2022 Water Quality Report

Prepared for the City of Plymouth

Prepared by: Three Rivers Park District

DEPARTMENT OF WATER RESOURCES

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1.0 INTRODUCTION

The City of Plymouth contracts Three Rivers Park District (TRPD) to conduct water quality monitoring at several locations in or around the City of Plymouth. This partnership began in the year 2000 and has continued ever since. The partnership continues to be mutually beneficial as it provides targeted monitoring data for City of Plymouth while producing valuable background water quality data for large watersheds that encompass TRPD resources.

This report summarizes the water quality monitoring conducted by the TRPD Water Resources Department for the City of Plymouth during the 2022 calendar year. Nine stormwater sites, a rain garden and five sub-watershed assessment sites around Mooney Lake were monitored. Monitoring results are reported in sections separated by watershed. Each section contains an overview of the watershed, monitoring locations, and site descriptions. If applicable, daily average flow hydrographs, flow weighted nutrient concentrations, and annual load estimates are provided.

In addition to 2022 monitoring results, this report summarizes the past five or more years of data collection and analyzes trends in the watersheds. Where watershed BMPs have occurred (Appendix, Figure 8.1), their potential water quality impacts are discussed.

2.0 MONITORING METHODS

Precipitation

The estimated daily precipitation was collected from two locations. During the monitoring season, the City of Plymouth's rain gage at 14800 23rd Ave N was used. Rain totals were estimated from a rain gage tipping bucket and data was used from 4/1/22 to 10/31/22. Because this location does not measure snow water weight equivalence, cold season precipitation from the rest of the year was collected from the Minneapolis airport rain gauge (USW00014922) as reported by National Oceanic and Atmospheric Administration (NOAA). This combined dataset was used to assess all sites in City of Plymouth.

For a third consecutive year, annual precipitation was below average. Since the record setting 43.3 inches observed in 2019, 2020 - 2022 annual precipitation was 25.9, 23.4, and 22.7 inches, respectively. The 2000-2020 twenty-year average precipitation for this area was 30.2 inches. Only two rain events of more than one inch occurred in 2022 monitoring season (1.13 in on 4/30/22 and 1.41 in on 8/6/22). In total, 65%, or 14.8 inches, of annual precipitation occurred during the sampling season.

Stormwater

Stormwater samples were collected under one of three sampling regimes. Grab samples were collected at the raingarden site during rain events only. The five sites within the Mooney Lake subwatershed assessment were grab sampled during rain events, as well as routine base flow grab sampling on a biweekly basis when flow was present. The remainder of the sites were grab sampled on a routine basis and had automated sampling equipment installed to collect flow weighted composite samples in response to rain events. Water quality parameters tested included total phosphorus (TP), soluble reactive phosphorus (SRP), total nitrogen (TN), total suspended sediments (TSS), and chloride (Cl^-). A list of stormwater sites along with parameters monitored is included in Table 2.1.

Sites with automated sampling equipment included ISCO 2100 series area velocity flow meters to estimate flow rates. Flow estimates were created using stage x velocity x stream cross sectional area. Sites located within culverts have a known area so flows can be estimated confidently based on stage and velocity. Manual stream discharge measurements were taken at open channel sites using FlowTracker2. These discharge measurements were used to confirm flow estimates or to help calibrate site flow equations.

Annual Load Estimation

Annual loading of nutrients and sediments were estimated using the US Army Corps of Engineers' Flux32 program (Soballe, 2020). This program builds a relationship between constituent concentrations and flow rates and then applies that relationship to the entire seasonal flow record. The result is the flow weighted average concentration and the total pounds of constituent load over the sampling period. This number is extrapolated out to the entire year using total annual precipitation.

$$\boldsymbol{annual\ lbs\ loading = sample\ lbs\ loading\ x \frac{annual\ precipitation}{sample\ \ precipitation}}$$

Lastly, the annual nutrient loads were converted to unit area loads (UAL) by dividing loading by watershed size to get lbs./acre. UALs were compared with the MPCA Stormwater Manual (MPCA, 2017) typical unit area loads for TP and TSS based on land use (Table 2.2 and Table 2.3). Chloride concentrations were assessed based on MPCA standard of no more than two exceedances of 230 mg/L over a three-year period.

Table 2.1 List of stormwater monitoring sites, types of samples taken, parameters analyzed and whether a rating curve was established. Sites were monitored from 3/29/22 to 10/31/22.

		Grabs Bi-weekly					ISCO auto sampler Storm events					Grabs Storm events					Flow Tracker
Location	**Site Name**	**TP**	**SRP**	**TN**	**TSS**	**Cl^-**	**TP**	**SRP**	**TN**	**TSS**	**Cl^-**	**TP**	**SRP**	**TN**	**TSS**	**Cl^-**	
Inlet to Bass Lake	BL3	x	x	x	x	-	x	x	x	x	-	-	-	-	-	-	-
Elm Creek at Elm Road	ECER	x	x	x	x	x	x	x	x	x	x	-	-	-	-	-	Yes
Gleason Creek	GC-1	x	x	x	x	x	x	x	x	x	x	-	-	-	-	-	Yes
Elm Creek at Hamel	Hamel	x	x	x	x	x	x	x	x	x	x	-	-	-	-	-	Yes
Inlet below IP2	IP1	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-
Plymouth Creek at Industrial Park	IP2	x	x	x	x	x	x	x	x	x	x	-	-	-	-	-	-
Plymouth Creek at Medicine Lake	PC2	x	x	x	x	x	x	x	x	x	x	-	-	-	-	-	Yes
Elm Creek at Peony Ln	PEONY	x	x	x	x	x	x	x	x	x	x	-	-	-	-	-	-
South Inlet to Parker Lake	PL1	-	-	-	-	-	x	x	x	x	x	-	-	-	-	-	-
North inlet to Parker Lake	PL2	x	x	x	x	x	x	x	x	x	x	-	-	-	-	-	-
Ponderosa Rain Garden	PRG	-	-	-	-	-	-	-	-	-	-	x	x	x	x	-	-
Mooney sub-watershed assessment	MOO: SW1-SW5	x	x	x	x	-	-	-	-	-	-	x	x	x	x	-	-

Lab

Water samples were analyzed at Three Rivers Park Districts' MPCA certified lab following Standard Methods for the Examination of Water and Wastewater, 22nd edition (2011). Stormwater analyses included total phosphorus (TP), soluble reactive phosphorus (SRP), total nitrogen (TN), total suspended solids (TSS), and chloride (Cl^-). A list of parameters analyzed, and the standard method used, is contained in (Table 2.4).

Table 2.2 MPCA Stormwater manual TP unit area load values by land use and a common range of runoff concentrations by land use (MPCA, 2017).

Typical Total Phosphorus values as stated in the MN Stormwater Manual				
Land Use	**Unit Area Loads (lbs/ac)**	**Median Concentration (µg/L)**	**Minimum Concentration (µg/L)**	**Maximum Concentration (µg/L)**
Residential	1.35	260	< 10	19,900
Commercial	2.25	200	< 10	4,270
Industrial	-	230	< 20	7,900
Freeway	3.50	-	-	-
Open Space	-	130	< 10	760

Table 2.3 MPCA Stormwater manual TSS unit area loads by land use and common range of runoff concentrations by land use (MPCA, 2017).

Typical Total Suspended Solids values as stated in the MN Stormwater Manual				
Land Use	**Unit Area Loads (lbs/ac)**	**Median Concentration (mg/L)**	**Minimum Concentration (mg/L)**	**Maximum Concentration (mg/L)**
Residential	76	58	< 0.5	4,168
Mixed Residential	111	-	-	-
Commercial	221	52	< 0.5	2,385
Industrial	193	75	< 1	2,490
Freeway	560	-	-	-
Open Space	35	58	< 1	4,168

Table 2.4. Three Rivers certified lab analysis methods used in 2022.

Analyte	Method
Total Phosphorus (TP)	EPA 365.3
Orthophosphate as P (SRP)	EPA 365.3
Total Nitrogen (TN)	SM 4500-N-C
Residue-nonfilterable (TSS)	SM 2540 D-11
Chloride (Cl^-)	SM 4500-Cl^- B-11

MPCA Lab ID: MNL0003, EPA Lab ID: MN01044

Trend Analysis

For each site with at least five years of data, parameter annual load and flow weighted concentrations were assessed for trends using the Mann-Kendall (MK) trend test (Mann, 1945 and Kendall, 1975). The null hypothesis (H_0) is that there is no change in load or concentration over time. The alternative hypothesis (H_a) is that there is a change over time. The alpha value,

or threshold for statistical significance, is set at 0.05. Therefore, results of the MK test are only significant for p-values less than 0.05. The *tau* statistic is reported along with the p-value. *Tau* is a value ranging from -1 to +1 and is a measure of the monotony of the trend. For example, a concentration or load that increased every year would have a *tau* of +1. MK is a nonparametric test, making it applicable to data sets with normal or nonnormal distributions. It uses a rank-based method of assessing the data so that extreme values do not skew results.

3.0 RESULTS AND DISCUSSION BY WATERSHED

3.1. Parkers Lake Watershed

The Parkers Lake Watershed is 1,150 acres and is located entirely within the City of Plymouth (Figure 3.1). Parkers Lake is part of the Bassett Creek Watershed and its outflow eventually flow into Medicine Lake. Parkers Lake was listed as impaired for chloride in 2014. A TMDL was approved by EPA in 2016 as part of the Twin Cities Metro Area Chloride TMDL. Parkers Lake is currently meeting nutrient standards.

3.1.1. Stormwater Monitoring Sites

To assess the nutrients and chloride flowing into Parkers Lake, two tributaries were monitored that accounted for 38% of the total watershed area (Table 3.1). The PL1 monitoring station is located on the south side of the lake off the Luce Line State Trail. It drains approximately 258 acres into Parkers Lake. Monitoring instrumentation is installed within a 48" diameter round culvert that passes below a walking path near the lake.

PL2 conveys water under County Road 6 and outlets near the lake. It is located on the northwest side of the lake adjacent to the public boat access. This site also has a 48" diameter culvert that outlets the watershed into Parkers Lake. There are 189 acres of multi-residential and industrial land use that drain to PL2. While PL2's watershed is smaller than PL1, it has steeper topography and more impervious surfaces which creates more runoff.

Table 3.1. Summary of watershed characteristics for sites PL1 and PL2.

Site	Sub watershed Area (acres)	% Impervious (acres)[1]	% of Parkers Lake Watershed	Dominant land uses[2]
PL1	258	19% (48 ac.)	22%	Residential
PL2	189	49% (92 ac.)	16%	Multi-family Residential, Industrial

[1] % impervious area determined using the 2016 University of Minnesota TCMA 1-meter land cover classification GIS layer.
[2] Dominant Land Uses determined using GIS layer obtained from the City of Plymouth.

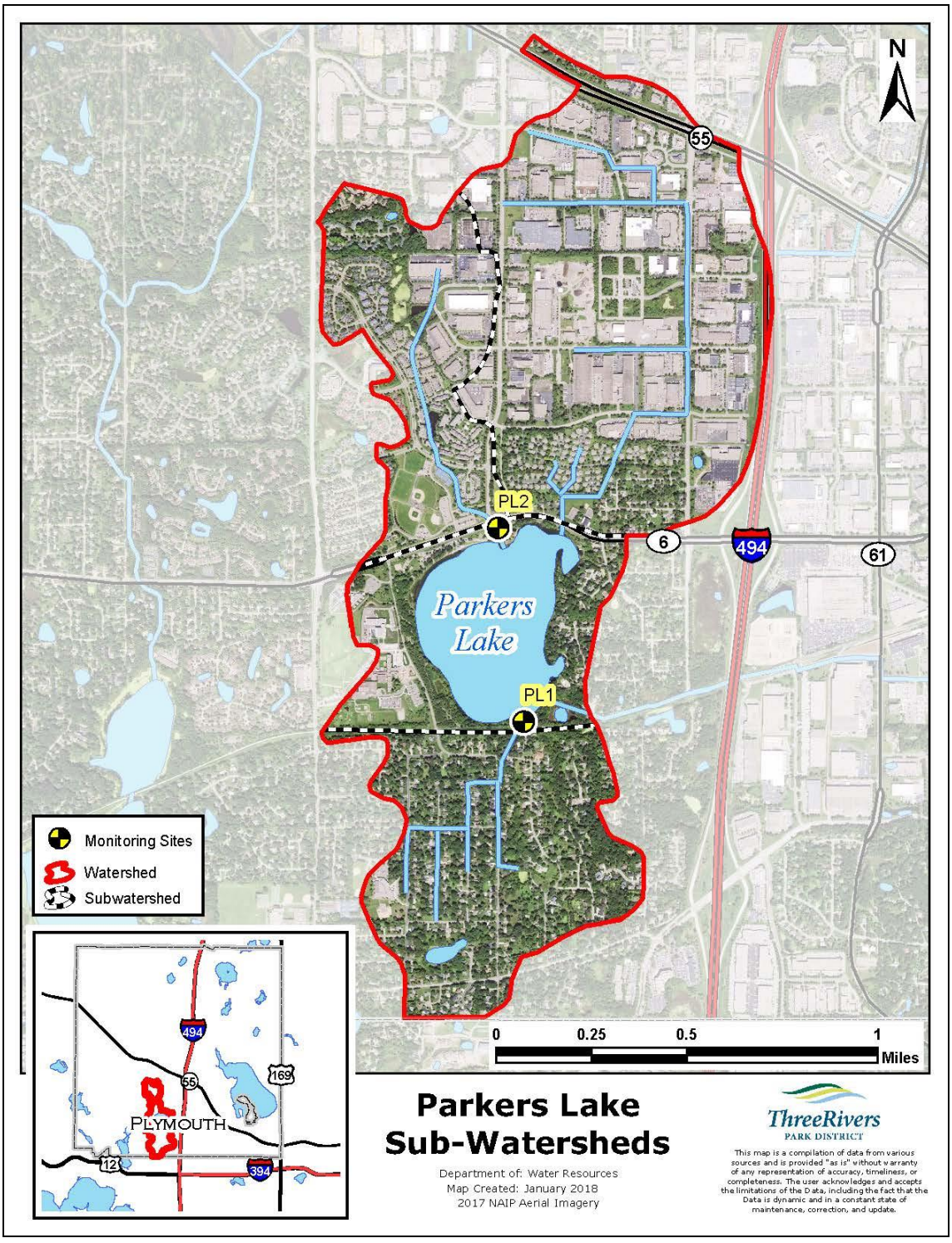


Figure 3.1 Parkers Lake sub-watershed map.

3.1.2. Hydrograph

The hydrographs for PL1 and PL2 responds rapidly to precipitation amount and intensity since the watersheds are small and developed (Figure 3.2). For example, peak 15-minute instantaneous flow at PL1 was 22.7 cfs on the morning of 8/6/22 after a 1.45 inch rain event. Average daily flow for the season was 0.05 cfs with 70% of days at no flow. At PL2, the peak 15-minute instantaneous flow was 29.9 cfs occurring the evening of 5/11/22, following a 0.89 inch rain event. Daily average flows for the season were 0.33 cfs. PL2 rarely goes completely dry and has continuous baseflow conditions throughout the season.

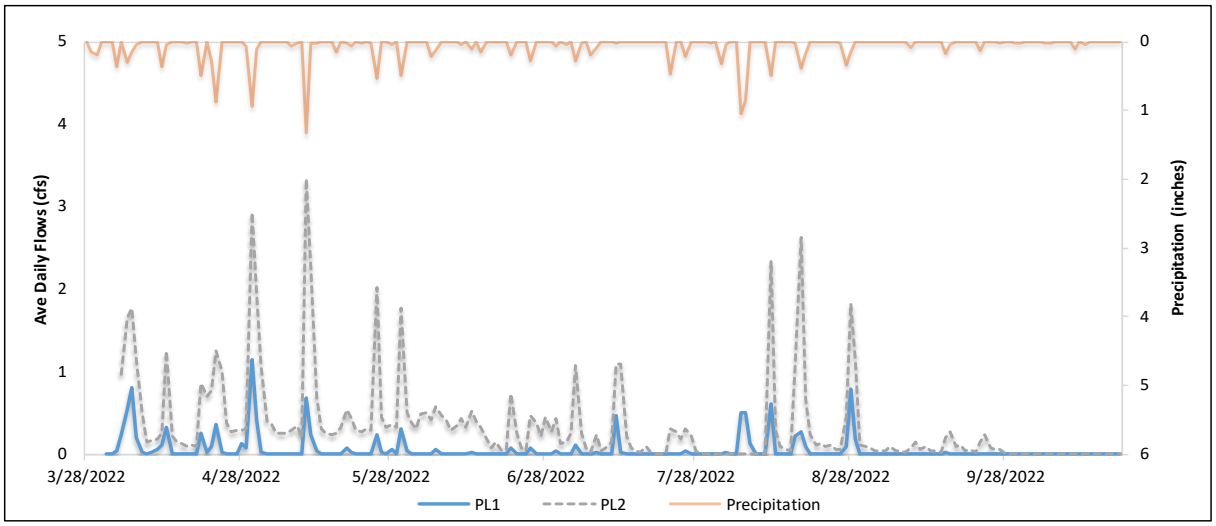


Figure 3.2 Average daily flow for Parkers Lake sites PL1 and PL2 in 2022.

3.1.3. Concentrations

There were eight samples collected at PL1, where all samples were composites with the exception of one grab sample. The single grab sample was taken during a rain event when the GLS sampler failed to enable after a rain event. PL2 had 22 samples of which six were composites and 16 grabs. A summary of sample averages and range of concentrations for both sites are reported in Table 3.1 and Figure 3.3. A history of maximum monthly chloride concentrations is reported in Figure 3.4. On average, SRP to TP ratios at PL1 and PL2 were 47% and 49%. PL1 is continuing to meet chloride standards without an exceedance in the past three years. PL2, on the other hand, had 11 exceedances in 2022 with the highest concentrations occurring March into June, with no exceedances after July. PL2 averaged 18 times higher chloride concentrations than PL1. The difference is likely explained by different land use and percent impervious area (Table 3.1).

Table 3.1 Summary of average, minimum, and maximum concentrations for TP, SRP, TN, TSS, and Cl^- at PL1 and PL2 in 2022.

Site	Avg TP (min-max) µg/L	Avg SRP (min-max) µg/L	Avg TN (min-max) mg/L	Avg TSS (min-max) mg/L	Avg Cl- (min-max) mg/L
PL1	363 (266 - 532)	172 (124 - 310)	3.5 (1.5 - 8.3)	47.0 (2.9 - 149.2)	14 (2 - 40)
PL2	213 (92 - 404)	105 (8 - 226)	1.3 (0.6 - 3.0)	15.7 (0.3 - 130.5)	250 (34 - 496)

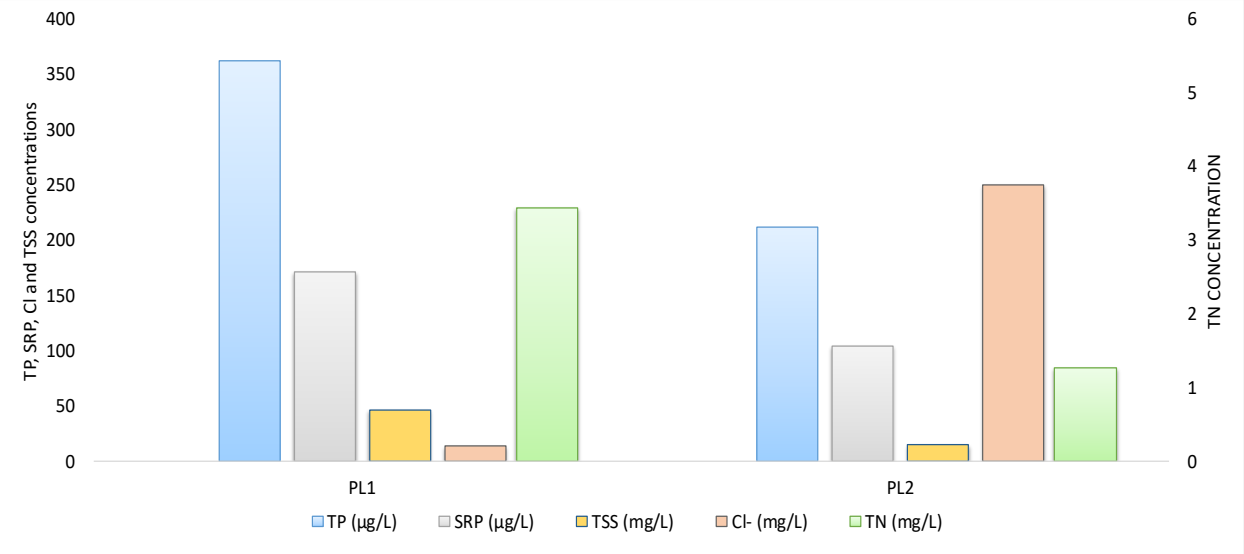


Figure 3.3 Average TP, SRP, TN, TSS, and Cl^- concentrations for PL1 and PL2 in 2022.

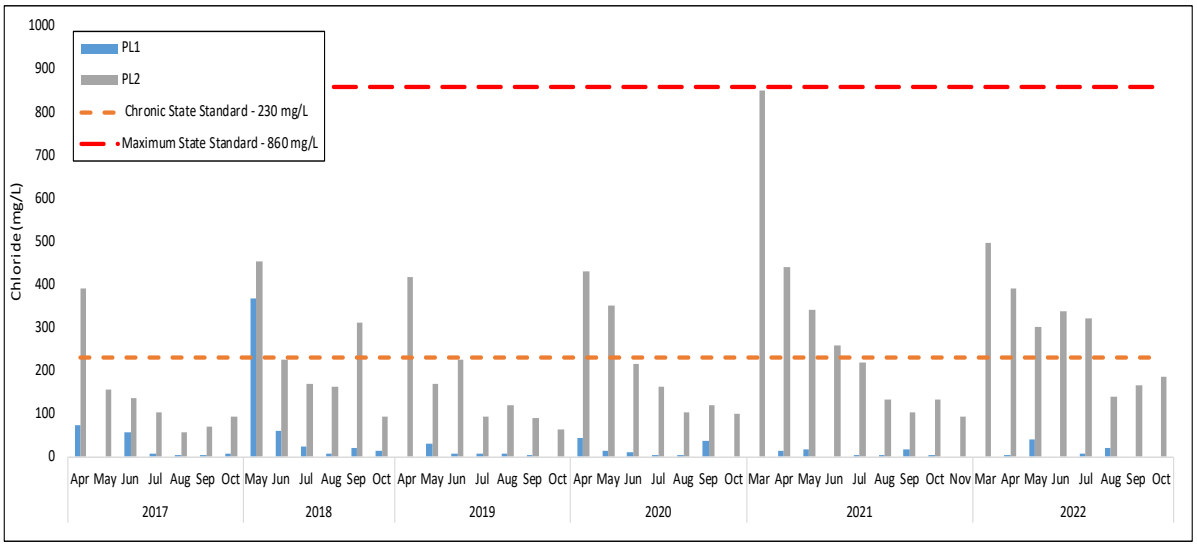


Figure 3.4 Maximum monthly chloride concentration at PL1 and PL2 versus the MPCA chloride standard. When standard is exceeded, there may be more than one exceedance in that month.

3.1.4. Yearly Summary

PL1

At PL1, data has been collected since 2000. The data in Table 3.2 segmented to pre-2006 and 2006-present to compare changes in water quality and flow relative to installation of stormwater infrastructure that included ponds and curbing with storm sewer catch basins and piping in 2005. The curbing and catch basins increased the conveyance of stormwater runoff that historically infiltrated in open ditch channels. The ponds allow for suspended sediments and nutrients to settle out. In general, there have been similar concentrations of nutrients pre and post 2006 when these stormwater BMPs were installed (Table 3.2). However, there have been an increase in flow volumes that have led to higher overall nutrient loading.

Precipitation in 2022 was 23% lower than the 2006-2022 average, which led to a decrease of flow volume by 38% below the 2006-2022 average. This site continues to have poor correlation between annual rain and flow on an annual basis ($r^2 = 0.40$).

Despite the less than average flow volume in 2022, nutrient concentrations remained similar to 2006-2022 average. TP and SRP were about 16% higher than average and TN was 27% higher. Chloride dropped by 45% and TSS was 10% lower. Less flow and similar concentrations led the annual loads of SRP, TP, and TN to be 20-24% less than 2006-2022 average. TSS and Chloride were 45% and 75% lower this year. The average UALs continue to be lower than MPCA stormwater manual estimates with only 0.14 lbs/acre TP and 36 lbs/acre TSS (Table 3.3). In fact, TSS has exceeded MPCA UAL estimates only twice in nineteen years of monitoring at PL1.

PL2

The PL2 site was monitored from 2000-2008 and from 2013 to 2022. The most recent BMP installation in the watershed was a 2022 stream restoration project located upstream of PL2. In

Table 3.4, the data is segmented based on a break in data collection with 2000-2008 and 2013-2022. Between the two periods, flow weighted concentrations and loadings have increased significantly.

The precipitation in 2022 was 27% lower compared to the 2013-2022 average, which led to a reduction of flow volume by 32%. Flow and precipitation have been weakly correlated ($r^2 = 0.31$) on an annual basis since 2013.

Flow weighted concentrations in 2022 were all higher than 2013-2022 average. TP, SRP, and TN were each within 5% of the average. TSS however was 64% higher and chloride was 89% higher than average. These high chloride concentrations tend to occur during low flow years. Higher amounts of precipitation dilute chloride runoff from the landscape.

Table 3.2 Loading and flow weighted concentrations for TP, SRP, TN, TSS, and Cl^- at PL1. The data is segmented by pre and post installation of ponds and curbs in 2005. The percent change compares the average loadings and concentrations before and after 2005.

PL1 - Parkers Lake - Site 1												
	Nutrient Loading					Nutrient Concentration					Flow Volume	Annual Precipitation
Year	TP (lbs/yr)	SRP (lbs/yr)	TN (lbs/yr)	TSS (lbs/yr	Cl^- (lbs/yr)	TP (µg/L)	SRP (µg/L)	TN (mg/L)	TSS (mg/L)	Cl^- (mg/L)	(x 10^6 m^3)	(inches)
Pre-2006												
2000	6	2	42	1,304	-	243	89	1.50	48	-	0.01	32.3
2001	11	6	58	1,392	-	293	157	1.60	39	-	0.01	34.6
2002	40	16	225	11,365	-	318	124	1.80	91	-	0.05	38.1
2003	39	21	215	12,139	-	308	165	1.70	95	-	0.06	25.8
2004	23	14	140	5,531	-	272	138	1.40	62	-	0.04	32.1
2005	35	10	230	23,196	-	377	108	2.60	252	-	0.04	32.6
Average	**26**	**12**	**152**	**9,155**	**-**	**302**	**130**	**1.77**	**98**	**-**	**0.04**	**32.6**
2006 – Present												
2006	27	12	119	10,003	-	343	169	1.50	126	-	0.04	29.1
2007	22	8	136	4,419	-	232	82	1.40	47	-	0.04	31.1
2009	22	15	75	1,246	-	291	191	1.00	17	-	0.03	19.6
2013	49	23	392	10,663	3,239	248	119	1.98	54	16.4	0.09	31.6
2014	63	37	763	18,517	1,158	264	132	2.71	66	9.1	0.13	27.5
2015	34	12	241	6,536	1,052	302	107	2.15	58	9.4	0.04	29.1
2016	59	21	389	10,125	1,797	296	103	1.96	51	8.3	0.08	38.6
2017	41	17	286	8,269	4,904	269	110	1.87	54	32.0	0.07	27.8
2018	46	18	290	3,243	4,701	321	125	2.02	23	33.1	0.06	30.8
2019	88	31	786	29,968	926	307	109	2.75	105	3.2	0.13	43.3
2020	30	19	292	5,905	679	303	192	2.99	60	6.9	0.04	25.9
2021	25	11	180	4,883	532	319	137	2.26	61	6.7	0.04	23.4
2022	33	15	251	5,238	533	340	152	2.61	54	7.7	0.04	22.7
Average	**41**	**18**	**323**	**9,155**	**1,952**	**295**	**133**	**2.09**	**60**	**13**	**0.06**	**29.3**
Change	**62%**	**60%**	**113%**	**0%**	**-**	**-2%**	**2%**	**18%**	**-39%**	**-**	**77%**	**-10%**

Due to low flows, loading was down this year for all constituents, except chloride, compared to 2013-present average. TP, SRP, and TN were each around 30% lower this year and TSS was 75% lower than average. Chloride was 41% higher than average. Average UAL for TP was 0.78 lbs/acre and remains below MPCA stormwater manual estimate for residential land use (

Table 3.5). TSS UAL of 77 lbs/acre in 2022 is just below the MPCA stormwater manual estimate for residential land use. However, it the 19 year average TSS UAL for the site of 242lbs/acre is above both commercial and residential land use estimates.

Table 3.3 Unit area loads for TP, SRP, TN, TSS, and Cl^- at PL1.

PL1 - Parkers Lake - Site 1					
Year	**TP (lbs/acre)**	**SRP (lbs/acre)**	**TN (lbs/acre)**	**TSS (lbs/acre)**	**Cl^- (lbs/acre)**
2000	0.02	0.01	0.16	5	-
2001	0.04	0.02	0.22	5	-
2002	0.16	0.06	0.87	44	-
2003	0.15	0.08	0.83	47	-
2004	0.09	0.05	0.54	21	-
2005	0.14	0.04	0.89	90	-
2006	0.10	0.05	0.46	39	-
2007	0.09	0.03	0.53	17	-
2009	0.09	0.06	0.29	5	-
2013	0.19	0.09	1.52	41	12.6
2014	0.24	0.14	2.96	72	4.5
2015	0.13	0.05	0.93	25	4.1
2016	0.23	0.08	1.51	39	7.0
2017	0.16	0.07	1.11	32	19.0
2018	0.18	0.07	1.12	13	18.2
2019	0.34	0.12	3.05	116	3.6
2020	0.11	0.07	1.13	23	2.6
2021	0.10	0.04	0.70	19	2.1
2022	0.13	0.06	0.97	20	2.1
Average	**0.14**	**0.06**	**1.04**	**35.5**	**7.6**

Table 3.4 Loading and flow weighted concentrations of TP, SRP, TN, TSS, and Cl^- at PL2. Data is segmented by a break in data collection from 2009-2012.

PL2 - Parkers Lake - Site 2												
	Nutrient Loading					**Nutrient Concentration**						
Year	**TP (lbs/yr)**	**SRP (lbs/yr)**	**TN (lbs/yr)**	**TSS (lbs/yr)**	**Cl^- (lbs/yr)**	**TP (µg/L)**	**SRP (µg/L)**	**TN (mg/L)**	**TSS (mg/L)**	**Cl^- (mg/L)**	**Flow Volume (x 10^6 m^3)**	**Annual Precipitation (inches)**
2000-2008												
2000	18	5	219	2,459	-	125	39	1.50	17	-	0.06	32.3
2001	125	43	1,132	24,170	-	160	56	1.50	31	-	0.33	34.6
2002	124	36	1,217	45,038	-	148	143	1.40	54	-	0.36	38.1
2003	80	42	882	31,784	-	121	63	1.30	48	-	0.30	25.8
2004	117	45	1,131	33,485	-	136	53	1.30	39	-	0.39	32.1
2005	126	50	1,243	40,351	-	125	50	1.20	40	-	0.45	32.6
2006	176	54	1,632	33,941	-	153	47	1.40	30	-	0.52	29.1
2007	255	118	1,780	107,627	-	239	110	1.70	101	-	0.48	31.1
2008	48	7	392	2,901	-	277	39	2.28	17	-	0.08	20.8
Average	**119**	**44**	**1,070**	**35,751**	**-**	**165**	**67**	**1.51**	**42**	**-**	**0.33**	**30.7**
2013-present												
2013	145	73	1,299	50,840	105,991	169	85	1.51	59	123	0.39	31.6
2014	182	100	1,980	73,498	55,650	152	84	1.66	62	103	0.54	27.5
2015	221	85	1,776	68,765	161,814	234	90	1.88	73	120	0.42	29.1
2016	262	95	1,648	65,665	66,855	272	99	1.71	67	68.1	0.44	38.6
2017	219	72	1,716	61,684	122,460	188	62	1.48	53	105	0.49	27.8
2018	169	59	1,363	37,574	138,692	187	65	1.51	42	153	0.41	30.8
2019	195	80	1,659	110,549	84,831	184	76	1.56	104	80	0.48	43.3
2020	52	27	448	10,961	71,449	131	68	1.13	28	179	0.18	25.9
2021	150	52	861	53,130	73,146	316	110	1.82	112	154	0.21	23.4
2022	125	49	1,006	14,596	137,612	208	81	1.67	24	228	0.27	22.7
Average	**172**	**69**	**1,376**	**54,726**	**101,850**	**204**	**82**	**1.59**	**62**	**131**	**0.38**	**30.1**
Change	**45%**	**56%**	**29%**	**53%**	**-**	**24%**	**23%**	**6%**	**49%**	**-**	**16%**	**-2.09%**

Table 3.5 Unit area loads for TP, SRP, TN, TSS, and Cl^- at PL2.

