

Technical Memorandum

To: Black Dog Watershed Management Organization (BDWMO)
From: Kevin Menken
Subject: Orchard Lake 2017 Water Quality Assessment
Date: February 13, 2018
Project: 23/19-0375

This memorandum presents the results of 2017 management-level water quality monitoring of Orchard Lake, conducted by Barr Engineering Co. (Barr) on behalf of the BDWMO. Monitoring was also performed by a citizen volunteer participating in the Metropolitan Council sponsored Citizen-Assisted Monitoring Program (CAMP).

Introduction and Background

Orchard Lake is 243 acres in size, 75% of which is less than 15 feet deep. The maximum depth is 33 feet, and the average depth is 10 feet. Its tributary watershed is 2,277 acres, 100% of which is within the borders of the city of Lakeville. Orchard Lake is primarily used for fishing, but swimming, boating, and aesthetic and wildlife viewing are also popular recreational uses of the lake.

2017 Water Quality Monitoring Activities

The BDWMO Watershed Management Plan requires that Orchard Lake undergo “management-level” water quality monitoring once every three years. Management-level monitoring involves a more detailed collection of water quality data than the Metropolitan Council’s Citizen-Assisted Monitoring Program (CAMP). This expanded effort was conducted by Barr in 2017 and included collection of the following data:

- Measurement of Secchi disc transparency (a measure of water clarity).
- Field probe measurements of dissolved oxygen concentration, water temperature, specific conductivity, pH, and oxidation/reduction potential at 1-meter depth intervals.
- Composite water samples from the surface of Orchard Lake (0–2 meters); these samples were sent to a laboratory for analyses of total phosphorus and chlorophyll *a* concentrations (a measure of algal abundance).
- Water samples from 3 meters to 8 meters, taken at 1-meter depth intervals; these samples were sent to a laboratory for analyses of total phosphorus concentrations.

Tabulated water quality data collected by Barr (Table 2) and the CAMP volunteer (Table 3) are attached at the end of this memorandum. The 2017 Barr and CAMP measurements of Secchi disc transparency, total

phosphorus, and chlorophyll *a* measurements are plotted in Figure 1. Measurements of SDT collected by Barr were very similar to the CAMP measurements during the summer-average period of June-September, demonstrating better water clarity in early-summer compared to late-summer. Barr measurements of total phosphorus were slightly higher than CAMP measurements for total phosphorus during most of the summer averaging period of June-September, while CAMP total phosphorus was higher in May and October. Concentrations of phosphorus were lowest in June, and increase by late summer. Barr measurements of chlorophyll *a* were similar to CAMP measurements, and showed a pronounced increase in chlorophyll *a* in late-summer compared to early-summer, with concentrations 3 to 4 times higher in August-September compared to May-June.

Summer Averages of Water Quality Parameters and Associated Goals

The 2017 summer (June-September) averages of water quality parameters were calculated for Orchard Lake, and plotted along with previous years' summer averages. The plots of summer averages for Secchi disc transparency (Figure 2), total phosphorus (Figure 3), and chlorophyll *a* (Figure 4) are attached to this memorandum. The BDWMO classified Orchard Lake as a Category I water body (supporting swimming and other direct contact recreational activities). The water quality action level for summer average (June-September) Secchi disc transparency (SDT) for Orchard Lake was recalculated to be 2.49 meters (8.2 feet) for the most recent 10 years of monitoring (2008-2017). The summer average SDT in 2017 was 2.62 meters (8.6 feet), which is better than the action level of 2.49 meters. However, there was a statistically significant trend (90% confidence interval) of worsening water quality in summer average SDT for the most recent 10-year period. There were no statistically significant trends in summer averages of total phosphorus or chlorophyll *a*.

The MPCA's lake eutrophication standards include numeric criteria for summer averages (June-September) of Secchi disc transparency, total phosphorus, and chlorophyll *a*. Table 1 provides the eutrophication standards for a deep lake within the North Central Hardwood Forest ecoregion, along with the averages of the most recent 10 years (2008-2017) of monitoring for Orchard Lake. Summer averages of Orchard Lake water quality parameters are consistently much better than the MPCA's lake eutrophication standards. The BDWMO's *2012-2022 Watershed Management Plan* (Plan) lists recommended lake water quality management actions for strategic waterbodies under different scenarios of observed water quality. According to Table 4-1 of the BDWMO Plan, if Orchard Lake has summer average water quality better than the Management Action Level, and a statistically significant 10-year trend of degrading water quality (i.e., SDT), the following actions are recommended: 1) management level lake water quality monitoring, and 2) a watershed land use review. Barr's recommendations for future activities on Orchard Lake are discussed at the end of this memorandum.

