2015 Water Quality Summary for Shavehead Lake

OVERVIEW

The Shavehead Lake Association (SLA) authorized Kieser & Associates, LLC (K&A) to provide water quality sampling, data analysis and reporting services for Shavehead Lake in 2015. This work is a continuation of water quality assessments performed from 1993-2004 by both another professional consultant and/or Shavehead Lake Association volunteers.

Shavehead Lake is located in Cass County, Michigan in Sections 19 and 30 of Porter Township. The lake has a surface area of approximately 289 acres comprised of two deep basins connected at the south end by a shallower channel area. The west basin has a maximum depth of 58 feet and the east basin has a maximum depth of 70 feet (Michigan Department of Natural Resources, 1956). An inlet from Birch Lake enters Shavehead Lake at the north end of the west basin. Two additional unnamed inlets enter the west basin connecting the lake to nearby wetland complexes. The lake outlet to Mud Creek is located at the south end of the west basin.

K&A conducted water quality sampling on Shavehead Lake to evaluate current conditions and identify any emerging upward or downward trends in key water quality parameters that might indicate improving or worsening conditions. This report summarizes K&A sampling, results and findings. The report also discusses comparisons with historical sampling and highlights recommendations to the SLA for 2016 consideration based on 2015 findings.

WATER QUALITY SAMPLING APPROACH

K&A was contracted to collect water samples and field measurements from the historically-sampled Shavehead Lake locations. These samples were collected by K&A on July 21, 2015 from three in-lake locations: **Site 1** (over the 58' deep west basin), **Site 2** (at the 40' deep south channel area), and **Site 3** (over the 70' deep east basin). (See Figure 1 for site locations; all report figures appear after the reference section of this report and before appendices.) Samples were collected at the surface, middle and bottom locations at each site. The deepest samples are representative of water quality conditions in the bottom waters during summer temperature stratification.

The samples collected from the surface at each site were analyzed for total phosphorus (TP), nitrate-nitrogen (NO_3), total alkalinity, chlorophyll *a*, pH, conductivity, dissolved oxygen (DO), and temperature. Samples were also collected at each of the three locations from mid-depths and near the bottom for similar parameters, with the exception of chlorophyll *a*. In addition, Secchi disk depth was measured at each of the three locations. DO and temperature were measured from the surface of each sample site and at five foot intervals to the bottom to generate a depth profile for these parameters.

The TP, NO_3, and alkalinity analyses were conducted at Bio-Chem Laboratories, Inc., in Grand Rapids, Michigan. Chlorophyll *a* analysis was provided by Upstate Freshwater Institute (UFI) in Syracuse, NY (Laboratory analytical results are presented in Appendix A). Field parameters of pH, conductivity, DO, temperature and Secchi disk depth were measured on-site by K&A staff.

Parameter Descriptions

A discussion of the water quality parameters examined in this study is provided here to illustrate the value of these measures with respect to water quality characterization.

Total Phosphorus

Both algae and aquatic plants require a wide range of nutrients for growth. The nutrient that typically is in shortest supply with respect to aquatic plant and algal growth needs is termed the "limiting nutrient".

