Aquatic Ecosystem Sciences LLC

TECHNICAL MEMORANDUM

Upper Klamath Lake 2017 Data Summary Report

Prepared By:

Jacob Kann, Ph.D.
Aquatic Ecosystem Sciences LLC
295 East Main St., Suite 7
Ashland, OR 97520

Prepared For:

Klamath Tribes Natural Resources Department
PO Box 436
Chiloquin, OR 97624

June 2018

Table of Contents

Table of Contents 2
List of Figures 3
List of Tables 4
INTRODUCTION 5
METHODS 5
RESULTS/DISCUSSION 8
Seasonal and Water Column Trends in Profile Water Quality Data (T, DO, and pH) 8
2017 Station Distributions 12
Seasonal Chlorophyll Pattern and Climate Interaction 18
2016 Monthly and Seasonal Water Quality, Chlorophyll, and Nutrient Patterns 24
Comparison of 2017 to Previous 1990-2016 Data 33
2017 Microcystin Sampling 42
SUMMARY 43
LITERATURE CITED 54
APPENDIX I: Summary statistics of monthly distributions for the June-September period, Upper Klamath Lake Stations; 1990-2017 (LQ= Lower Quartile; UQ=Upper Quartile). 57
APPENDIX III: Chlorophyll-a adjustment to account for method change from spectrophotometric to fluorometric in 2009. 85

List of Figures

Figure 1. Location of Upper Klamath Lake sampling stations, 2016. Google Earth Imagery date 8/1/2011. 6
Figure 2. Spatial-temporal sampling matrix for Upper Klamath Lake, 2017. 7
Figure 3. Depth-time distributions of isotherms of T (°C) and isopleths of D.O (mg/L) and pH at UKL station Eagle Ridge (ER), 2017. Note: 1) brown shaded area on the abscissa denotes the bottom profile depth, and 2) contours are not valid outside of vertical brown lines (begin and end dates for seasonal sampling)..... 9
Figure 4. Depth-time distributions of isotherms of T (˚C) and isopleths of D.O (mg/L) and pH at UKL station Mid North (MN), 2017. Note: 1) brown shaded area on the abscissa denotes the bottom profile depth, and 2) contours are not valid outside of vertical brown lines (begin and end dates for seasonal sampling)..... 10
Figure 5. Water column mean dissolved oxygen values in Upper Klamath Lake in 2017..... 11
Figure 6. Station distributions of T (˚C), pH, D.O (mg/L), and Secchi depth, June-September, 2017..... 13
Figure 7. Station distributions of CHL, TP, SRP, TN, NO_3+ NO_2-N, NH_4-N, SiO_2 and un-ionized ammonia, June-September, 2017. 15
Figure 8. Seasonal CHL and temperature trends for UKL stations, 2013-2017 (blue line shows the median value for UKL-only, red line shows the median value for Agency Lake-only). 19
Figure 9. Time series of the 7-day running mean of daily air temperature (a) and 7-day running mean of the daily wind run in miles (b), April-June, 2006-2017. Data are from the Bureau of Reclamation AgriMet station located at Agency Lake (AGKO). 21
Figure 10. Annual distribution of Agency Lake AgriMet (AGKO) daily air temperatures, May-October, 2006-2017. 22
Figure 11. Scatter plot of the 7-day running mean of the daily wind run (miles) vs. 7-day running mean of daily air temperature (^oC) during May and June. Data are from the Bureau of Reclamation AgriMet station located at Agency Lake (AGKO). Data labels are day of the month. Confidence ellipses are drawn for dates occurring during the last 10 days of May and first 10 days of June; confidence ellipses are centered on the sample means of the x and y variables where the unbiased sample standard deviations of x and y determine its major axes and the sample covariance between x and y, its orientation (Systat 2013). 23
Figure 12. Monthly distributions of T (˚C), pH, D.O (mg/L), and Secchi depth, 2017 (symbol "a" denotes values for Agency Lake plotted separately from the box plot distribution). 24
Figure 13. Monthly distributions of CHL, TP, SRP, TN, NO_3+ NO_2-N, NH_4-N, SiO_2 and un-ionized ammonia, 2017 (symbol "a" denotes values for Agency Lake plotted separately from the box plot distribution). 25
Figure 14. Chlorophyll, SRP, and TIN time-series for UKL and Agency Lake Stations, 2017... 27
Figure 15. Lake-wide mean Chlorophyll, SRP, TIN, and nutrient ratio time-series for UKL Stations, 2015-2017. 28
Figure 16. Outflow Chlorophyll, SRP, TIN (nitrate and ammonia), and silica time-series, 2012 - 2017..... 29
Figure 17. Quantile plot (cumulative frequency) of April-October chlorophyll to TP ratios in Upper Klamath Lake, 2017. 30
Figure 18. Photic zone depth and maximum depth at UKL and Agency Lake stations in 2017 (periods when the blue line is shallower than the red line indicate that a portion of the water column is not within the photic zone. 31
Figure 19. Percent of the water column in the photic zone for UKL and Agency Lake Stations, 2017..... 32