	PL2 - Parkers Lake - Site 2 Load/Acre				
Year	**TP (lbs/acre)**	**SRP (lbs/acre)**	**TN (lbs/acre)**	**TSS (lbs/acre)**	**Cl^- (lbs/acre)**
2000	0.10	0.03	1.16	13	-
2001	0.66	0.23	5.99	128	-
2002	0.66	0.19	6.44	238	-
2003	0.42	0.22	4.67	168	-
2004	0.62	0.24	5.98	177	-
2005	0.67	0.26	6.58	213	-
2006	0.93	0.29	8.63	180	-
2007	1.35	0.62	9.42	569	-
2008	0.25	0.04	2.07	15	-
2013	0.77	0.39	6.87	269	561
2014	0.96	0.53	10.48	389	294
2015	1.17	0.45	9.40	364	856
2016	1.39	0.50	8.72	347	354
2017	1.16	0.38	9.08	326	648
2018	0.89	0.31	7.21	199	734
2019	1.03	0.43	8.78	585	449
2020	0.28	0.14	2.37	58	378
2021	0.79	0.28	4.55	281	387
2022	0.66	0.26	5.32	77	728
Average	**0.78**	**0.30**	**6.51**	**242**	**539**

3.1.5. Trend Analysis

PL1 trend analysis included data from 2006 to 2022. There were two significant results from the Mann-Kendall test. Both TP concentration and TN concentration results were significant, indicating there was a change in concentrations since 2006. Since the curb and storm sewer installation in 2006, the general trend has been an increase in concentration and no change in load. Both TP and TN concentrations had positive *tau* values, indicating concentrations had increased year to year more often than not.

PL2 had one significant result, SRP loading has changed since 2013. The negative *tau* value indicates SRP loading has decreased. There were no other trends that were significant for TP, TN, or TSS loading. There were no significant trends in concentrations at PL2 since 2006.

Table 3.6. Mann-Kendall trend analysis results for PL1 (2006-2022) and PL2 (2013-2022).

	PL1		PL2	
	tau	**p-value**	***tau***	**p-value**
TP (lbs/yr)	0.046	0.891	-0.333	0.211
TP (µg/L)	0.697	**0.002**	0.111	0.721
SRP (lbs/yr)	0.000	1.000	-0.600	**0.020**
SRP (µg/L)	0.303	0.193	-0.022	1.000
TN (lbs/yr)	0.091	0.732	-0.467	0.074
TN (mg/L)	0.485	**0.034**	0.000	1.000
TSS (lbs/yr)	-0.030	0.945	-0.378	0.152
TSS (mg/L)	0.321	0.169	-0.156	0.592

3.1.6. Parkers Lake

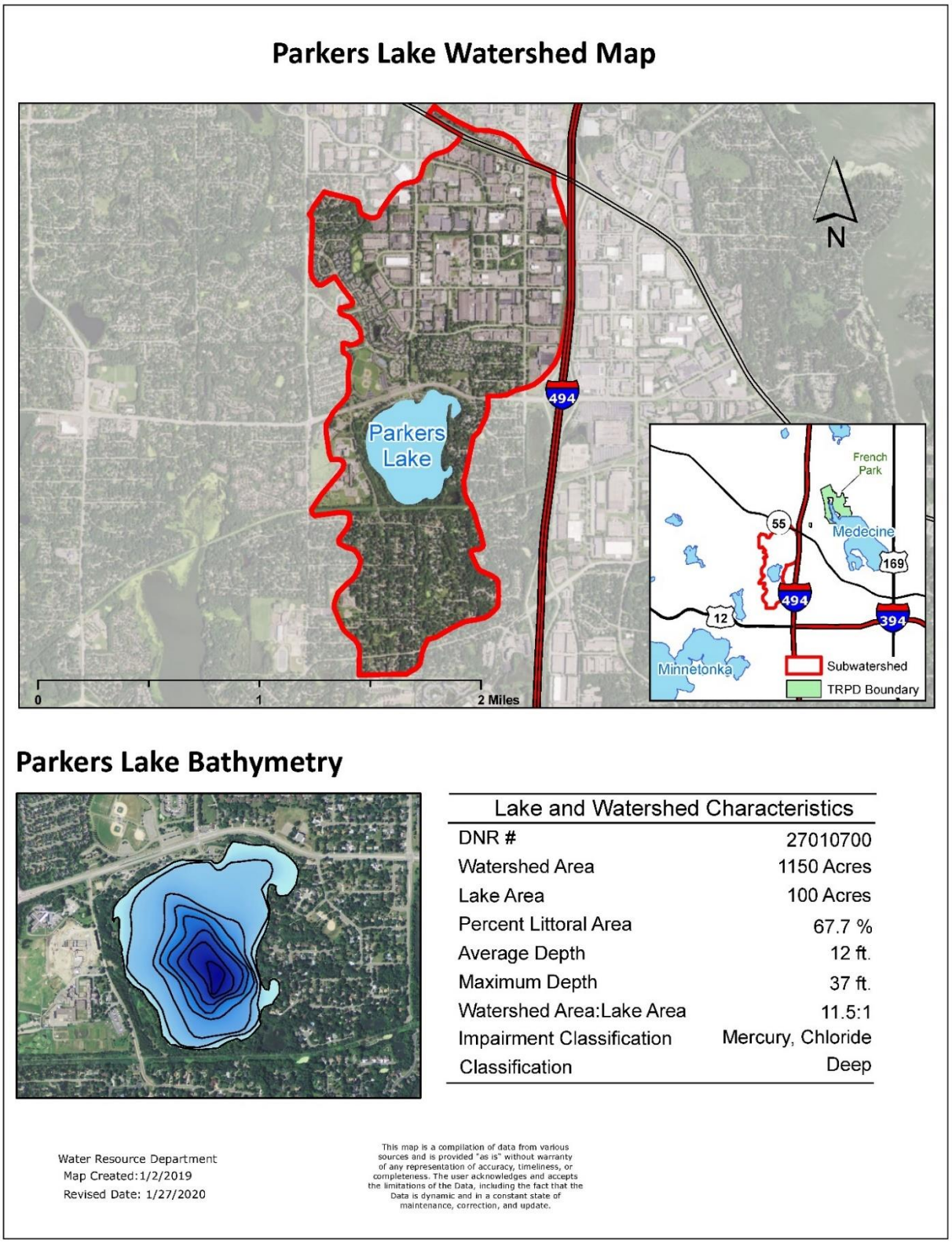
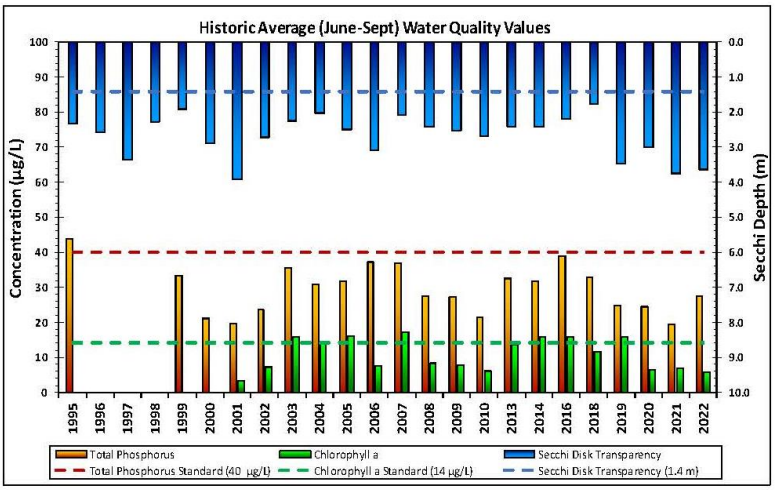
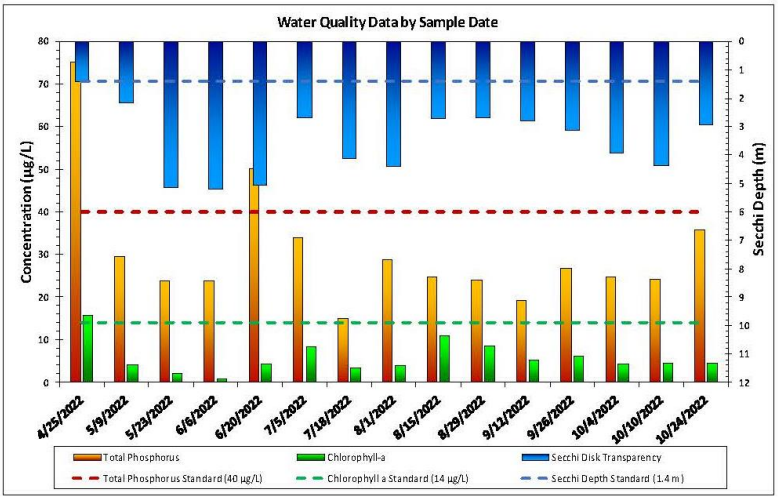
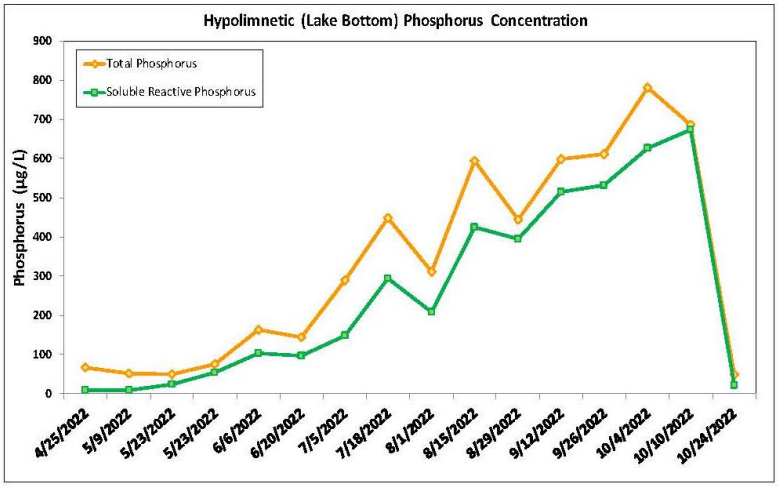


Figure 3.5. Summary of Parkers Lake watershed lake characteristics.

Parkers Lake is a deep lake in Plymouth with maximum and average depths of 37ft and 12ft. It is 100 acres in surface area and has a contributing watershed of 1,150 acres (Figure 3.5). It was listed as impaired for chloride in 2016. The lake continues to meet nutrient standards.







Parkers Lake Water Quality Report Card				
Year	TP	Chl-a	Secchi	Avg Grade
1995	C		B	B-
1996			B	B
1997			A	A
1998			B	B
1999	C		C	C
2000	A		B	A-
2001	A	A	A	A
2002	B	A	B	B+
2003	C	B	B	B-
2004	B	B	C	B-
2005	B	B	B	B
2006	C	A	A	B+
2007	C	B	C	C+
2008	B	A	B	B+
2009	B	A	B	B+
2010	A	A	B	A-
2013	C	B	B	B-
2014	B	B	B	B
2016	C	B	B	B-
2018	C	B	C	C+
2019	B	B	A	B+
2020	A	A	A	A
2021	A	A	A	A
2022	B	A	A	A-
MPCA Standard	C	B	C	C+

Met Council Grading System for Lake Water Quality

ThreeRivers PARK DISTRICT

Division of Water Resources
December 2023

Figure 3.6. Parkers Lake report card.

Growing season averages of phosphorus, chlorophyl-a, and secchi depth transparency each met water quality standards in 2022. Sechi depth transparency has met state standard every year TRPD has monitored, and phosphorus has met standard every year but one. Chlorophyl-a has exceeded standard on occasion (Figure 3.6). Hypolimnetic phosphorus concentrations increased throughout the year as the lake stratified (Figure 3.7) and as dissolved oxygen levels depleted (Figure 3.8).

Chloride was monitored at surface 15 times and at the bottom 14 times in 2022. The average at the surface was 196 mg/L while bottom average was 207 mg/L. In 2022, there were no samples that exceeded 230 mg/L state standard. This was the first monitored year since 2016 that did not have an observed exceedance of the chloride standard. There is a very slight decline in overall chloride average since 2014. However, chloride concentrations over that time at the surface increased slightly while concentrations near the bottom declined (Figure 3.9 and Figure 3.10).

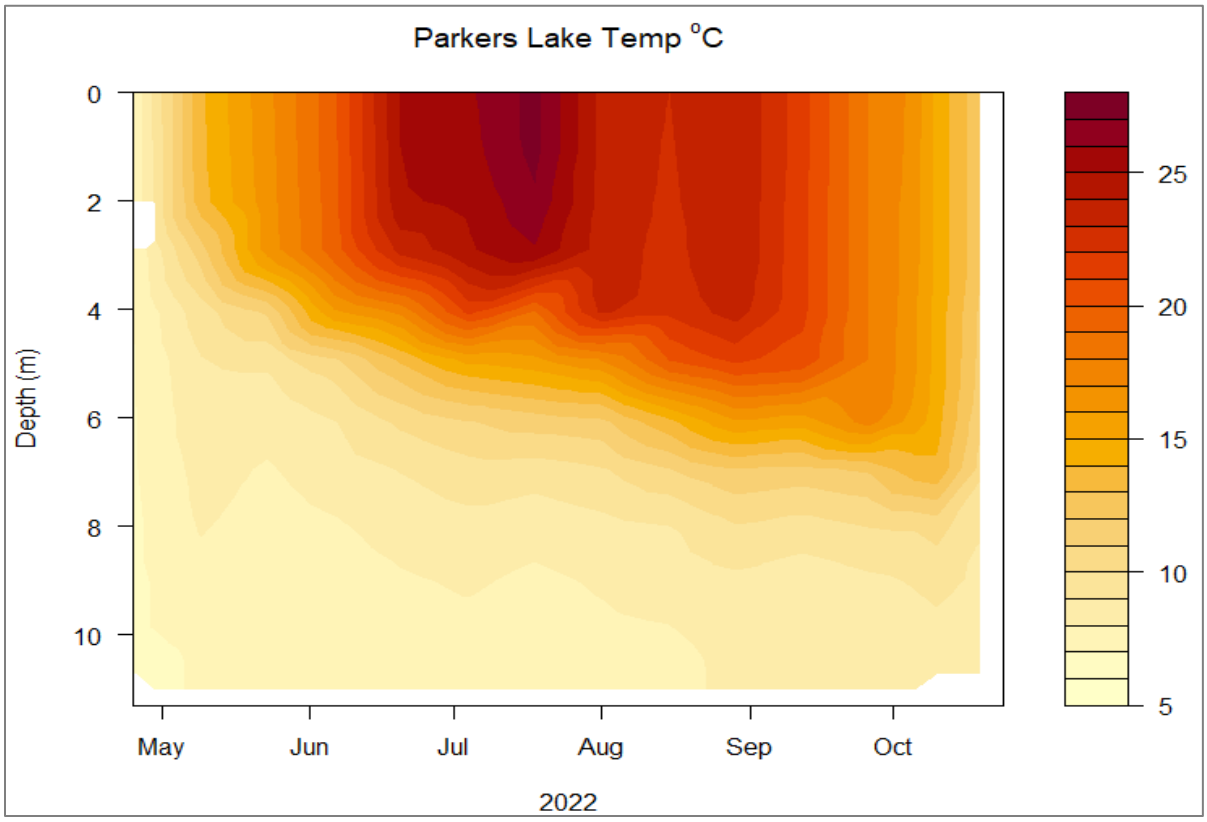


Figure 3.7. Parkers Lake temperature depth profile 2022.

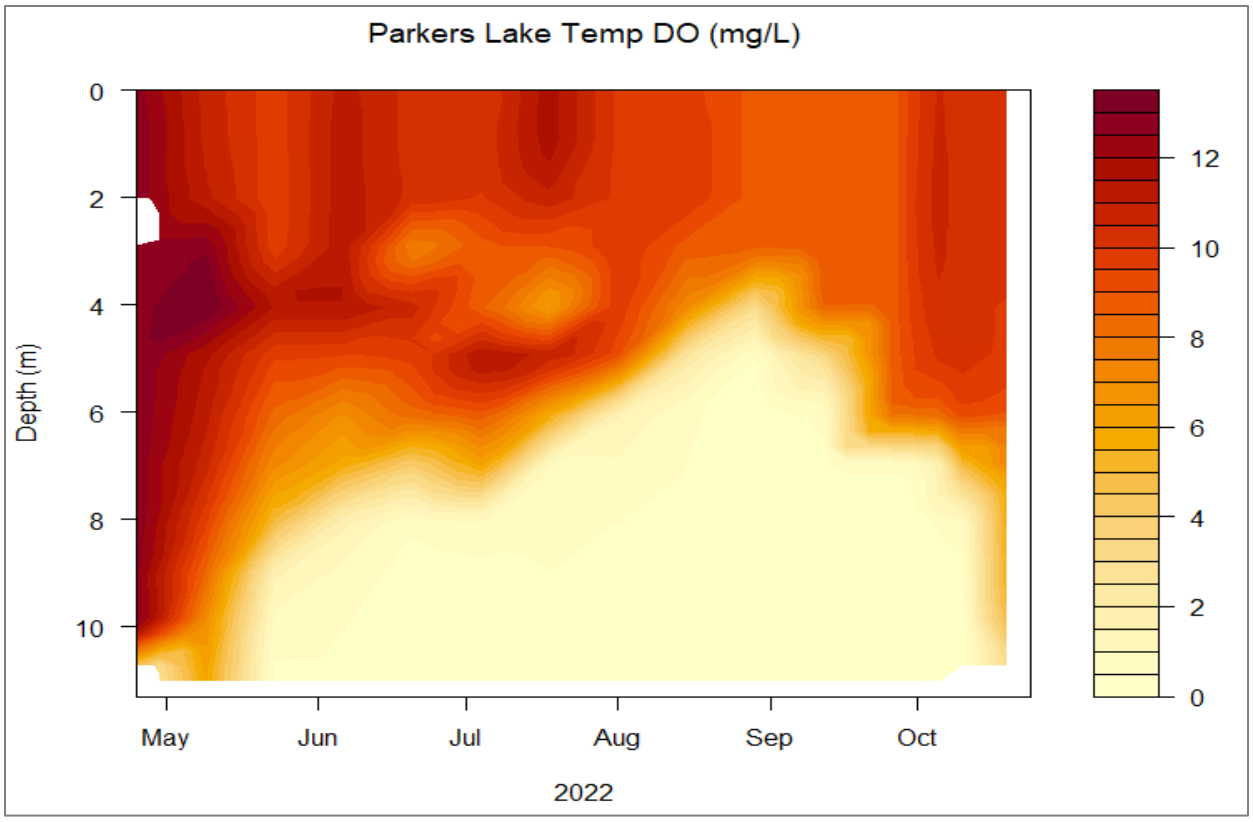


Figure 3.8. Parkers Lake dissolved oxygen depth profile 2022.

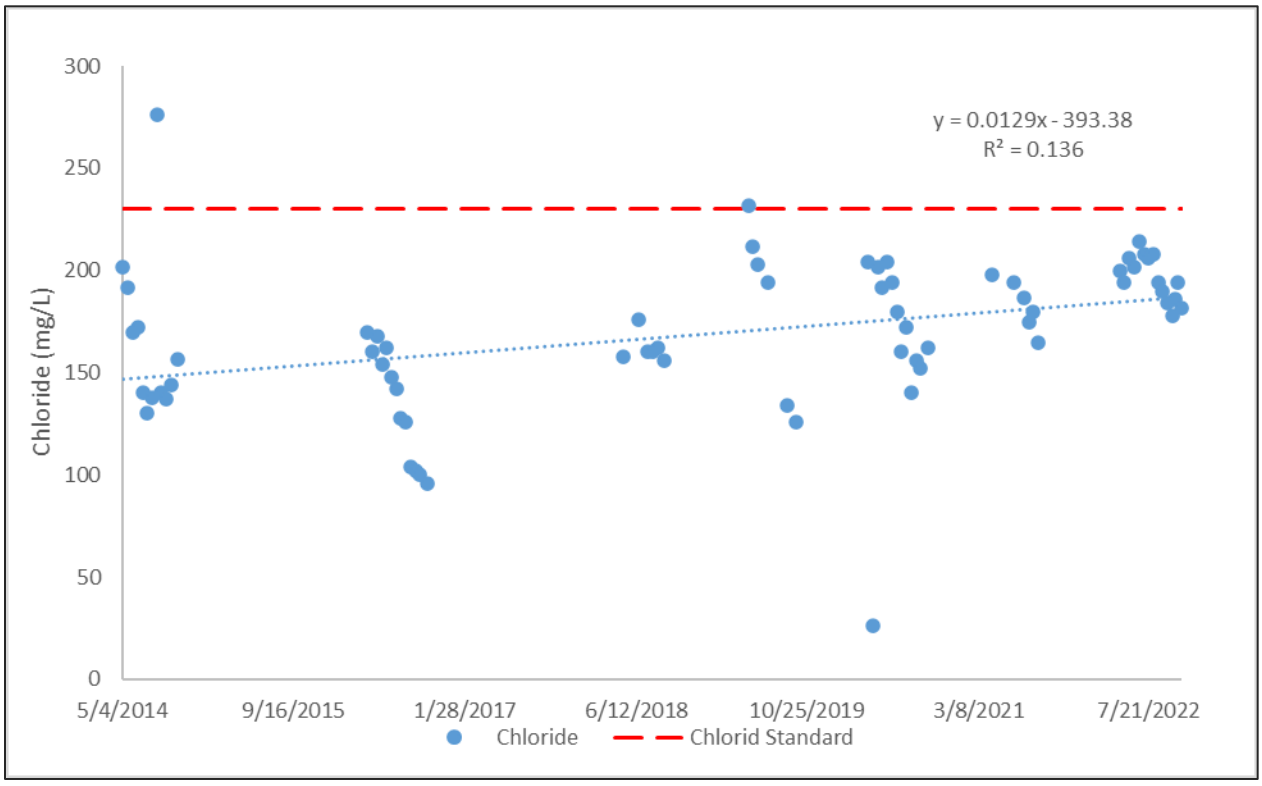


Figure 3.9. Parkers Lake chloride surface samples (2014-2022).

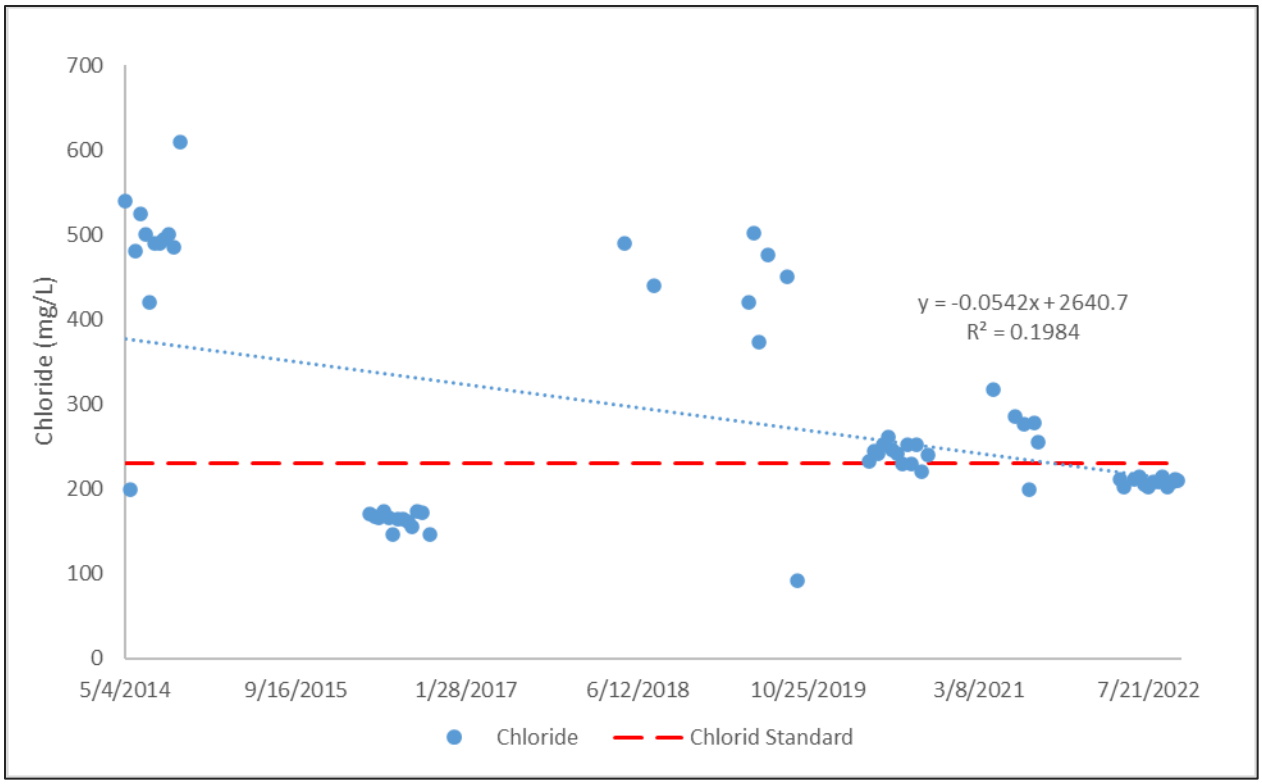


Figure 3.10. Parkers Lake chloride bottom samples (2014-2022).

3.2. Medicine Lake Watershed

The Medicine Lake watershed is 11,666 acres that lies within several municipalities (Figure 3.11). Most of the watershed is in the City of Plymouth (10,147 acres, 87%). Medicine lake watershed has 919 acres (8%) in Minnetonka. Cities of Medicine Lake, Golden Valley, New Hope, and Medina combine for the remaining 5% of watershed area. Medicine Lake is part of the larger Bassett Creek Watershed.

Medicine Lake was listed as impaired for excess nutrients in 2004. Plymouth Creek, the largest tributary to Medicine Lake, was listed as impaired for chloride and *E. coli* in 2014. The lake is considered at risk for chloride impairment.

A TMDL was completed for Medicine Lake excess nutrients in 2011. Plymouth Creek was included in the Twin Cities Metro Area Chloride TMDL approved by EPA in 2016 as well as Upper Mississippi River Bacteria TMDL approved by EPA in 2014.

Several BMPs or infrastructure changes were implemented since these TMDLs were completed. Detention ponds were installed upstream of PC2 in 2009-2010 to reduce nutrient loading to Medicine Lake and flooding impact from Plymouth Creek. A stream restoration upstream of PC2

in 2010-2011 was completed to improve water conveyance. Additionally, a streambank stabilization project upstream of IP2 was completed in 2017-2018.

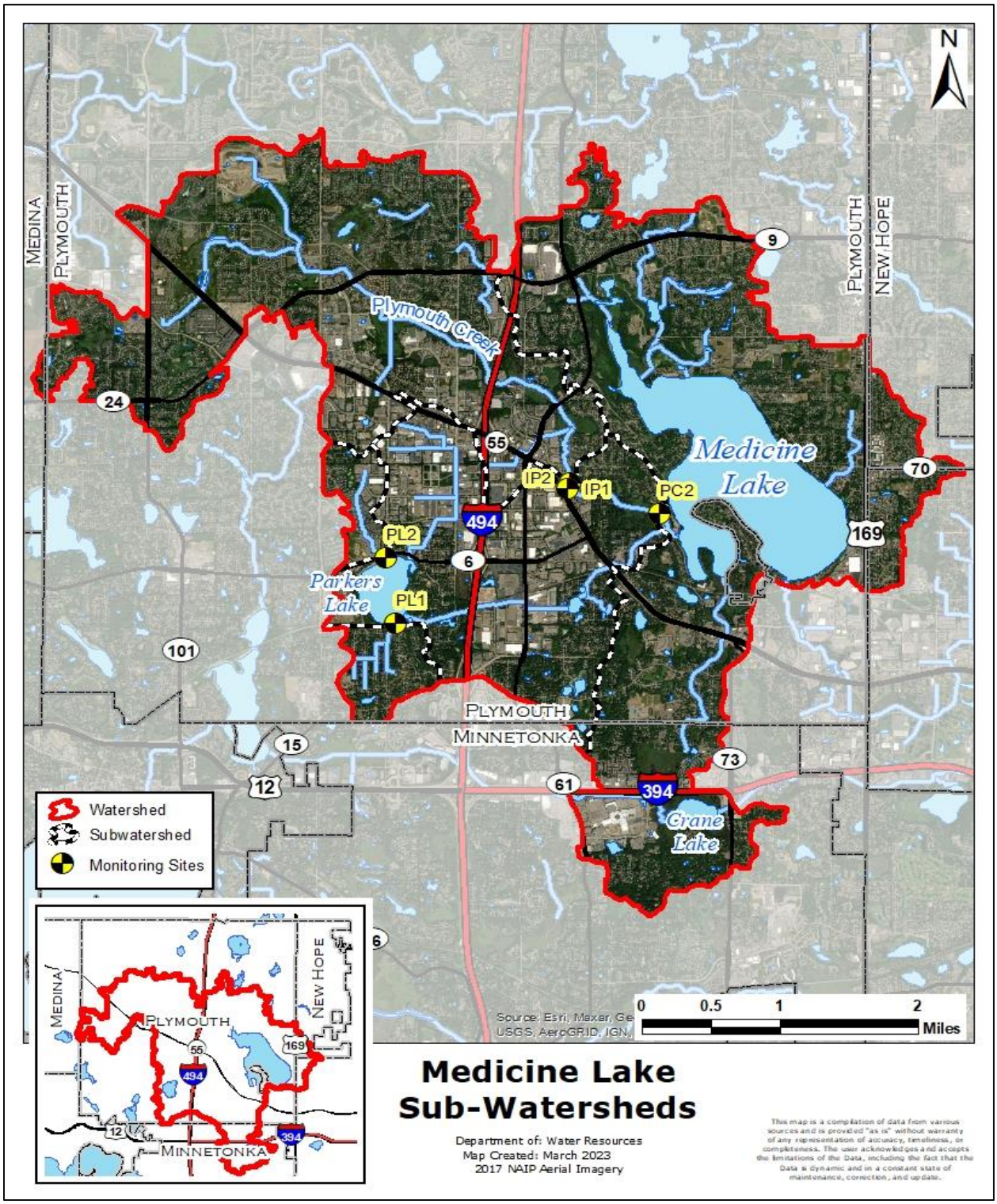


Figure 3.11 Medicine Lake sub-watershed map.

3.2.1. Stormwater Monitoring Sites

To assess the nutrients and chloride flowing into Medicine Lake, two sites along Plymouth Creek were monitored that account for 55% of the Medicine Lake watershed area (Table 3.7). The IP2 monitoring station is located at a 14-foot wide concrete weir behind an industrial building at 12940 Teakwood Ln N. Continuous water level measurements are recorded and applied to a weir equation to estimate streamflow at this site. IP2 captures nutrient loading from upstream portions of Plymouth Creek before discharging into a wetland complex and detention pond. The second site, PC2, is located on Medicine Lake Drive W near West Medicine Lake Beach. This site captures drainage from IP2 as well as the Parkers Lake watershed, just before it reaches Medicine Lake. PC2 is an open channel site that is close enough to Medicine Lake to experience occasional lake effect, where high lake levels slow the velocity of water discharging from the stream into the lake.

In 2022, an additional monitoring station was created in partnership with City of Plymouth and Bassett Creek Watershed Management Commission. IP1 is a concrete and steel culvert that outlets downstream of IP2. It receives runoff from 222.1 acres of the subwatershed west of Hwy 55. This site is also accessed next to the building at 12940 Teakwood Ln N. IP1 was primarily monitored for chloride and temperature, along with flow.

Table 3.7. Summary of watershed characteristics for sites IP2, PC2, and IP1.

Site	Sub watershed Area (acres)	% Impervious (acres)[1]	% of Medicine Lake Watershed	Dominant land uses[2]
IP2	3,725	34% (1,279 ac.)	32%	Residential
PC2	6,390	37% (2,363 ac.)	55%	Residential, commercial
IP1	222.1	58% (129.2 ac.)	0.4%	Commercial

[1] % impervious area determined using the 2016 University of Minnesota TCMA 1-meter land cover classification GIS layer.
[2] Dominant Land Uses determined using GIS layer obtained from the City of Plymouth.

3.2.2. Hydrograph

The IP2 monitoring site is upstream of PC2 and therefore has a smaller watershed (Figure 3.11). IP2 had an average daily flow in 2022 of 3.0 cfs and a peak daily average flow of 32.8 cfs on 5/1/22, following a two-day 1.2-inch rain event. PC2 average daily flow was 3.9 cfs and had a peak daily flow of 44 cfs on 5/12/22. Prolonged periods of no flow occurred at both Plymouth Creek sites in late summer and fall of 2022 (Figure 3.12).

Because IP1's watershed is mostly commercial land use with impervious surface (58%), it responds rapidly to small amounts of rainfall (Figure 3.13). The maximum 15-minute instantaneous flow recorded in 2022 was 83.7 cfs at 10:30 pm on 5/11/2022 (following a 0.89-inch rain event), while the maximum daily average flow was 2.22 cfs on 4/20/22 after 0.4 inches of rain. Flow rates can increase rapidly and decline almost as fast. Most runoff events last for as long as the rain event does.

