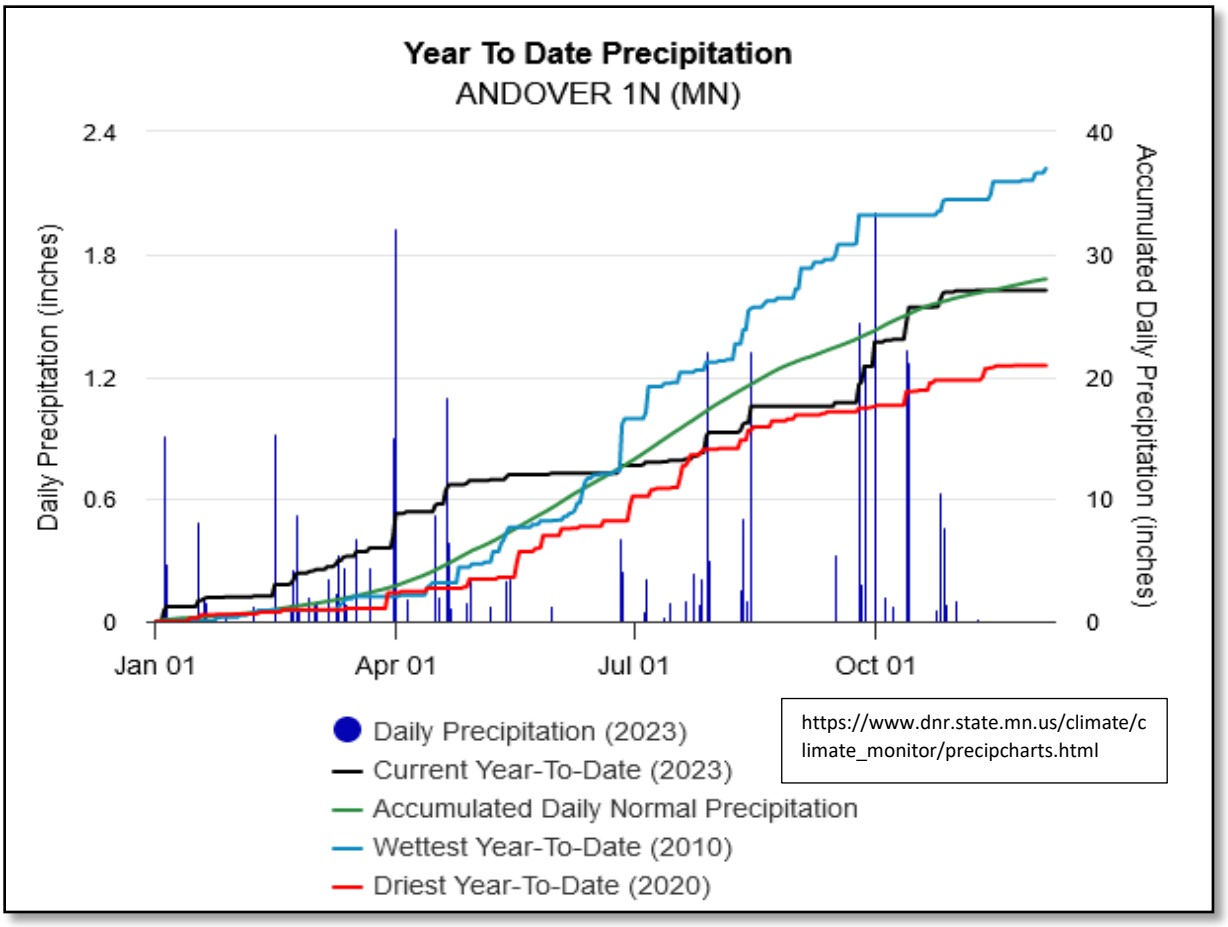

Figure 2. 2023 precipitation summary for the closest MNDNR monitoring station to the CLFLWD. Total precipitation for 2023 is considered "normal," however much of the precipitation occurred during winter and early spring.

3.1 DIY Monitoring – Comfort Lake Direct drainages and County Line Subwatershed

The 2023 DIY effort focused on the direct drainages to Comfort Lake while also continuing efforts to identify loading in the County Line subwatershed studied in 2022 (a subwatershed of the Sunrise River monitored in 2021 & 2022). Eleven locations were included in the Comfort Lake monitored effort, but due to drought conditions in mid and late summer, only five of the sampling locations were able to be monitored on multiple occasions (Figure 3, Table 1.). Water quality samples were collected from another four monitoring locations sporadically – primarily in the spring. Five sampling events took place during the 2023 diagnostic effort with a total of only 16 samples collected and analyzed – with most of the samples coming from the five locations mentioned above. It is possible that during a more evenly distributed average precipitation year that more of the eleven sites could be continuously monitored throughout the field season.