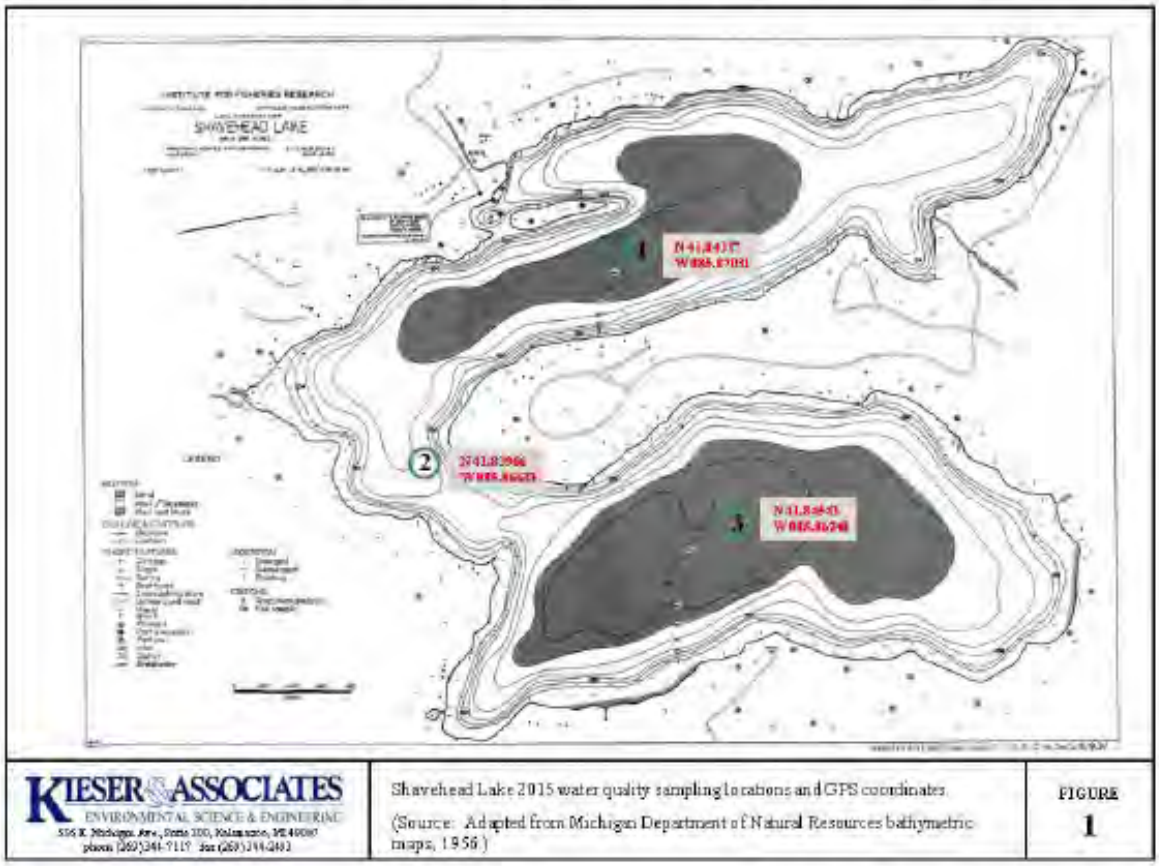
This term implies that the relative unavailability of this particular nutrient will limit plant and algae growth. In most freshwater ecosystems, phosphorus historically has been the limiting nutrient. Therefore, increases in phosphorus likely will lead to increases in nuisance plant and algae growth. This is especially true for blue-green algal blooms.

The form of phosphorus most often used for general assessments of lake water quality is TP. Measured concentrations of TP in lake water can be used to determine the trophic status of the lake based on scientific data compiled for other similar inland lakes. The term "trophic state" refers to the level of primary productivity (i.e., algal growth) in an aquatic system. The four trophic states are "oligotrophic," "mesotrophic,", "eutrophic" and "hypereutrophic." These correspond to low, medium, high and extremely high levels of productivity, respectively. **Trophic state values (based on Michigan Department of Natural Resources data) for TP are presented in Table 1.** An additional point of reference for TP values in our region is the 2000 U.S. Environmental Protection Agency (USEPA) guidance document *Ambient Water Quality Criteria Recommendations for Lakes and Reservoirs in Nutrient Ecoregion VII*. **The TP draft criterion established in this EPA document is 14.75 µg/L.**

Table 1. Lake Trophic State and Classification Ranges-
Based on Michigan Data (USGS, 2012)

Lake Trophic State	TP (ug/L)	Chlorophyll a (ug/L)	Secchi Depth Transparency (ft)
Oligotrophic	<10	<2.2	>15
Mesotrophic	10-20	2.2-6	7.5-15
Eutrophic	21-50	6.1-22	3-7.5
Hypereutrophic	>50	>22	<3

Figure 1. Shavehead Lake Map with 2015 Sampling Site Coordinates



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Shavehead Lake 2015 water quality sampling locations and GPS coordinates.
(Source: Adapted from Michigan Department of Natural Resources bathymetric maps, 1956.)

FIGURE 1

RECOMMENDATIONS

K&A provides here, recommendations for future monitoring consistent with the 2015 reporting:

1. **Continue water quality monitoring program.** Continued collection and analysis of water quality parameters on Shavehead Lake allows for the detection of long-term trends. Monitoring programs can be conducted by volunteers (through the Michigan Cooperative Lakes Monitoring Program) or consultants. Without consistent data, it is difficult to identify meaningful changes in lake conditions over time.

   The addition of *Escherichia coli* (*E. coli*) analysis is recommended for future Shavehead Lake water quality monitoring to evaluate the presence of potential human pathogens in Shavehead Lake swimming areas. *E. coli* is the indicator organism used by the Michigan Department of Environmental Quality (MDEQ) for its beach monitoring program (MDEQ, 2015). *E. coli* bacteria are found in the intestinal tract of warm-blooded animals, and laboratory detection methods for these bacteria are well-established.