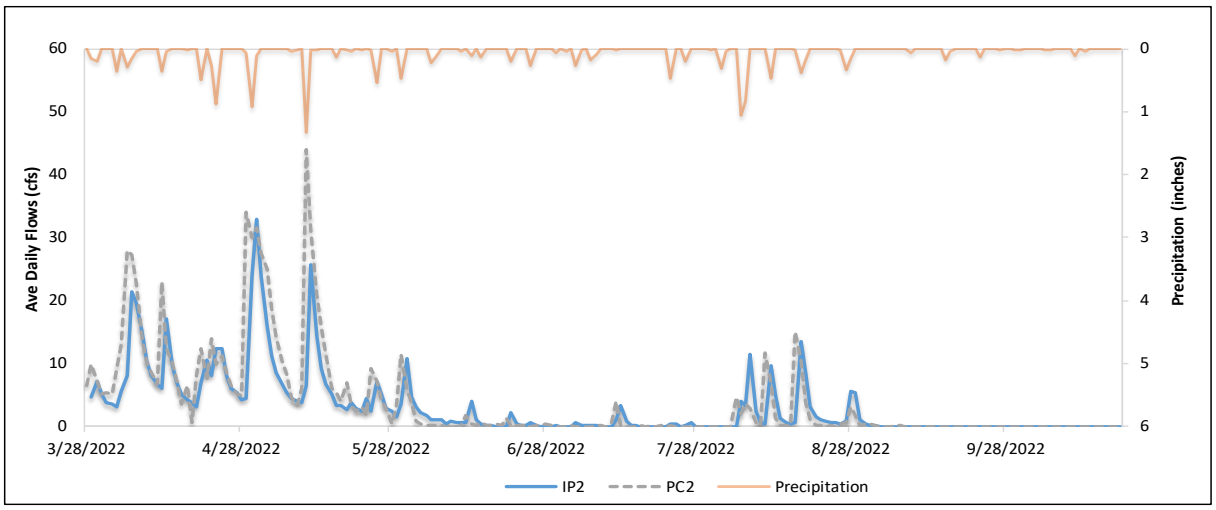


Figure 3.12. Average daily flow for IP2 and downstream PC2 in 2022.

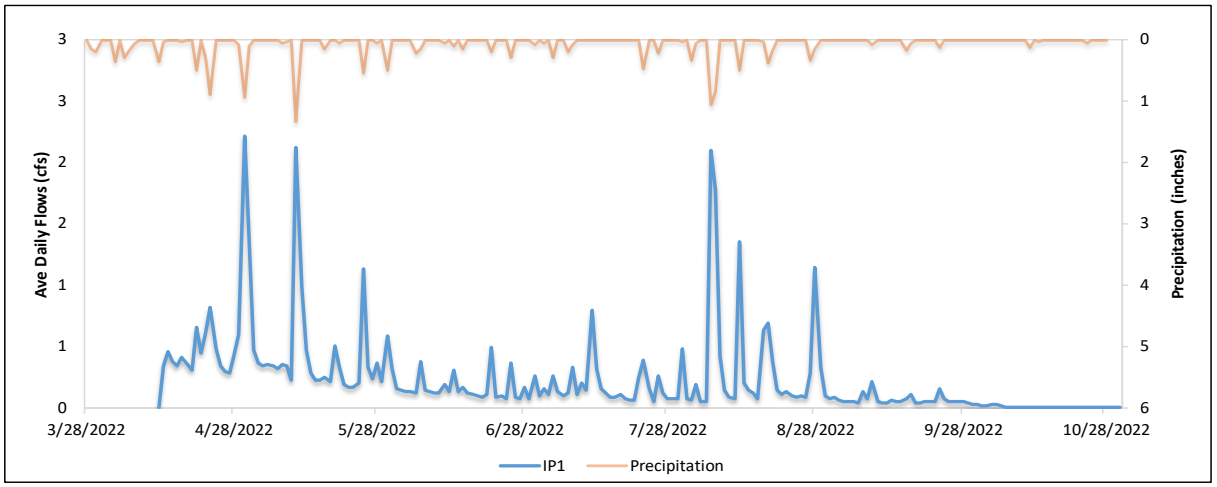


Figure 3.13. Average daily flow at IP1 in 2022.

3.2.3. Concentrations

A summary of 2022 sample results is reported in Table 3.8 and Figure 3.14. IP2 was sampled 15 times in 2022. Seven of those were composites and eight were grab samples. The highest nutrient samples were collected in a comp sample on 5/1/22 during the season's peak flows.

IP2 is not meeting chloride standards since it has had more than two (seven total) chloride concentration exceedances in the past three years (Figure 3.15). There was no clear trend in chloride exceedances over the season. On average, SRP to TP ratio was 24%.

PC2 was sampled 12 times in 2022, including three composites and nine grab samples. PC2 is not meeting chloride standards either due to more than two exceedances in the past three years. There were three chloride exceedances in 2022 alone. Average SRP to TP ratio was 33%.

IP1 was sampled for only chloride in 2022. There were 12 comp samples collected in total. Average chloride concentrations were lower than IP2 and PC2 even though IP1 had the highest individual sample at 382 mg/L.

Table 3.8. Average, minimum, and maximum concentrations for TP, SRP, TN, TSS, and Cl^- at Plymouth Creek sites in 2022.

Site	Avg TP (min-max) µg/L	Avg SRP (min-max) µg/L	Avg TN (min-max) mg/L	Avg TSS (min-max) mg/L	Avg Cl^- (min-max) mg/L
IP2	229 (84 - 477)	56 (14 - 145)	1.7 (0.9 - 3.7)	22.9 (1.1 - 139.0)	186 (66 - 300)
PC2	180 (93 - 379)	60 (13 - 118)	1.5 (0.8 - 2.3)	9.5 (1.1 - 28.8)	167 (70 - 284)
IP1	-	-	-	-	163 (14 - 382)

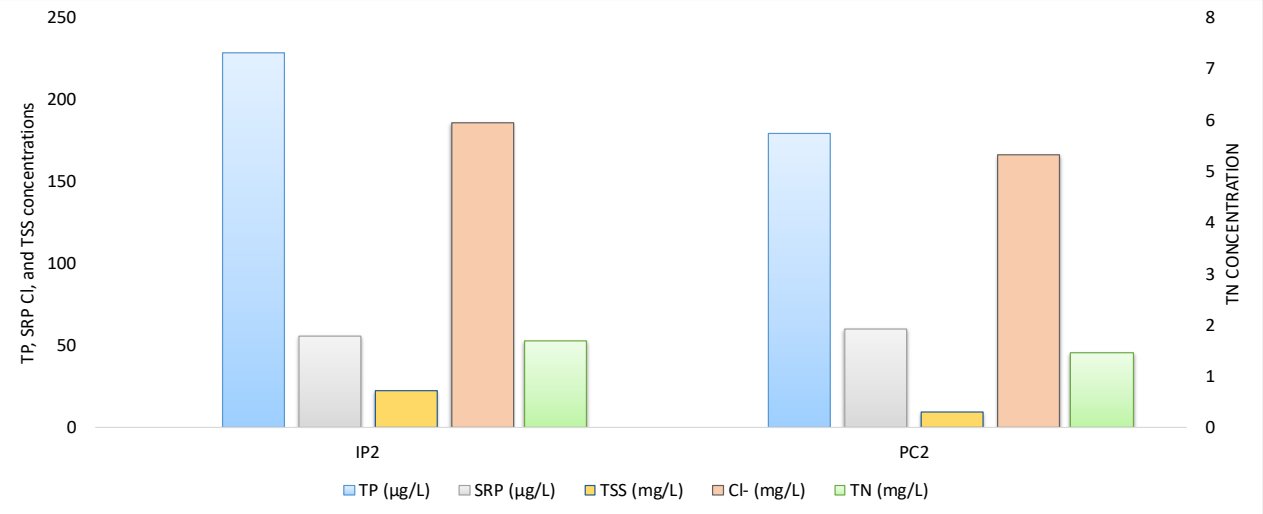


Figure 3.14. Average concentrations of TP, SRP, TSS, Cl^-, and TN for sites IP2 and PC2 in 2022.

Remote loggers continuously measured IP1 and IP2 conductivity at 15-minute intervals. The continuous conductivity was with the 15-minute instantaneous flow (Figure 3.16). IP1 is flashier than IP2 in terms of both flow and specific conductance. IP1 conveys less total water than IP2 but can convey more instantaneous flow than IP2 immediately following rain events. Conductivity at IP1 is also less than at IP2 during baseflow conditions but will spike higher than IP2 during rain events.

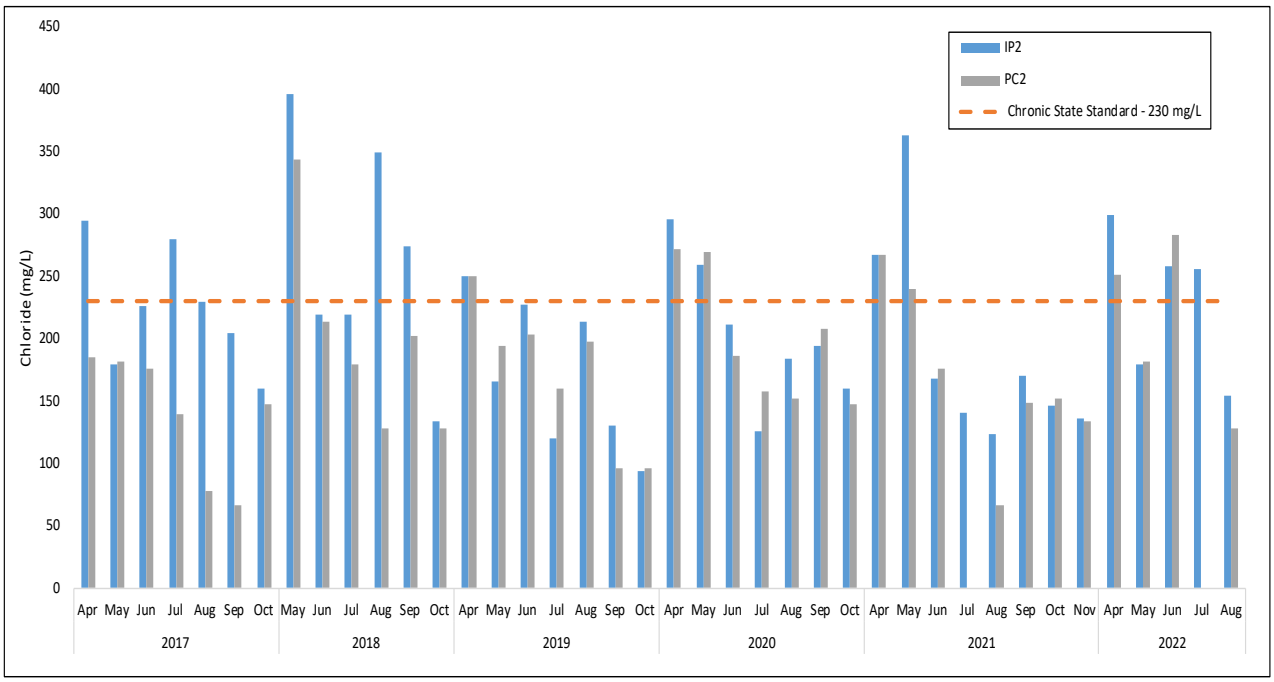


Figure 3.15 Maximum monthly chloride concentration at IP2 and PC2.

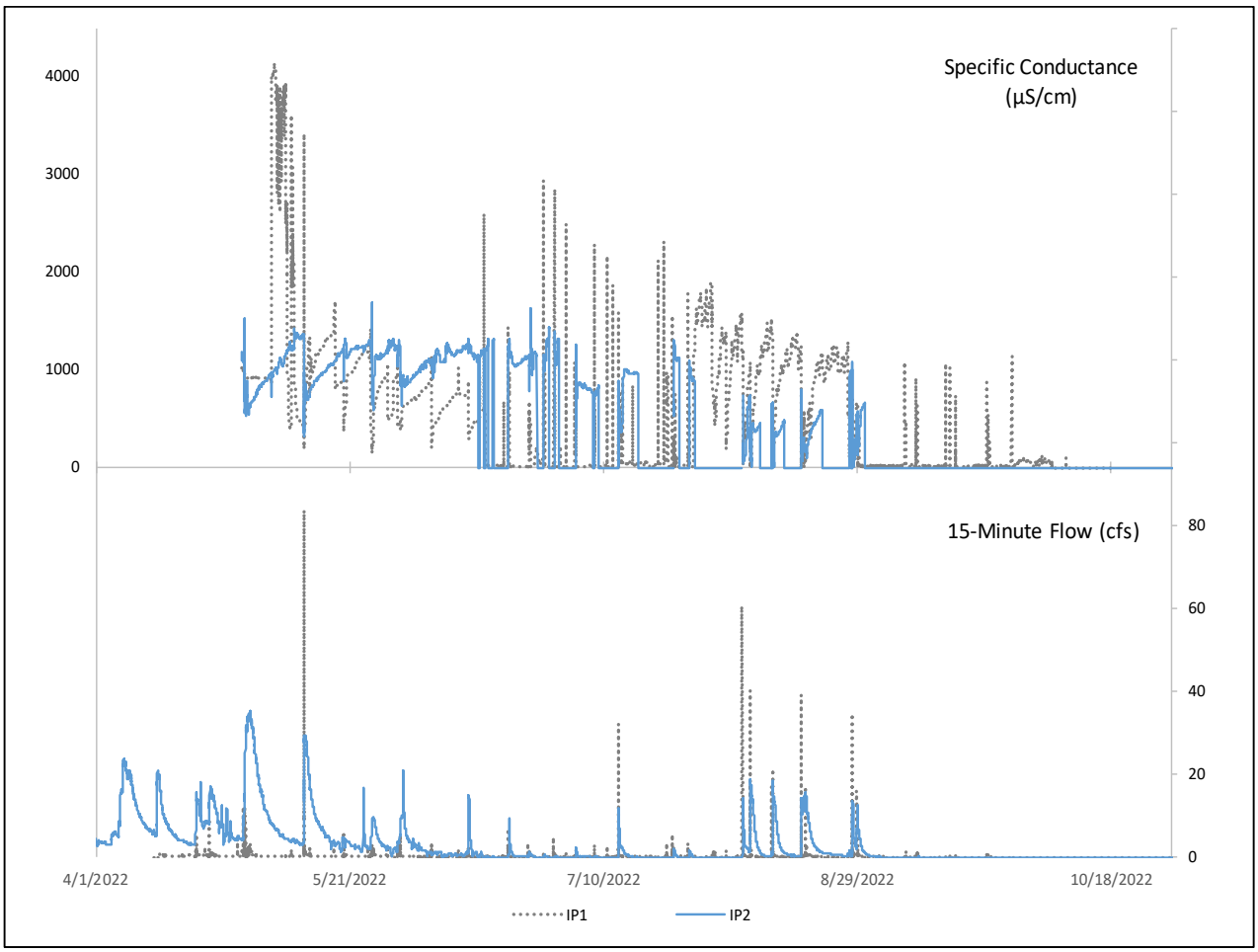


Figure 3.16. Specific Conductivity and 15-min flow at IP1 and IP2 in 2022.

3.2.4. Yearly Summary

IP2

At IP2, data has been collected since 2004 except for 2007, 2010, and 2011. In Table 3.9, the annual flow-weighted concentrations and loadings are segmented to pre-2012 and 2012-present due to the gap in data and to maintain comparability with PC2. In general, there have been similar concentrations in the 2012-present dataset compared to the pre-2012 dataset, but the 36% increased flow volumes between pre and post 2012 due to increased precipitation have led to higher loadings overall.

In 2022, precipitation was down 26% compared with the 2012-present average, causing a 62% reduction in flow. There were extended periods of no flow, which is not typical for this site. The correlation between precipitation and flow has remained strong since 2004 ($r^2 = 0.81$).

The 2022 flow weighted concentrations were between 24% and 43% higher than 2012-present average for TP, TN, TSS, and chloride (Table 3.9). SRP was 23% lower than average. Even with above average concentrations, the lowest flow on record led to 26-72% lower loading for all parameters compared to 2012-present averages. The UALs remained below MPCA estimates for land use type with 0.54 lbs/acre TP and 76 lbs/acre TSS (Table 3.10).

Table 3.9 Loading and flow weighted concentrations for TP, SRP, TN, TSS, and Cl^- at IP2. The % change compares the average loadings and concentrations before and after 2012

IP2 - Industrial Park site 2												
	Nutrient Loading					Nutrient Concentration						
Year	TP (lbs/yr)	SRP (lbs/yr)	TN (lbs/yr)	TSS (lbs/yr)	Cl^- (lbs/yr)	TP (µg/L)	SRP (µg/L)	TN (mg/L)	TSS (mg/L)	Cl^- (mg/L)	Flow Volume (x 10^6 m^3)	Annual Precipitation (inches)
Pre-2012												
2004	1,716	1,081	13,441	189,407	-	128	81	1.00	14	-	6.04	32.1
2005	1,785	816	13,080	348,060	-	144	66	1.06	24	-	4.69	32.6
2006	1,768	558	15,039	497,672	-	147	46	1.25	41	-	5.47	29.1
2008	1,228	265	9,131	183,900	-	147	36	1.20	25	-	3.35	20.8
2009	713	338	5,520	52,461	-	127	61	0.99	9	-	2.54	19.6
Average	**1,442**	**612**	**11,242**	**254,300**	**-**	**139**	**58**	**1.10**	**23**	**-**	**4.42**	**26.9**
2012-present												
2012	2,168	920	20,615	392,171	-	171	73	1.62	31	-	5.75	26.7
2013	2,812	1,438	25,699	338,965	-	161	82	1.47	19	-	7.93	31.6
2014	2,153	882	24,143	405,612	1,651,825	161	66	1.81	30	124	6.06	27.5
2015	2,237	693	17,870	164,959	2,038,841	191	59	1.53	14	174	3.89	29.1
2016	3,704	1,403	33,662	412,583	2,492,823	183	70	1.67	20	123	9.16	38.6
2017	1,864	569	19,240	273,001	1,515,227	142	43	1.47	21	115	5.94	27.8
2018	2,309	746	19,523	306,631	1,865,496	173	56	1.47	23	140	6.04	30.8
2019	3,092	1,473	29,896	328,862	1,828,800	136	65	1.31	14	80	10.34	43.3
2020	1,382	404	11,772	167,236	1,298,661	150	44	1.28	18	141	4.18	25.9
2021	1,998	602	18,272	265,181	1,158,983	216	65	1.97	29	125	4.20	23.4
2022	1,281	256	10,247	227,213	863,836	241	48	1.93	43	163	2.41	22.7
Average	**2,273**	**853**	**20,994**	**298,401**	**1,634,944**	**175**	**61**	**1.59**	**24**	**132**	**5.99**	**29.8**
Change	**58%**	**40%**	**87%**	**17%**	**-**	**26%**	**5%**	**45%**	**6%**	**-**	**36%**	**11%**

Table 3.10 Unit area loads for TP, SRP, TN, TSS, and Cl^- at IP2

Industrial Park - Site 2					
	Load/Acre				
Year	TP (lbs/acre)	SRP (lbs/acre)	TN (lbs/acre)	TSS (lbs/acre)	Cl^- (lbs/acre)
2004	0.46	0.29	3.61	51	-
2005	0.48	0.22	3.51	93	-
2006	0.47	0.15	4.04	134	-
2008	0.33	0.07	2.45	49	-
2009	0.19	0.09	1.48	14	-
2012	0.58	0.25	5.53	105	-
2013	0.75	0.39	6.90	91	-
2014	0.58	0.24	6.48	109	443
2015	0.60	0.19	4.80	44	547
2016	0.99	0.38	9.04	111	669
2017	0.50	0.15	5.17	73	407
2018	0.62	0.20	5.24	82	501
2019	0.83	0.40	8.03	88	491
2020	0.37	0.11	3.16	45	349
2021	0.54	0.16	4.91	71	311
2022	0.34	0.07	2.75	61	232
Average	**0.54**	**0.21**	**4.82**	**76**	**439**

PC2

At PC2, data has been collected since 2001. In Table 3.11, the data is segmented to pre-2012 and 2012-present due to the implementation of BMP's upstream of site. Just prior to 2012, there were ponds installed along with a stream restoration upstream of the site. There has been a significant decrease in nutrient concentrations after 2012 with TSS showing the largest decrease of 71%. TP and SRP loading did not change after 2012, but TN increased 39% and TSS decreased 44%.

In 2022, a decrease in precipitation of 26% led to a flow reduction of 62% compared with the 2012-2022 averages. The annual correlation between precipitation and flow remains moderate with an r^2 of 0.56. The lake effect from Medicine Lake when lake levels are high makes it difficult to build a strong rating curve to compare with flow estimates. Manual flow measurements are still useful to confirm instantaneous flow measurements made by the installed Isco 2100 data logger.

The flow weighted average concentrations in 2022 increased slightly for TP and TN (15-20%) compared with 2012-present average. SRP and TSS were both lower by 31% and 46%. Chloride increased 21%. Low flows tend to concentrate chloride.

The lower flow volumes in 2022 led to lower loadings compared to average. Nutrient loadings were between 50% and 73% lower than 2012-present averages (Table 3.11). Chloride was 45% lower and TSS was 80% lower than 2012-present averages. The UALs for TP and TSS were both below MPCA estimates for residential land use (Table 3.12).

3.2.5. Trend Analysis

IP2 and PC2 each had data included since 2012. IP2 did not show any significant results from the Mann-Kendall test for load or concentration, indicating there is no change in trend. PC2 did have two significant results for concentration. Both SRP and TSS showed a significant change in trend. Each of these parameters have negative *tau* values, indicating concentrations have decreased since 2012. BMPs in the watershed, such as settling ponds, are working to reduce sediments.

Table 3.11. Loading and flow weighted concentrations for TP, SRP, TN, TSS, and Cl^- at PC2. The data is segmented based on the before and after of pond installation and stream stabilization. The percent change compares the average loadings and concentrations before and after 2012.

PC2 - Plymouth Creek Site 2												
	Nutrient Loading					Nutrient Concentration						
Year	**TP (lbs/yr)**	**SRP (lbs/yr)**	**TN (lbs/yr)**	**TSS (lbs/yr)**	**Cl^- (lbs/yr)**	**TP (µg/L)**	**SRP (µg/L)**	**TN (mg/L)**	**TSS (mg/L)**	**Cl^- (mg/L)**	**Flow Volume (x 10^6 m^3)**	**Annual Precipitation (inches)**
Pre-2012												
2001	1,484	534	7,416	95,455	-	236	85	1.20	15	-	2.92	34.6
2002	3,931	1,761	21,261	316,003	-	212	110	1.30	20	-	8.41	38.1
2003	2,274	1,125	11,040	208,858	-	216	107	1.05	20	-	4.76	25.8
2004	2,306	1,052	12,630	490,844	-	182	83	1.00	42	-	5.73	32.1
2005	1,327	783	10,761	421,668	-	161	95	1.30	51	-	3.14	32.6
2006	2,619	983	22,491	1,623,423	-	272	102	2.34	169	-	4.42	29.1
2007	3,157	1,244	23,625	1,319,995	-	275	108	2.06	115	-	5.22	31.1
2008	969	191	9,925	827,829	-	206	105	2.10	175	-	2.14	20.8
2009	496	222	4,834	121,726	-	131	59	1.28	32	-	1.71	19.6
2010	1,588	790	12,118	80,263	-	134	67	1.02	7	-	5.40	31.2
2011	2,737	851	30,284	468,328	-	148	46	1.64	25	-	8.37	26.3
Average	**2,081**	**867**	**15,126**	**543,127**	**-**	**198**	**88**	**1.48**	**61**	**-**	**4.75**	**29.2**
2012-present												
2012	2,049	740	19,555	273,588	-	149	54	1.42	20	-	6.25	26.7
2013	2,487	1,198	22,839	395,732	-	157	76	1.44	25	-	13.75	31.6
2014	2,920	1,602	35,271	686,184	3,482,178	125	59	1.29	25	127	12.42	27.5
2015	1,289	599	12,577	104,856	1,512,773	131	61	1.28	11	154	4.46	29.1
2016	3,846	1,899	35,957	494,863	2,472,477	147	73	1.37	19	95	11.88	38.6
2017	1,323	622	15,689	255,076	1,153,509	110	52	1.30	21	96	5.13	27.8
2018	2,296	827	23,727	331,692	1,901,731	145	52	1.50	21	120	7.18	30.8
2019	3,489	1,278	35,260	569,318	1,332,400	120	44	1.21	20	46	13.22	43.3
2020	1,165	465	11,860	137,478	1,466,676	111	44	1.13	13	139	4.77	25.9
2021	717	228	7,475	56,526	975,438	121	39	1.27	10	165	2.68	23.4
2022	1,039	258	10,908	66,938	977,169	151	38	1.59	10	142	3.12	22.7
Average	**2,056**	**883**	**21,004**	**306,511**	**1,759,255**	**133**	**54**	**1.34**	**18**	**120**	**7.71**	**29.8**
Change	**-1%**	**2%**	**39%**	**-44%**	**-**	**-33%**	**-39%**	**-9%**	**-71%**	**-**	**62%**	**2%**

Table 3.12. Unit area loads for TP, SRP, TN, TSS, and Cl^- at PC2.

Plymouth Creek Site 2 - PC2					
	Load/Acre				
Year	**TP (lbs/acre)**	**SRP (lbs/acre)**	**TN (lbs/acre)**	**TSS (lbs/acre)**	**Cl^- (lbs/acre)**
2001	0.23	0.08	1.16	15	-
2002	0.62	0.28	3.33	49	-
2003	0.36	0.18	1.73	33	-
2004	0.36	0.16	1.98	77	-
2005	0.21	0.12	1.68	66	-
2006	0.41	0.15	3.52	254	-
2007	0.49	0.19	3.70	207	-
2008	0.15	0.03	1.55	130	-
2009	0.08	0.03	0.76	19	-
2010	0.25	0.12	1.90	13	-
2011	0.43	0.13	4.74	73	-
2012	0.32	0.12	3.06	43	-
2013	0.39	0.19	3.57	62	-
2014	0.46	0.25	5.52	107	545
2015	0.20	0.09	1.96	16	324
2016	0.60	0.30	5.63	77	387
2017	0.21	0.10	2.46	40	181
2018	0.36	0.13	3.71	52	298
2019	0.55	0.20	5.52	89	209
2020	0.18	0.07	1.86	22	310
2021	0.11	0.04	1.17	9	153
2022	0.16	0.04	1.71	10	153
Average	**0.32**	**0.14**	**2.83**	**66**	**275**

Table 3.13. Mann Kendal trend analysis at IP2 and PC2.

	IP2		PC2	
	tau	**p-value**	***tau***	**p-value**
TP (lbs/yr)	-0.309	0.213	-0.345	0.161
TP (µg/L)	0.147	0.585	-0.236	0.350
SRP (lbs/yr)	-0.455	0.062	-0.382	0.119
SRP (µg/L)	-0.455	0.062	-0.697	**0.004**
TN (lbs/yr)	-0.382	0.119	-0.345	0.161
TN (mg/L)	-0.075	0.813	-0.164	0.533
TSS (lbs/yr)	-0.382	0.119	-0.345	0.161
TSS (mg/L)	0.073	0.815	-0.486	**0.050**

3.3. Bass Lake Watershed

The Bass Lake watershed is 3,105 acres and is located entirely within the City of Plymouth (Figure 3.17). Bass Lake was listed as impaired for excess nutrients in 2002 and a TMDL was completed in 2009 (Wenck, 2009). In 2017, a follow up report reviewed the progress toward meeting reductions in the TMDL report (Wenck, 2017). An alum treatment was subsequently completed in both Pomerleau Lake and Bass Lake in 2019.

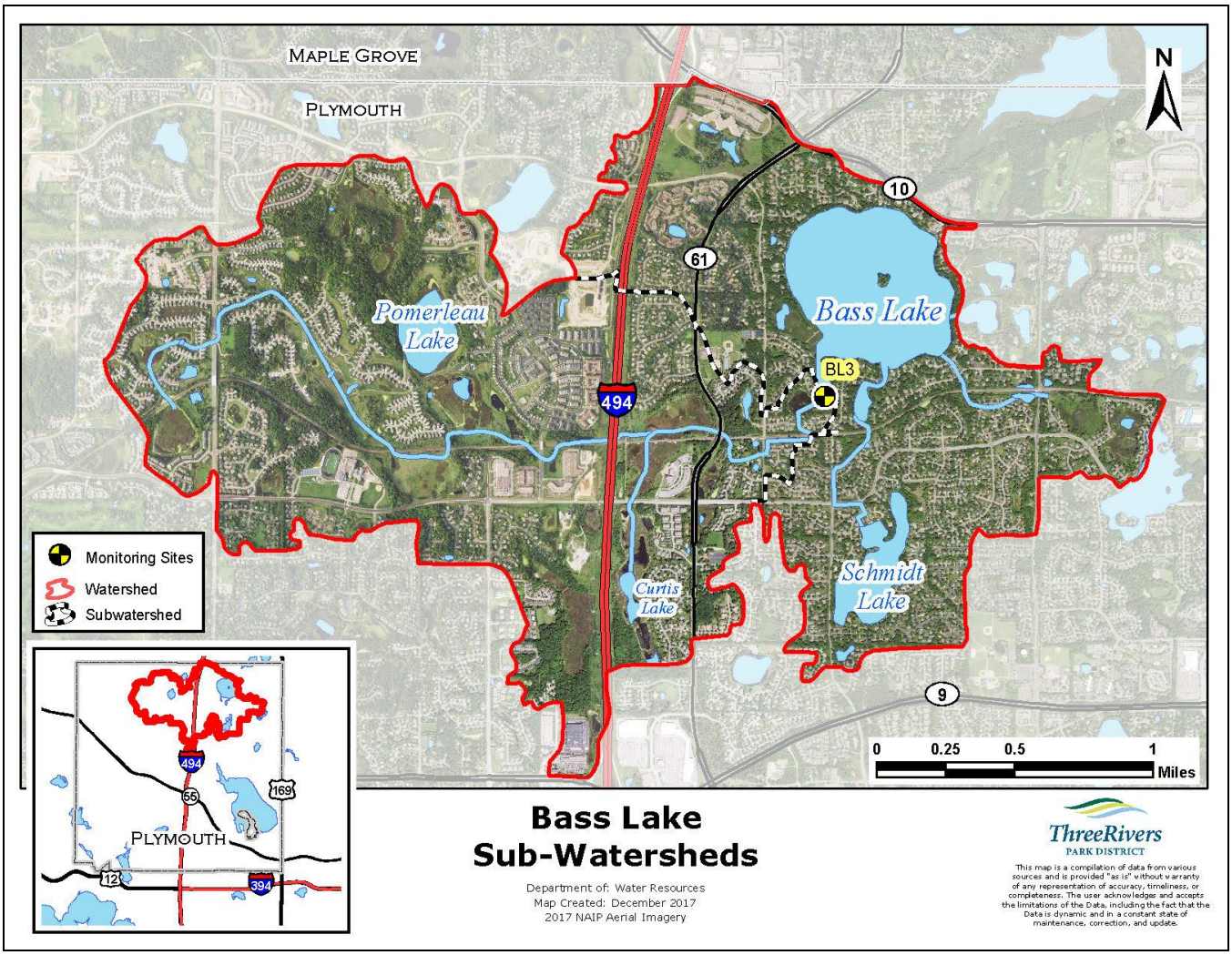


Figure 3.17. Bass Lake sub-watershed map.

3.3.1. Stormwater Monitoring Site

To assess nutrient inputs into Bass Lake, one site (BL3) which accounts for 59% of the Bass Lake watershed area, was monitored (Figure 3.17). BL3 is located east of 54th Ave N on Norwood Ln N. This site is just downstream of a 6.5 acre wetland pond that attenuates flow and allows settling of particulates. The pond outlet is two 24-inch culverts that convey water under a private driveway to Bass Lake. Water level and velocity are monitored in each culvert and flow estimates from each culvert are combined for nutrient analysis and total flow calculations.

Table 3.14. Summary of watershed characteristics for site BL3.

Site	Subwatershed Area (acres)	% Impervious (acres)1	% of Bass Lake Watershed	Dominant land uses2
BL3	1,846	28% (511 ac.)	59%	Residential

[1] % impervious area determined using the 2016 University of Minnesota TCMA 1-meter land cover classification GIS layer.
[2] Dominant Land Uses determined using GIS layer obtained from the City of Plymouth.

3.3.2. Hydrograph

The monitoring site has a delayed hydrologic response following storm events due to the upstream wetland pond (Figure 3.18). BL3 flows may not respond to rain events when there is excess storage capacity in the pond. A delayed hydrologic response produced the largest daily average flow (13.4 cfs) on 5/1/2022, four days after a 1.42-inch rain event started. The average flow rate for the season was 1.6 cfs and there were long periods with no flow starting mid-summer.