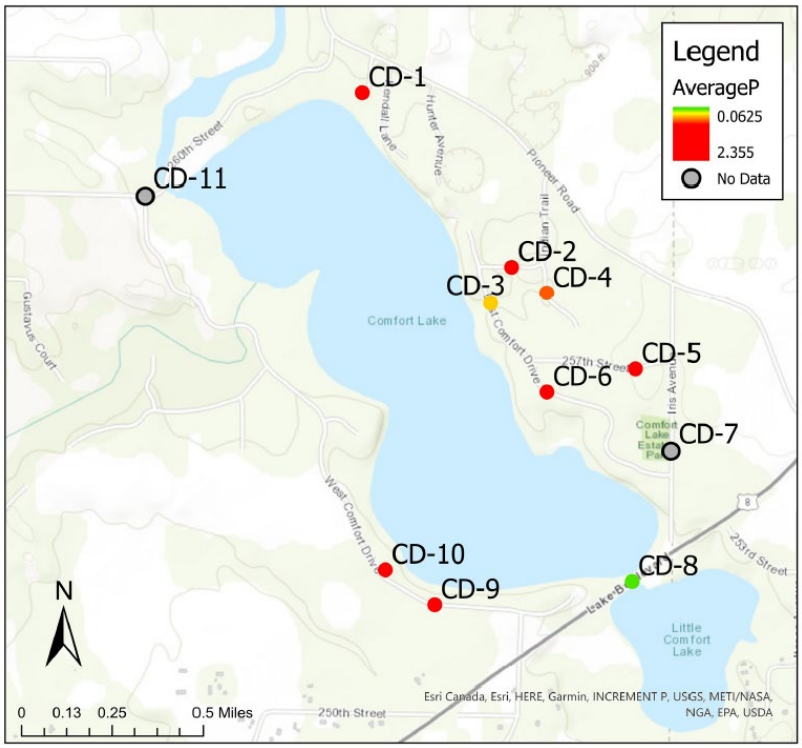

Figure 3. Map of the Comfort Lake Direct Drainage DIY Diagnostic monitoring effort for 2023. The dots represent the monitoring locations and their color indicate the average orthophosphate concentrations detected.

The County Line sub-shed (Figure 4) was identified in 2021 as a potential nutrient source for the Sunrise River. To pinpoint the source of the nutrient in this sub-shed, additional sites were added along this drainage network and samples were collected in both 2022 and 2023. Seven sites were monitored in 2023 with a total of 18 samples collected over five precipitation events. Several of the sites could not be sampled regularly due to drought conditions and as such, the source of the excess nutrient was unable to be pinpointed. Additional monitoring in future years is thus warranted.

Wetland soil samples were also collected in the County Line sub-shed in 2023 to further evaluate the wetlands, themselves, as a potential source of nutrient. Seven soil samples were collected from the wetlands adjacent to Highway 8 with assistance from the District Engineering Firm, EOR (Figure 5). Soil samples were labeled, sorted, and sent to the University of Minnesota soil lab for analysis. The results of this monitoring effort can be found below.

Table 1. Description of the 2023 Comfort Lake Direct Drainage and County Line Subwatershed sampling sites.

Sites	Comfort Lake Direct Drainage
CD 1	Hiawatha Ct drainage are / culvert
CD 2	Wetland @ Indian trail
CD 3	Main channel @ East Comfort Drive
CD 4	Ditch at Indian Ave
CD 5	Ditch on 257th
CD 6	Private stormwater pond outflow @ 25614 E. Comfort
CD 7	Park Pond outflow
CD 8	Little Comfort Lake outflow
CD 9	Manhole @ 25253 W Comfort
CD 10	Wetland manhole @ W. Comfort
CD 11	Ditch along 260th St
	County Line Subwatershed
CL-A	@ Greenway /Hwy 8 crossing
CL-B	Roadway ditch at same location as A
CL-C	East side of HWY 8 at outflow of wetland complex
CL-D	Channel to north of Greenway Ln
CL-E	Ditch to south of Greenway Ln
CL-F	Culver crossing at Greenway Ave N. downstream of "E"
CL-G	Culver crossing off Granada Ave N. near 23919 Granada Ave N – drainage easement here