Figure 20. June-September distribution of UKL-only lake-wide means for T (˚C), pH, D.O (mg/L), and Secchi depth, 1990-2017. 34
Figure 21. June-September distribution of UKL-only lake-wide means for CHL, TP, SRP, TN, NO_3+ NO_2-N, SiO_2 and NH_4-N, 1990-2017. 35
Figure 22. June-September distribution of Agency Lake means for T (˚C), pH, D.O (mg/L), and Secchi depth, 1990-2017. 44
Figure 23. June-September distribution of Agency Lake means for CHL, TP, SRP, TN, NO_3+ NO_2-N, SiO_2 and NH_4-N, 1990-2017. 45
Figure 24. Microcystin concentration in Upper Klamath and Agency Lakes in 2017 (top panel) and compared between 2016 and 2017 for the June-October period (bottom panel). 53

List of Tables

Table 1. Limnological parameters sampled in Upper Klamath Lake, 2017. 6
Table 2. Water Column mean summary statistics for each UKL station for the June-September period, 2017 (LQ= Lower Quartile; UQ=Upper Quartile). 15
Table 3. Summary statistics for June-September UKL-only lake-wide means, 1990-2017 (LQ= Lower Quartile; UQ=Upper Quartile). 36
Table 4. Summary statistics for June-September Agency Lake means, 1990-2017 (LQ=Lower Quartile; UQ=Upper Quartile). 46

INTRODUCTION

The Klamath Tribes have been monitoring water quality in Upper Klamath Lake (UKL) since 1990. These data have been described and summarized to varying degrees in a series of reports and manuscripts (e.g., Kann 1998; Kann and Smith 1999; Kann and Welch 2005; Kann 2007 through Kann 2017). The UKL electronic water quality database was previously updated with 2017 data (*see Excel spreadsheet: UKL_1990-2017_data_ver_6_6_2018.xlsx*). In addition, several reports provide additional detail and comprehensive analysis of the first 19-20 years of the database (Jassby and Kann 2010; Eldridge et al. 2014). The current 2017 data report is intended to serve as an annual update to the UKL water quality database, including a summary of 2017 data (basic summary statistics and graphical analysis), and limited comparison of inter-annual trends of UKL data collected for the 28 year period between 1990 and 2017.

METHODS

Methods followed the Klamath Tribes established procedures for field collection and laboratory analysis of water quality parameters (see Klamath Tribes 2013a,b for a complete description of these methods). Beginning in 2008 for nutrient parameters and 2009 for Chlorophyll-a (CHL), laboratory analyses transitioned from Aquatic Research, INC. in Seattle WA (ARI) to the Sprague River Water Quality Laboratory in Chiloquin OR (SRWQL). During the transition period duplicate samples were analyzed by both laboratories to confirm parameter reproducibility. With the exception of chlorophyll-a[1], all parameters were within acceptable limits with respect to relative percent differences among labs and to expected 1:1 relationships.

During the 2017 sampling season limnological data (Table 1) were collected approximately biweekly from the end of April through October[2] at 10 standardized stations in UKL and Agency Lake (Figure 1; Figure 2). Nutrient quality assurance/quality control analyses are contained in data spreadsheets (UKL_1990-2017_data_with QA_ver_6_6_2018.xlsx and UKL_1990-2017_QA_only.xlsx) available upon request.

In addition, beginning in 2016 the Klamath Tribes initiated data collection for the cyanotoxin, microcystin. Samples were collected both as surface grab and depth-integrated samples at five locations: ALBL (Agency Lake Boat Launch- surface grab only), PM, ER, MN, and AS. Samples were analyzed at the SRWQL using ELISA methodology for total microcystins[3].