Table 1 Orchard Lake Water Quality and the MPCA's Lake Eutrophication Standards for Deep Lakes in North Central Hardwood Forest

Water Quality Parameter	MPCA Lake Eutrophication Standard	Orchard Lake 10-yr Average (2008-2017)
Total Phosphorus ($\mu\text{g/L}$)	≤ 40	17
Chlorophyll <i>a</i> ($\mu\text{g/L}$)	≤ 14	5.2
Secchi Disc Transparency (m)	≥ 1.4	2.6

Aquatic Macrophyte Surveys

Blue Water Science conducted aquatic plant surveys of Orchard Lake on behalf of the City of Lakeville in 2017. The first survey was conducted in April, and survey results were used to direct curlyleaf pondweed herbicide treatment of 3 areas of the lake that totaled 14.5 acres in size. Curlyleaf pondweed is a non-native, invasive aquatic plant that dies off in early- to mid-summer. The early-summer die off can release phosphorus into the lake and negatively affect water quality, and may have contributed to poorer water quality in Orchard Lake prior to management of curlyleaf pondweed. Blue Water Science's report *Aquatic Plant Surveys for Orchard Lake, Lakeville, Minnesota, 2017* notes that researchers from the University of Minnesota conducting a study on Orchard Lake in July 2017 found Eurasian watermilfoil, another exotic invasive aquatic plant. Additional surveys reportedly found the Eurasian watermilfoil was limited to the one area of the lake, and an area of 1.15 acres was treated with an herbicide to target the Eurasian watermilfoil. Although Eurasian watermilfoil does not die off in early summer and negatively affect water quality like curlyleaf pondweed, it can outcompete native plants and grow to nuisance levels. Additional details of the 2017 Orchard Lake aquatic plant survey can be found in *Aquatic Plant Surveys for Orchard Lake, Lakeville, Minnesota, 2017* prepared by Blue Water Science for the City of Lakeville.

Lake Levels

Lake elevation data have been collected on Orchard Lake regularly since 1992. The highest observed lake elevation was 977.75 feet above mean sea level on June 20, 2014, while the lowest observed was 975.84 feet on November 6, 2003, a difference of 1.9 feet. In recent years (2015-2018), the lake elevation has fluctuated between 976.54 feet and 977.15 feet, a difference of 0.6 feet (7 inches). Lake elevations are plotted on Figure 5.

Fishery

The Minnesota Department of Natural Resources (DNR) reports results of fishery surveys on the DNR's Lake Finder web portal. The Lake Finder webpage for Orchard Lake details results of DNR fish surveys performed on Orchard Lake. Results of recent surveys are summarized below:

- A nighttime electrofishing survey of Orchard Lake in 2016 that targeted largemouth bass found a relatively high abundance of largemouth bass compared to other lakes in the East Metro area.

- A 2012 DNR survey using trap nets and gill nets found a fishery dominated by small sunfish. Only 1 walleye was sampled in 2012, and northern pike abundance was reported as average. Crappie and yellow perch numbers were also reported as average.
- The lake is regularly stocked with walleye (most recently in 2015) and tiger muskellunge (most recently in 2016).

Discussion of Orchard Lake Water Quality Results

Orchard Lake continues to experience good water quality. Summer averages of Secchi disc transparency, chlorophyll *a*, and total phosphorus are consistently better than the MPCA's eutrophication standards. A statistical analysis shows a worsening trend (90% confidence) of summer averages of Secchi disc transparency for the recent 10-year period of 2008-2017. However, there were no statistically significant trends in either total phosphorus or chlorophyll *a*.

The City of Lakeville continues its efforts to control curlyleaf pondweed in Orchard Lake, with an herbicide treatment of 14.5 acres in May 2017. Efforts to control curlyleaf pondweed in Orchard Lake have included herbicide treatments and harvesting, starting in 2004. The reduction in the amount of curlyleaf pondweed may be one reason why water quality over the period of 2008-2017 is substantially better when compared to the previous decade. In addition to control of curlyleaf pondweed in Orchard Lake, the City of Lakeville installed aeration devices in Orchard Pond, a wetland that contributes flow to Orchard Lake. The aeration system is designed to reduce phosphorus export from Orchard Pond, and has operated for the past several seasons.

The BDWMO Plan includes recommended lake water quality management actions for strategic waterbodies under different scenarios of observed water quality. According to Table 4-1 of the Plan, if Orchard Lake has summer average water quality better than the Management Action Level, and a statistically significant 10-yr trend of degrading water quality, the following actions are recommended: 1) Management Level lake water quality monitoring, and 2) a watershed land use review. Barr recommends continuation of the yearly CAMP level water quality monitoring of Orchard Lake, and continuation of the management-level water quality monitoring once every 3 years (year 2020). The City of Lakeville has indicated that land use changes in the watershed of Orchard Lake in the past decade have been minimal, consisting of the addition of a few small residential neighborhoods. Barr does not recommend performing a watershed land use review for the Orchard Lake watershed, given the minimal land use changes in the watershed's recent past.

Orchard Lake has a healthy community of native aquatic plants. The non-native curlyleaf pondweed is also present, but is kept in check by continued management efforts – most recently targeted herbicide treatments. Curlyleaf pondweed can negatively impact water quality when it releases phosphorus as it dies off in early to mid-summer. Barr recommends the City of Lakeville continue their efforts in monitoring aquatic vegetation and targeted treatments of curlyleaf pondweed with herbicides, or other

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suitable methods for reducing curlyleaf pondweed. Although Eurasian watermilfoil does not die off early in summer and negatively affect water quality like curlyleaf pondweed, it can grow to nuisance levels, forming dense growth at the water surface that outcompetes native vegetation and impedes recreation activities. Barr recommends continued monitoring and targeted herbicide control of Eurasian watermilfoil to prevent it from becoming established and growing to nuisance levels in Orchard Lake.