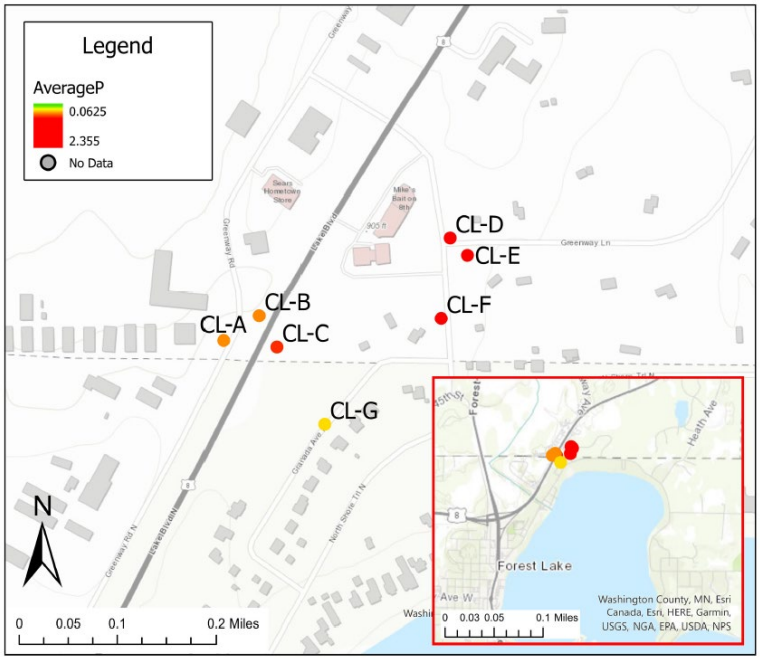

Figure 4. Map of the County line sub-shed DIY Diagnostic monitoring effort for 2023. The dots represent the monitoring locations and their color indicate the average orthophosphate concentrations detected.

Figure 5. Overview Map of the County Line Wetland Soil Monitoring. The yellow Polygon indicates the study area and the stars indicate where the wetland soil cores were collected. The darker red the star appears, the higher the phosphorus concentration. The red arrows indicate inlet flow paths and the blue arrow indicates outflow.

Due to dry conditions throughout much of the monitoring season, only five DIY monitoring events were conducted. Despite targeting larger precipitation events (over 0.75 inches in total precipitation), staff found that these rainfall events did not activate many of the direct drainages to Comfort Lake or all the branches of the County Line subwatershed. Most of the Comfort Lake drainages originate from wetland complexes (especially on the east side of the lake). These wetlands have a tremendous capacity to collect and store rainfall and stormwater when already drawn down, such as during drought conditions. As such, little runoff was transported downstream to Comfort Lake along these direct drainage networks, and likewise, few samples were able to be collected in 2023. Similarly, the County Line subwatershed is relatively small in area and therefore is considered hydrologically flashy. This makes it difficult to collect samples from this subwatershed as water does not flow for long periods after a rain event, and much of the precipitation may be infiltrated withing the drainage network if already depleted of moisture.

Due to the sparse dataset, it is difficult to draw many conclusions from the 2023 Comfort Lake direct drainage diagnostic monitoring effort (Table 2, Figure 6). Some elevated orthophosphate levels were noted, mostly associated with the storm sewer/manhole collection areas on the west side of the lake. This seems logical as these are designed stormwater collection areas with little to no natural vegetation to filter nutrients. The elevated readings at these locations may be influenced by sediments already present within the stormwater feature. Several other sites did have elevated orthophosphate readings,

however there is not enough data (in some cases only one reading) to determine if these elevated levels are a chronic issue or just a one-off higher reading due to spring runoff or a temporary natural phenomenon. Staff recommend repeating the Comfort Lake Direct Drainage DIY diagnostic in 2024 to further evaluate these areas as potential sources of nutrient into Comfort Lake.

Table 2. Results from 2022 Comfort Lake direct drainage DIY diagnostic monitoring effort in numerical format. All results are in mg/l of orthophosphate. Cells with dots indicate no sample was collected during that monitoring event.

Date	CD 1	CD 2	CD 3	CD 4	CD 5	CD 6	CD 7	CD 8	CD 9	CD 10	CD 11
4/12	1.78	0.35	0.43	0.65	0.45	1.15	.	0.12	1.68	1.15	.
5/19	.	.	.	.	.	.	.	0.05	.	.	.
8/14	.	.	.	.	.	.	.	.	.	.	.
9/26	.	1.89	.	.	.	.	.	0.02	.	.	.
10/1	.	.	.	.	2.09	0.47	.	0.06	.	3.3	.

Similarly, the dataset for the County Line subwatershed was also insufficient to draw any sound conclusions in 2023 (Table 3, Figure 7). The highest orthophosphate levels found were associated with the ditches along Greenway Lane and Greenway Ave N, though only two readings were taken from these ditches. Both ditches are within proximity of each other and follow a busy roadway connecting Hwy 8 and North Shore Trail. It is possible that these roadways are a source of nutrient due to heavy traffic, or that the ditches themselves are now a source of nutrient as they have collected decades of nutrient input from the roadway. Perhaps both statements are accurate. Additional study is recommended to further understand the County Line subwatershed and how the roadway and ditches affect nutrient loading.

Table 3. Results from 2023 County Line subwatershed diagnostic monitoring effort in numerical format. All results are in mg/l of orthophosphate. Cells with dots indicate no sample was collected during that monitoring event.

Date	CL-A	CL-B	CL-C	CL-D	CL-E	CL-F	CL-G
4/12	0.79	.	0.9	1.3	1.79	.	.
5/19	0.13	.	.	.	.	1.41	.
8/14	0.61	0.46	0.79	.	.	.	.
9/26	0.43	.	0.47	.	.	.	0.38
10/1	0.78	0.65	0.75	.	2.34	3.3	0.43

Wetland soil samples were collected in the County Line sub-shed in 2023 to further evaluate the wetlands as a potential source of nutrient. Seven soil samples were collected from the wetland complex adjacent to Highway 8 (Figure 5). The soil samples were sent to the University of Minnesota soil lab for analysis. The results indicated the areas closest to the highway had elevated levels of Bray phosphorus (Table 4). This information was shared with Chisago County to help inform the coming Highway 8 expansion. The County expressed willingness to include the removal of these sediments (if within the

highway right-of-way or highway expansion envelope) during the reconstruction/expansion of the highway. When/if implemented, this would help to reduce the nutrient loads being exported from these wetland complexes.