   Additional monitoring during the spring turnover period is recommended to gain an understanding of the lake system during mixing events. This is important in order to determine nutrient availability for algae and plant uptake during the summer growing season. Based on the elevated TP concentrations in the low-oxygen bottom waters at the sampling locations, it is likely that sediment nutrient release is occurring. Thus, increased nutrient levels might be evident in upper lake waters during mixing. Both spring (mixed) and summer (stratified) monitoring will help to determine if internal nutrient loading might be a future concern for Shavehead Lake water quality.

2. **Collect lake bottom sediments for nutrient analysis.** Elevated nutrient levels in the bottom waters at the sampling sites indicate nutrient-enriched sediments in Shavehead Lake. Sediment grab samples from the deep basins of each of the sampling sites should be analyzed for nutrients to further understand the internal nutrient loading to the lake.

3. **Conduct an aquatic vegetation survey to assess the plant community.** A thorough aquatic vegetation assessment is recommended to identify the species, locations and densities of plants present in Shavehead Lake and to serve as a baseline for detecting future changes or trends. Invasive species are much easier to control if detected early, so annual monitoring by a consultant or volunteer is essential in identifying invasive species before they require costly management and impede recreation.

Shavehead Lake Water Quality Data (1993 – 2015)

Sampling stations	Date	Temp. (oC)	Secchi Depth (ft)	DO (mg/L)	Conductivity (umhos/cm)	pH (SU)	Total Phosphorus ug/L	Nitrate-N ug/L	Alkalinity (mg/L)	Chlorophyll a (ug/L)
1	4/28/1993	---	6	---	405	9.3	19	1020	190	16
2	4/28/1993	---	6	---	405	8.2	21	945	190	17.2
3	4/28/1993	---	6	---	405	8.2	17	830	188	11.9
1	8/17/1993	26	10	9.3	340	8.4	16	681	154	0.8
2	8/17/1993	26	10	9.5	330	8.4	10	620	154	1.2
3	8/17/1993	26	10	10.2	330	8.4	12	550	151	2.7
1	5/8/1994	---	7	---	400	8.3	18	940	182	5.5
2	5/8/1994	---	7	---	400	8.2	11	980	182	5.5
3	5/8/1994	---	7	---	400	8.2	11	980	185	4.1
1	8/24/1994	24	9	11.2	330	8.6	19	622	139	3.8
2	8/24/1994	24	9	11.2	330	8.6	18	574	140	3.1
3	8/24/1994	24	8	11.9	330	8.6	19	517	141	3.4
1	8/17/1995	30	6	9.4	280	8.6	8	470	135	0.4
2	8/17/1995	30	6	10.2	280	8.6	18	471	132	0.4
3	8/17/1995	30	7	9.8	280	8.6	14	449	138	1.6
1T	8/17/1995	15	---	21.6*	280	8.5	7	503	138	
3T	8/17/1995	15	---	21.6*	320	8.4	16	426	151	
1	8/31/1995	25	14	9.3	300	8.6	9	568	139	0.8
2	8/31/1995	25	15	8.8	300	8.6	8	524	139	1.2
3	8/31/1995	25	13	9	300	8.6	7	485	139	1.2
1T	8/31/1995	16	---	21.6*	---	---	---	---	---	8.1
3T	8/31/1995	17	---	21.6*	---	---	---	---	---	19.6
1	4/23/1996	---	11	---	350	7.6	25	946	156	10.9
2	4/23/1996	---	11	---	335	7.5	21	1020	145	10.8
3	4/23/1996	---	11	---	350	7.5	22	1080	152	10.8
1	9/3/1996	26	10	9.5	260	7.6	10	621	133	2
2	9/3/1996	26	11	9.3	280	7.7	15	660	134	0.7
3	9/3/1996	26	10	9.3	300	7.6	10	645	133	1
1	5/9/1997	---	6	---	300	7.6	12	1238	145	10.4
2	5/9/1997	---	6	---	300	7.5	11	1253	140	11.2
3	5/9/1997	---	6	---	290	7.5	9	1404	146	9.2