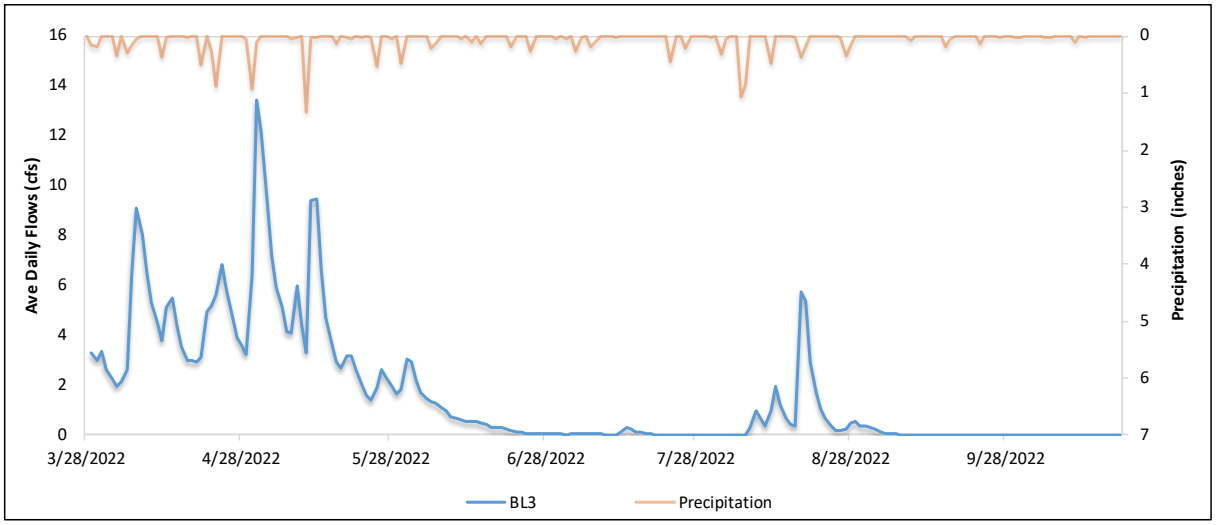


Figure 3.18. Average daily flow for BL3 in 2022.

3.3.3. Concentrations

Eleven grab samples were collected at BL3 in 2022. A summary of the sample results is in Table 3.15. The average SRP to TP ratio was 24%. Chloride was not monitored at BL3 this year.

Table 3.15 Summary of average, minimum, and maximum concentrations for TP, SRP, TN, and TSS at BL3 in 2022.

Site	Avg TP (min-max) µg/L	Avg SRP (min-max) µg/L	Avg TN (min-max) mg/L	Avg TSS (min-max) mg/L
BL3-W	200 (59 - 735)	46 (6 - 97)	1.8 (0.8 - 4.9)	4.9 (0.4 - 20.0)

3.3.4. Yearly Summary

At BL3, data has been collected continuously since 2015 (Table 3.17). There was a 45% decrease in flow volume due to below average precipitation in 2022. There remains a strong correlation between annual precipitation and flows with r^2 of 0.85.

Flow weighted concentrations in 2022 were considerably lower than average for TP (17%), TN (19%), and TSS (50%) compared to 2015-2022 sampling period. SRP was 39% above average. The below average flows resulted in less total loading for each parameter where SRP decreased 35%, TP and TN decreased 59%, and TSS decreased 79% compared to 2015-2022 sampling period. UALs also remained well below MPCA stormwater estimates (Table 3.17).

Table 3.16. Loading and flow weighted concentrations of TP, SRP, TN, and TSS at BL3

BL3 - Bass Lake Site 3										
	Nutrient Loading				Nutrient Concentration					
Year	TP (lbs/yr)	SRP (lbs/yr)	TN (lbs/yr)	TSS (lbs/yr)	TP (µg/L)	SRP (µg/L)	TN (mg/L)	TSS (mg/L)	Flow Volume (x 10^6 m^3)	Annual Precipitation (inches)
2015	1,079	396	9,546	40,986	172	63	1.52	6.5	2.84	29.1
2016	800	368	8,774	24,015	111	51	1.22	3.3	3.27	38.6
2017	316	121	4,739	17,210	69	26	1.04	3.8	1.04	27.8
2018	612	248	6,983	36,118	114	46	1.30	6.7	2.44	30.8
2019	668	317	9,824	29,408	73	34	1.07	3.2	4.18	43.3
2020	193	79	3,153	5,812	65	27	1.06	2.0	1.35	25.9
2021	200	49	2,819	6,528	77	19	1.08	2.5	1.18	23.4
2022	227	147	2,681	4,908	81	53	0.96	2.0	1.27	22.7
Average	**512**	**215**	**6,065**	**20,623**	**95**	**40**	**1.16**	**3.8**	**2.20**	**30.20**

Table 3.17. Unit area loading for TP, SRP, TN, and TSS at BL3

Year	Bass Lake - Site 3 Load/Acre TP (lbs/acre)	SRP (lbs/acre)	TN (lbs/acre)	TSS (lbs/acre)
2015	0.58	0.21	5.17	22
2016	0.43	0.20	4.75	13
2017	0.17	0.07	2.57	9
2018	0.33	0.13	3.78	20
2019	0.36	0.17	5.32	16
2020	0.10	0.04	1.71	3
2021	0.11	0.03	1.53	4
2022	0.12	0.08	1.45	2.66
Average	**0.28**	**0.12**	**3.29**	**11**

3.3.5. Trend Analysis

A Mann-Kendall trend analysis of BL3 load and concentration since 2015 had three significant results (Table 3.18). The Total Nitrogen loading trend has changed significantly during the monitoring period. There was also a significant change in TSS concentration and loading trends. The *tau* values were negative for each parameter tested, indicating concentration or load has decreased year to year more often than not.

Table 3.18. Mann-Kendall trend analysis results for BL3 (2012-2022).

2015-2022	BL3 *tau*	p-value
TP (lbs/yr)	-0.571	0.063
TP (µg/L)	-0.286	0.386
SRP (lbs/yr)	-0.571	0.063
SRP (µg/L)	-0.357	0.266
TN (lbs/yr)	-0.643	**0.035**
TN (mg/L)	-0.500	0.108
TSS (lbs/yr)	-0.643	**0.035**
TSS (mg/L)	-0.667	**0.033**

3.4. Gleason Lake Watershed

The Gleason Lake Watershed is 2,643 acres with 93% of the watershed located in the City of Plymouth (Figure 3.19). Gleason Lake is part of the Minnehaha Creek watershed. Gleason Lake was impaired for excess nutrients in 2010. The unnamed creek north of Gleason Lake where GC1 monitoring station is located was impaired for low dissolved oxygen in 2020. A TMDL was approved by EPA in 2014 for the upper Minnehaha Creek watershed for nutrient and bacteria impairment. In 2022, a tree removal project along the stream as well as a curb and gutter installation in the surrounding neighborhood were completed that may impact water quality at the site.

3.4.1. Stormwater Monitoring

The GC1 sampling site captures 67% of the watershed area (Table 3.19). This is an open channel site located off of the bike path that connects County Road 6 and Black Oaks Lane N.

Table 3.19. Summary of watershed characteristics for site GC-1

Site	Subwatershed Area (acres)	% impervious (acres)[1]	% of Gleason Lake Watershed	Dominant land uses[2]
GC-1	1,650	28% (454 ac.)	67%	Residential

[1] % impervious area determined using the 2016 University of Minnesota TCMA 1-meter land cover classification GIS layer.
[2] Dominant Land Uses determined using GIS layer obtained from the City of Plymouth.

3.4.2. Hydrograph

The hydrograph for GC-1 corresponds with precipitation but has a delayed hydrologic response following storm events that persists for several days (Figure 3.20). A peak daily average flow of 7.3 cfs occurred on 5/1/2022 following a 2-day 1.2-inch rain event. In 2022, the mean daily average flow was 0.8 cfs. There were significant periods of no flow during periods of drought condition. The majority of flow this year occurred between March and May.

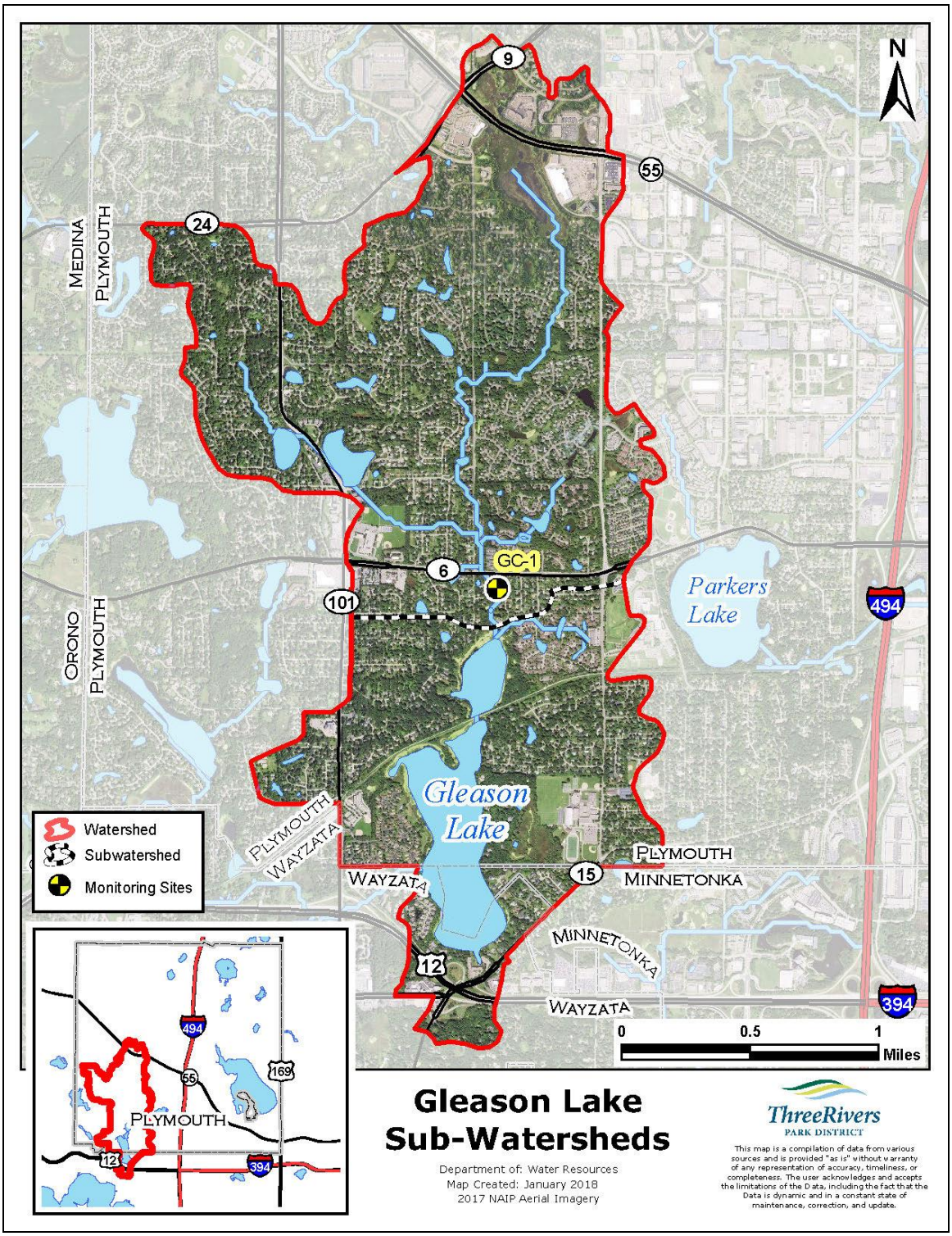


Figure 3.19. Gleason Creek sub-watershed map

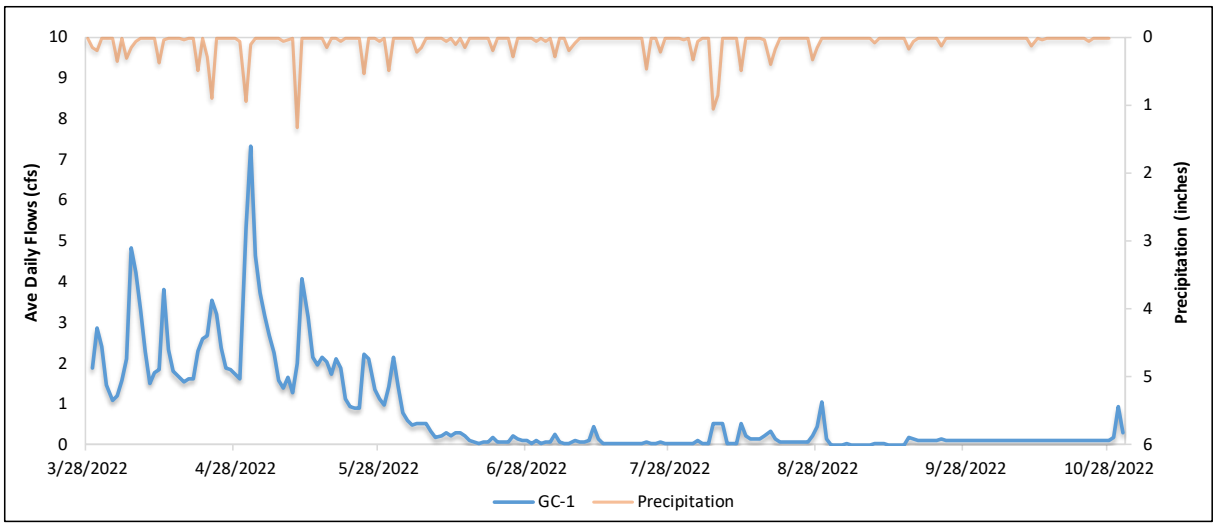


Figure 3.20. Average daily flow at GC-1.

3.4.3. Concentrations

Fourteen samples were collected in 2022 with half of the sample collected as grabs and half as composites. Nine of the 14 samples were collected before June. Due to drought conditions, no samples were collected after August. On average, the soluble reactive fraction of total phosphorus was 32%. There was one sample, on 5/16/2022, that exceeded chronic chloride standard of 230 mg/L by 2 mg/L. Along with one exceedance in 2021, there have now been two exceedances in the past three years. Chloride concentrations were highest in the spring. Sample concentrations are summarized in Table 3.20.

Table 3.20. Summary of average, minimum, and maximum concentrations for TP, SRP, TN, TSS, and Cl^- at GC-1 in 2022.

Site	Avg TP (min-max) µg/L	Avg SRP (min-max) µg/L	Avg TN (min-max) mg/L	Avg TSS (min-max) mg/L	Avg Cl^- (min-max) mg/L
GC-1	197 (90 - 365)	64 (10 - 114)	1.7 (1.0 - 3.4)	16.9 (2.6 - 59.0)	128 (8 - 232)

3.4.4. Yearly Summary

Three Rivers Park District from has monitored GC-1 from 2017-2022. Prior to that, Minnehaha Creek Watershed District (MCWD) monitored this site from 2005-2016 with no monitoring in 2006 (Table 3.21). If comparing results between these agencies, it is important to understand the differences in monitoring methodology. TRPD estimates annual loading and flows based on percentage of annual precipitation occurring within the sampling season. MCWD only reports loading and flow occurring within the sampling season. Therefore, total reported loadings are

not directly comparable. Additionally, TRPD collected storm event composite samples along with routine grab samples, whereas MCWD only collected routine grab samples. The difference in strategy likely caused TRPD to include more data points with higher concentrations because storm events tend to wash more nutrients off the landscape and cause erosion. Care should be taken if comparing flow weighted concentrations. The following section does not compare data collected between agencies.

In 2022, flow volumes were 50% below the 2017-2021 average due to the drought conditions. The correlation of precipitation and flow at this site from 2017 to present remained high with an r^2 of 0.96.

Due to low flows, overall loading of monitored parameters in 2022 were down between 46-84% compared to 2017-2021 averages (Table 3.21), with the exception of chloride which increased by 43%. Flow weighted concentrations decreased by 10% for TN, 11% for TP, and 73% for TSS compared to 2017-2021 averages. The only two concentrations that increased were Chloride (133%) and SRP (13%). The Average unit area loads were at or below MPCA Stormwater manual UALs for TP and TSS (Table 3.22).

Table 3.21. Loading and flow weighted concentrations of TP, SRP, TN, TSS, and Cl^- at GC-1.

GC-1 - Gleason Lake Sub watershed												
	Nutrient Loading					Nutrient Concentration						
Year	TP (lbs)	SRP (lbs)	TN (lbs)	TSS (lbs)	Cl^- (lbs)	TP (µg/L)	SRP (µg/L)	TN (mg/L)	TSS (mg/L)	Cl^- (mg/L)	Flow Volume (x 10^6 m^3)	Annual Precipitation (inches)
2005-2016												
2005*	156	34	1,031	15,376	-	197	42	1.30	19	-	0.77	32.6
2007*	456	72	2,621	39,107	-	228	36	1.31	17	-	1.64	31.1
2008*	75	15	854	10,337	-	123	24	1.39	17	-	0.58	20.8
2009*	35	7	283	2,487	-	129	26	1.03	9	-	0.23	19.6
2010*	232	100	2,095	7,377	-	123	53	1.12	4	-	1.46	31.2
2011*	387	133	3,537	43,103	-	143	49	1.31	16	-	2.10	26.3
2012*	214	75	1,004	14,450	-	149	52	0.70	10	-	1.58	26.7
2013*	583	297	1,691	28,555	-	194	99	0.56	10	-	2.84	31.6
2014*	576	308	4,978	15,477	-	147	79	1.27	4	-	3.59	27.5
2015*	331	137	1,648	25,900	-	161	67	0.80	13	-	1.51	29.1
2016*	266	104	1,914	11,035	-	143	56	1.03	6	-	1.24	38.6
Average	**301**	**117**	**1,969**	**19,382**	**-**	**158**	**53**	**1.08**	**11**	**-**	**1.59**	**28.6**
2017-present												
2017	479	85	4,194	120,809	-	211	37	1.85	53	-	0.97	27.8
2018	498	150	3,812	194,593	-	216	65	1.66	85	-	1.04	30.8
2019	1,008	364	8,578	233,617	191,710	160	58	1.36	37	30	2.85	43.3
2020	247	68	2,821	83,197	189,118	134	37	1.53	45	102	0.84	25.9
2021	366	66	2,858	107,268	86,870	309	56	2.42	91	73	0.54	23.4
2022	256	79	2,205	23,430	222,815	184	57	1.59	17	160	0.63	22.7
Average	**476**	**135**	**4,078**	**127,152**	**172,628**	**202**	**52**	**1.73**	**55**	**92**	**1.15**	**29.0**

* Data collected by Minnehaha Creek Watershed District (MCWD)[1].

Table 3.22. Loading per acre for TP, SRP, TN, TSS, and Cl^- at GC-1.

GC-1 Load/Acre					
Year	TP (lbs/acre)	SRP (lbs/acre)	TN (lbs/acre)	TSS (lbs/acre)	Cl^- (lbs/acre
2017	0.29	0.05	2.54	73	-
2018	0.30	0.09	2.31	118	-
2019	0.61	0.22	5.20	142	116
2020	0.15	0.04	1.71	50	115
2021	0.22	0.04	1.73	65	53
2022	0.16	0.05	1.34	14	135
Average	**0.29**	**0.08**	**2.47**	**77**	**105**

[1] MCWD Disclaimer: The data to which this notice is attached are made available pursuant to the Minnesota Government Data Practices Act (Minnesota Statutes Chapter 13). THE DATA ARE PROVIDED TO YOU AS IS AND WITHOUT ANY WARRANTY AS TO THEIR PERFORMANCE, MERCHANTABILITY, OR FITNESS FOR ANY PARTICULAR PURPOSE. These data were developed by the Minnehaha Creek Watershed District for its own business purposes. The Minnehaha Creek Watershed District (MCWD) makes every effort to assure that the data and the associated documentation are error-free, complete, current, and accurate; however, the Minnehaha Creek Watershed District does not guarantee this. The Minnehaha Creek Watershed District is NOT responsible for any consequences resulting from your use of the data. You should consult the available online documentation or contact the staff contact listed in the MCWD's website to determine the limitations of the data. If you transmit or provide the data (or any portion of it) to another user, the data must include a copy of this disclaimer.

3.4.5. Trend Analysis

No significant results were found from the Mann-Kendall trend analysis at GC-1 for years 2017-2022 (Table 3.23). Even though all *tau* values are negative, we cannot say there are significant changes in water quality at GC-1 based on our data.

Table 3.23. Mann Kendal trend analysis at GC-1 (2017-2022).

	GC-1	
2017-2022	***tau***	**p-value**
TP (lbs/yr)	-0.333	0.452
TP (µg/L)	-0.067	1.000
SRP (lbs/yr)	-0.333	0.452
SRP (µg/L)	-0.067	1.000
TN (lbs/yr)	-0.600	0.133
TN (mg/L)	-0.067	1.000
TSS (lbs/yr)	-0.467	0.260
TSS (mg/L)	-0.200	0.707

3.5. Elm Creek Watershed

A portion of Elm Creek runs through the northwest corner of the City of Plymouth (Figure 3.21). The upper reaches of Elm Creek watershed have seen a significant amount of development over recent years, particularly in Medina and the City of Plymouth.

Elm Creek was listed as impaired in 2010 for high levels of *E. coli*. In 2014 it was listed as impaired for high chloride and low dissolved oxygen. In addition to the creek, several lakes within its watershed are impaired for excess nutrients. A TMDL was approved by EPA in 2017 for the Elm Creek Watershed (TRPD, 2016).

There have been several BMPs and infrastructure changes implemented in the watershed.

- Stream restoration and retention pond downstream of Hamel in 2015
- Stream restoration and retention pond with iron enhanced benches above Peony in 2016
- Stream restoration and passive iron enhanced filter installed above Wayzata High School in 2019
- Chankahda Trail street reconstruction and stormwater pond installation in 2022 above ECER

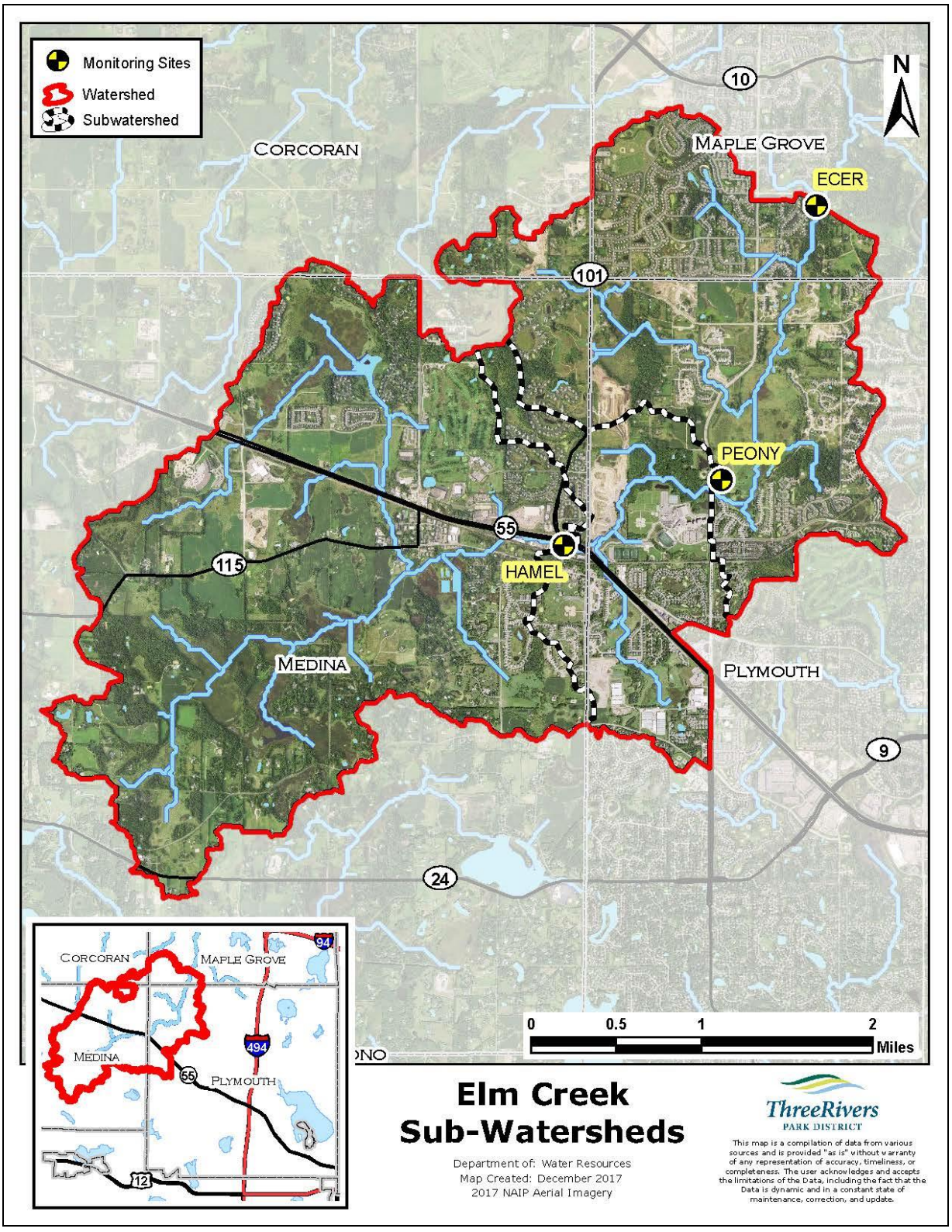


Figure 3.21. Elm Creek sub-watershed map.

3.5.1. Stormwater Monitoring Sites

To assess Elm Creek nutrients and chloride that flow through the City of Plymouth, three sites were monitored. Hamel is the most upstream site in the watershed and is located at the intersection of Hamel Road and Hwy 55. This site monitors Elm Creek prior to it reaching the City of Plymouth. The site is monitored within an eight-feet wide by four-feet high concrete box culvert. Peony is the next site downstream and is located mid-way through City of Plymouth near Wayzata High School along Peony Ln N. This site is monitored within a box culvert with the same dimensions as Hamel. The furthest downstream site, ECER, monitors Elm Creek as it leaves Plymouth and enters Maple Grove near Elm Road. This is an open channel site just downstream of a 210-acre wetland complex that attenuates flow and filters nutrients and sediment. Watershed characteristics of these sites, including watershed size and percent located within City of Plymouth can be found in Table 3.24.

Table 3.24. Summary of Elm Creek watershed characteristics for sites Hamel and ECER.

Site	Subwatershed Area (acres)	% Impervious (acres)[1]	% of Total Watershed in Plymouth
Hamel	4,272	12% (506 ac.)	0%
Peony	5,429	15% (811 ac.)	17%
ECER	7,921	18% (1,414 ac.)	29%

[1] % impervious area determined using the 2016 University of Minnesota TCMA 1-meter land cover classification GIS layer

3.5.2. Hydrograph

The cumulative flow volume increases downstream with watershed size at each monitoring station. There is a delayed hydraulic response at ECER after precipitation events due to flood plain and wetland storage capacity (Figure 3.22). Average daily flow rate in 2022 increased from Hamel (3.3 cfs) to Peony (3.5 cfs) to ECER (6.7 cfs). Hamel and Peony had their peak daily flow rate on 5/12/22 of 22 cfs and 30 cfs following a 0.92-inch rain event. ECER peak daily flow rate occurred on 5/1/22 with 54 cfs following a 1.3-inch rain event.

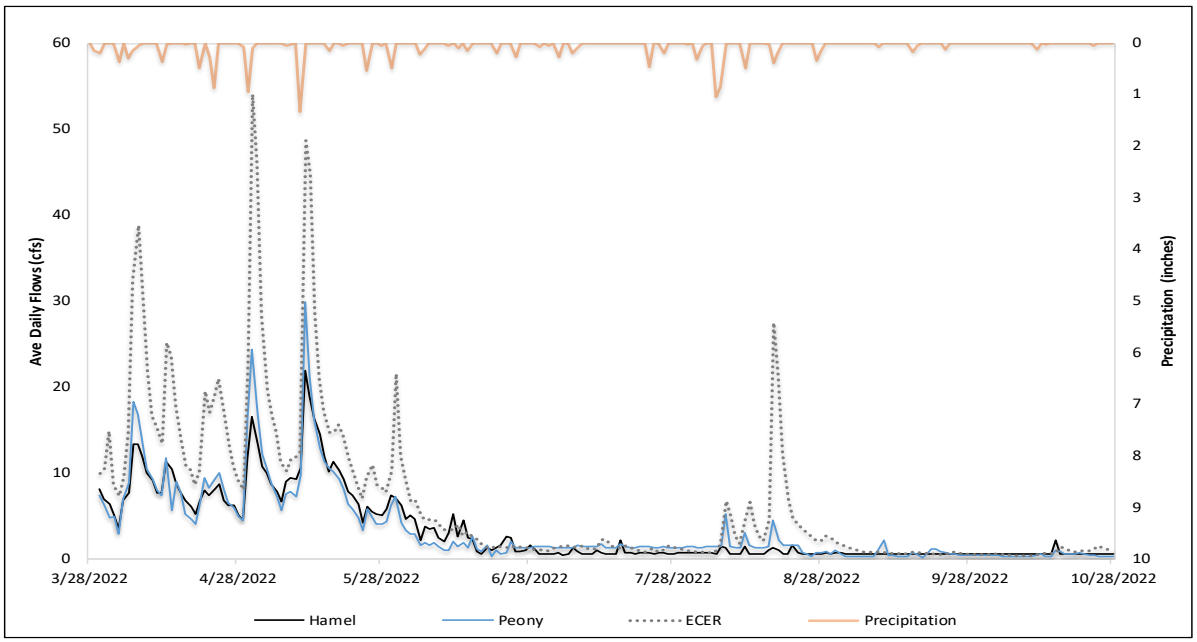


Figure 3.22. Average daily flow for Elm Creek watershed sites Hamel, Peony, and ECER in 2022.

3.5.3. Concentrations

Hamel and Peony each had 17 total samples collected in 2022. Included in those samples, Hamel had four composite samples and Peony had three composite samples. ECER had 21 total samples with six of them being composite samples. Hamel exceeded the 230 mg/L chloride standard five times this year compared to two times last year. Peony has yet to have a chloride exceedance in the two years chloride has been monitored there. ECER had its first exceedance on record on 4/20/22. Ratios of SRP to TP was 25% at Hamel, 48% at Peony, and 47% at ECER. The range of nutrient concentrations are reported in Table 3.25 and Figure 3.23. A history of monthly maximum chloride samples is reported in Figure 3.24.

Table 3.25. Summary of average, minimum, and maximum concentrations for TP, SRP, TN, TSS, and Cl^- at Hamel, Peony, and ECER in 2022.

Site	Avg TP (min-max) µg/L	Avg SRP (min-max) µg/L	Avg TN (min-max) mg/L	Avg TSS (min-max) mg/L	Avg Cl^- (min-max) mg/L
HAMEL	207 (116 - 382)	52 (8 - 130)	1.9 (0.9 - 4.4)	19.2 (1.1 - 199.3)	173 (68 - 448)
PEONY	388 (136 - 706)	187 (79 - 423)	1.7 (0.2 - 4.7)	46.1 (3.3 - 450.0)	86 (60 - 148)
ECER	310 (98 - 610)	146 (48 - 265)	1.6 (0.9 - 4.9)	22.8 (1.9 - 180.6)	112 (32 - 512)

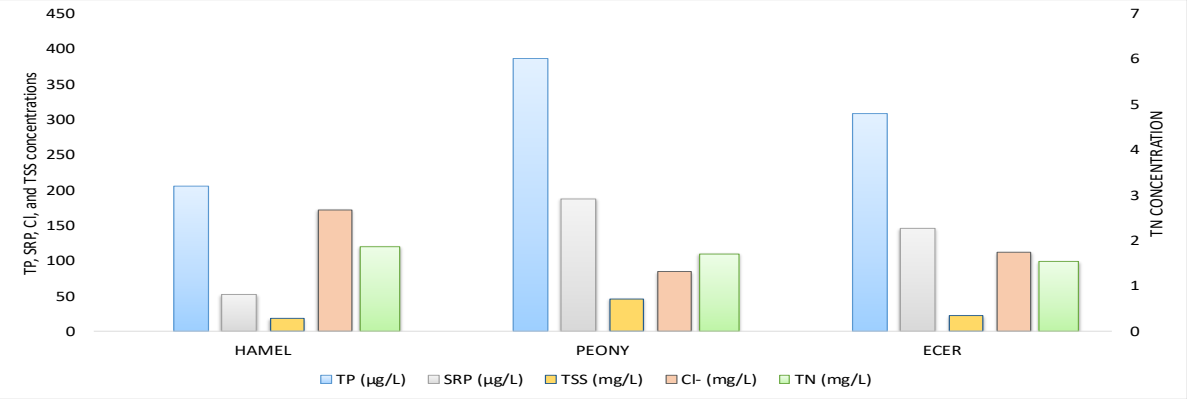


Figure 3.23. Average concentrations of TP, SRP, TSS, Cl^-, and TN for the Elm Creek Watershed sites including Hamel, Peony, and ECER in 2022.