Table 2: Orchard Lake 2017 Water Quality Measured by Barr Engineering

Date	Sample Depth	Field Measurements							Laboratory Analyses	
		Secchi Disc Transparency [m]	Dissolved Oxygen [mg/l]	pH	Redox (Oxidation Potential) [mV]	Specific Conductance @ 25 °C [umhos/cm]	Water Temperature [°C]	Turbidity [NTU]	Chlorophyll-a, Pheophytin Corrected [µg/l]	Total Phosphorus [µg/l]
4/04/2017	0 - 2 m	2.2	--	--	--	--	--	2.4	< 1.0	18
4/04/2017	0 m	--	12.5	8.0	179	791	7.8	--	--	--
4/04/2017	1 m	--	12.5	8.1	177	792	7.8	--	--	--
4/04/2017	2 m	--	12.5	8.1	176	790	7.8	--	--	--
4/04/2017	3 m	--	12.5	8.2	175	791	7.8	--	--	20
4/04/2017	4 m	--	12.5	8.2	175	791	7.8	--	--	19
4/04/2017	5 m	--	12.5	8.2	175	792	7.8	--	--	17
4/04/2017	6 m	--	12.2	8.2	175	791	7.8	--	--	18
4/04/2017	7 m	--	12.0	8.2	175	793	7.0	--	--	17
4/04/2017	8 m	--	11.9	8.2	175	792	6.9	--	--	17
5/08/2017	0 - 2 m	4.2	--	--	--	--	--	1.9	2.2	14
5/08/2017	0 m	--	13.6	8.3	181	785	14.7	--	--	--
5/08/2017	1 m	--	13.7	8.3	177	786	14.7	--	--	--
5/08/2017	2 m	--	13.7	8.4	175	786	14.6	--	--	--
5/08/2017	3 m	--	13.8	8.4	174	786	14.6	--	--	14
5/08/2017	4 m	--	13.8	8.4	173	786	14.5	--	--	14
5/08/2017	5 m	--	14.0	8.2	175	787	12.9	--	--	14
5/08/2017	6 m	--	11.3	8.0	176	788	11.2	--	--	17
5/08/2017	7 m	--	10.4	7.9	177	789	10.7	--	--	14
5/08/2017	8 m	--	8.7	7.7	179	790	10.4	--	--	19
5/22/2017	0 - 2 m	2.9	--	--	--	--	--	5.0	2.0	16
5/22/2017	0 m	--	8.1	8.3	246	746	13.6	--	--	--
5/22/2017	1 m	--	8.1	8.3	248	750	13.6	--	--	--
5/22/2017	2 m	--	8.1	8.3	244	748	13.6	--	--	--
5/22/2017	3 m	--	8.1	8.3	243	748	13.6	--	--	14
5/22/2017	4 m	--	8.1	8.3	242	749	13.6	--	--	17
5/22/2017	5 m	--	8.1	8.3	241	748	13.5	--	--	15
5/22/2017	6 m	--	7.8	8.3	241	750	13.5	--	--	25
5/22/2017	7 m	--	6.8	8.0	243	759	12.7	--	--	20
5/22/2017	8 m	--	4.8	7.7	244	781	12.2	--	--	22

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		Secchi Disc Transparency [m]	Dissolved Oxygen [mg/l]	pH	Redox (Oxidation Potential) [mV]	Specific Conductance @ 25 °C [umhos/cm]	Water Temperature [°C]	Turbidity [NTU]	Chlorophyll-a, Pheophytin Corrected [µg/l]	Total Phosphorus [µg/l]
6/13/2017	0 - 2 m	3.6	--	--	--	--	--	3.1	3.2	17
6/13/2017	0 m	--	8.5	8.4	232	748	23.5	--	--	--
6/13/2017	1 m	--	8.5	8.4	228	748	23.6	--	--	--
6/13/2017	2 m	--	8.5	8.4	226	748	23.5	--	--	--
6/13/2017	3 m	--	8.4	8.4	224	747	23.5	--	--	13
6/13/2017	4 m	--	8.5	8.4	223	746	23.5	--	--	13
6/13/2017	5 m	--	8.5	8.2	224	758	18.5	--	--	13
6/13/2017	6 m	--	4.8	7.7	228	763	15.3	--	--	15
6/13/2017	7 m	--	2.2	7.4	229	777	13.5	--	--	14
6/13/2017	8 m	--	0	7.3	219	793	12.6	--	--	21
6/13/2017	9 m	--	0	7.3	-20	803	12.1	--	--	37
6/26/2017	0 - 2 m	3.0	--	--	--	--	--	2.4	3.8	16
6/26/2017	0 m	--	7.9	7.9	173	764	20.6	--	--	--
6/26/2017	1 m	--	7.9	8.0	169	764	20.6	--	--	--
6/26/2017	2 m	--	7.9	8.1	164	764	20.6	--	--	--
6/26/2017	3 m	--	7.9	8.1	160	764	20.6	--	--	17
6/26/2017	4 m	--	7.9	8.1	157	764	20.6	--	--	17
6/26/2017	5 m	--	7.7	8.1	154	765	20.6	--	--	17
6/26/2017	6 m	--	4.0	7.6	156	770	18.5	--	--	21
6/26/2017	7 m	--	0	7.3	156	785	13.8	--	--	40
6/26/2017	8 m	--	0	7.3	-23	806	12.5	--	--	31
6/26/2017	8.5 m	--	0	7.4	-65	808	12.3	--	--	58
7/11/2017	0 - 2 m	4.1	--	--	--	--	--	2.7	2.5	17
7/11/2017	0 m	--	10.4	8.5	180	759	25.9	--	--	--
7/11/2017	1 m	--	10.4	8.6	176	760	25.9	--	--	--
7/11/2017	2 m	--	10.4	8.6	172	758	25.9	--	--	--
7/11/2017	3 m	--	10.3	8.6	169	759	25.8	--	--	18
7/11/2017	4 m	--	10.1	8.5	168	758	25.0	--	--	16
7/11/2017	5 m	--	6.9	8.0	173	766	22.0	--	--	22
7/11/2017	6 m	--	2.0	7.4	179	770	20.0	--	--	25
7/11/2017	7 m	--	2.7	7.4	179	782	15.5	--	--	20
7/11/2017	8 m	--	0	7.3	-50	806	13.1	--	--	50
7/11/2017	8.5 m	--	0	7.5	-139	814	12.8	--	--	74