Table 4. Results from the County Line Wetland Soil Core study. Results in pink/red indicate elevated Bray Phosphorus levels.

Lab Sample Number	Sample ID (location and depth of soil)	Bray P (mg/kg soil)
1	CLW-B 0-24	14 / 13
2	CLW-B 24-28	15
3	CLW-B 28-48	7
4	CLW-A 0-24	17
5	CLW-A 24-44	12
6	CLW-C 0-26	22
7	CLW-C 26-30	1
8	CLW-C 30-40	1
9	CLW-D 0-24	9
10	CLW-D 24-30	7
11	CLW-D 30-48	6
12	CLW-E 0-48	8
13	CLW-F 0-24	10
14	CLW-F 24-42	6
15	CLW-G 0-18	12
16	CLW-G 18-22	13
17	CLW-G 22-36	1

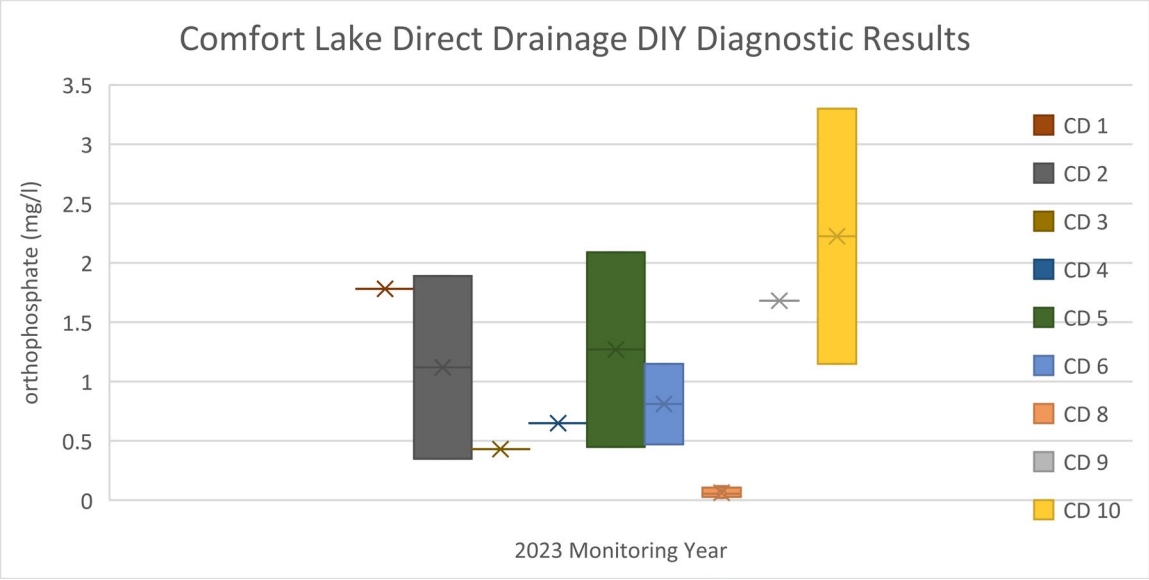

Figure 6. Results from 2023 Comfort Lake direct drainage DIY diagnostic monitoring effort represented as box and whisker plots. The box represents the interquartile range (25% on each side of the median), the line in the box is the median, the X is the mean, and the whiskers represent the lower and upper extremes or maximum values. Any circles/dots beyond the whisker ends indicate data outliers. All results are in mg/l of orthophosphate.