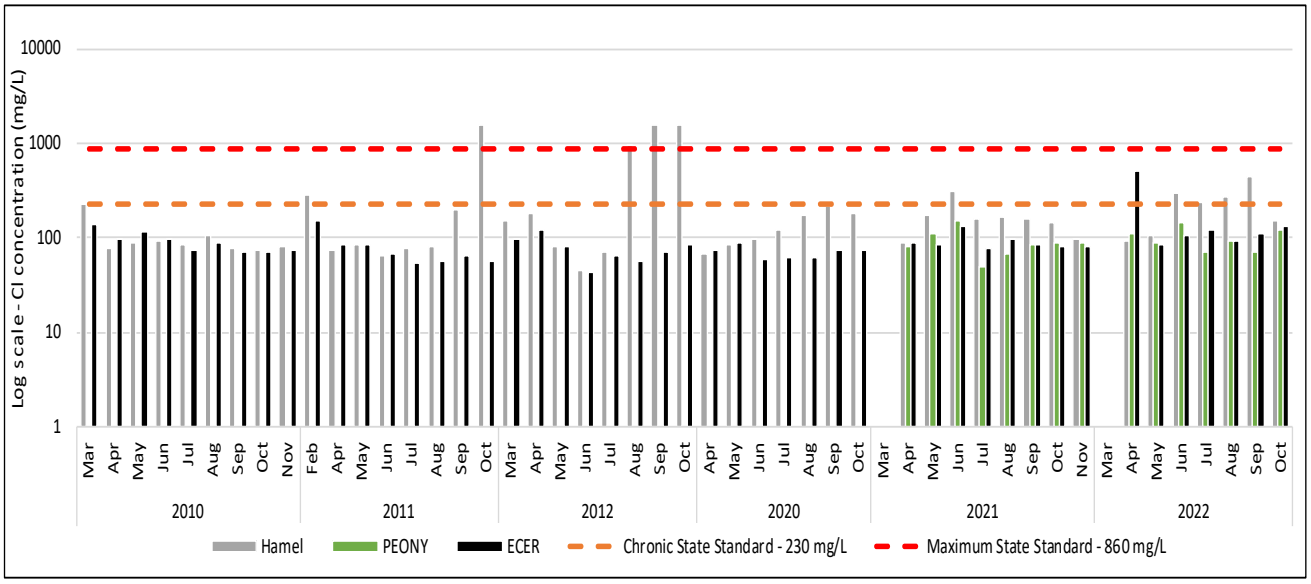


Figure 3.24. Log scale of maximum monthly chloride concentration at Hamel, Peony, and ECER versus the MPCA chloride standard and maximum standard. When standard is exceeded, there may be more than 1 exceedance in that month.

3.5.4. Yearly Summary

In general, flow weighted nutrient concentrations and sediment loading increase between Hamel and ECER since there is two times as much flow at ECER. The Hamel site provides baseline flow and nutrient loading conditions as Elm Creek leaves Medina and enters Plymouth. The ECER site represents flow and nutrient loading as Elm Creek leaves Plymouth and enters Maple Grove.

Hamel

At Hamel, data has been collected since 2000 except for 2004-2006 and 2013-2015 (Table 3.26). Because monitoring began at the downstream Peony site in 2016, Hamel data is segmented to 2000-2012 and 2016-present so that averages between Hamel and Peony are comparable.

Flow volumes decreased 45% in 2022 compared to the2016-2021 average due to drought conditions. There is still an excellent correlation between annual precipitation and stream flow of $r^2 = 0.95$.

The flow weighted concentrations compared to 2016-2021 decreased for TN (-7%), TP (-17%), SRP (-25%), and TSS (-56%). Chloride increased by 10% but was still less than in 2021. With lower flows and concentrations, 2022 annual loading was also down 52% to 77%, except for chloride which was up 29% (Table 3.26). The UALs for TP were lower than MPCA estimates for residential land use (Table 3.27). While 2022 UAL for TSS was lower than MPCA estimates for residential land use, the average UAL for TSS since monitoring began is still greater than MPCA estimates. This was only the second year out of the past seven for TSS to be lower than MPCA estimates (Table 3.27).

Hamel has seen development in the watershed over recent years, which may in part explain the decrease in nutrient concentrations and increase in loading between 2000-2012 and 2016-2022. This is a sign of increased impervious surface area in the watershed.

Table 3.26. Loading and flow weighted concentrations of TP, SRP, TN, TSS, and Cl^- at Hamel.

Hamel												
	Nutrient Loading					Nutrient Concentration						
Year	TP (lbs/yr)	SRP (lbs/yr)	TN (lbs/yr)	TSS (lbs/yr	Cl^- (lbs/yr)	TP (µg/L)	SRP (µg/L)	TN (mg/L)	TSS (mg/L)	Cl^- (mg/L)	Flow Volume (x 10^6 m^3)	Annual Precipitation (inches)
2000-2012												
2000	195	73	1,288	32,551	-	304	113	2.00	54	-	0.31	32.3
2001	1,164	533	5,922	39,637	-	354	162	1.80	12	-	1.97	34.6
2002	5,967	2,769	30,496	771,083	-	378	175	1.90	49	-	7.14	38.1
2003	1,233	703	9,442	141,995	-	234	133	1.80	27	-	2.39	25.8
2007	308	171	4,268	155,002	-	158	88	2.19	98	-	0.88	31.1
2008	798	261	7,111	246,323	-	208	68	1.85	76	-	3.22	20.8
2009	280	122	3,425	40,295	-	187	82	2.29	30	-	0.68	19.6
2010	2,157	721	9,810	166,074	538,727	331	111	1.51	25	73	2.95	31.2
2011	4,021	1,004	36,604	365,365	698,750	301	75	2.74	27	100	6.07	26.3
2012	2,459	853	20,583	645,515	-	349	121	2.92	92	-	3.20	26.7
Average	**1,858**	**721**	**12,895**	**260,384**	**618,739**	**280**	**113**	**2.10**	**49**	**87**	**2.88**	**28.6**
2016 – present												
2016	7,803	1,877	50,003	1,377,750	-	435	103	2.74	76	-	8.13	38.6
2017	1,601	475	16,871	670,208	-	214	64	2.25	90	-	3.19	27.8
2018	2,497	935	19,250	543,975	-	247	93	1.91	54	-	4.58	30.8
2019	4,981	1,395	40,569	1,324,682	-	242	68	1.97	64	-	9.35	43.3
2020	358	166	6,257	85,089	299,959	81	38	1.42	19	68	2.01	25.9
2021	1,596	324	11,993	493,267	704,687	289	59	2.17	89	128	2.50	23.4
2022	1,259	316	11,611	172,646	649,503	209	53	1.93	29	108	2.73	22.7
Average	**2,871**	**784**	**22,365**	**666,802**	**551,383**	**245**	**68**	**2**	**60**	**101**	**4.64**	**30.36**
Change	**54%**	**9%**	**73%**	**156%**	**-11%**	**-12%**	**-40%**	**-2%**	**23%**	**17%**	**61%**	**6%**

Table 3.27. Hamel unit area loading for TP, SRP, TN, TSS, and Cl^-.

Hamel					
	Load/Acre				
Year	TP (lbs/acre)	SRP (lbs/acre)	TN (lbs/acre)	TSS (lbs/acre)	Cl^- (lbs/acre)
2000	0.05	0.02	0.30	8	-
2001	0.27	0.12	1.39	9	-
2002	1.40	0.65	7.14	180	-
2003	0.29	0.16	2.21	33	-
2007	0.07	0.04	1.00	36	-
2008	0.19	0.06	1.66	58	-
2009	0.07	0.03	0.80	9	-
2010	0.50	0.17	2.30	39	126
2011	0.94	0.24	8.57	86	-
2012	0.58	0.20	4.82	151	164
2016	1.83	0.44	11.7	323	-
2017	0.37	0.11	3.95	157	-
2018	0.58	0.22	4.51	127	-
2019	1.17	0.33	9.50	310	-
2020	0.08	0.04	1.46	20	70
2021	0.37	0.08	2.81	115	165
2022	0.29	0.07	2.72	40	152
Average	**0.53**	**0.17**	**3.93**	**100**	**135**

Peony

At Peony, data has been collected since 2016 (Table 3.28). Data was not collected in 2020 due to construction in and around the stream. The monitoring location moved from an open stream location to the road crossing at Peony after the construction project in 2021.

Precipitation in 2022 was 28% below the 2016-2021 average leading to a reduction of flow of 58%. The correlation between annual precipitation and flow is very strong from 2016-2022 (r^2 = 0.94).

The flow weighted average nutrient concentrations in 2022 were slightly lower for TP, SRP, and TN (Table 3.28). TSS concentrations were down by 73%. Loading decreased substantially in 2022 due to low flows and lower than average concentrations. TP, SRP, and TN were all 60-65% lower than average. TSS loading was 89% lower than the average since monitoring began in 2016.

The UAL was assessed as a whole watershed and as a subsection of the watershed minus the upstream site's area and load using the formula:

$$\frac{(\boldsymbol{Peony\ load - Hamel\ load})}{(\boldsymbol{Peony\ acres - Hamel\ acres})}$$

UAL estimates at Peony increased substantially for most parameters after subtracting the portion of the watershed above Hamel, with the exception of two parameters (Table 3.29). There was a small decrease in TN UAL from Hamel to Peony. There was a large decrease in UAL for Chloride from Hamel to Peony. An increase in UAL for TP and TSS suggests that most of the loading is downstream of Hamel.

Table 3.28. Loading and flow weighted concentrations of TP, SRP, TN, and TSS at Peony.

	Peony											
	Nutrient Loading					Nutrient Concentration						
Year	**TP (lbs/yr)**	**SRP (lbs/yr)**	**TN (lbs/yr)**	**TSS (lbs/yr**	**Cl^- (lbs/yr)**	**TP (µg/L)**	**SRP (µg/L)**	**TN (mg/L)**	**TSS (mg/L)**	**Cl^- (mg/L)**	**Flow Volume (x 10^6 m^3)**	**Annual Precipitation (inches)**
	2016-present											
2016	11,470	2,575	54,362	4,284,931	-	643	144	3.05	240	-	8.08	31.2
2017	3,734	1,549	22,516	5,139,148	-	317	127	1.85	422	-	5.19	27.8
2018	5,161	1,659	28,147	5,167,027	-	453	146	2.47	453	-	5.17	30.8
2019	9,627	3,463	67,505	6,016,665	-	355	128	2.49	222	-	12.29	43.3
2021	2,381	746	11,661	458,109	358,986	391	123	1.92	75	59	2.76	23.4
2022	2,403	765	12,943	479,044	526,831	387	123	2.08	77	85	2.82	22.7
Average	**5,796**	**1,793**	**32,856**	**3,590,821**	**442,908**	**424**	**132**	**2**	**248**	**72**	**6.05**	**29.9**

Table 3.29. Unit area loads for TP, SRP, TN, and TSS at Peony along with unit area loads at Peony adjusted for Hamel loading.

Year	Peony Load/Acre					Peony adjusted for Hamel loading Load/Acre				
	TP (lbs/acre)	SRP (lbs/acre)	TN (lbs/acre)	TSS (lbs/acre)	Cl (lbs/acre)	TP (lbs/acre)	SRP (lbs/acre)	TN (lbs/acre)	TSS (lbs/acre)	Cl (lbs/acre)
2016	2.11	0.47	10.01	789	-	3.17	0.60	3.77	2,513	-
2017	0.69	0.29	4.15	947	-	1.84	0.93	4.88	3,863	-
2018	0.95	0.31	5.18	952	-	2.30	0.63	7.69	3,996	-
2019	1.77	0.64	12.43	1,108	-	4.02	1.79	23.3	4,055	-
2021	0.44	0.14	2.15	84	66	0.68	0.36	-0.29	-30	-299
2022	0.44	0.14	2.38	88	97	0.99	0.39	1.15	265	-106
Average	**1.07**	**0.33**	**6.05**	**661**	**82**	**2.17**	**0.78**	**6.75**	**2443**	**-202**

ECER

At ECER, data has been collected since 2000 except for 2004-2006 and 2013-2015 (

Table 3.30). The data is segmented to 2000-2012 and 2016-2022.

The drought conditions and below average precipitation in 2022 resulted in a 42% reduction in flow volume. There is a very good correlation ($r^2 = 0.90$) between annual precipitation and flow since 2016.

Flow weighted concentrations in 2022 increased slightly for TP (7%) and SRP (14%). Both TN and TSS decreased by 14% and 77% compared to average. The significant TSS reduction in flow weighted concentration in 2022 compared to 2021 was due to above average concentrations in 2021 due to construction activities in the area.

Despite these changes in flow weighted concentrations, there was a noticeable decrease in loading for all parameters due to the drought conditions. The decrease in flow volume led to between 35% and 50% less TP, SRP, and TN loads compared to average since 2016. TSS was 83% lower.

The average UAL versus MPCA Stormwater manual UAL is reported in Table 3.31. The UAL was assessed as a whole watershed and as the subsection of the watershed minus the upstream site's area and load using the formula:

$$\frac{(\boldsymbol{ECER\ load - Peony\ load})}{(\boldsymbol{ECER\ acres - \ Peony\ acres})}$$

The TP average UAL was negative 0.31 lbs/acre after adjusting for the Peony fraction of the watershed. TSS is also averaging a negative 995 lbs/acre. The large wetland complex between

Peony and ECER is likely contributing to the reduction in UALs between sites. It should allow sediments to settle and act as phosphorus sink.

Table 3.30. Loading and flow weighted concentrations of TP, SRP, TN, TSS, and Cl^- at ECER.

ECER - Elm Creek @ Elm Road												
	Nutrient Loading					Nutrient Concentration						
Year	**TP (lbs/yr)**	**SRP (lbs/yr)**	**TN (lbs/yr)**	**TSS (lbs/yr)**	**Cl^- (lbs/yr)**	**TP (µg/L)**	**SRP (µg/L)**	**TN (mg/L)**	**TSS (mg/L)**	**Cl^- (mg/L)**	**Flow Volume (x 106 M3)**	**Annual Precipitation (inches)**
2000-2012												
2000	869	261	6,415	104,191	-	232	70	1.70	28	-	1.62	32.3
2001	4,408	1,946	26,544	342,708	-	289	131	1.80	23	-	5.37	34.6
2002	7,994	2,911	30,541	838,460	-	416	151	1.60	44	-	8.72	38.1
2003	2,218	968	12,840	215,520	-	263	115	1.50	26	-	3.82	25.8
2007	659	583	8,238	390,206	-	227	201	2.84	134	-	2.29	31.1
2008	941	576	8,744	473,456	-	261	160	2.43	131	-	2.25	20.8
2009	654	372	4,539	65,183	-	232	132	1.61	23	-	1.42	19.6
2010	3,601	2,063	19,074	728,546	814,569	381	218	2.02	77	65	5.19	31.2
2011	5,615	2,753	18,313	147,238	1,410,158	287	141	1.98	16	64	9.81	26.3
2012	2,784	1,890	22,641	284,335	-	209	142	1.70	21	-	7.08	26.7
Average	**2,974**	**1,432**	**15,789**	**358,984**	**1,112,364**	**280**	**146**	**1.92**	**52**	**65**	**4.76**	**28.6**
2016 - present												
2016	8,214	2,731	54,385	1,198,469	-	333	111	2.20	49	-	11.47	38.6
2017	3,281	1,889	26,705	460,503	-	184	106	1.50	26	-	7.60	27.8
2018	6,388	2,907	43,845	2,341,010	-	276	126	1.90	101	-	10.48	30.8
2019	6,734	3,715	46,806	493,109	-	171	94	1.19	13	-	17.86	43.3
2020	1,852	734	11,746	528,096	612,321	205	81	1.30	58	68	4.10	25.9
2021	2,540	996	17,212	1,976,906	752,711	261	102	1.77	203	77	4.42	23.4
2022	3,034	1,401	16,864	197,433	1,140,477	254	118	1.41	17	96	5.41	22.7
Average	**4,578**	**2,053**	**31,080**	**1,027,932**	**835,503**	**241**	**105**	**2**	**67**	**80**	**8.76**	**30.4**
Change	**54%**	**43%**	**97%**	**186%**	**-25%**	**-14%**	**-28%**	**-16%**	**27%**	**25%**	**84%**	**6%**

Table 3.31. Unit area loads for TP, SRP, TN, TSS, and Cl^- at ECER and UALs for ECER adjusted for Peony loading.

	ECER Load/Acre					ECER adjusted for Peony loading Load/Acre				
Year	**TP (lbs/acre)**	**SRP (lbs/acre)**	**TN (lbs/acre)**	**TSS (lbs/acre)**	**Cl^- (lbs/acre)**	**TP (lbs/acre)**	**SRP (lbs/acre)**	**TN (lbs/acre)**	**TSS (lbs/acre)**	**Cl^- (lbs/acre)**
2000	0.11	0.03	0.81	13	-	-	-	-	-	-
2001	0.56	0.25	3.35	43	-	-	-	-	-	-
2002	1.01	0.37	3.86	106	-	-	-	-	-	-
2003	0.28	0.12	1.62	27	-	-	-	-	-	-
2007	0.08	0.07	1.04	49	-	-	-	-	-	-
2008	0.12	0.07	1.10	60	-	-	-	-	-	-
2009	0.08	0.05	0.57	8	-	-	-	-	-	-
2010	0.45	0.26	2.41	92	103	-	-	-	-	-
2011	0.71	0.35	2.31	19	178	-	-	-	-	-
2012	0.35	0.24	2.86	36	-	-	-	-	-	-
2016	1.04	0.34	6.87	151	-	-1.31	0.06	0.01	-1,239	-
2017	0.41	0.24	3.37	58	-	-0.18	0.14	1.68	-1,877	-
2018	0.81	0.37	5.54	296	-	0.49	0.50	6.30	-1,134	-
2019	0.85	0.47	5.91	62	-	-1.16	0.10	-8.31	-2,217	-
2020	0.23	0.09	1.48	67	77	-	-	-	-	-
2021	0.32	0.13	2.17	250	95	0.06	0.10	2.23	609	158
2021	0.38	0.18	2.13	25	144	0.25	0.26	1.57	-113	246
Average	**0.46**	**0.21**	**2.79**	**80**	**119**	**-0.31**	**0.19**	**0.58**	**-995**	**202**

3.5.5. Trend Analysis

A Mann-Kendal analysis was performed on each Elm Creek site individually using data from 2016 to 2022 (Table 3.28). There were no significant changes in trends of nutrient concentration or loading at Hamel, Peony, or ECER. All the negative *tau* values at these sites indicate trends are declining, but not at a level of significance.

	Hamel		Peony		ECER	
2016-2022	***tau***	**p-value**	***tau***	**p-value**	***tau***	**p-value**
TP (lbs/yr)	-0.524	0.133	-0.467	0.260	-0.429	0.230
TP (µg/L)	-0.333	0.368	-0.200	0.707	-0.143	0.764
SRP (lbs/yr)	-0.524	0.133	-0.333	0.452	-0.238	0.548
SRP (µg/L)	-0.619	0.072	-0.467	0.260	-0.143	0.764
TN (lbs/yr)	-0.524	0.133	-0.333	0.452	-0.524	0.133
TN (mg/L)	-0.429	0.230	-0.200	0.707	-0.333	0.368
TSS (lbs/yr)	-0.619	0.072	-0.067	1.000	-0.143	0.764
TSS (mg/L)	-0.333	0.368	-0.467	0.260	0.048	1.000

3.6. Ponderosa Rain Garden (PRG)

An iron enhanced rain garden was installed near 2625 Garland Lane N. in the summer of 2016. The rain garden is monitored during rain events by taking samples of stormwater runoff going in and out of the rain garden. At PRG-IN, water samples are collected from street runoff flowing into the rain garden by funneling water into a sample bottle from the curb. PRG-OUT water samples are collected at the outlet of a perforated pipe from rain garden to a nearby storm drain. Because of the drought year and untimeliness of rain events, staff were not able to collect any paired in and out flow samples. One inflow sample was collected during a rain event that did not produce any outflows from the raingarden. Five paired samples were collected in 2021 and one paired sample was collected in 2020.

3.6.1. Concentration

While only one sample of the inflowing water was collected in 2022, this sample and data from previous years are summarized in Figure 3.25, Table 3.32, and Figure 3.26. Nutrient concentrations of raingarden inputs have varied widely over the years. The lone sample collected in 2022 was within the range of expected values.

As per the most recent available data, yearly trends show the rain garden TP and SRP removal rates have improved since monitoring began, but still have not removed phosphorus from runoff. TSS reductions have remained similar each year and remain effective. SRP is leaching from the system at high concentrations – this possibly due to compost and other organic material decomposition rates exceeding plant uptake.

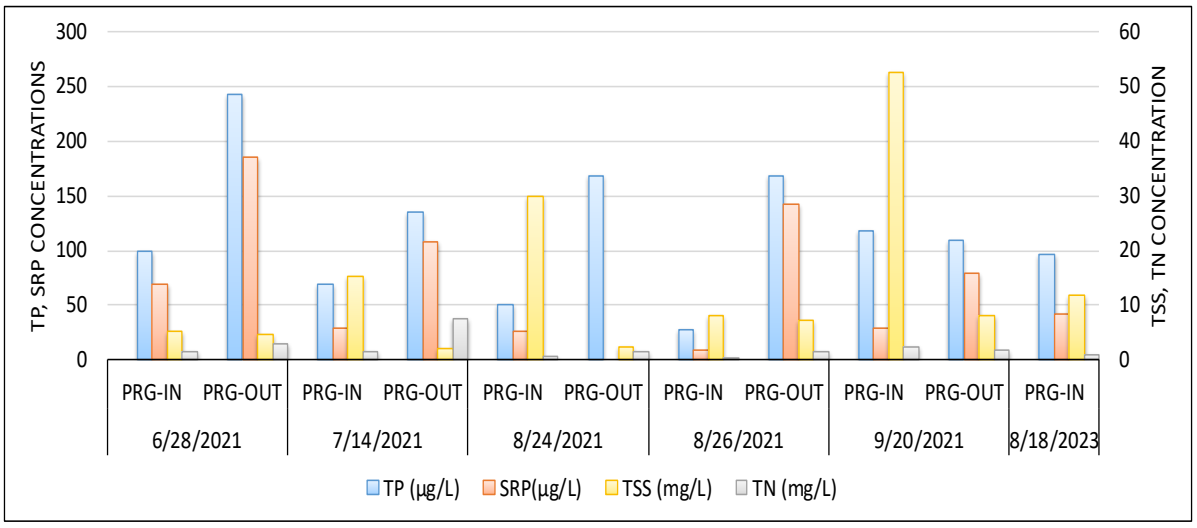


Figure 3.25. Concentrations of TP, SRP, TSS, and TN for the Ponderosa Rain Garden inlet versus outlet for each sampling occurrence 2021-2022.

Table 3.32. Summary of average, minimum, and maximum concentrations for TP, SRP, TN, and TSS at the Ponderosa rain garden for inflowing water and outflowing water.

Year	Site	Avg TP (min-max) µg/L	Avg SRP (min-max) µg/L	Avg TN (min-max) mg/L	Avg TSS (min-max) mg/L	SRP: TP ratio
2017	PRG-IN	103 (18 - 156)	39 (8 - 101)	1.3 (0.3 - 2.0)	22 (3.2 - 55)	38
	PRG-OUT	383 (244 - 586)	309 (164 - 497)	2.0 (1.4 - 3.2)	7.1 (1.7 - 21)	81
2018	PRG-IN	63 (33 - 77)	25 (9 - 52)	1.6 (0.3 - 4.2)	7.2 (5.2 - 11.2)	40
	PRG-OUT	251 (107 - 388)	140 (3 - 308)	2.4 (1.1 - 4.6)	1.9 (0.2 - 3.2)	56
2019	PRG-IN	175 (20 - 558)	79 (7 - 205)	0.8 (0.2 - 1.2)	19.1 (3.8 - 34.2)	45
	PRG-OUT	177 (139 - 211)	127 (36 - 192)	2.0 (1.1 - 3.3)	3.2 (0.8 - 9.8)	72
2020	PRG-IN	94	52	1.7	17.6	56
	PRG-OUT	139 (114 - 165)	118 (95 - 141)	2.1 (1.7 - 2.5)	3.1 (2.0 - 4.1)	85
2021	PRG-IN	73 (28 - 118)	32 (9 - 69)	1.3 (0.4 - 2.4)	22.2 (5.2 - 52.6)	44
	PRG-OUT	165 (110 - 243)	129 (79 - 186)	3.0 (1.4 - 7.6)	4.8 (2.0 - 8.0)	78
2022	PRG-IN	97	42	1	11.8	43

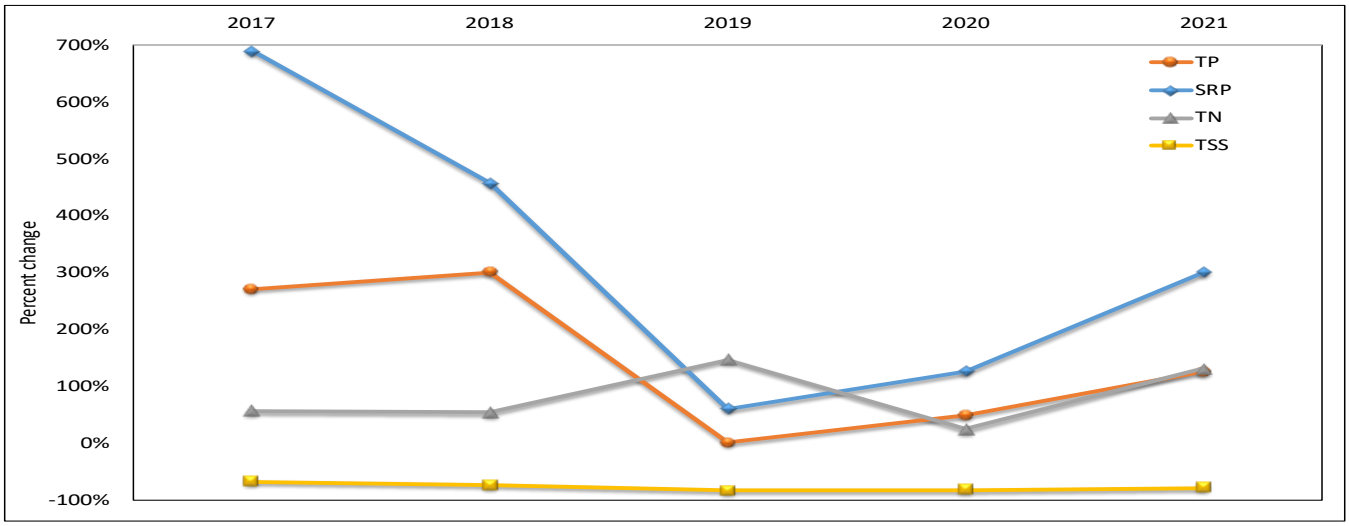


Figure 3.26. Percent change from PRG-In to PRG-Out by year when paired samples available.

3.7. Mooney Lake Watershed

Five locations around Mooney Lake watershed were monitored in 2022(Figure 3.27). Grab samples were taken to compare concentrations only. No flow estimates were included. MOO SW1 and SW2 were collected from culverts before discharging into Mooney Lake. MOO SW3, SW4, and SW5 were each sampled from storm sewers with a grab arm pole sampler. Except for MOO SW2, sites were only sampled during or just after rain events when enough flow was present. MOO SW2 periodically maintained base flow following rain events.

3.7.1. Concentration

Of the five locations, MOO-SW2 had the most samples. MOO-SW2 had nine grab samples while the other sites had between one and three samples each. Multiple sites were sampled on days with rain, including 4/4/22, 5/25/22, and 8/18/22. Average sample results are displayed in Figure 3.28 and Table 3.33. A summary 2019 to 2022 average concentrations are reported for each parameter for TP (Figure 3.29), SRP (Figure 3.30), TN (Figure 3.31), and TSS (Figure 3.32). TP, SRP, and TN concentrations are relatively close among sites, however, TSS concentrations are much higher at MOO-SW4 and MOO-SW5 compared to the other Mooney sites.

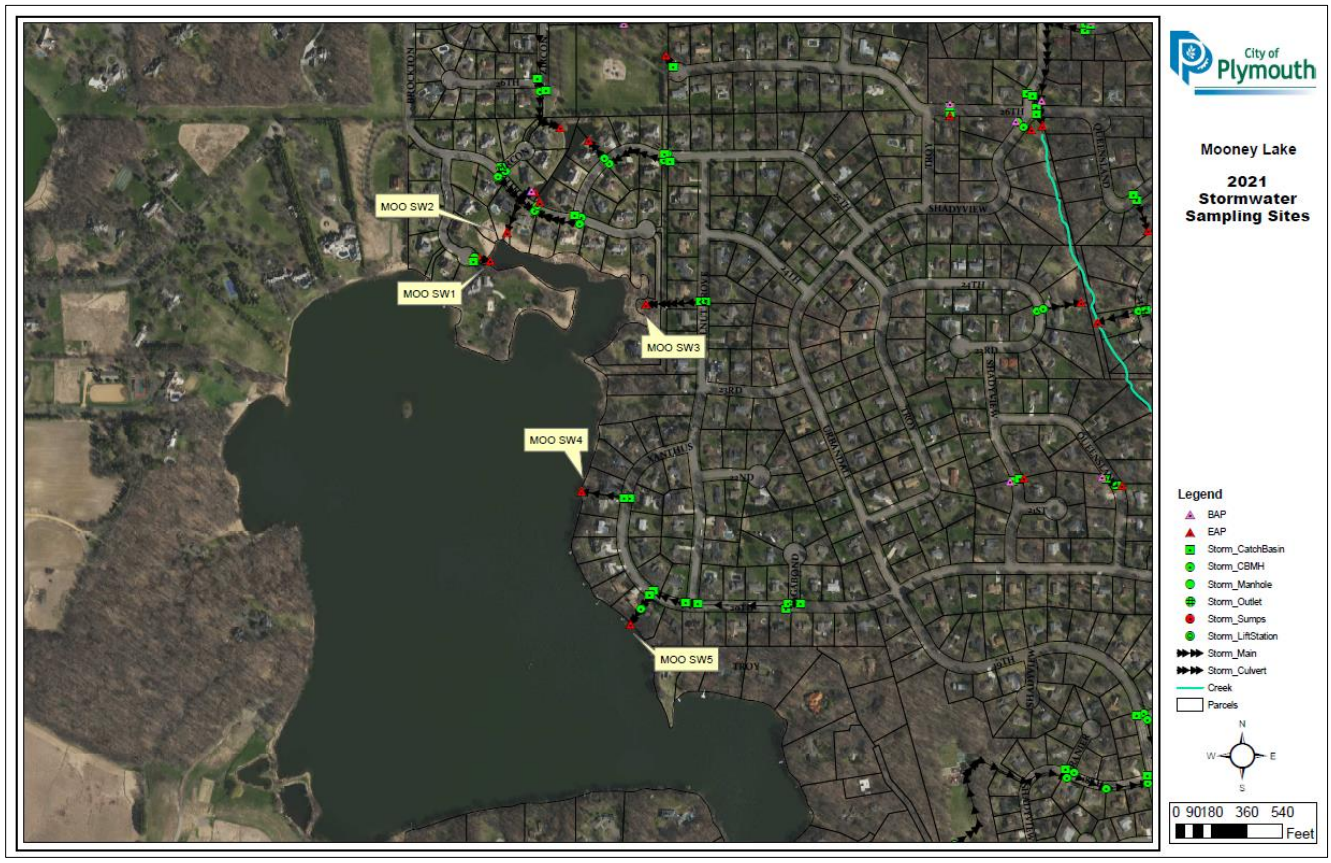


Figure 3.27. Mooney Lake sampling locations.

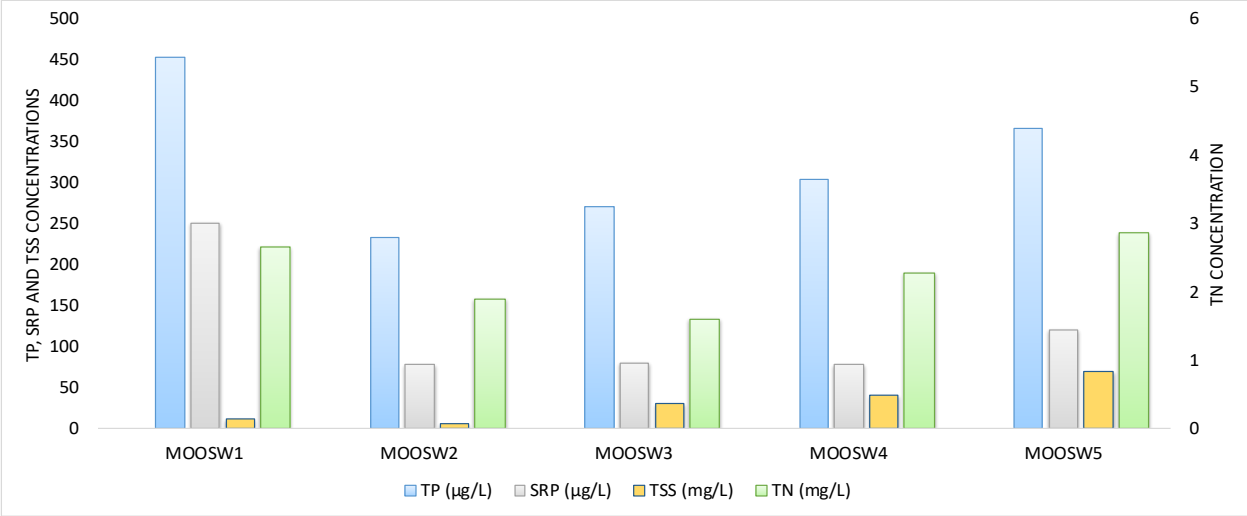


Figure 3.28. Average concentrations of TP, SRP, TSS, and TN for the Mooney watershed sites in 2022.