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		Secchi Disc Transparency [m]	Dissolved Oxygen [mg/l]	pH	Redox (Oxidation Potential) [mV]	Specific Conductance @ 25 °C [umhos/cm]	Water Temperature [°C]	Turbidity [NTU]	Chlorophyll-a, Pheophytin Corrected [µg/l]	Total Phosphorus [µg/l]
7/24/2017	0 - 2 m	2.4	--	--	--	--	--	2.5	5.3	18
7/24/2017	0 m	--	9.8	8.7	122	753	25.6	--	--	--
7/24/2017	1 m	--	9.7	8.8	141	754	25.6	--	--	--
7/24/2017	2 m	--	9.7	8.8	137	754	25.6	--	--	--
7/24/2017	3 m	--	9.7	8.8	135	754	25.6	--	--	19
7/24/2017	4 m	--	9.8	8.8	134	752	25.5	--	--	17
7/24/2017	5 m	--	4.1	7.8	143	777	24.2	--	--	18
7/24/2017	6 m	--	0.17	7.4	147	779	20.2	--	--	23
7/24/2017	7 m	--	0	7.4	114	796	16.2	--	--	53
7/24/2017	8 m	--	0	7.6	-121	825	13.7	--	--	78
7/24/2017	8.5 m	--	0	7.7	-154	834	12.9	--	--	170
8/08/2017	0 - 2 m	2.4	--	--	--	--	--	2.5	8.0	24
8/08/2017	0 m	--	9.1	8.2	211	755	23.6	--	--	--
8/08/2017	1 m	--	9.1	8.3	206	755	23.6	--	--	--
8/08/2017	2 m	--	9.1	8.4	201	756	23.6	--	--	--
8/08/2017	3 m	--	9.1	8.4	198	756	23.6	--	--	30
8/08/2017	4 m	--	6.7	8.0	200	761	23.3	--	--	24
8/08/2017	5 m	--	3.8	7.6	202	763	22.8	--	--	23
8/08/2017	6 m	--	0.4	7.3	204	770	21.3	--	--	35
8/08/2017	7 m	--	0	7.3	75	794	16.5	--	--	58
8/08/2017	8 m	--	0	7.3	-124	822	14.3	--	--	160
8/08/2017	8.5 m	--	0	7.4	-134	836	13.2	--	--	220
8/22/2017	0 - 2 m	2.5	--	--	--	--	--	2.6	8.2	19
8/22/2017	0 m	--	8.4	8.4	193	724	22.5	--	--	--
8/22/2017	1 m	--	8.4	8.5	190	722	22.5	--	--	--
8/22/2017	2 m	--	8.4	8.5	187	723	22.5	--	--	--
8/22/2017	3 m	--	8.4	8.5	185	723	22.5	--	--	20
8/22/2017	4 m	--	8.4	8.5	183	722	22.5	--	--	18
8/22/2017	5 m	--	5.3	8.0	187	718	21.7	--	--	22
8/22/2017	6 m	--	2.7	7.6	187	721	21.0	--	--	28
8/22/2017	7 m	--	0	7.5	40	762	18.9	--	--	42
8/22/2017	8 m	--	0	7.5	-124	830	14.1	--	--	120
8/22/2017	8.5 m	--	0	7.6	-165	837	13.5	--	--	300