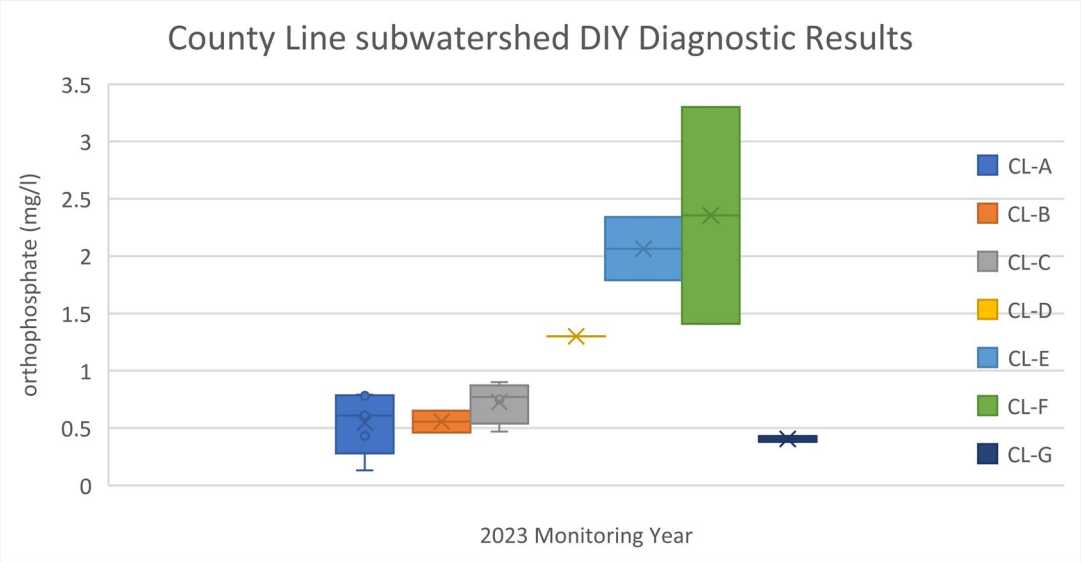

Figure 7. Results from 2023 County Line subwatershed DIY diagnostic monitoring effort represented as box and whisker plots. The box represents the interquartile range (25% on each side of the median), the line in the box is the median, the X is the mean, and the whiskers represent the lower and upper extremes or maximum values. Any circles/dots beyond the whisker ends indicate data outliers. All results are in mg/l of orthophosphate.

3.2 Forest Lake Subwatershed Citizen Assisted Tributary Monitoring

With the efforts of Jess Hall and Victoria D'Amico, the 2023 Forest Lake subwatershed Citizen Assisted Tributary (CAT) monitoring program expanded to all three basins of Forest Lake. Their hard work increased the CAT volunteer team to 12 members which allowed the team to monitor an additional 14 sites as compared to 2022.

In 2023, water samples were collected at 17 direct drainage sites throughout the Forest Lake subwatershed by CAT volunteers (Figure 8, Table 5). Another eight sites were monitored at the beginning of the season (spring runoff) by CLFLWD staff but were determined to be unsuitable monitoring locations for CAT volunteers due to their flashy nature and/or other logistical reasons. Over the sampling season, a total of 69 samples were collected and processed from seven primary rainfall events and an additional eight minor events. Despite the impact of summer drought conditions, this is a significant increase in data collected (as compared to 2021 / 2022) and is mosty due to the expansion of the program into all basins of Forest Lake and increase in volunteer participation.

Of the 17 primary sites, 71% had an average phosphorus concentration above the MNPCA's recommended concentration for urban residential areas (0.325 mg/L, MPCA 2023), as seen in Figure 8. It is important to note that infrequent precipitation events can contribute to these elevated numbers. During dry periods impervious surfaces, such as sidewalks, and streets can build up with phosphorus laden sediment. When it does rain, the sediments are washed towards storm drains and into lakes. Longer dry periods allow more build up and can contribute to runoff having higher concentrations of phosphorus.

However, this does not necessarily equate to higher phosphorus loading, just a shift in the timing of the loading.

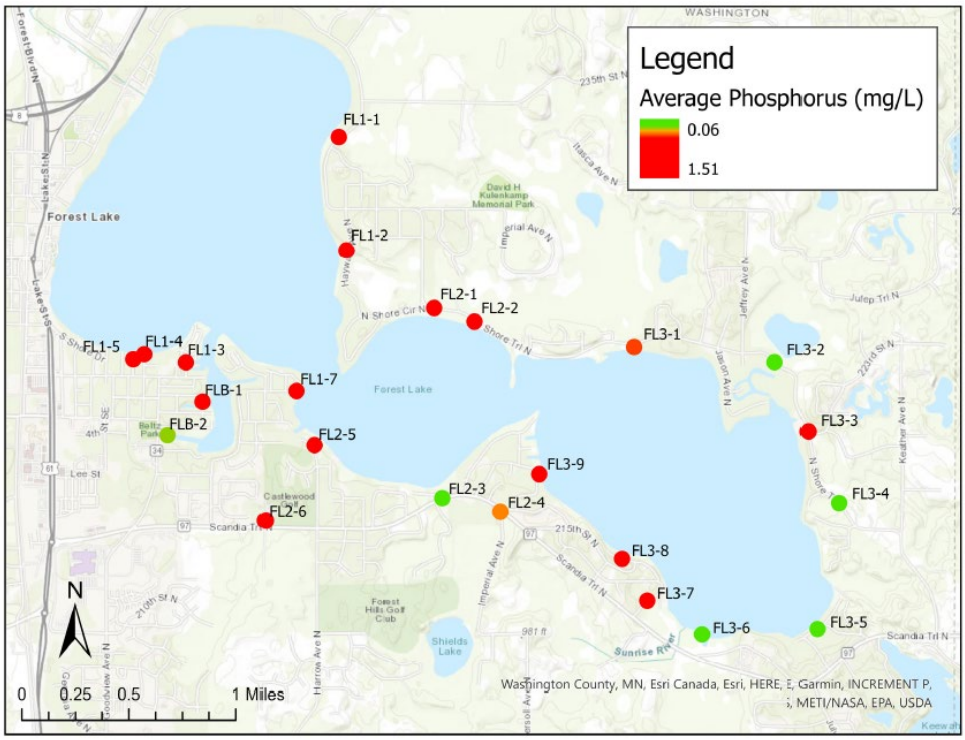

Figure 8. Map showing all monitoring locations around Forest Lake. The dots represent the monitoring locations and their color indicate the average orthophosphate concentrations detected. Orange represents the MNPCA's recommended level of phosphorus concentration in residential runoff of 0.325 mg/L. Green sites had average levels lower than recommended while red sites had average levels higher than recommended.