Table 3.33. Summary of average, minimum, and maximum concentrations for TP, SRP, TN, and TSS at the Mooney watershed sites.

Site	# of samples	Avg TP (min-max) µg/L	Avg SRP (min-max) µg/L	Avg TN (min-max) mg/L	Avg TSS (min-max) mg/L
MOO SW1	3	453 (314 - 670)	251 (97 - 430)	2.7 (2.2 - 3.3)	12.2 (7.3 - 19.7)
MOO SW2	9	233 (126 - 434)	79 (33 - 171)	1.9 (1.5 - 2.7)	6.7 (3.3 - 11.6)
MOO SW3	3	270 (167 - 355)	81 (66 - 98)	1.6 (1.4 - 1.9)	31.4 (20.0 - 45.9)
MOO SW4	1	304 (304 - 304)	79 (79 - 79)	2.3 (2.3 - 2.3)	41.2 (41.2 - 41.2)
MOO SW5	2	367 (339 - 394)	120 (110 - 130)	2.9 (2.6 - 3.2)	70.4 (23.2 - 117.6)

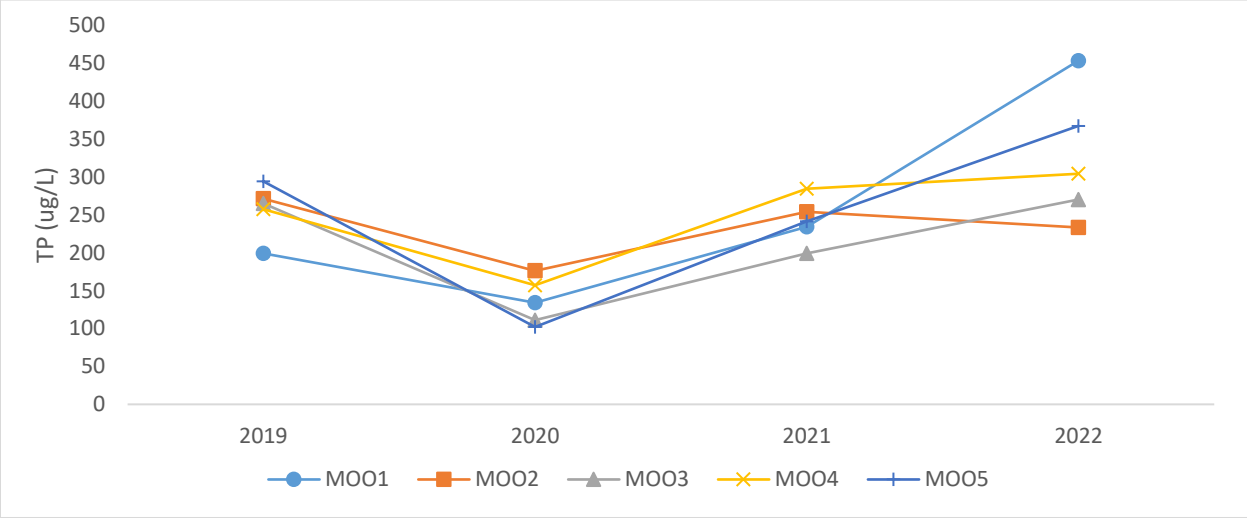


Figure 3.29. Historic average TP concentrations in Mooney subwatershed (2019-2022).

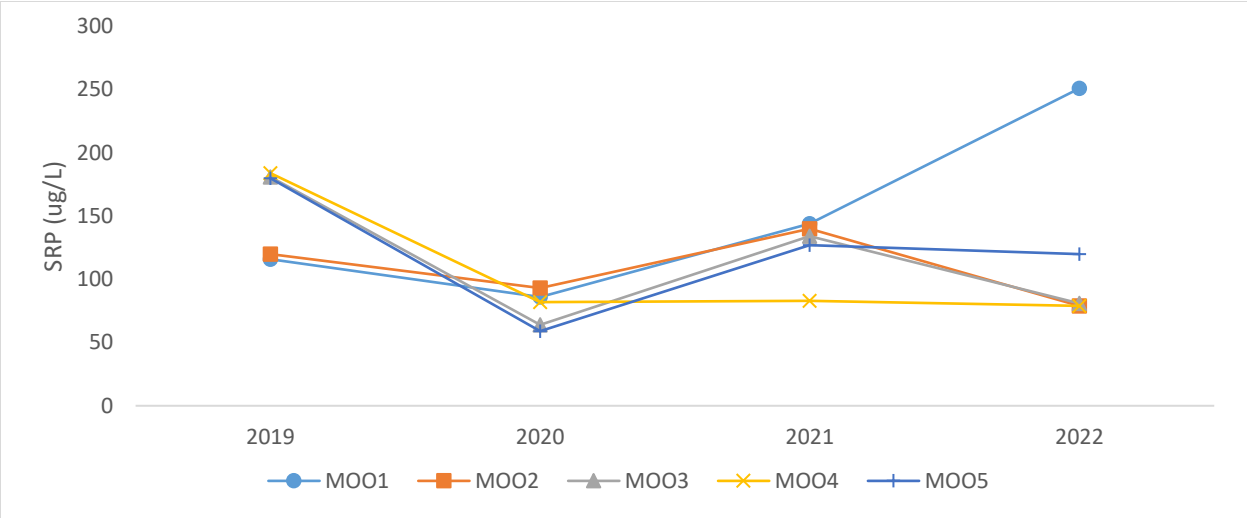


Figure 3.30. Historic average SRP concentrations in Mooney subwatershed (2019-2022).

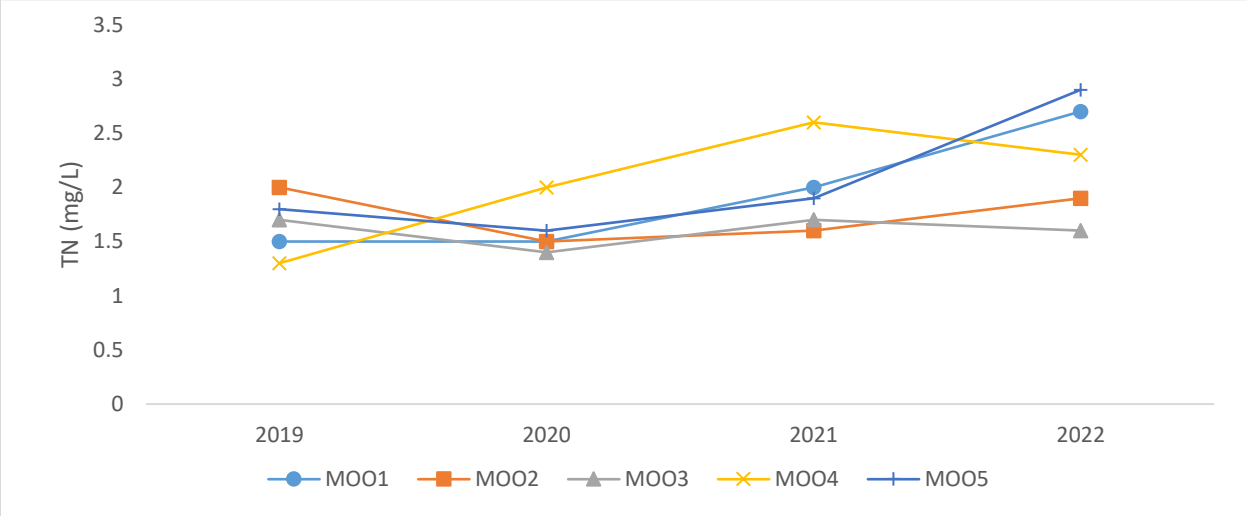


Figure 3.31. Historic average TN concentrations in Mooney subwatershed (2019-2022).

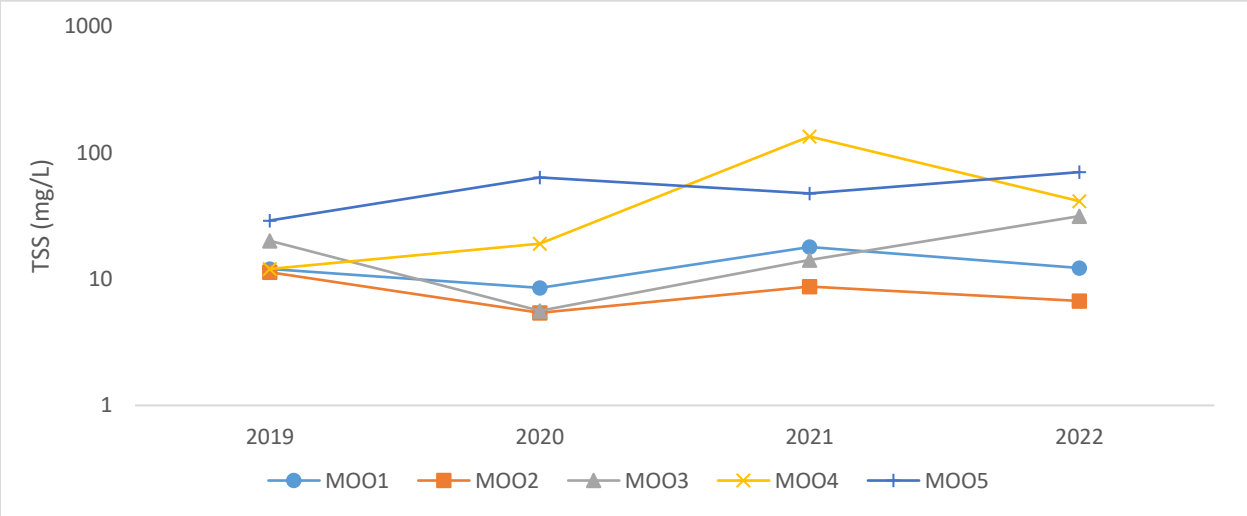


Figure 3.32. Historic average TSS concentrations (log scale) in Mooney subwatershed (2019-2022).

3.8. Northwood Lake Sub-watershed

The Northwood Lake sub-watershed creates the headwaters of the north branch of Bassett Creek. The watershed area above the NLS monitoring station located on the west side of Hwy 169 is located entirely within the City of Plymouth. NLS is upstream of Northwood Lake, which is in the City of New Hope (Figure 3.33). Northwood Lake was listed as impaired for excess nutrients in 2004. A TMDL has not been completed for the lake. The City of New Hope did install several improvements around the lake to reduce phosphorus loading in 2016-2017. More information about these projects can be found on the Basset Creek WMO website. There was also a large demolition project to remove the Four Seasons Mall in 2022 located just upstream from the NLS monitoring site.

3.8.1. Stormwater Monitoring Site

The NLS monitoring site is located at the edge of the City of Plymouth. Watershed area and percent impervious area are listed in Table 3.34. The monitoring station is located behind the apartment complex at 3940 Lancaster Ln N. The stream is monitored just before it enters a six-foot culvert that passes under Hwy 169. This site captures the confluence of the northern and western tributaries (Figure 3.33).

Table 3.34. Summary of watershed characteristics for NLS.

Site	Sub watershed Area (acres)	% Impervious (acres)1	% of Watershed in Plymouth	Dominant land uses2
NLS	835	34% (285 ac.)	100%	Residential

[1] % impervious area determined using the 2016 University of Minnesota TCMA 1-meter land cover classification GIS layer
[2] Dominant Land Uses determined using GIS layer obtained from the City of Plymouth

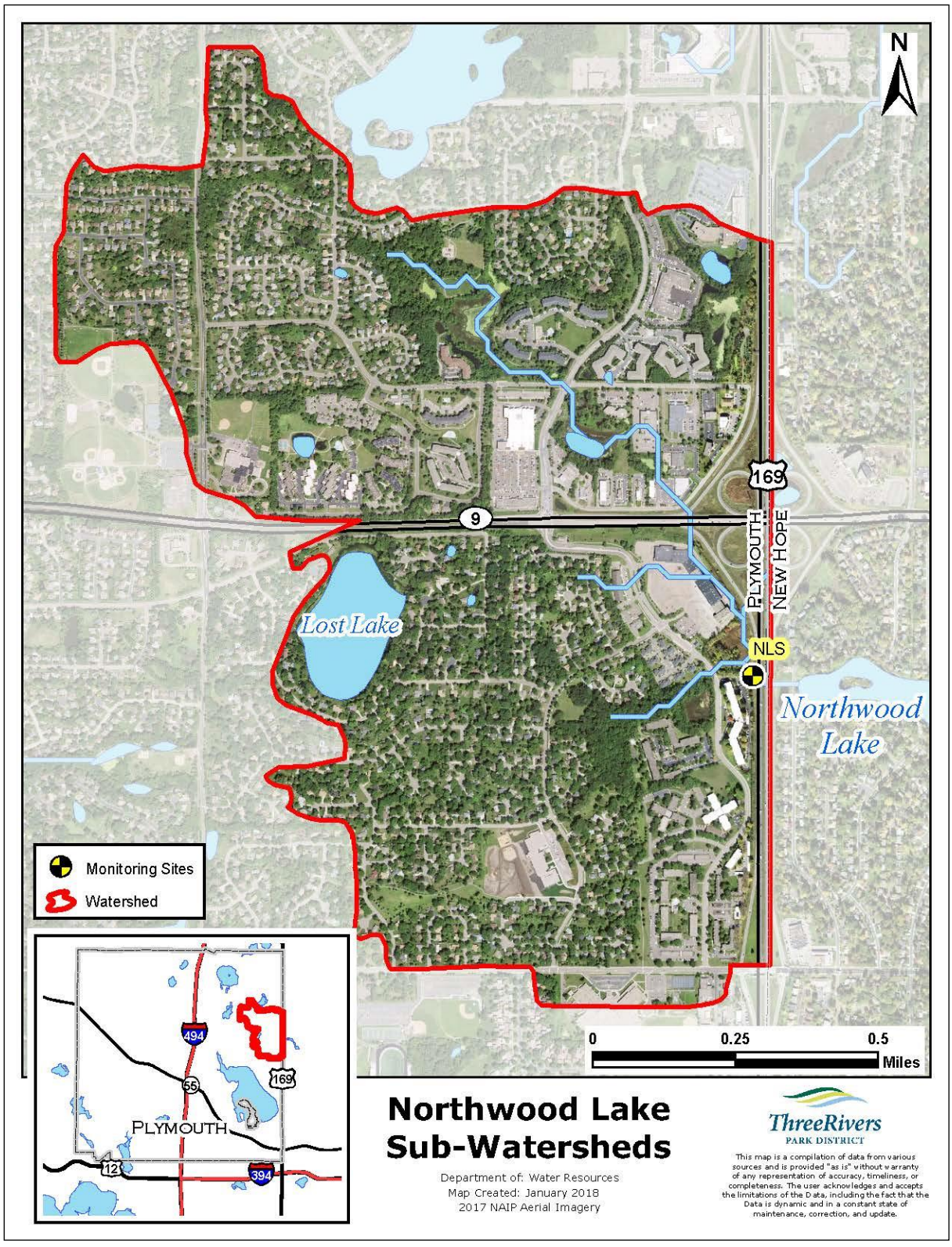


Figure 3.33. Northwood Lake Sub-watershed map.

3.8.2. Hydrograph

This site was not monitored in 2022 so no data is reported for this year. In general, being at the headwaters of the North Branch of Bassett Creek, this site is quite flashy and responds quickly to precipitation. The outlet structure on Northwood Lake causes the NLS site to go stagnant at around 1.45 feet on TRPD's installed staff gage.

3.8.3. Yearly Summary

Since 2012, water quality has been monitored every year except for 2020 and 2022. In Table 3.35, the yearly flow-weighted concentrations and loadings are segmented to 2012-2016 and 2017-2022 since there has been a shift in the flow regime. In 2016, several stormwater infrastructure projects occurred adjacent to Northwood Lake that affected the flows at the monitoring station; the downstream improvements seem to back the flow up into the monitoring site, which allows more infiltration, thereby reducing flow.

The average flows since 2017 have decrease by 21% as compared to the pre 2017 average. This is remarkable given that average precipitation increased by 2% over the same time period. This supports the claim that watershed improvements, including the weir structure added to Northwood Lake outlet, have slowed flow and increased infiltration. Even with the decreased flow, since 2017 there has been an increase in TSS concentrations (+ 66%) and total loading (+ 37%). TP (+ 32%) and TN (+ 18%) concentrations also increased but TP loading remained unchanged and TN loading decreased by 11%.

Since 2017, there is a positive correlation ($r^2 = 0.89$) between flow and precipitation. There was a positive correlation prior to 2017 ($r^2 = 0.76$). The relationship between precipitation and flow has shifted to have lower flows given the same precipitation since 2017.

On average since 2012, UALs at NLS are below MPCA estimates for TP and above estimates for TSS (Table 3.36). TP loading was less than MPCA estimates in seven of nine years monitored. TSS exceeded estimates in every year monitored.

Table 3.35. Loading and flow weighted concentrations of TP, SRP, TN and TSS at NLS.

NLS - Northwood Lake Sub watershed										
	Nutrient Loading				Nutrient Concentration					
Year	**TP (lbs/yr)**	**SRP (lbs/yr)**	**TN (lbs/yr)**	**TSS (lbs/yr)**	**TP (µg/L)**	**SRP (µg/L)**	**TN (mg/L)**	**TSS (mg/L)**	**Flow Volume (x 10^6 M^3)**	**Annual Precipitation (inches)**
2012-2016										
2012	641	254	6,198	98,605	153	61	1.48	24	1.90	26.7
2013	821	361	7,492	225,785	185	83	1.71	52	1.99	31.6
2014	1,279	589	12,748	377,933	265	122	2.64	78	1.87	27.5
2015	933	296	8,142	266,447	214	68	1.87	61	1.97	29.1
2016	585	195	5,211	240,786	278	93	2.47	114	0.95	38.6
Average	**852**	**339**	**7,958**	**241,911**	**219**	**85**	**2.03**	**66**	**1.74**	**30.7**
2017-current										
2017	803	210	7,401	439,568	254	66	2.34	139	1.35	27.8
2018	1,215	372	8,202	427,514	388	119	2.62	137	1.42	30.8
2019	739	261	7,226	284,697	184	65	1.80	71	1.82	43.3
2021	640	154	5,421	173,546	332	80	2.82	90	0.87	23.4
Average	**849**	**249**	**7,063**	**331,331**	**290**	**83**	**2.39**	**109**	**1.37**	**31.3**
Change	**0%**	**-26%**	**-11%**	**37%**	**32%**	**-3%**	**18%**	**66%**	**-21%**	**2%**

Table 3.36 Unit area loading for TP, SRP, TN and TSS at NLS

NLS - Northwood Lake Sub watershed				
	Load/Acre			
Year	**TP (lbs/acre)**	**SRP (lbs/acre)**	**TN (lbs/acre)**	**TSS (lbs/acre)**
2012	0.77	0.30	7.42	118
2013	0.98	0.43	8.97	270
2014	1.53	0.71	15.26	453
2015	1.12	0.35	9.75	319
2016	0.70	0.23	6.24	288
2017	0.96	0.25	8.86	526
2018	1.46	0.45	9.82	512
2019	0.89	0.31	8.65	341
2021	0.77	0.18	6.49	208
Average	**1.02**	**0.36**	**9.05**	**337**

3.8.4. Trend Analysis

There were no significant changes in water quality trend at NLS in terms of total loading or nutrient concentrations from 2012-2021.

Table 3.37. Mann-Kendall analysis at NLS for years 2012-2021.

	NLS	
2012-2021	***tau***	**p-value**
TP (lbs/yr)	-0.167	0.602
TP (µg/L)	0.444	0.118
SRP (lbs/yr)	-0.278	0.348
SRP (µg/L)	0.000	1.000
TN (lbs/yr)	-0.167	0.602
TN (mg/L)	0.444	0.118
TSS (lbs/yr)	0.222	0.466
TSS (mg/L)	0.500	0.076

3.9. Pomerleau Lake and Lake Camelot (Historic Monitoring)

3.9.1. Pomerleau Lake

Pomerleau Lake is a small, deep lake located in the Bass Lake watershed in City of Plymouth (Figure 3.34). It is impaired for excess nutrients. TRPD monitored Pomerleau for a total of seven years; 2007, 2008, 2013, 2014, and 2016-2018. There have been two half-dose alum treatments in Pomerleau in 2019 and 2020. Pomerleau is likely meeting standards since the alum treatment. Water quality seemed to improve the last several years TRPD monitored with phosphorus and Chl-a levels approaching state standards (Figure 3.35). Water clarity also improved during years with low TP concentration (2016-2018). Excessive TP concentrations result in algal blooms and a decrease in water clarity.

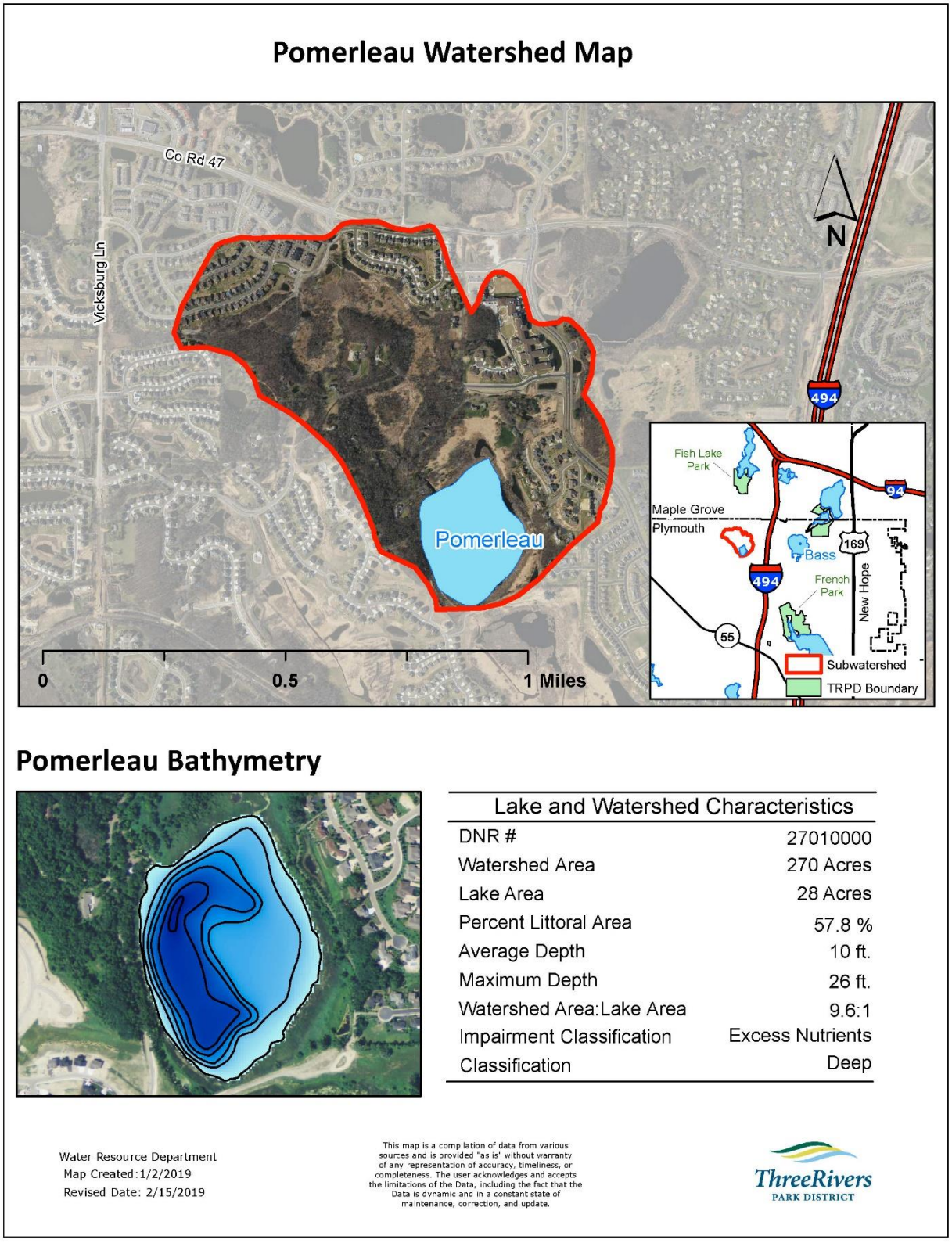


Figure 3.34. Pomerleau Lake watershed map.

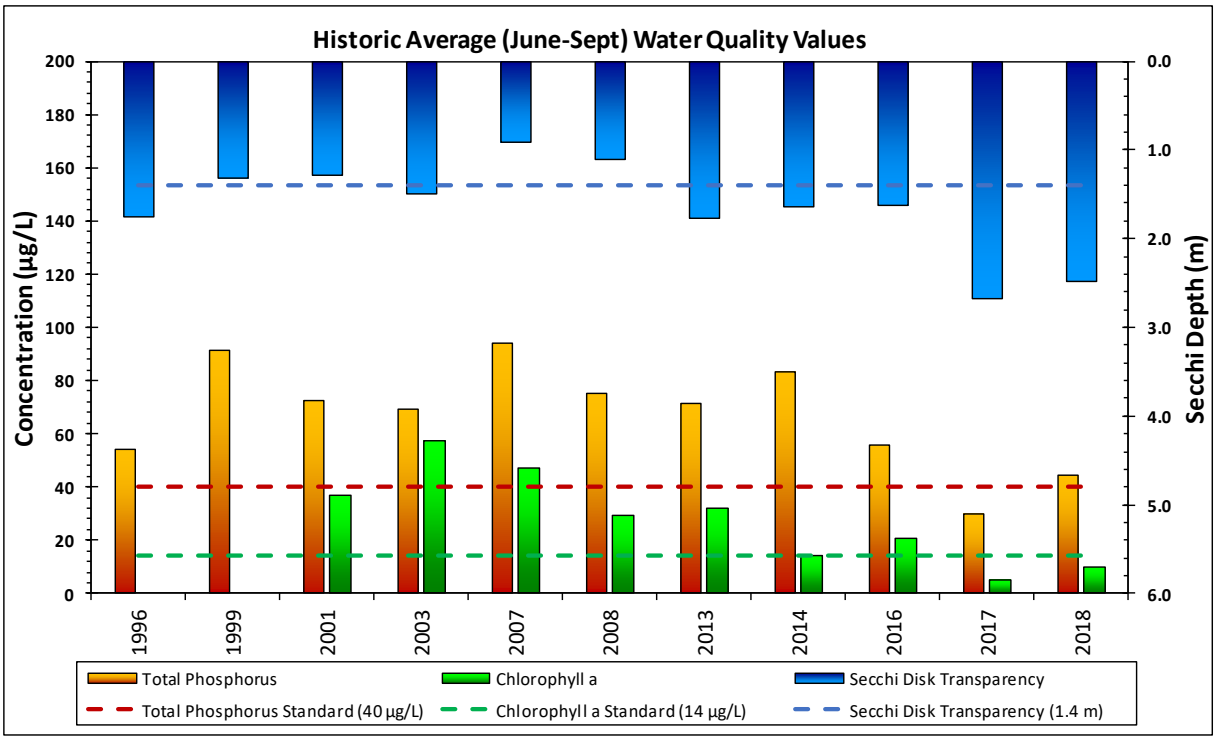
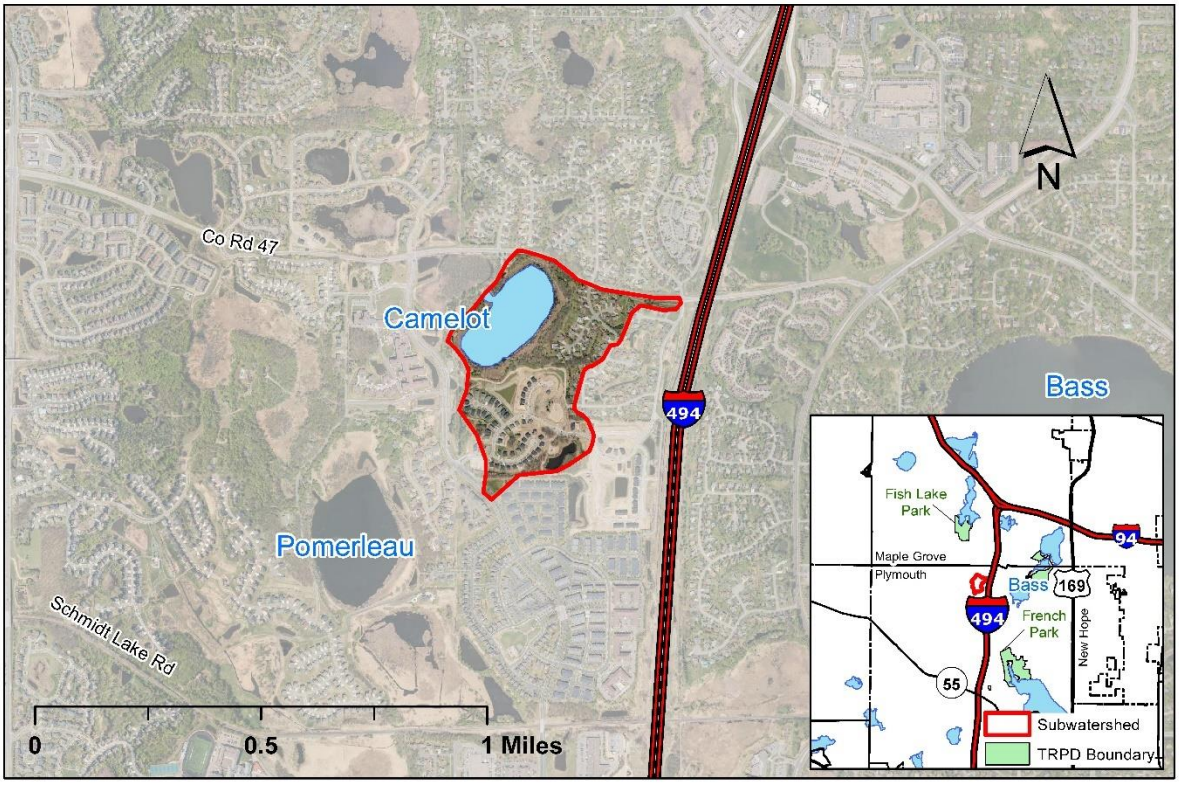


Figure 3.35. Pomerleau Lake growing season water quality averages.

3.9.2. Camelot Lake

Camelot Lake is a small, shallow waterbody located in Bass Lake watershed within City of Plymouth (Figure 3.36). Because of the shallowness of the lake, it is technically considered a wetland and lake water quality standards do not apply. TRPD monitored Camelot in 2007, 2008, and 2019-2021. In the years monitored, total phosphorus has remained steady (Figure 3.37). Chl-a concentrations are more varied but there does not appear to be any trend. Turbid water conditions have caused water clarity to remain low on Camelot. The poor water clarity is not conducive for germination and growth of native plants that would be needed to stabilize and reduce resuspension of sediments. This is needed to improve water quality conditions for the wetland.

Camelot Watershed Map



Camelot

Lake and Watershed Characteristics	
DNR #	27009900
Watershed Area	85 Acres
Lake Area	16 Acres
Percent Littoral Area	100 %
Maximum Depth	4.9 ft
Watershed : Lake Area	5.2:1
Impairment Classification	N/A
Classification	Shallow wetland

Water Resource Department
Map Created:1/2/2019
Revised Date: 2/7/2020

This map is a compilation of data from various sources and is provided "as is" without warranty of any representation of accuracy, timeliness, or completeness. The user acknowledges and accepts the limitations of the Data, including the fact that the Data is dynamic and in a constant state of maintenance, correction, and update.

Figure 3.36. Camelot Lake watershed map.