Table 2: Orchard Lake 2017 Water Quality Measured by Barr Engineering

Date	Sample Depth	Field Measurements							Laboratory Analyses	
		Secchi Disc Transparency [m]	Dissolved Oxygen [mg/l]	pH	Redox (Oxidation Potential) [mV]	Specific Conductance @ 25 °C [umhos/cm]	Water Temperature [°C]	Turbidity [NTU]	Chlorophyll-a, Pheophytin Corrected [µg/l]	Total Phosphorus [µg/l]
9/07/2017	0 - 2 m	1.7	--	--	--	--	--	3.1	9.3	20
9/07/2017	0 m	--	8.0	8.3	255	729	19.7	--	--	--
9/07/2017	1 m	--	8.0	8.5	249	727	19.7	--	--	--
9/07/2017	2 m	--	8.0	8.6	244	727	19.7	--	--	--
9/07/2017	3 m	--	8.0	8.6	240	727	19.7	--	--	21
9/07/2017	4 m	--	8.0	8.6	236	727	19.7	--	--	21
9/07/2017	5 m	--	7.9	8.6	234	728	19.7	--	--	20
9/07/2017	6 m	--	7.3	8.6	233	729	19.6	--	--	21
9/07/2017	7 m	--	4.8	8.2	235	739	19.3	--	--	27
9/07/2017	8 m	--	0	7.7	-140	835	15.4	--	--	100
9/07/2017	8.5 m	--	0	7.7	-170	846	14.4	--	--	370
9/21/2017	0 - 2 m	1.9	--	--	--	--	--	3.6	6.8	18
9/21/2017	0 m	--	8.6	8.5	289	738	20.2	--	--	--
9/21/2017	1 m	--	8.6	8.5	284	740	20.2	--	--	--
9/21/2017	2 m	--	8.6	8.5	280	740	20.2	--	--	--
9/21/2017	3 m	--	8.6	8.6	278	738	20.2	--	--	16
9/21/2017	4 m	--	8.6	8.6	277	738	20.2	--	--	16
9/21/2017	5 m	--	8.6	8.6	276	738	20.2	--	--	19
9/21/2017	6 m	--	5.0	8.2	279	742	19.7	--	--	23
9/21/2017	7 m	--	0	7.7	269	744	18.6	--	--	29
9/21/2017	8 m	--	0	7.5	-79	779	17.0	--	--	52
9/21/2017	8.5 m	--	0	7.6	-127	800	16.5	--	--	120

Notes

< 1.0 Value is less than the laboratory's method detection limit.

Table 3: Orchard Lake 2017 Water Quality Measured by CAMP Volunteer

Sample Date	Sample Depth [m]	Secchi Disc Transparency [m]	Water Temperature, [°C]	Chlorophyll-a, Pheophytin Corrected [µg/L]	Nitrogen, Total Kjeldahl [mg/L]	Total Phosphorus [µg/L]
4/21/2017	0	1.3	11.7	4.7	0.66	16
5/2/2017	0	5.8	10.4	1.5	0.73	24
5/31/2017	0	3.9	16.3	< 1	0.56	13
6/10/2017	0	2.5	24.0	3.2	0.70	~ 9
6/17/2017	0	2.9	24.6	2.7	0.55	10
7/6/2017	0	2.9	25.3	1.2	0.59	14
7/13/2017	0	3.9	25.3	2.4	0.69	14
8/5/2017	0	2.1	23.8	6.4	0.89	19
8/19/2017	0	2.1	23.7	5.1	0.76	15
9/6/2017	0	2.0	19.7	7.1	0.80	19
9/20/2017	0	1.9	19.8	8.3	0.87	24
10/6/2017	0	2.3	16.3	6.3	0.80	21
10/16/2017	0	3.0	12.9	9.1	0.76	22

Notes

Data presented in Table 3 are preliminary data provided by the Metropolitan Council.

< 1 Value is less than the laboratory's method detection limit.

~ 9 Value is less than the laboratory's method reporting limit, and is therefore an estimated value.