Three of the primary sites had average orthophosphate levels above 1.00 mg/l (Table 6, Figure 9). Two of these sites were along high traffic residential roadways and the third site was a culvert draining Parsons Wetland along Hayward Ave North. Four or fewer grab samples taken from each of these sites so there is limited data to evaluate the loading from these locations. As such, additional monitoring is warranted, and close attention should be paid to these three locations.

It is also important to note that 13 of the total 25 monitoring sites (17 volunteer sites plus the 8 spring staff sites) had two or fewer samples collected throughout the monitoring season (Table 6). Due to the lack of significant precipitation in mid and late summer, the Forest Lake drainage network remained very dry and much of the precipitation or stormwater was infiltrated or stored in local wetlands instead of being conveyed downstream to the lake. As such, many of the monitoring locations remained dry or were very flashy during even the largest rain events and few samples were able to be collected. It is possible that during an average precipitation year more of the 25 sites could be continuously monitored. It is therefore difficult, and perhaps misleading, to evaluate potential nutrient sources based on the sparse dataset collected in 2023. Staff recommend that this year's CAT effort is continued in future years to fully evaluate loading in the Forest Lake watershed.

The incidence of overall elevated phosphorus readings found this year speaks to the importance of the District's enhanced street sweeping program - a partnership with the City of Forest Lake. Frequent street sweeping ensures that more sediment is removed from pavement before it can become a phosphorus source for Forest Lake. Enhanced street sweeping in highly developed urban areas has proven to be one of the most cost-effective water quality improvement programs in the district and consideration should be given to supporting the expansion of this program around Forest Lake and throughout the watershed where appropriate.

Table 5. Description of the monitoring sites around Forest Lake for the 2023 CAT program.

Monitoring Location	Description
FL1-1	Culvert on North Shore Trail near 233rd St N
FL1-2	Culvert on Hayward Ave N – drains Parsons wetland
FL1-3	Culvert at 704 Woodland Dr SE
FL1-4	Drain/culvert dead end of 7th St SE
FL1-5	Drain/culvert dead end of 6th St SE
FL1-7	Culvert at corner of 9th Ave Se and 19th St SE
FL2-1	Ditch on North Shore Trail near junction with North Shore Circle
FL2-2	Ditched channel near the "Art" house on North Shore Circle
FL2-3	Culvert at 21710 ideal Ave
FL2-4	Shields Lake channel at the Fish barrier on Hwy 97
FL2-5	Culvert at 21833 Healy Ave N
FL2-6	Channel at Hwy 97 at Castlewood Golf Course
FL3-1	Culvert near 8793 N. Shore Trail - east of the Willow Pt. boat launch
FL3-2	Cranberry Lake channel
FL3-3	Culvert located on the corner of N Shore Trail and 219th St. N
FL3-4	Culvert under N. Shore Trial – inflow into 3rd Lake Pond
FL3-5	Channel near Karoline Ct / private docks
FL3-6	WDJ6 channel @ Hwy 97 near Timm's Marina
FL3-7	Small culvert near 21150 Iverson Ave N near Hwy 97
FL3-8	Second culvert at 21421 Iverson Ave N – closest to lake
FL3-9	Ditch/creek at dead end of Imperial Ave N
FLB-2	South Bay channel near Beltz Park
FLB-1	10th St SE channel

Table 6. Results from 2023 Forest Lake CAT monitoring effort in numerical format. All results are in mg/l of orthophosphate. Cells with dots indicate no sample was collected. Sites with only one data point were eliminated from this table to aid in the display of the data.

Date	*FL1-1*	*FL1-2*	*FL1-3*	*FL1-4*	*FL1-5*	*FL1-7*	*FL2-1*	*FL2-2*	*FL*
4/11/2023	*0.44*	*0.78*	*1.75*	*0.5*	*0.53*	*0.99*	*0.71*	*0.67*	*0.1*
4/19/2023	*0.41*	*1.15*					*0.6*	*0.5*	
5/6/2023							*1.05*	*0.34*	*0.2*
5/7/2023					*0.21*				
5/13/2023		*1.27*							
6/25/2023	*1.34*								
7/19/2023				*0.95*	*0.33*				
7/26/2023					*0*				
7/27/2023									
8/11/2023									
9/12/2023				*1.33*	*1.58*				
9/24/2023				*0.18*	*0.22*				
9/29/2023			*0.89*	*0.38*	*0.34*				
10/13/2023			*1.24*	*0.26*	*0.44*				
10/25/2023									