---

[1] Chlorophyll-a was adjusted to account for a change from spectrophotometric method to fluorometric method beginning in 2009. Between 1990 and 2008 the spectrophotometric method was used by the Aquatic Research Inc. laboratory (ARI) and beginning in 2009 the Sprague River Water Quality Lab (SRWQL) used the fluorometric method. The fluorometric method is more sensitive so values beginning in 2009 are higher relative to years prior to 2009, especially at higher Chl levels. The adjustment is based on 225 split samples collected between 2007 and 2008 that were analyzed by both labs (Appendix III). The adjusted values are used for all time-series comparisons that include data prior to 2009, and the un-adjusted values are used when evaluating individual years.

[2] Note that the Fremont Bridge station at the outlet of UKL was sampled prior to April and after October as part of the tributary loading study (see Kann 2015) and based on analyses showing that PM and FB values follow a 1:1 trajectory values for both stations are included here with FB renamed PM for those months (see Figure 2).

[3] EPA Method 546 analyzes for "total" microcystins (MC) and nodularins (NOD) in finished drinking water and in ambient water using enzyme-linked immunosorbent assay (ELISA). The term "Total microcystins and nodularins" is defined as the sum of the congener-independent, intracellular and extracellular microcystin and nodularin that is measurable in a sample.

Table 1. Limnological parameters sampled in Upper Klamath Lake, 2017.

Parameter	Abbreviation/ Unit	Profile [a]	Grab [b]
Temperature	T (^{o}C)	X	
Dissolved Oxygen	DO (mg/L)	X	
pH	pH	X	
Specific Conductivity	(µSiemens/cm)	X	
Secchi Transparency	Secchi (m)		
Light (Photosynthetically Active Radiation)	PAR (uEm^{-2}s^{-1})	X	
Total Phosphorus	TP (µg/L)		X
Soluble Reactive phosphorus	SRP (µg/L)		X
Total Nitrogen	TN (µg/L)		X
Ammonia Nitrogen	NH_4-N (µg/L)		X
Nitrate-Nitrite Nitrogen	NO_3+ NO_2-N (µg/L)		X
Silica	SiO_2 (µg/L)		X
Chlorophyll *a*	CHL (µg/L)		X
Phytoplankton Species Composition and Biomass[c]	(mm^3/L)		X
Zooplankton Species Composition and Biomass[c]	(mg/L)		X

a Profile = collected with multi-parameter WQ probe at multiple depths in water column
b Grab = depth-integrated water column sample collected with "tube sampler" except for zooplankton which was collected with a Schindler-Patalis Trap
c. Phytoplankton and zooplankton data are compiled in spreadsheets provided separately and are not analyzed herein.

Site Code	Code	Site Description	Coordinates	
AN	KL0011	AGENCY NORTH	N 42° 33' 38.0	W 121° 56' 50.8
AS	KL0010	AGENCY SOUTH	N 42° 31' 24.9	W121° 59' 03.4
CP	KL0009	COON POINT	N 42° 26' 08.6	W 122° 01' 41.5
ER	KL0006	EAGLE RIDGE	N 42° 25' 19.5	W 121° 56' 35.8
FB	KL0001	FREMONT BRIDGE	N 42.238706	W 121.805771
ML	KL0005	MID LAKE	N 42° 22' 08.7	W 121° 50' 55.3
MN	KL0008	MID NORTH	N 42° 26' 28.9	W 121° 59' 55.8
NB	KL0003	NORTH BUCK IS.	N 42° 18' 30.2	W 121° 51' 22.4
PM	KL0002	PELICAN MARINA	N 42° 14' 16.892	W 121° 48' 37.341
SB	KL0007	SHOALWATER BAY	N 42° 24' 26.1	W 121° 57' 47.1
WB	KL0004	WOCUS BAY	N 42° 19' 35.0	W 121° 55' 11.9

Figure 1. Location of Upper Klamath Lake sampling stations, 2016. Google Earth Imagery date 8/1/2011.

Figure 2. Spatial-temporal sampling matrix for Upper Klamath Lake, 2017.

Due to a gap in 2015 Klamath Tribe data collection[4] between June 11th and July 13th, typically a critical period for bloom development in UKL, data from nearby USGS stations were used to depict conditions during that time period in 2015 (see Kann 2016 for data description).