Figure 1a: Orchard Lake 2017 Secchi Disc Transparency

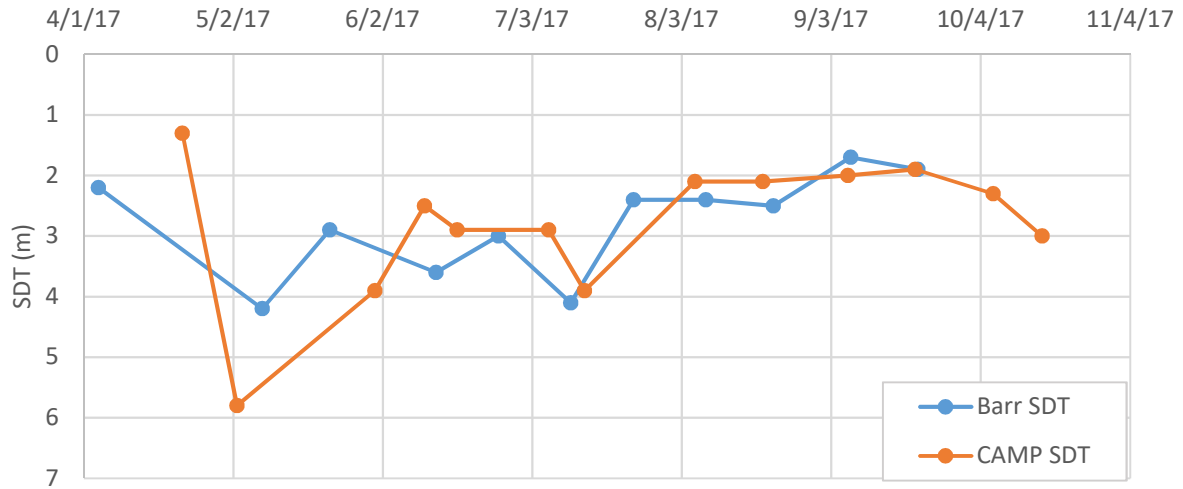


Figure 1b: Orchard Lake 2017 Surface Measurements of Total Phosphorus

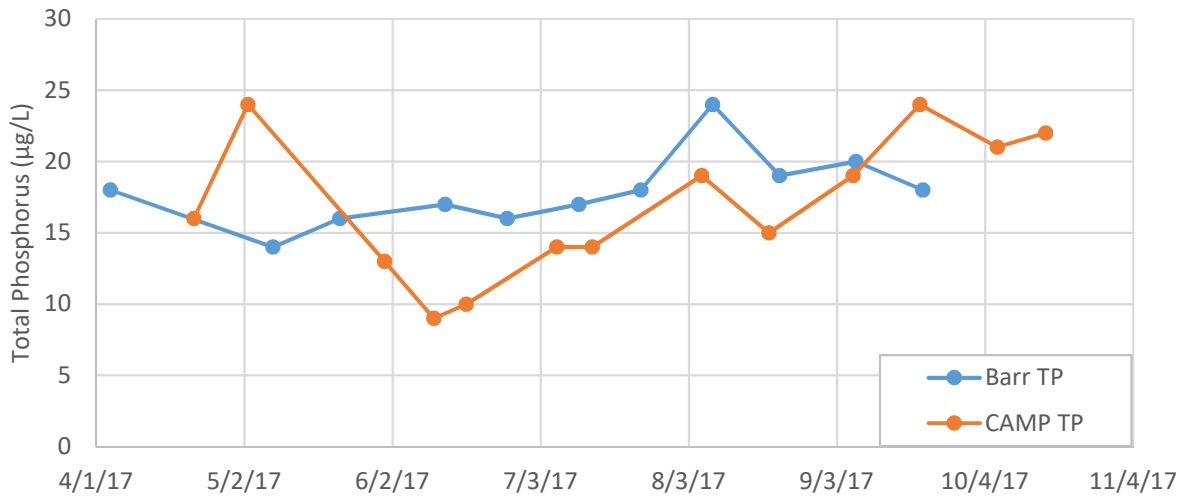
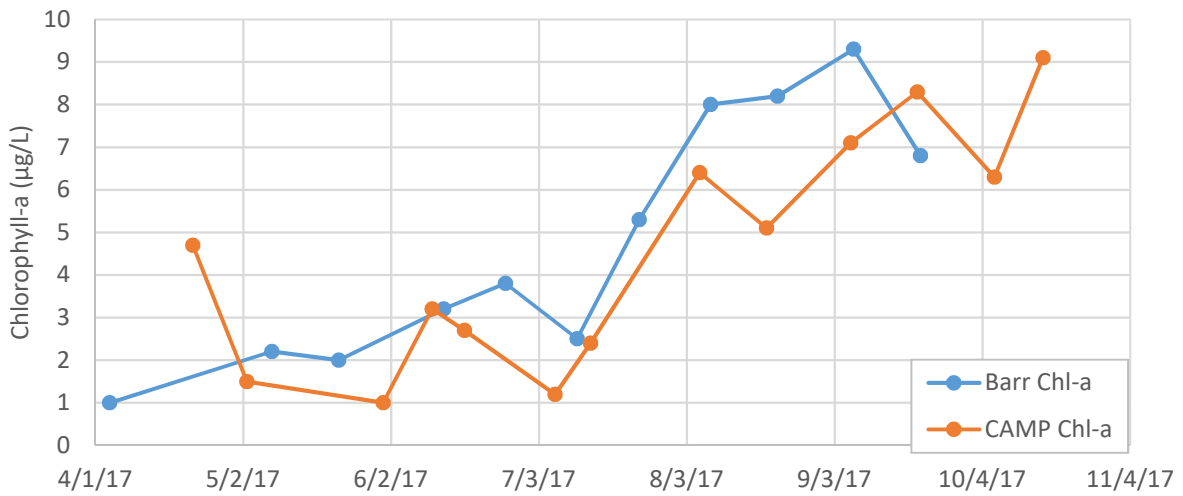
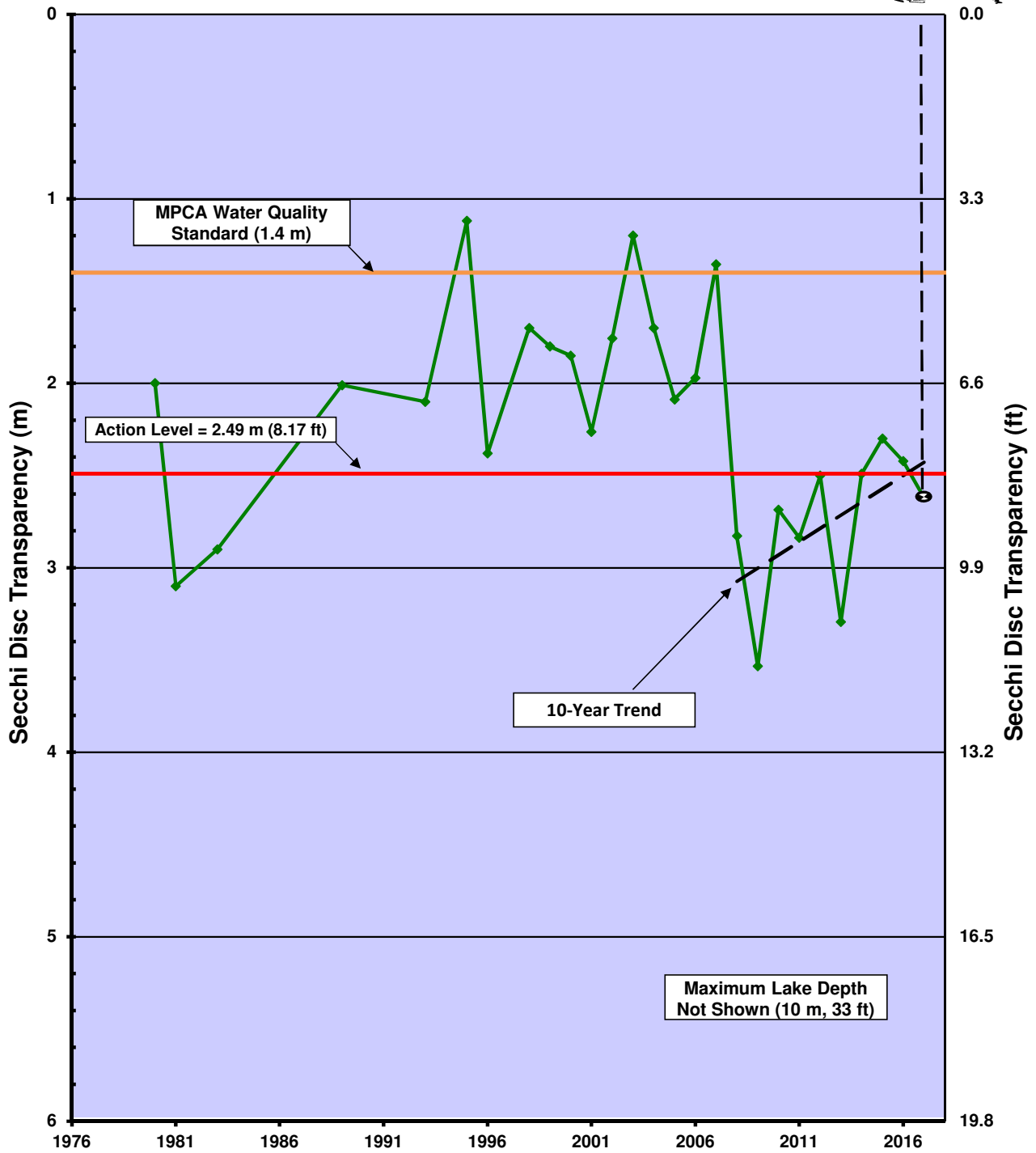