Date	FL1-1	FL1-2	FL1-3	FL1-4	FL1-5	FL2-1	FL2-2	FL2-3	FL2-4	FL3-1	FL3-2	FL3-3	FL3-4	FL3-6	FLB-1	FLB-2
11-Apr	0.44	0.78	1.75	0.5	0.53	0.71	0.67	0.16	0.49	0.08	0.1	0.73	0.24	0.26	.	.
19-Apr	0.41	1.15	.	.	.	0.6	0.5	.	.	0.19	0.03	.	0.16	.	.	.
6-May	.	.	.	.	.	1.05	0.34	0.21	0.18	.	.	.	.	.	.	.
7-May	.	.	.	.	0.21	.	.	.	.	.	.	1.7	0.18	0.06	.	.
13-May	.	1.27	.	.	.	.	.	.	.	.	.	.	.	.	.	.
25-Jun	1.34	.	.	.	.	.	.	.	.	.	.	.	.	0	.	.
19-Jul	.	.	.	0.95	0.33	.	.	.	.	.	.	.	.	.	.	0.22
26-Jul	.	.	.	.	0	.	.	.	.	.	.	.	.	0.05	.	.
27-Jul	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11-Aug	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.27
12-Sep	.	.	.	1.33	1.58	.	.	.	.	.	.	.	.	.	3.3	.
24-Sep	.	.	.	0.18	0.22	.	.	.	.	.	.	.	.	0.24	0.26	.
29-Sep	.	.	0.89	0.38	0.34	.	.	.	.	0.9	0.09	.	.	.	1.86	.
13-Oct	.	.	1.24	0.26	0.44	.	.	.	.	0.78	0.05	.	.	.	0.61	.
25-Oct	.	.	.	.	.	.	.	.	.	0.45	0.05	.	.	.	.	.

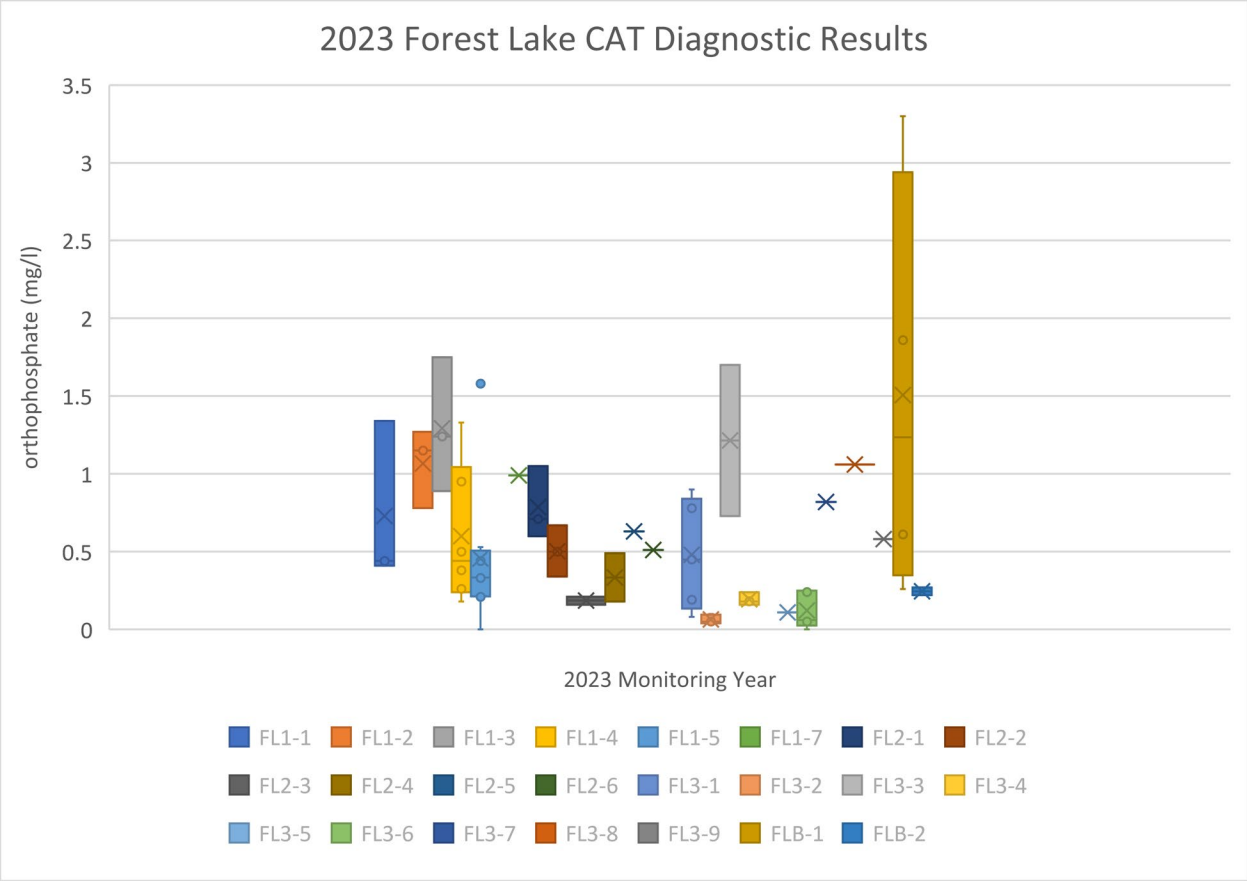

Figure 9. Results from 2023 Forest Lake CAT monitoring effort represented as box and whisker plots. The box represents the interquartile range (25% on each side of the median), the line in the box is the median, the X is the mean, and the whiskers represent the lower and upper extremes or maximum values. Any circles/dots beyond the whisker ends indicate data outliers.