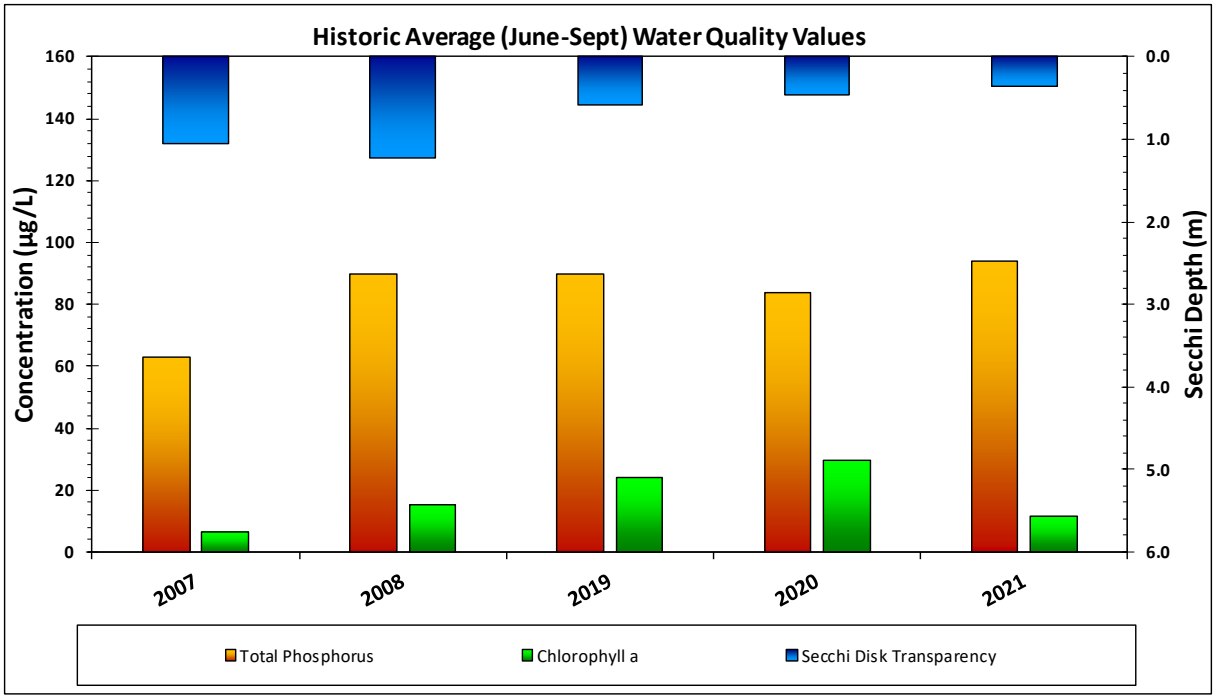


Figure 3.37. Lake Camelot growing season WQ averages.

4.0 CITATIONS

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5.0 STORMWATER AVERAGE DAILY FLOWS

Average daily flow in cfs for all sites along with precipitation in Plymouth, MN.

Date	BL3-East	BL3-West	ECER	GC-1	Hamel	IP2	PC2	Peony	PL1	PL2	Precip (in)
3/28/2022							6.41				0
3/29/2022	1.61	1.70		1.88		4.58	9.78				0.15
3/30/2022	1.53	1.45	9.89	2.89	8.15	7.12	7.18	7.43			0.19
3/31/2022	1.85	1.50	10.57	2.41	7.04	5.11	5.21	6.36			0
4/1/2022	1.42	1.20	14.88	1.48	6.38	3.68	5.39	4.81	0.00		T
4/2/2022	1.16	1.10	8.72	1.11	5.05	3.53	5.08	4.91	0.00		0
4/3/2022	0.98	0.96	7.37	1.20	3.51	3.16	9.16	2.87	0.04		0.35
4/4/2022	1.12	1.03	9.57	1.60	6.84	5.69	13.06	6.97	0.24	0.97	0
4/5/2022	1.30	1.35	14.72	2.10	7.74	8.15	27.86	8.89	0.54	1.64	0.29
4/6/2022	3.24	3.23	32.42	4.86	13.32	21.32	27.27	18.36	0.80	1.77	0.15
4/7/2022	4.59	4.50	38.83	4.23	13.40	19.69	22.78	16.84	0.20	1.14	0.04
4/8/2022	4.05	4.01	30.46	3.34	11.91	14.84	13.75	13.70	0.02	0.48	T
4/9/2022	3.39	3.14	21.87	2.32	10.03	10.40	10.18	10.42	0.00	0.15	0
4/10/2022	2.92	2.39	16.68	1.50	9.23	7.99	8.45	9.26	0.02	0.16	0
4/11/2022	2.51	2.00	15.49	1.76	7.64	6.63	6.75	8.06	0.06	0.19	0
4/12/2022	2.15	1.65	13.48	1.84	7.68	6.02	23.02	7.38	0.12	0.26	0.36
4/13/2022	2.83	2.33	25.19	3.81	11.27	17.05	12.29	11.83	0.33	1.25	0.03
4/14/2022	3.00	2.49	23.61	2.35	10.51	9.65	10.09	5.74	0.00	0.22	T
4/15/2022	2.46	1.94	18	1.81	8.72	6.94	7.13	9.08	0.00	0.14	T
4/16/2022	2.01	1.54	13.61	1.68	7.73	5.25	3.56	7.73	0.00	0.12	0
4/17/2022	1.66	1.31	10.87	1.54	6.85	4.19	6.54	5.18	0.00	0.10	0.02
4/18/2022	1.34	1.65	10.42	1.62	6.10	3.80	0.705	4.62	0.00	0.12	T
4/19/2022	1.12	1.78	8.7	1.63	5.20	3.17	8.06	4.04	0.00	0.09	0
4/20/2022	1.21	1.89	10.26	2.30	6.84	7.02	12.4	6.62	0.26	0.86	0.49
4/21/2022	2.06	2.89	19.55	2.61	7.97	10.47	7.66	9.52	0.02	0.71	0
4/22/2022	2.15	3.02	17.08	2.70	7.46	8.08	14.06	8.23	0.10	0.78	0.27
4/23/2022	2.36	3.25	18.79	3.56	8.09	12.47	9.93	9.28	0.37	1.26	0.88
4/24/2022	2.95	3.89	21.02	3.23	8.68	12.30	11.22	10.02	0.03	1.00	T
4/25/2022	2.51	3.32	16.78	2.39	6.84	8.07	8.59	8.11	0.00	0.39	0
4/26/2022	2.14	2.87	13.4	1.89	6.25	5.97	6.52	6.51	0.00	0.27	0
4/27/2022	1.62	2.26	10.86	1.85	6.23	5.46	5.15	5.95	0.00	0.29	0
4/28/2022	1.49	2.12	9.3	1.73	5.10	4.34	4.99	4.97	0.13	0.28	0
4/29/2022	1.29	1.92	8.05	1.63	4.46	4.55	34.05	4.55	0.07	0.31	0.06
4/30/2022	2.79	3.63	23.1	5.32	11.78	24.02	30.1	16.21	1.14	2.94	0.93
5/1/2022	5.98	7.46	54.13	7.33	16.49	32.84	31.66	24.38	0.41	1.95	0.1
5/2/2022	5.40	6.75	46	4.65	13.44	23.83	27.6	16.75	0.03	1.06	0
5/3/2022	4.17	5.23	28.45	3.76	10.78	16.01	24.98	12.28	0.00	0.40	0

5/4/2022	3.21	4.02	19.7	3.16	10.10	11.21	18.66	10.56	0.00	0.35	0
5/5/2022	2.58	3.37	16.81	2.69	8.70	8.42	14.16	8.90	0.00	0.25	T
5/6/2022	2.20	2.91	14.71	2.26	7.82	6.78	10.27	7.28	0.00	0.25	0
5/7/2022	1.72	2.41	11.23	1.58	6.74	5.46	8.33	5.75	0.00	0.25	0
5/8/2022	1.69	2.40	10.28	1.39	9.07	4.42	4.76	7.51	0.00	0.28	0.05
5/9/2022	2.64	3.35	11.71	1.68	9.45	4.06	3.4	7.83	0.01	0.35	0.02
5/10/2022	1.87	2.55	11.86	1.30	9.28	3.84	6.09	7.27	0.00	0.20	0
5/11/2022	1.30	1.97	12.45	2.02	10.64	6.45	44.08	9.80	0.69	3.34	1.32
5/12/2022	4.18	5.25	48.7	4.09	21.86	25.75	31.19	29.90	0.24	2.28	0.01
5/13/2022	4.30	5.17	44.78	3.14	18.88	14.42	20.87	21.21	0.05	0.68	0.01
5/14/2022	2.98	3.60	28.67	2.14	16.39	9.14	15.72	16.22	0.00	0.31	0
5/15/2022	2.06	2.65	20.93	1.98	14.52	6.72	11.48	12.97	0.00	0.25	0
5/16/2022	1.56	2.13	17.18	2.14	11.86	5.23	6.09	11.35	0.00	0.23	0
5/17/2022	1.19	1.71	14.75	2.04	10.14	3.40	5.4	10.60	0.00	0.26	0.14
5/18/2022	1.10	1.58	14.79	1.74	11.40	3.24	4.03	10.19	0.00	0.33	T
5/19/2022	1.34	1.82	15.65	2.12	10.38	2.75	6.88	9.25	0.07	0.54	0.01
5/20/2022	1.41	1.79	14.5	1.90	9.29	3.70	3.38	8.16	0.01	0.43	0.05
5/21/2022	1.12	1.51	11.76	1.14	7.90	2.78	2.44	6.42	0.00	0.30	0
5/22/2022	0.85	1.17	10.07	0.96	7.35	2.50	3.1	5.86	0.00	0.26	0.01
5/23/2022	0.67	0.92	8.55	0.91	6.37	4.40	1.66	4.87	0.00	0.31	0
5/24/2022	0.60	0.82	7.04	0.89	4.22	2.42	9.18	3.35	0.00	0.28	0.01
5/25/2022	0.81	1.08	9.55	2.24	6.05	7.19	7.2	5.87	0.23	2.03	0.53
5/26/2022	1.14	1.48	11.04	2.10	5.55	5.20	4.14	5.02	0.02	0.44	0
5/27/2022	1.00	1.29	8.66	1.36	5.19	2.99	2.89	4.12	0.00	0.32	0
5/28/2022	0.85	1.11	8.34	1.13	5.05	2.43	0.449	4.04	0.06	0.37	0.04
5/29/2022	0.72	0.92	7.79	1.00	5.82	1.48	3.24	4.44	0.01	0.32	T
5/30/2022	0.79	1.02	10.21	1.44	7.49	3.58	11.53	6.29	0.31	1.77	0.48
5/31/2022	1.33	1.74	21.6	2.15	7.06	10.79	5.81	7.23	0.04	0.51	M
6/1/2022	1.25	1.67	11.94	1.45	6.33	4.70	3.81	4.25	0.00	0.39	0
6/2/2022	0.92	1.28	9.51	0.80	4.72	3.03	0.81	3.35	0.00	0.31	0
6/3/2022	0.72	1.01	6.67	0.59	5.12	2.31	0.367	2.87	0.00	0.48	0
6/4/2022	0.59	0.86	6.7	0.48	4.70	1.85	0.169	2.93	0.00	0.51	0
6/5/2022	0.54	0.82	5.43	0.52	2.22	1.18	0.15	1.68	0.00	0.42	0.21
6/6/2022	0.52	0.78	4.66	0.53	3.74	1.08	0.232	1.94	0.05	0.57	0.13
6/7/2022	0.43	0.68	4.55	0.53	3.51	1.11	0.0896	1.69	0.00	0.47	T
6/8/2022	0.37	0.61	4.58	0.35	3.58	0.35	0.0228	1.87	0.00	0.41	0
6/9/2022	0.32	0.41	4.05	0.20	2.46	0.80	0.103	1.45	0.00	0.30	0
6/10/2022	0.27	0.38	3.38	0.21	2.09	0.64	0	0.98	0.00	0.34	0
6/11/2022	0.24	0.38	3.41	0.29	3.13	0.62	0.0918	1.08	0.00	0.43	0.04
6/12/2022	0.20	0.35	3.48	0.21	5.23	0.70	1.86	2.12	0.00	0.33	0
6/13/2022	0.21	0.36	3.98	0.31	2.59	4.03	0.362	1.54	0.03	0.52	0.1
6/14/2022	0.20	0.34	2.69	0.30	4.47	1.12	0.0879	1.90	0.00	0.40	0

6/15/2022	0.18	0.31	3.16	0.24	2.43	0.44	0.716	1.34	0.00	0.32	0.14
6/16/2022	0.15	0.30	2.63	0.10	2.35	0.17	0.082	2.57	0.00	0.19	0
6/17/2022	0.11	0.21	2.22	0.05	0.88	0.06	0.0674	1.23	0.00	0.08	0
6/18/2022	0.10	0.19	1.74	0.05	0.53	0.03	0.38	0.97	0.00	0.14	0
6/19/2022	0.09	0.19	1.46	0.06	1.26	0.00	0.19	1.55	0.00	0.04	0
6/20/2022	0.07	0.16	1.31	0.09	1.03	0.00	1.2	0.33	0.00	0.06	0
6/21/2022	0.06	0.14	1.48	0.19	1.40	2.18	0.0718	1.03	0.07	0.74	0.19
6/22/2022	0.03	0.11	1.46	0.09	1.68	0.34	0.0814	0.54	0.00	0.26	0
6/23/2022	0.02	0.10	1.4	0.08	2.59	0.21	0.0664	0.75	0.00	0.07	0
6/24/2022	0.01	0.07	1.31	0.08	2.47	0.24	0.15	2.07	0.00	0.04	0
6/25/2022	0.01	0.05	1.6	0.24	0.95	0.58	0.0444	1.38	0.07	0.47	0.27
6/26/2022	0.01	0.05	1.45	0.14	0.94	0.09	0.109	1.34	0.00	0.38	0
6/27/2022	0.00	0.02	1.33	0.12	1.06	0.00	0.195	1.39	0.00	0.21	0
6/28/2022	0.02	0.03	1.31	0.12	1.58	0.25	0.318	1.38	0.01	0.46	T
6/29/2022	0.00	0.04	1.1	0.05	1.13	0.01	0.25	1.41	0.00	0.27	0
6/30/2022	0.01	0.03	1.04	0.09	0.63	0.15	0.0515	1.45	0.04	0.43	0.06
7/1/2022	0.01	0.02	0.989	0.03	0.66	0.00	0	1.48	0.00	0.13	0
7/2/2022	0.01	0.02	0.939	0.06	0.64	0.00	0	1.50	0.00	0.14	0.04
7/3/2022	0.01	0.02	1.21	0.07	0.64	0.00	0.196	1.37	0.00	0.25	T
7/4/2022	0.01	0.03	1.42	0.26	0.71	0.68	0.0305	1.38	0.11	1.07	0.27
7/5/2022	0.01	0.03	1.57	0.05	0.53	0.15	0	1.33	0.00	0.25	0.01
7/6/2022	0.01	0.03	1.56	0.05	0.54	0.15	0	1.33	0.00	0.08	0
7/7/2022	0.01	0.02	1.34	0.05	1.34	0.09	0.0047	1.35	0.00	0.02	0.18
7/8/2022	0.01	0.03	1.4	0.13	0.87	0.16	0.0924	1.61	0.02	0.23	0.08
7/9/2022	0.01	0.02	1.49	0.06	0.67	0.00	0.106	1.41	0.00	0.04	0
7/10/2022	0.01	0.02	1.32	0.07	0.67	0.00	0.0213	1.45	0.00	0.07	T
7/11/2022	0.01	0.02	1.16	0.09	0.65	0.00	0.72	1.43	0.01	0.15	T
7/12/2022	0.01	0.02	1.2	0.44	1.02	0.99	4.05	1.41	0.47	1.10	0.01
7/13/2022	0.05	0.10	2.24	0.17	0.68	3.31	0.0998	1.71	0.02	1.10	0
7/14/2022	0.13	0.17	2.23	0.03	0.57	0.83	0	1.33	0.00	0.22	T
7/15/2022	0.07	0.14	1.56	0.02	0.59	0.19	0.0376	1.33	0.00	0.08	0
7/16/2022	0.02	0.11	1.36	0.02	0.61	0.06	0	1.34	0.00	0.05	0
7/17/2022	0.02	0.10	1.25	0.02	2.25	0.00	0.182	1.72	0.00	0.02	0
7/18/2022	0.01	0.07	1.5	0.02	0.69	0.00	0.0464	1.43	0.00	0.09	0
7/19/2022	0.00	0.04	1.38	0.02	0.69	0.00	0.0536	1.37	0.00	0.01	T
7/20/2022	0.00	0.02	1.14	0.02	0.67	0.00	0.0186	1.40	0.00	0.01	0
7/21/2022	0.00	0.02	0.986	0.02	0.72	0.00	0.121	1.45	0.00	0.00	0
7/22/2022	0.00	0.01	0.854	0.02	0.73	0.00	0.0262	1.48	0.00	0.00	T
7/23/2022	0.01	0.01	1.11	0.08	0.68	0.29	0.0824	1.43	0.00	0.31	0.46
7/24/2022	0.00	0.01	1.21	0.05	0.63	0.47	0.0315	1.34	0.00	0.28	0
7/25/2022	0.01	0.01	0.876	0.02	0.68	0.00	0	1.39	0.00	0.19	0
7/26/2022	0.01	0.01	1.15	0.09	0.80	0.26	0	1.41	0.03	0.31	0.2

7/27/2022	0.00	0.01	1.57	0.05	0.58	0.52	0.0251	1.35	0.00	0.21	0
7/28/2022	0.00	0.01	1.4	0.04	0.65	0.00	0	1.35	0.00	0.03	0
7/29/2022	0.00	0.01	1.23	0.04	0.68	0.00	0.0044	1.38	0.00	0.01	0
7/30/2022	0.00	0.01	1.1	0.04	0.72	0.00	0.0346	1.40	0.00	0.01	0
7/31/2022	0.00	0.01	1.01	0.04	0.70	0.00	0	1.42	0.00	0.00	0.02
8/1/2022	0.00	0.01	0.91	0.04	0.71	0.00	0.0102	1.43	0.00	0.00	0
8/2/2022	0.00	0.01	0.835	0.04	0.72	0.00	0	1.40	0.00	0.01	0.32
8/3/2022	0.00	0.01	0.879	0.13	0.69	0.00	0.0033	1.35	0.03	0.00	0.04
8/4/2022	0.00	0.01	0.768	0.05	0.69	0.00	0.0217	1.42	0.00	0.00	0
8/5/2022	0.00	0.01	0.689	0.03	0.70	0.00	4.65	1.48	0.00	0.00	0
8/6/2022	0.01	0.01	1	0.51	0.66	4.08	2.01	1.44	0.50	0.00	1.05
8/7/2022	0.01	0.01	1.67	0.54	1.43	3.44	3.52	1.53	0.50	0.00	0.84
8/8/2022	0.14	0.18	6.75	0.53	1.31	11.47	2.78	5.28	0.13	0.00	0
8/9/2022	0.46	0.49	4.97	0.05	0.57	2.50	0.541	1.42	0.00	0.00	0
8/10/2022	0.32	0.36	2.77	0.05	0.62	0.68	0.0546	1.33	0.00	0.00	0
8/11/2022	0.16	0.21	1.86	0.05	0.66	0.34	11.71	1.35	0.00	0.00	0
8/12/2022	0.45	0.50	4.75	0.54	1.53	9.65	6.65	3.02	0.61	2.34	0.48
8/13/2022	0.95	1.01	6.69	0.24	0.55	4.84	1.19	1.57	0.00	0.28	0
8/14/2022	0.60	0.65	3.96	0.13	0.59	1.33	0.191	1.34	0.00	0.09	0
8/15/2022	0.30	0.35	2.76	0.13	0.60	0.64	0.0939	1.33	0.00	0.07	0
8/16/2022	0.18	0.23	2.14	0.13	0.59	0.44	0.164	1.34	0.00	0.04	0
8/17/2022	0.17	0.22	4.65	0.24	1.02	0.60	15.11	1.44	0.22	1.07	0.02
8/18/2022	2.79	2.95	27.57	0.32	1.40	13.43	10.32	4.55	0.26	2.63	0.38
8/19/2022	2.64	2.74	21.43	0.16	1.03	8.61	3.79	2.25	0.09	0.67	0.17
8/20/2022	1.43	1.52	12.27	0.08	0.64	3.14	1.01	1.67	0.00	0.24	0
8/21/2022	0.83	0.86	6.87	0.09	0.54	1.60	0.206	1.65	0.00	0.11	0
8/22/2022	0.47	0.57	4.69	0.08	1.55	1.01	0.224	1.55	0.00	0.13	0
8/23/2022	0.26	0.40	4.17	0.08	0.73	0.84	0.037	1.60	0.00	0.09	0
8/24/2022	0.12	0.25	3.52	0.08	0.58	0.70	0.104	0.79	0.00	0.10	0
8/25/2022	0.11	0.09	3.02	0.09	0.58	0.54	0.0414	0.54	0.00	0.06	T
8/26/2022	0.11	0.09	2.5	0.09	0.58	0.42	0.361	0.38	0.00	0.05	0.01
8/27/2022	0.12	0.10	2.06	0.23	0.56	0.91	0.626	0.81	0.10	0.45	0.33
8/28/2022	0.24	0.25	2.09	0.44	0.57	5.51	3.16	0.73	0.79	1.83	0.15
8/29/2022	0.27	0.28	2.76	1.04	0.69	5.42	1.71	0.87	0.17	1.15	0
8/30/2022	0.19	0.19	2.43	0.15	0.54	1.16	0.114	0.61	0.00	0.11	0
8/31/2022	0.17	0.18	1.92	0.01	0.74	0.38	0.372	1.06	0.00	0.10	0
9/1/2022	0.13	0.15	1.62	0.01	0.73	0.18	0.418	0.60	0.00	0.07	0
9/2/2022	0.11	0.11	1.54	0.01	0.59	0.11	0.0799	0.38	0.00	0.04	0
9/3/2022	0.06	0.07	1.25	0.02	0.60	0.04	0.0239	0.34	0.00	0.03	0
9/4/2022	0.02	0.05	1.05	0.01	0.63	0.03	0	0.30	0.00	0.04	0
9/5/2022	0.00	0.03	0.906	0.01	0.63	0.00	0	0.30	0.00	0.09	0
9/6/2022	0.00	0.03	0.85	0.01	0.62	0.00	0.0906	0.30	0.00	0.04	0

9/7/2022	0.00	0.01	0.8	0.01	0.61	0.00	0.108	0.29	0.00	0.04	0
9/8/2022	0.00	0.01	0.767	0.01	0.61	0.01	0.0245	0.32	0.00	0.02	0
9/9/2022	0.00	0.00	0.863	0.02	0.58	0.00	0.0075	1.11	0.00	0.07	0.07
9/10/2022	0.00	0.00	0.876	0.02	0.60	0.03	0.0158	2.22	0.01	0.14	T
9/11/2022	0.00	0.00	0.747	0.02	0.61	0.00	0.0053	0.42	0.00	0.06	0
9/12/2022	0.00	0.00	0.684	0.02	0.61	0.00	0	0.40	0.00	0.10	0
9/13/2022	0.00	0.00	0.63	0.02	0.61	0.00	0	0.38	0.00	0.04	0
9/14/2022	0.00	0.00	0.581	0.01	0.61	0.00	0	0.38	0.00	0.03	0
9/15/2022	0.00	0.00	0.616	0.01	0.64	0.00	0.0026	0.29	0.00	0.02	0
9/16/2022	0.00	0.00	0.762	0.18	0.61	0.00	0	0.68	0.03	0.20	0.17
9/17/2022	0.00	0.00	0.792	0.16	0.59	0.00	0	0.58	0.01	0.28	0.04
9/18/2022	0.00	0.00	0.724	0.10	0.59	0.00	0	0.22	0.00	0.09	0
9/19/2022	0.00	0.00	0.679	0.10	0.60	0.00	0.0035	0.56	0.00	0.10	0
9/20/2022	0.00	0.00	0.61	0.09	0.59	0.00	0	1.16	0.00	0.04	0
9/21/2022	0.00	0.00	0.537	0.10	0.61	0.00	0.0058	1.14	0.00	0.05	T
9/22/2022	0.00	0.00	0.464	0.10	0.60	0.00	0.0048	0.94	0.00	0.01	0
9/23/2022	0.00	0.00	0.56	0.14	0.58	0.00	0.0075	0.76	0.00	0.15	0.12
9/24/2022	0.00	0.00	0.892	0.11	0.56	0.00	0.0177	0.56	0.00	0.24	T
9/25/2022	0.00	0.00	0.859	0.10	0.57	0.00	0.004	0.56	0.00	0.07	T
9/26/2022	0.00	0.00	0.723	0.11	0.58	0.00	0.0311	0.47	0.00	0.05	0
9/27/2022	0.00	0.00	0.641	0.11	0.57	0.00	0	0.49	0.00	0.06	0.01
9/28/2022	0.00	0.00	0.524	0.11	0.57	0.00	0.0017	0.49	0.00	0.01	0
9/29/2022	0.00	0.00	0.484	0.11	0.57	0.00	0.0024	0.50	0.00	0.00	0
9/30/2022	0.00	0.00	0.477	0.10	0.56	0.00	0	0.45	0.00	0.00	0.01
10/1/2022	0.00	0.00	0.495	0.10	0.56	0.00	0.0029	0.44	0.00	0.00	0.01
10/2/2022	0.00	0.00	0.583	0.10	0.56	0.00	0.0021	0.45	0.00	0.00	0
10/3/2022	0.00	0.00	0.611	0.10	0.55	0.00	0	0.47	0.00	0.00	0
10/4/2022	0.00	0.00	0.52	0.10	0.54	0.00	0	0.44	0.00	0.00	T
10/5/2022	0.00	0.00	0.503	0.10	0.54	0.00	0.0181	0.26	0.00	0.00	T
10/6/2022	0.00	0.00	0.466	0.11	0.54	0.00	0.001	0.36	0.00	0.00	0.01
10/7/2022	0.00	0.00	0.4	0.11	0.55	0.00	0.0004	0.34	0.00	0.00	0.01
10/8/2022	0.00	0.00	0.392	0.11	0.53	0.00	0	0.34	0.00	0.00	0
10/9/2022	0.00	0.00	0.446	0.11	0.54	0.00	0	0.35	0.00	0.00	0
10/10/2022	0.00	0.00	0.421	0.11	0.54	0.00	0	0.33	0.00	0.00	0
10/11/2022	0.00	0.00	0.438	0.10	0.56	0.00	0	0.32	0.00	0.00	0
10/12/2022	0.00	0.00	0.558	0.11	0.53	0.00	0	0.44	0.00	0.00	0.11
10/13/2022	0.00	0.00	0.731	0.12	0.55	0.00	0	0.67	0.00	0.00	0
10/14/2022	0.00	0.00	0.662	0.11	0.57	0.00	0	0.32	0.00	0.00	0.03
10/15/2022	0.00	0.00	0.677	0.11	0.56	0.00	0	0.31	0.00	0.00	0
10/16/2022	0.00	0.00	0.669	0.12	2.16	0.00	0	1.06	0.00	0.00	0
10/17/2022	0.00	0.00	1.4	0.12	0.61	0.00	0	0.88	0.00	0.00	0
10/18/2022	0.00	0.00	1.26	0.12	0.63	0.00	0	0.60	0.00	0.00	0

10/19/2022	0.00	0.00	0.922	0.12	0.63	0.00	0	0.64	0.00	0.00	0
10/20/2022	0.00	0.00	0.851	0.11	0.62	0.00	0	0.66	0.00	0.00	0
10/21/2022	0.00	0.00	0.912	0.11	0.62	0.00	0	0.69	0.00	0.00	0
10/22/2022	0.00	0.00	0.926	0.11	0.62	0.00	0	0.58	0.00	0.00	0
10/23/2022	0.00	0.00	0.916	0.10	0.62	0.00	0	0.46	0.00	0.00	0
10/24/2022	0.00	0.00	1.13	0.11	0.61	0.00	0	0.52	0.00	0.00	0.05
10/25/2022	0.00	0.00	1.57	0.11	0.61	0.00	0	0.37	0.00	0.00	0
10/26/2022	0.00	0.00	1.31	0.11	0.59	0.00	0	0.35	0.00	0.00	0
10/27/2022	0.00	0.00	1.09	0.11	0.57	0.00	0.00	0.38	0.00	0.00	T
10/28/2022	0.00	0.00	1.06	0.10	0.57	0.00	0.16	0.31	0.00	0.00	0
10/29/2022	0.00	0.00	1.30	0.17	0.58	0.00	0.27	1.84	0.00	0.00	0
10/30/2022	0.00	0.00	6.41	0.96	0.58	0.00	4.79	3.00	0.00	0.00	0
10/31/2022	0.00	0.00	11.11	0.29	0.57	0.00	3.21	2.83	0.00	0.00	0

6.0 STORMWATER SAMPLE DATA

Site	Date	Flow (cfs)	TP (ug/l)	SRP (ug/l)	TN (mg/l)	TSS (mg/l)	Cl (mg/l)	Type
BL3	4/4/2022	1.04	97.44	19.47	1.08	3.17		GRAB
BL3	4/18/2022	1.12	67.96	5.55	0.76	1.29		GRAB
BL3	5/2/2022	7.32	79.21	69.60	0.95	1.78		GRAB
BL3	5/16/2022	2.24	71.03	35.39	0.92	0.39		GRAB
BL3	5/31/2022	1.83	59.19	17.86	0.94	1.57		GRAB
BL3	6/13/2022	0.34	127.57	56.73	1.18	1.86		GRAB
BL3	6/27/2022	0.02	734.96	60.83	4.59	20.00		GRAB
BL3	8/8/2022	0.08	587.11	97.11	4.87	15.14		GRAB
BL3	8/18/2022	3.56	112.06	42.06	1.05	2.25		GRAB
BL3	8/22/2022	0.56	88.26	46.36	0.80	1.45		GRAB
BL3	9/6/2022	0.03	177.92	59.72	2.82	4.75		GRAB
ECER	4/4/2022	9.25	152.10	57.47	1.91	7.90	91.97	GRAB
ECER	4/18/2022	10.22	128.52	47.68	1.22	3.80	89.97	GRAB
ECER	4/20/2022	8.98	97.51	65.77	1.11	2.91	511.84	COMP
ECER	5/2/2022	46.54	320.48	101.50	1.06	3.75	77.98	GRAB
ECER	5/12/2022	36.15	241.87	104.26	1.65	31.50	63.98	COMP
ECER	5/16/2022	17.09	177.05	139.31	0.88	2.50	69.98	GRAB
ECER	5/30/2022	13.88	277.35	109.95	1.43	15.50	81.97	COMP
ECER	5/31/2022	21.35	233.10	131.74	1.23	4.00	85.97	GRAB
ECER	6/13/2022	5.22	241.90	191.21	1.22	7.55		GRAB
ECER	6/27/2022	1.30	261.93	197.40	1.54	3.69	105.97	GRAB
ECER	7/11/2022	1.21	593.04	264.55	1.52	4.00	119.96	GRAB
ECER	7/25/2022	0.88	337.06	224.02	1.46	25.33	103.97	GRAB
ECER	7/27/2022	1.60	359.95	170.27	1.78	20.89	93.97	COMP
ECER	8/7/2022	3.90	461.61	154.94	2.40	126.00	85.97	COMP
ECER	8/8/2022	6.58	271.20	139.87	1.38	9.60	91.97	GRAB
ECER	8/18/2022	34.59	610.00	133.43	4.87	180.65	31.99	COMP
ECER	8/22/2022	4.83	213.13	148.04	0.90	3.02	73.98	GRAB
ECER	9/6/2022	0.85	235.80	157.01	1.23	1.86	105.97	GRAB
ECER	9/19/2022	0.69	274.37	152.29	1.30	4.00	109.97	GRAB
ECER	10/3/2022	0.62	435.19	183.66	1.01	6.60	135.96	GRAB
ECER	10/17/2022	1.26	580.76	190.82	1.56	14.32		GRAB
GC1	4/4/2022	1.55	149.35	24.44	1.14	5.80	179.94	GRAB
GC1	4/18/2022	1.58	89.70	10.11	1.00	3.40	229.93	GRAB
GC1	4/20/2022	2.87	166.55	33.42	1.55	32.80	141.96	COMP
GC1	5/2/2022	4.56	92.50	30.25	1.03	3.88	159.95	GRAB
GC1	5/11/2022	6.76	296.28	64.72	2.41	59.00	91.97	COMP
GC1	5/16/2022	2.15	119.24	103.23	0.96	5.67	231.93	GRAB