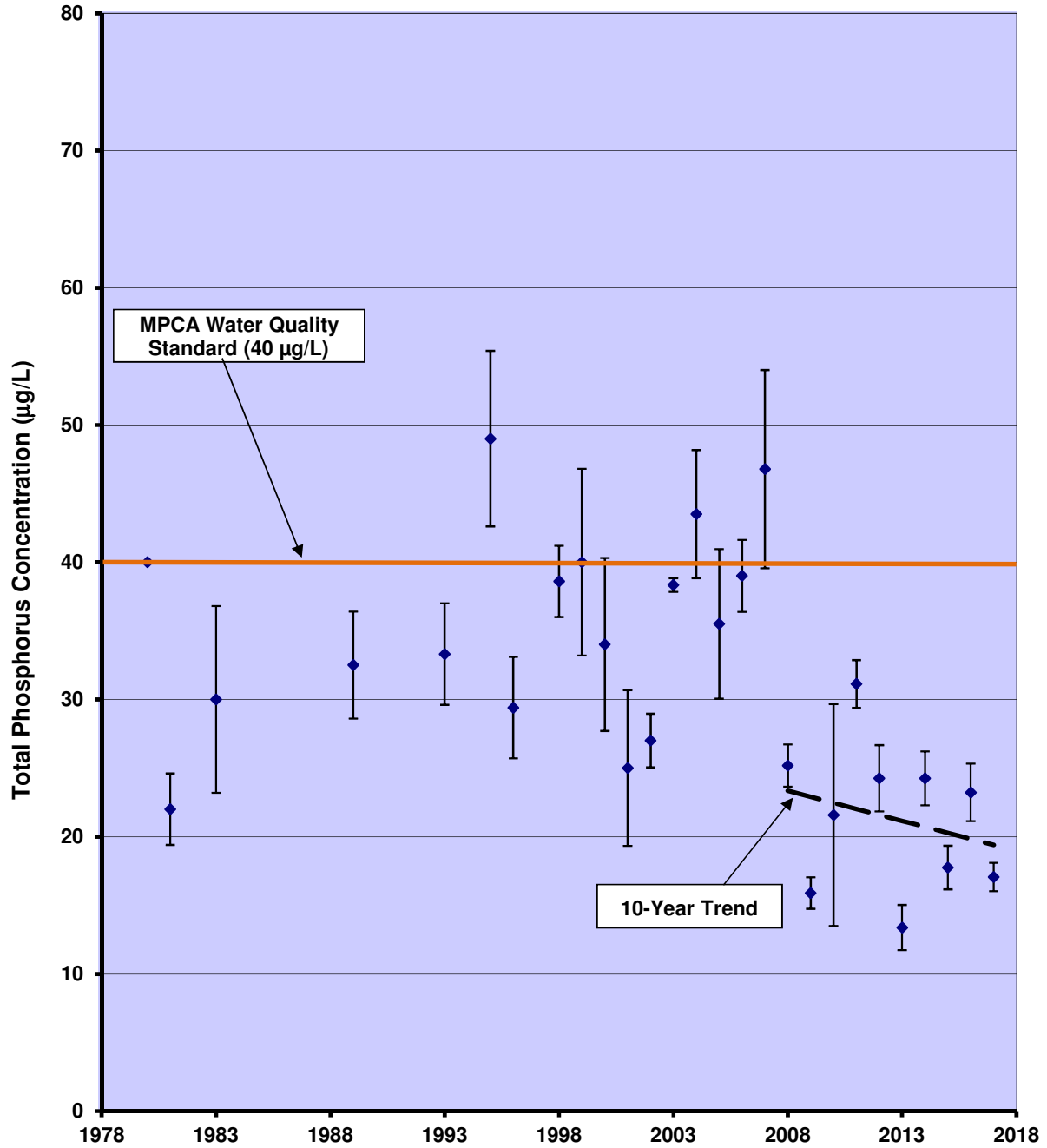
Figure 1c: Orchard Lake 2017 Surface Measurements of Chlorophyll-a