Sampling stations	Date	Temp.	Secchi Depth	DO	Conductivity	pH	Total Phosphorus	Nitrate-N	Alkalinity	Chlorophyll a
1	9/15/1997	23	10	10.7	340	8.6	12	740	152	1.4
2	9/15/1997	23	9	10.6	340	8.6	12	680	150	1.4
3	9/15/1997	22	10	10.8	340	8.6	11	760	147	1.1
3-10	9/15/1997	21	---	10.7	340	8.6	20	760	150	
3-20	9/15/1997	20	---	10.9	340	8.7	28	400	150	
3-30	9/15/1997	13	---	0	395	7.8	32	320	180	
3-40	9/15/1997	9	---	0	420	7.7	25	148	194	
3-50	9/15/1997	8	---	0	420	7.5	19	124	199	
3-60	9/15/1997	8	---	0	440	7.4	32	48	214	
3-70	9/15/1997	8	---	0	460	7.3	69	48	222	
1	9/1/1998	25	8	10	320	8.8	18	666	150	2.4
1-10	9/1/1998	21	.	10.7	310	8.8	16	691	150	
1-20	9/1/1998	20	---	10.9	320	8.5	26	691	156	
1-30	9/1/1998	13	---	0	320	8.5	42	107	164	
1-40	9/1/1998	9	---	0	385	7.6	60	75	200	
1-50	9/1/1998	8	---	0	405	7.6	68	63	213	
1-55	9/1/1998	8	---	0	415	7.3	82	13	240	
2	9/1/1998	25	9	10.2	320	8.8	12	647	150	1.5
3	9/1/1998	25	7	10.5	320	8.8	10	710	150	1.8
1	8/28/2001	24	4	10.4	280	8.4	26	471	135	3.6
2	8/28/2001	24	5	10.2	280	8.4	24	575	135	2.4
3	8/28/2001	24	5	10.2	280	8.4	14	617	135	3.6
1	8/20/2002	25	11	9.4	330	8	14	678	150	1.9
2	8/20/2002	25	8	9	330	8	13	763	148	1.5
3	8/20/2002	25	8	9.7	330	8.1	9	803	146	1.9
1	4/15/2003	---	5	---	350	7.5	21	900	138	7.7
2	4/15/2003	---	6	---	340	7.5	27	588	139	8.3
3	4/15/2003	---	7	---	360	7.4	29	691	152	6.1
1	8/13/2003	25	6	9.6	330	8.7	13	828	151	3.7
2	8/13/2003	25	6	9.1	330	8.6	18	868	145	3.6
3	8/13/2003	25	6	9.6	340	8.6	18	863	150	2.4
1	4/11/2004	---	6	---	350	7.8	32	926	147	4.2
2	4/11/2004	---	6	---	350	7.8	34	797	150	4.6
3	4/11/2004	---	6	---	360	7.8	30	900	154	5.3

Sampling stations	Date	Temp.	Secchi Depth	DO	Conductivity	pH	Total Phosphorus	Nitrate-N	Alkalinity	Chlorophyll a
1	8/31/2004	23	8	9.3	320	8.6	14	712	150	1.9
2	8/31/2004	23	8	9.1	320	8.5	14	752	147	1.2
3	8/31/2004	23	8	9.5	320	8.4	12	796	145	1
1	4/9/2009	--	8	--	340	7.8	16	662	158	
2	4/9/2009	--	6	--	330	7.9	18	651	161	
3	4/9/2009	--	6	--	330	7.9	17	673	160	
1	8/14/2009	26	6	11.2	310	8.2	12	697	140	
2	8/14/2009	25	6	10.1	322	8.2	12	774	140	
3-0	8/14/2009	25	6	11.2	320	8.2	14	781	144	
3-10	8/14/2009	25	---	12	320	8.3	14	798	144	
3-20	8/14/2009	20	---	17.2	320	8.2	16	819	150	
3-30	8/14/2009	12	---	3.2	350	8.1	23	571	167	
3-40	8/14/2009	9	---	3	360	7.9	28	690	178	
3-50	8/14/2009	7	---	0	370	7.9	14	938	170	
3-60	8/14/2009	7	---	0	380	7.9	20	826	180	
3-70	8/14/2009	7	---	0	400	7.6	24	326	190	
1 surface	7/21/2015	26.2	8	9.24	380	8.6	<10	<100	180	1.7
1 mid	7/21/2015	13.6	---	15.68	420	8.57	13	<100	180	
1 bottom	7/21/2015	6.4	---	0	410	7.62	41	<100	220	
2 surface	7/21/2015	26.9	10	8.92	380	8.38	<10	<100	170	1
2 mid	7/21/2015	19.1	---	14.67	380	8.48	12	<100	180	
2 bottom	7/21/2015	8.2	---	0.25	370	8.47	17	<100	190	
3 surface	7/21/2015	26.1	8	8.98	380	8.38	<10	<100	180	1
3 mid	7/21/2015	7.9	---	4.48	380	8.04	38	<100	200	
3 bottom	7/21/2015	5.5	---	0	340	7.46	38	<100	220	