GC1	5/25/2022	2.60	132.53	49.25	1.13	3.00	199.94	COMP
GC1	5/31/2022	2.29	258.77	53.95	2.13	41.33	101.97	COMP
GC1	5/30/2022	2.54	151.55	64.15	1.12	2.57	199.94	GRAB
GC1	6/13/2022	0.45	299.87	114.49	2.36	18.78	131.96	GRAB
GC1	7/12/2022	0.35	232.79	103.23	2.51	24.19	39.99	COMP
GC1	7/27/2022	0.13	365.03	100.92	3.40	16.67	23.99	COMP
GC1	8/8/2022	0.08	218.49	74.39	1.03	2.60	43.99	GRAB
GC1	8/18/2022	0.39	181.80	66.71	2.43	16.75	8.00	COMP
HAMEL	4/4/2022	10.69	237.23	53.11	1.68	9.37	91.97	GRAB
HAMEL	4/18/2022	3.87	116.16	31.96	1.79	3.17	79.98	GRAB
HAMEL	5/2/2022	12.37	216.89	38.70	2.01	7.86	69.98	GRAB
HAMEL	5/11/2022	8.29	382.27	54.58	4.36	199.33	107.97	COMP
HAMEL	5/16/2022	13.02	132.43	55.16	1.17	6.33	67.98	GRAB
HAMEL	5/29/2022	8.24	139.71	49.90	1.21	3.33	87.97	COMP
HAMEL	5/31/2022	7.78	216.18	71.97	1.65	7.00	83.97	GRAB
HAMEL	6/13/2022	1.75	295.71	130.44	1.94	3.11	85.97	GRAB
HAMEL	6/27/2022	1.91	150.57	32.79	1.67	2.00	299.91	GRAB
HAMEL	7/11/2022	0.64	176.59	48.71	2.03	2.54	221.93	GRAB
HAMEL	7/27/2022	0.83	207.16	75.56	1.44	11.14	239.93	COMP
HAMEL	8/6/2022	0.62	227.10	46.74	1.89	36.47	273.92	COMP
HAMEL	8/8/2022	0.62	227.23	87.47	1.13	4.77	173.95	GRAB
HAMEL	8/22/2022	0.53	154.16	57.79	0.92	1.11	99.97	GRAB
HAMEL	9/6/2022	0.62	183.23	8.28	2.27	9.15	355.89	GRAB
HAMEL	9/19/2022	0.60	200.23	14.77	3.36	14.77	447.86	GRAB
HAMEL	10/3/2022	0.55	248.86	27.89	1.46	5.00	149.95	GRAB
IP1	5/11/2022	20.39	252.79	75.35	2.41	38.00	23.99	COMP
IP1	5/19/2022	0.38					341.89	COMP
IP1	5/25/2022	0.81	121.79				137.96	COMP
IP1	5/30/2022	0.68					149.95	COMP
IP1	6/16/2022	0.18					381.88	COMP
IP1	6/28/2022	0.41	222.90	168.57			131.96	COMP
IP1	7/11/2022	0.15					317.90	COMP
IP1	7/12/2022	0.56					14.00	COMP
IP1	7/23/2022	0.32					209.93	COMP
IP1	7/27/2022	0.36					133.96	COMP
IP1	8/8/2022	0.14					91.97	COMP
IP1	8/17/2022	8.75					19.99	COMP
IP2	4/4/2022	6.08	190.60	27.50	1.57	3.60	299.91	GRAB
IP2	4/18/2022	3.75	83.52	14.04	1.19	2.80	259.92	GRAB
IP2	5/2/2022	24.27	99.03	36.64	1.37	3.50	129.96	GRAB
IP2	5/11/2022	24.47	476.66	17.50	3.73	139.00	125.96	COMP
IP2	5/16/2022	5.12	199.37	55.89	1.37	4.20	179.94	GRAB

IP2	5/30/2022	9.16	191.20	45.21	1.69	13.75	161.95	COMP
IP2	5/31/2022	8.54	375.61	54.04	2.59	60.00	171.95	GRAB
IP2	6/13/2022	11.58	337.66	49.43	2.37	36.25	247.92	COMP
IP2	6/14/2022	8.04	170.02	48.85	1.41	4.31	245.92	GRAB
IP2	6/28/2022	0.45	228.03	67.19		5.69	257.92	COMP
IP2	7/26/2022	0.88	189.56	48.36	1.25	3.80	255.92	COMP
IP2	8/6/2022	7.91	235.45	55.15	1.69	33.08	65.98	COMP
IP2	8/8/2022	0.00	219.39	98.51	1.01	3.40	113.96	GRAB
IP2	8/17/2022	10.04	246.83	145.41	1.70	28.40	119.96	COMP
IP2	8/22/2022	1.03	193.80	78.68	0.92	1.14	153.95	GRAB
MOOSW1	4/4/2022		314.45	97.29	2.45	9.60		GRAB
MOOSW1	5/25/2022		670.30	430.44	3.31	19.66		GRAB
MOOSW1	8/18/2022		373.94	225.98	2.22	7.25		GRAB
MOOSW2	4/4/2022		145.51	59.49	2.37	8.50		GRAB
MOOSW2	4/18/2022		223.17	33.93	1.94	9.40		GRAB
MOOSW2	5/2/2022		126.35	32.65	1.75	5.50		GRAB
MOOSW2	5/16/2022		191.02	74.81	1.55	6.67		GRAB
MOOSW2	5/25/2022		200.70	77.28	1.57	3.33		GRAB
MOOSW2	5/31/2022		239.00	84.76	2.67	5.54		GRAB
MOOSW2	6/13/2022		434.27	171.48	1.98	5.25		GRAB
MOOSW2	8/8/2022		294.17	72.28	1.81	11.60		GRAB
MOOSW2	8/18/2022		241.63	100.94	1.47	4.20		GRAB
MOOSW3	4/4/2022		354.71	78.04	1.43	45.85		GRAB
MOOSW3	5/25/2022		289.49	97.92	1.89	20.00		GRAB
MOOSW3	8/18/2022		167.15	66.39	1.48	28.29		GRAB
MOOSW4	8/18/2022		304.16	79.14	2.28	41.18		GRAB
MOOSW5	5/25/2022		394.08	130.10	2.61	23.18		GRAB
MOOSW5	8/18/2022		339.40	109.80	3.15	117.60		GRAB
PC2	4/4/2022	11.04	98.65	20.99	1.61	4.80	249.92	GRAB
PC2	4/18/2022	6.25	92.87	13.49	1.50	4.80	251.92	GRAB
PC2	5/2/2022	41.21	107.63	33.28	1.46	3.75	137.96	GRAB
PC2	5/12/2022	26.66	201.03	23.19	2.25	17.00	99.97	COMP
PC2	5/16/2022	12.26	135.48	59.61	1.29	2.50	181.94	GRAB
PC2	5/31/2022	12.63	158.20	47.09	1.31	3.83	171.95	GRAB
PC2	6/13/2022	4.76	169.52	45.83	1.31	7.40	283.91	GRAB
PC2	6/27/2022	0.00	197.26	64.23	1.24	4.83	223.93	GRAB
PC2	8/6/2022	11.42	220.90	69.46	1.42	23.08	71.98	COMP
PC2	8/8/2022	0.00	169.10	91.43	0.92	3.67	95.97	GRAB
PC2	8/18/2022	15.32	229.44	110.59	1.78	28.80	69.98	COMP
PC2	8/22/2022	0.98	175.81	88.05	0.80	1.14	127.96	GRAB
PEONY	4/4/2022	9.45	218.00	81.92	1.99	11.71	113.96	GRAB
PEONY	4/18/2022	4.77	135.77	114.84	1.57	3.60	81.97	GRAB

PEONY	5/2/2022	16.43	353.13	79.25	1.72	7.56	75.98	GRAB
PEONY	5/11/2022	32.62	574.89	82.25	4.74	450.00	89.97	COMP
PEONY	5/16/2022	11.62	150.91	94.56	1.14	6.40	69.98	GRAB
PEONY	5/30/2022	5.72	484.59	105.59	2.44	60.50	83.97	COMP
PEONY	5/31/2022	6.62	314.62	182.00	1.37	8.50	85.97	GRAB
PEONY	6/13/2022	0.49	350.70	169.96	1.68	7.18	71.98	GRAB
PEONY	6/27/2022	1.38	295.14	188.22	1.16	7.85	147.95	GRAB
PEONY	7/11/2022	1.42	413.32	97.76	1.31	7.00	69.98	GRAB
PEONY	7/25/2022	1.38	559.76	423.47	1.21	7.60	59.98	GRAB
PEONY	8/8/2022	4.00	546.96	357.83	0.17	9.60	93.97	GRAB
PEONY	8/18/2022	8.42	706.32	288.08	3.89	170.40	65.98	COMP
PEONY	9/6/2022	0.32	394.04	241.53	1.06	6.72	71.98	GRAB
PEONY	9/19/2022	0.22	424.75	299.40	1.03	6.62	65.98	GRAB
PEONY	10/3/2022	0.47	411.13	271.14	1.10	9.02	119.96	GRAB
PEONY	10/17/2022	0.96	259.79	108.90	1.30	3.26		GRAB
PL1	4/20/2022	0.64	413.60	177.54	3.02	67.18	4.00	COMP
PL1	5/12/2022	0.18	274.27	143.88	2.03	2.89	39.99	GRAB
PL1	5/20/2022	0.07	469.44	168.48	8.30		6.00	COMP
PL1	5/25/2022	0.52	272.92	141.41	1.53	3.33	27.99	COMP
PL1	7/8/2022	0.17	531.78	310.26	5.02	44.00	4.00	COMP
PL1	7/12/2022	3.60	278.68	177.74	2.54	14.00	6.00	COMP
PL1	8/6/2022	6.90	395.25	123.80	2.63	149.20	2.00	COMP
PL1	8/17/2022	4.47	265.53	130.47	2.56	48.05	19.99	COMP
PL2	3/22/2022						495.85	GRAB
PL2	3/29/2022						303.91	GRAB
PL2	4/4/2022	0.97	221.63	8.49	1.87	10.20	389.88	GRAB
PL2	4/18/2022	0.11	92.49	38.99	1.14	1.60	331.90	GRAB
PL2	5/2/2022	1.12	94.91	27.33	1.55	4.44	127.96	GRAB
PL2	5/12/2022	2.39	150.78	40.03	1.56	10.25	269.92	GRAB
PL2	5/16/2022	0.30	150.94	98.15	0.86	1.43	297.91	GRAB
PL2	5/19/2022	1.08	253.56	47.84	2.35		285.91	COMP
PL2	5/31/2022	0.68	161.05	57.99	1.09	2.67	299.91	GRAB
PL2	6/13/2022	0.77	249.53	124.70	1.20	6.46	337.90	GRAB
PL2	6/27/2022	0.18	289.29	222.26	0.90	1.22	337.90	GRAB
PL2	6/28/2022	0.59	308.59	187.13		16.27		COMP
PL2	7/8/2022	0.21	319.72	118.69	3.00	48.00	173.95	COMP
PL2	7/11/2022	0.20	403.56	225.52	0.86	2.14	321.90	GRAB
PL2	7/12/2022	0.26	289.46	154.03	1.50	130.50	235.93	COMP
PL2	7/25/2022	0.20	313.01	207.76	1.01	3.72	277.91	GRAB
PC2	7/26/2022	0.82	378.73	117.60	2.05	17.67	199.94	COMP
PL2	8/8/2022	0.00	243.30	105.03	0.91	2.02	139.96	GRAB
PL2	8/17/2022	2.23	231.96	36.40	2.10	70.67	33.99	COMP

PL2	8/22/2022	0.15	151.63	96.73	0.65	1.07	107.97	GRAB
PL2	9/6/2022	0.00	173.21	140.59	0.65	0.29	137.96	GRAB
PL2	9/19/2022	0.09	141.43	92.68	0.82	0.61	165.95	GRAB
PL2	10/3/2022	0.00	121.81	103.10	0.74	0.43	183.94	GRAB
PL2	10/17/2022	0.00	100.84	74.43	0.60	0.57		GRAB
PRG-IN	8/18/2022		96.98	42.04	1.02	11.86		GRAB

7.0 LAKE DATA

7.1. Sonde Data

Date	Site	Depth (m)	Temp (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Specific Conductivity (uS/cm)	pH
4/25/2022	PAR	0.0	7.0	104.7	12.68	999	8.6
4/25/2022	PAR	1.0	7.0	106.2	12.86	997	8.5
4/25/2022	PAR	2.0	7.0	106.0	12.84	996	8.5
4/25/2022	PAR	3.0	7.0	105.5	12.78	996	8.4
4/25/2022	PAR	4.0	7.0	105.5	12.78	996	8.4
4/25/2022	PAR	5.0	6.9	106.8	12.94	996	8.4
4/25/2022	PAR	6.0	6.9	106.0	12.85	997	8.4
4/25/2022	PAR	7.0	6.9	105.2	12.75	997	8.4
4/25/2022	PAR	8.0	6.8	106.2	12.90	997	8.4
4/25/2022	PAR	9.0	6.8	104.3	12.68	997	8.4
4/25/2022	PAR	10.0	6.8	105.8	12.87	997	8.4
4/25/2022	PAR	11.0	5.7	15.0	1.88	1,327	7.2
4/25/2022	PAR	11.0	5.5	6.8	0.85	1,334	7.0
5/9/2022	PAR	0.0	13.8	104.8	10.82	959	8.4
5/9/2022	PAR	1.0	13.7	105.7	10.93	958	8.4
5/9/2022	PAR	2.0	13.6	106.8	11.08	957	8.5
5/9/2022	PAR	3.0	11.4	119.3	12.99	955	8.6
5/9/2022	PAR	4.0	9.6	119.5	13.59	957	8.6
5/9/2022	PAR	5.0	8.9	99.5	11.49	953	8.4
5/9/2022	PAR	6.0	8.6	95.7	11.15	954	8.4
5/9/2022	PAR	7.0	8.3	91.1	10.67	957	8.4
5/9/2022	PAR	8.0	8.1	81.8	9.65	963	8.3
5/9/2022	PAR	9.0	7.6	70.2	8.36	973	8.1
5/9/2022	PAR	10.0	7.5	56.9	6.81	977	8.0
5/9/2022	PAR	11.0	7.4	50.2	6.01	978	7.9
5/9/2022	PAR	11.0	7.4	46.7	5.59	979	7.9
5/23/2022	PAR	0.0	16.7	99.4	9.65	958	8.2
5/23/2022	PAR	1.0	16.6	99.9	9.71	959	8.3
5/23/2022	PAR	2.0	16.5	98.9	9.64	959	8.3
5/23/2022	PAR	3.0	16.4	99.1	9.67	959	8.3

5/23/2022	PAR	4.0	11.3	105.9	11.55	973	8.4
5/23/2022	PAR	5.0	9.1	82.9	9.52	979	8.1
5/23/2022	PAR	6.0	8.3	71.6	8.39	983	8.0
5/23/2022	PAR	7.0	7.9	59.9	7.09	987	7.9
5/23/2022	PAR	8.0	7.6	42.6	5.08	994	7.7
5/23/2022	PAR	9.0	7.3	13.2	1.58	1,000	7.5
5/23/2022	PAR	10.0	7.2	5.4	0.65	1,005	7.4
5/23/2022	PAR	11.0	7.0	3.4	0.41	1,033	7.1
5/23/2022	PAR	11.0	7.1	2.7	0.33	1,034	7.0
6/6/2022	PAR	0.0	19.7	123.3	11.23	999	8.5
6/6/2022	PAR	1.0	19.7	124.0	11.31	999	8.5
6/6/2022	PAR	2.0	19.6	123.3	11.28	1,000	8.5
6/6/2022	PAR	3.0	19.5	123.0	11.26	1,001	8.5
6/6/2022	PAR	4.0	16.1	117.7	11.57	1,037	8.4
6/6/2022	PAR	5.0	10.5	84.4	9.39	1,056	8.3
6/6/2022	PAR	6.0	9.0	61.0	7.01	1,055	8.1
6/6/2022	PAR	7.0	8.4	49.7	5.82	1,058	7.9
6/6/2022	PAR	8.0	7.9	14.4	1.70	1,070	7.7
6/6/2022	PAR	9.0	7.6	6.9	0.82	1,077	7.7
6/6/2022	PAR	10.0	7.3	4.3	0.51	1,083	7.6
6/6/2022	PAR	11.0	7.1	3.6	0.43	1,099	7.4
6/6/2022	PAR	11.0	7.1	3.1	0.37	1,102	7.2
6/20/2022	PAR	0.0	25.1	124.9	10.28	973	8.6
6/20/2022	PAR	1.0	25.0	125.4	10.33	974	8.7
6/20/2022	PAR	2.0	24.9	125.6	10.37	974	8.7
6/20/2022	PAR	3.0	23.2	85.2	7.26	992	8.4
6/20/2022	PAR	4.0	17.5	113.0	10.79	1,041	8.3
6/20/2022	PAR	5.0	12.9	91.5	9.63	1,060	8.2
6/20/2022	PAR	6.0	10.3	75.7	8.46	1,060	8.1
6/20/2022	PAR	7.0	9.0	33.9	3.91	1,071	7.9
6/20/2022	PAR	8.0	8.3	4.9	0.57	1,079	7.6
6/20/2022	PAR	9.0	7.9	2.9	0.34	1,088	7.5
6/20/2022	PAR	10.0	7.7	2.1	0.25	1,099	7.4
6/20/2022	PAR	11.0	7.6	1.8	0.22	1,105	7.2
7/5/2022	PAR	0.0	25.9	123.0	9.97	944	8.7
7/5/2022	PAR	1.0	25.7	124.8	10.15	945	8.8
7/5/2022	PAR	2.0	25.3	121.8	9.98	947	8.8
7/5/2022	PAR	3.0	24.9	107.0	8.84	949	8.7
7/5/2022	PAR	4.0	21.8	97.3	8.51	1,004	8.5
7/5/2022	PAR	5.0	15.0	117.0	11.77	1,045	8.5
7/5/2022	PAR	6.0	11.1	82.9	9.08	1,052	8.3
7/5/2022	PAR	7.0	9.6	54.5	6.19	1,058	8.2

7/5/2022	PAR	8.0	8.7	7.2	0.84	1,071	7.7
7/5/2022	PAR	9.0	8.1	3.3	0.39	1,084	7.5
7/5/2022	PAR	10.0	7.8	2.5	0.29	1,096	7.3
7/5/2022	PAR	11.0	7.7	1.9	0.23	1,101	7.2
7/18/2022	PAR	0.0	27.4	149.1	11.76	947	9.1
7/18/2022	PAR	1.0	27.4	149.3	11.78	948	9.1
7/18/2022	PAR	2.0	26.8	136.4	10.88	953	9.0
7/18/2022	PAR	3.0	25.8	108.3	8.80	941	8.8
7/18/2022	PAR	4.0	19.1	67.3	6.12	1,077	8.3
7/18/2022	PAR	5.0	15.5	112.3	11.18	1,053	8.4
7/18/2022	PAR	6.0	11.6	56.3	6.10	1,063	7.9
7/18/2022	PAR	7.0	9.4	7.3	0.83	1,071	7.6
7/18/2022	PAR	8.0	8.4	5.1	0.60	1,086	7.5
7/18/2022	PAR	9.0	7.8	3.9	0.46	1,102	7.3
7/18/2022	PAR	10.0	7.6	3.1	0.37	1,111	7.2
7/18/2022	PAR	11.0	7.5	2.7	0.32	1,117	7.0
7/18/2022	PAR	11.0	7.5	2.1	0.25	1,123	7.0
8/1/2022	PAR	0.0	23.7	117.3	9.91	938	8.9
8/1/2022	PAR	1.0	23.7	117.4	9.91	939	8.9
8/1/2022	PAR	2.0	23.7	117.5	9.93	939	8.9
8/1/2022	PAR	3.0	23.6	117.1	9.90	939	9.0
8/1/2022	PAR	4.0	23.6	116.4	9.85	939	9.0
8/1/2022	PAR	5.0	16.5	94.3	9.18	1,050	8.6
8/1/2022	PAR	6.0	11.9	15.0	1.61	1,049	7.9
8/1/2022	PAR	7.0	9.8	8.2	0.92	1,060	7.9
8/1/2022	PAR	8.0	8.7	4.6	0.54	1,072	7.8
8/1/2022	PAR	9.0	8.1	3.4	0.40	1,084	7.7
8/1/2022	PAR	10.0	7.8	2.9	0.35	1,098	7.3
8/1/2022	PAR	11.0	7.6	2.5	0.30	1,102	7.2
8/15/2022	PAR	0.0	23.0	113.9	9.74	887	8.9
8/15/2022	PAR	1.0	22.9	115.0	9.86	886	9.0
8/15/2022	PAR	2.0	22.8	114.9	9.86	887	9.0
8/15/2022	PAR	3.0	22.6	100.9	8.71	884	8.9
8/15/2022	PAR	4.0	22.3	83.8	7.26	885	8.8
8/15/2022	PAR	5.0	19.9	24.0	2.19	1,005	8.0
8/15/2022	PAR	6.0	14.0	5.7	0.59	1,066	7.9
8/15/2022	PAR	7.0	10.8	4.4	0.49	1,076	7.8
8/15/2022	PAR	8.0	8.9	3.0	0.35	1,087	7.8
8/15/2022	PAR	9.0	8.39	2.6	0.30	1,095	7.6
8/15/2022	PAR	10.0	7.90	2.2	0.26	1,109	7.4
8/15/2022	PAR	11.0	7.61	1.9	0.22	1,122	6.9
8/15/2022	PAR	11.0	7.61	1.8	0.22	1,120	6.9

8/29/2022	PAR	0.0	24.05	104.8	8.79	840	9.0
8/29/2022	PAR	1.0	24.04	104.8	8.79	840	9.0
8/29/2022	PAR	2.0	24.04	104.7	8.79	840	9.0
8/29/2022	PAR	3.0	24.03	103.0	8.64	841	9.0
8/29/2022	PAR	4.0	23.59	37.9	3.21	850	8.6
8/29/2022	PAR	5.0	21.07	4.5	0.40	934	8.1
8/29/2022	PAR	6.0	16.21	2.4	0.23	1,046	7.8
8/29/2022	PAR	7.0	11.81	1.8	0.19	1,054	7.8
8/29/2022	PAR	8.0	9.86	1.4	0.15	1,062	7.4
8/29/2022	PAR	9.0	8.82	1.2	0.14	1,088	7.3
8/29/2022	PAR	10.0	8.31	1.1	0.13	1,106	7.1
8/29/2022	PAR	11.0	8.32	1.0	0.12	1,105	7.1
9/12/2022	PAR	0.0	21.39	98.6	8.70	842	8.8
9/12/2022	PAR	1.0	21.38	98.9	8.73	842	8.9
9/12/2022	PAR	2.0	21.33	99.6	8.80	842	8.9
9/12/2022	PAR	3.0	21.32	99.8	8.82	843	9.0
9/12/2022	PAR	4.0	21.30	99.3	8.78	843	9.0
9/12/2022	PAR	5.0	20.59	33.3	2.98	888	8.4
9/12/2022	PAR	6.0	15.70	6.3	0.63	1,051	8.0
9/12/2022	PAR	7.0	11.52	3.8	0.42	1,061	7.9
9/12/2022	PAR	8.0	9.58	3.3	0.37	1,078	7.8
9/12/2022	PAR	9.0	8.43	2.9	0.34	1,103	7.4
9/12/2022	PAR	10.0	7.99	2.5	0.30	1,118	7.1
9/12/2022	PAR	11.0	7.97	2.2	0.26	1,126	6.9
9/26/2022	PAR	0.0	18.00	92.2	8.71	815	
9/26/2022	PAR	1.0	17.99	92.1	8.70	815	
9/26/2022	PAR	2.0	18.00	91.9	8.68	815	
9/26/2022	PAR	3.0	17.99	91.9	8.69	814	
9/26/2022	PAR	4.0	18.00	92.0	8.69	815	
9/26/2022	PAR	5.0	18.00	92.1	8.70	814	
9/26/2022	PAR	6.0	17.88	91.2	8.63	815	
9/26/2022	PAR	7.0	11.92	3.7	0.39	1,016	
9/26/2022	PAR	8.0	9.96	2.7	0.30	1,032	
9/26/2022	PAR	9.0	8.77	1.9	0.22	1,060	
9/26/2022	PAR	10.0	8.39	1.7	0.20	1,077	
9/26/2022	PAR	11.0	8.38	1.6	0.19	1,076	
10/4/2022	PAR	0.0	17.22	111.3	10.68	824	8.9
10/4/2022	PAR	1.0	17.09	112.0	10.78	823	9.0
10/4/2022	PAR	2.0	16.92	112.9	10.91	822	9.0
10/4/2022	PAR	3.0	16.88	112.0	10.83	822	9.1
10/4/2022	PAR	4.0	16.73	108.4	10.51	823	9.1
10/4/2022	PAR	5.0	16.58	104.1	10.13	823	9.0

10/4/2022	PAR	6.0	16.16	87.1	8.55	833	8.9
10/4/2022	PAR	7.0	13.47	6.6	0.69	1,009	8.2
10/4/2022	PAR	8.0	10.00	4.0	0.45	1,058	7.9
10/4/2022	PAR	9.0	8.98	2.4	0.28	1,061	7.4
10/4/2022	PAR	10.0	8.51	1.9	0.22	1,080	7.1
10/4/2022	PAR	11.0	8.41	1.6	0.19	1,090	7.0
10/10/2022	PAR	0.0	14.81	100.1	10.11	826	8.6
10/10/2022	PAR	1.0	14.78	100.6	10.17	825	8.6
10/10/2022	PAR	2.0	14.77	100.5	10.16	826	8.6
10/10/2022	PAR	3.0	14.75	100.7	10.19	825	8.6
10/10/2022	PAR	4.0	14.74	100.8	10.19	825	8.7
10/10/2022	PAR	5.0	14.72	101.0	10.22	825	8.7
10/10/2022	PAR	6.0	14.51	93.1	9.47	833	8.6
10/10/2022	PAR	7.0	13.84	46.0	4.75	882	8.2
10/10/2022	PAR	8.0	10.36	6.5	0.73	1,046	7.7
10/10/2022	PAR	9.0	9.26	3.3	0.38	1,063	7.4
10/10/2022	PAR	10.0	8.74	2.6	0.30	1,079	7.2
10/10/2022	PAR	11.0	8.53	2.2	0.25	1,087	7.1
10/24/2022	PAR	0.0	11.02	93.6	10.29	853	8.2
10/24/2022	PAR	1.0	11.01	93.6	10.29	852	8.2
10/24/2022	PAR	2.0	10.99	93.4	10.28	852	8.2
10/24/2022	PAR	3.0	10.88	92.6	10.21	851	8.3
10/24/2022	PAR	4.0	10.32	87.5	9.78	853	8.3
10/24/2022	PAR	5.0	10.15	86.2	9.67	852	8.3
10/24/2022	PAR	6.0	9.59	79.7	9.06	854	8.3
10/24/2022	PAR	7.0	8.88	74.2	8.57	855	8.3
10/24/2022	PAR	8.0	8.70	70.7	8.21	855	8.2
10/24/2022	PAR	9.0	8.64	68.5	7.96	856	8.2
10/24/2022	PAR	10.0	8.62	60.5	7.03	858	8.1
10/24/2022	PAR	11.0	8.59	39.1	4.56	866	7.9

7.2. Lake Water Quality Data

Date	Site	Depth (m)	TP (ug/L)	SRP (ug/L)	TN (mg/L)	Cl (mg/L)	CHL-a (ug/L) Measured	Secchi (m)
4/25/2022	PAR	0.0	75.14	12.29	0.69	200	15.6	1.45
4/25/2022	PAR	6.0	54.35	23.32				
4/25/2022	PAR	11.0	65.91	8.27		212		
5/9/2022	PAR	0.0	29.33	6.16	0.48	194	4.1	2.15
5/9/2022	PAR	6.0	36.94	7.2				
5/9/2022	PAR	11.0	51.42	6.97				
5/23/2022	PAR	0.0	23.77	3.95	0.49	206	2.0	5.18
5/23/2022	PAR	10.0	48.77	22.46				

5/23/2022	PAR	11.0	74.69	52.32		202		
6/6/2022	PAR	0.0	23.71	11.59	0.40	202	0.9	5.25
6/6/2022	PAR	8.0	42.05	12.85				
6/6/2022	PAR	11.0	162.68	102.51		212		
6/20/2022	PAR	0.0	50.24	16.06	0.62	214	4.2	5.23
6/20/2022	PAR	8.0	91.95	39.44				
6/20/2022	PAR	10.0	144.39	95.3		214		
7/5/2022	PAR	0.0	33.87	8.91	0.49	208	8.3	2.75
7/5/2022	PAR	8.0	69.48	23.51		206		
7/5/2022	PAR	10.0	289.11	147.76				
7/18/2022	PAR	0.0	15.03	4.52	0.44	206	3.5	4.24
7/18/2022	PAR	7.0	45.27	20.06				
7/18/2022	PAR	11.0	447.77	294.56		202		
8/1/2022	PAR	0.0	28.88	9.75	0.46	208	3.9	4.46
8/1/2022	PAR	6.0	29.92	7.23				
8/1/2022	PAR	10.0	311.9	206.83		208		
8/15/2022	PAR	0.0	24.7	7.71	0.76	194	10.9	2.80
8/15/2022	PAR	6.0	26.98	5.53				
8/15/2022	PAR	11.0	594.34	425.19		208		
8/29/2022	PAR	0.0	23.89	3.61	0.511	190	8.5	2.75
8/29/2022	PAR	5.0	34.6	6.23				
8/29/2022	PAR	10.0	443.89	394.82		214		
9/12/2022	PAR	0.0	19.31	6.36	0.354	184	5.2	3.15
9/12/2022	PAR	6.0	46.21	9.69		196		
9/12/2022	PAR	11.0	599.36	515.45		202		
9/26/2022	PAR	0.0	26.82	23.66	0.517	178	6.0	3.15
9/26/2022	PAR	7.0	64.79	28.49		198		
9/26/2022	PAR	10.0	611.78	532.01		208		
10/4/2022	PAR	0.0	24.72	4.22		186	4.2	3.99
10/4/2022	PAR	7.0	29.54	10.15		188		
10/4/2022	PAR	11.0	781.12	625.78		212		
10/10/2022	PAR	0.0	24.11	5.78	0.5	194	4.4	4.46
10/10/2022	PAR	8.0	73.5	25.08		192		
10/10/2022	PAR	10.0	686.62	672.98		210		
10/24/2022	PAR	0.0	35.81	14.12	0.7	182	4.4	3.05
10/24/2022	PAR	5.0	39.04	14.02		184		
10/24/2022	PAR	10.0	48.7	21.72		186		

8.0 APPENDIX

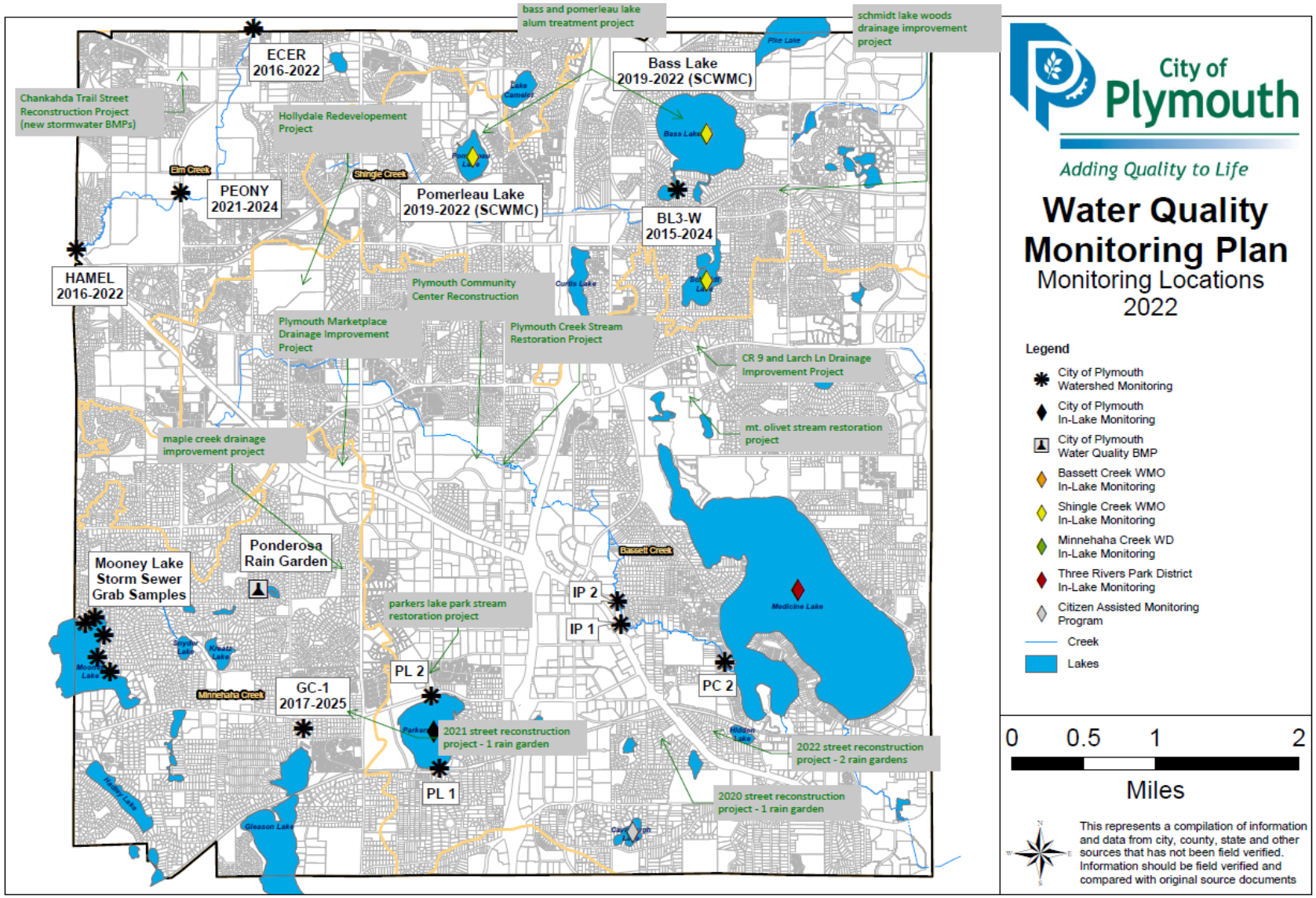

Figure 8.1. Summary of BMP installations in City of Plymouth over past 5 years.