**Figure 2: Orchard Lake (Lakeville)
Summer Average Water Clarity
& Trend Analysis**



**Figure 3: Orchard Lake (Lakeville)
Summer Average Surface Total Phosphorus Concentrations
& Trend Analysis
BDWMO Category I & MPCA Deep Lake**



**Figure 4: Orchard Lake (Lakeville)
Summer Average Surface Chlorophyll a Concentrations &
Trend Analysis
BDWMO Category I & MPCA Deep Lake**

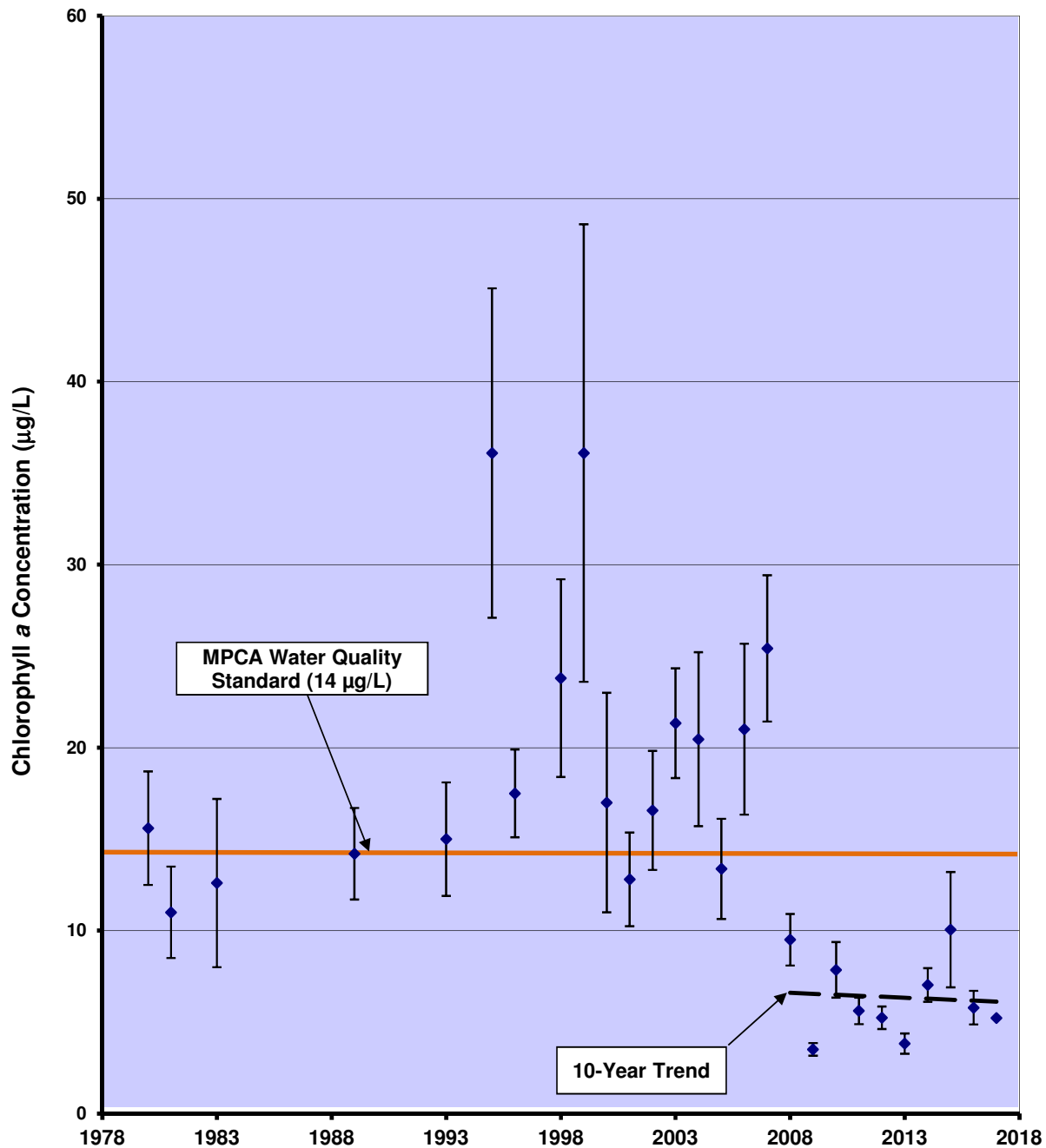


Figure 5: Orchard Lake Water Surface Elevation.