3.3 Duplicate Water Quality Sample Comparison

Dring the 2023 monitoring season, CLFLWD staff attempted to repeat the duplicate water quality sample comparison study that had been conducted in previous years. The goal of this study is to evaluate the accuracy and consistency of the DIY colorimeter technology by comparing results from the DIY colorimeter to those of a commercial laboratory. The District's engineering firm, Emmons and Olivier Resources, Inc (EOR) again provided duplicate water samples for use in this study; this year from the District's stream monitoring program. The stream samples were sent to Met Council's water laboratory for analysis. In previous years, duplicate water quality grab samples were collected in conjunction with the District's diagnostic monitoring program and samples were analyzed by Instrumental Labs in Fridley, MN.

As part of the standard suite of analytes for the stream monitoring program, water samples were analyzed by Met Council's Labs for only one form of phosphorus - total phosphorus. The DIY colorimeter is only capable of detecting orthophosphate. As such, these two datasets could not be compared as part of the duplicate study. This was an unfortunate oversight and staff will pick up the comparison study in 2024 using lake bottom water grab samples that are analyzed exclusively for orthophosphate.

Despite this setback, significant strides were made to improve the performance of the DIY technology in 2023. Staff implemented several new approaches to the water sample analysis protocol, including:

- Use of a micropipette to ensure the exact amount of water sample was being analyzed. In the past staff used the graduated vials included with the Hach colorimeter. The graduated vials proved to be not as accurate as needed for the analysis and thus skewed the water to reagent ratio.
- Water samples were brought up to room temperature before analysis to ensure that all the reagent could be dissolved in the water sample. In the past water samples were refrigerated or kept on ice prior to analysis.
- Staff performed regular testing of the DIY colorimeter with an orthophosphate standard solution.

Staff are confident that these changes to the water quality testing protocol will help to improve accuracy of the DIY colorimeter as compared to commercial laboratory equipment. The results from future comparison studies should verify these assumptions.

4. Conclusion

Similar to 2021 and 2022, the 2023 monitoring season proved to be somewhat challenging due to region-wide summer drought conditions. Minnesota DNR precipitation data indicates that 2023 was an average precipitation year, however, the majority of that precipitation came in late-winter and early spring, prior to the 2023 monitoring season. A long period of below average precipitation began in June of 2023 and continued through the fall. This resulted in a limited number of sampling events which equated to less data collected than anticipated. To compensate, staff sampled precipitation events with less than the recommended 0.75 inches of rainfall. This allowed additional sampling opportunities but lead to many data gaps as these smaller precipitation events did not fully activate the entire drainage network. This was especially prevalent with the CAT and DIY programs that focused on small, flashy direct drainages to Forest Lake and Comfort Lake. Many of the new CAT volunteers found that the sites they had been assigned seldom flowed water and thus could not be frequently sampled. Consequently, the DIY and CAT data sets for 2023 are incomplete and the results from these efforts are not as conclusive as anticipated. As Such, few nutrient loading conclusions can be inferred from these data sets.

4.1 Plans for the 2024 Monitoring Year

Based on recent drought related challenges, the CLFLWD plans to repeat the Forest Lake CAT monitoring effort in 2024. Staff are hopeful that many of the volunteers from 2023 will again be interested in participating in the program.

The 2024 DIY effort will again focus on the Comfort Lake direct drainage while continuing to investigate the County Line sub-watershed. Staff are optimistic that another year of DIY monitoring will fill in existing data gaps and allow for identification of sources of phosphorus loading within these watersheds.

The Duplicate Water Quality Sample Comparison Study will be resurrected in 2024. As mentioned above, the duplicate water quality grab samples will be taken from the lake bottom water monitoring effort to ensure that the DIY and commercial laboratory datasets are comparable.

4.2 Acknowledgments

The Comfort Lake-Forest Lake Watershed District would like to thank the volunteers who assisted in the implementation of the Citizen Assisted Tributary Monitoring program. This program wouldn't be possible without the dedication of our volunteers. Thank you to Doug Joens, Jeyanthy Kernik, Sue Koenitzer, Tom Koenitzer, Tony Kuehn, Keith Kuhnly, Cindy Lehman, Brad Oosterhuis, Randy Schumacher, Kristyn Stephens, Michelle Trudeau-Spanjers, and John Spanjers.

4.3 Citations

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