Data reduction consisted of computation of both lake-wide means on a given sample date and of growing season (June-September sample dates) means. Because of bloom timing differences between Upper Klamath and Agency Lake (e.g., see Kann 1998), lake-wide means and analyses are shown separately for Upper Klamath Lake only and Agency Lake only. Chlorophyll and nutrient data tended to be either normally or log-normally distributed both within a date and seasonally. Based on a comparison of both log transformed ($\log_{10}$ or $\log_{10}$ (x+1)) and non-transformed data with the normal distribution using Kolmogorov-Smirnov one-sample tests or the Shapiro-Wilk standard test for normality (*cf.* Systat® 2004), the geometric mean tended to provide the best estimate of lake-wide or seasonal central tendency[5]. Lake-wide variability is shown via boxplots which convey the median, interquartile range and outliers. In addition to median and interquartile values, lake-wide central tendency may be portrayed as a mean and standard error or coefficient of variation (e.g., see Table 2).

[4] Due to reduced Natural Resource Department staffing during that period.
[5] In some cases when the distribution remained significantly different form normal even after transformation, frequency distribution and normal-probability plots indicated that the normality assumption was nonetheless approximately satisfied, especially when compared to untransformed data.

RESULTS/DISCUSSION

Seasonal and Water Column Trends in Profile Water Quality Data (T, DO, and pH)

Water column and seasonal trends in T, DO, and pH are important aspects of water quality dynamics and fish habitat in UKL. Depth-time plots of isotherms and isopleths for these parameters allows both seasonal and depth distribution to be evaluated simultaneously. These are plotted below for two representative stations, ER located in the deep trench area, and MN located in an open-water area in the northern part of the lake (Figure 3; Figure 4)[6]. Similar to 2012-2016 temperature ranged from 11-14 ^{o}C during late-April and early-May at both stations. Values then increased through May and early-June (16-20 ^{o}C) and remained constant through before increasing sharply in early-July to values >22 ^{o}C. Overall this is in contrast to 2011 when temperatures generally remained below 12 ^{o}C into early-June. Temperatures remained elevated into mid-August before declining and then increasing slightly in late-August (Figure 3; Figure 4)[7].

Unlike 2010 when water column pH initially increased (>9.0) in late-April and early-May (lake observations at that time indicated a massive diatom bloom and further confirmation showed very high biomass of the diatom *Asterionella formosa*), pH in 2017 was similar to 2011-2016 and remained relatively low (<8.5) until late-May before increasing slightly in early-June. Following the trend in temperature, pH then remained suppressed through June before increasing to values >9.0 in early-July. Overall, pH patterns in 2017 were slightly suppressed compared to other years (see Kann 2017) through early-July. Values then peaked in mid-July before declining for the remainder of the season.

Water column DO values in 2017 were near or slightly below 9 mg/L until late-May, they declined slightly in early-June and achieved maximum values in early-July (11-14 mg/L) (Figure 3 and Figure 4), but only at some stations (Figure 5). Water column mean DO compared among all stations indicates that the southern stations and Agency lake tended to have higher DO during this period than the northern stations (Figure 5). Beginning in mid-July DO began to decline with seasonal minima occurring during August (Figure 3 and Figure 4). Trends in pH and DO can be influenced by temperature and algal dynamics (cool late-spring and early-summer conditions were associated with low algal productivity, a delayed bloom, and moderate bloom decline in 2011, for example). However, 2012 did not fit this trend with algal productivity remaining low in May and June despite water temperatures that were substantially warmer than 2011, indicating that factors other than water temperature also influence algal productivity and subsequent DO and pH dynamics. In 2013 earlier warming did appear to be associated with an earlier bloom peak and coinciding peaks in pH and DO, in 2014, despite mid-May warming, algal biomass remained low until mid-June (see below Figure 8), and in both 2015 and 2016 algal biomass did again appear to increase earlier in June in response to higher June temperatures. In 2017 cooler June temperatures appeared to delay the bloom, and a subsequent bloom decline after the mid-July peak was associated with low DO throughout the water column (Figure 3 and Figure 4). As shown below and in earlier data and analytical reports (e.g., Kann 2011; Jassby and Kann 2010), differences in pH and dissolved oxygen can be explained in part by the interaction of both climate and bloom dynamics, which can also be influenced by lake level.

---

[6] For reference purposes similar depth-time plots were constructed for these stations for all years of data (1990-2014) and are shown in Appendix I of Kann (2015).

[7] note that isopleths do not accurately capture the late-August temperature increase- see Figure 8).

Figure 3. Depth-time distributions of isotherms of T (°C) and isopleths of D.O (mg/L) and pH at UKL station Eagle Ridge (ER), 2017. Note: 1) brown shaded area on the abscissa denotes the bottom profile depth, and 2) contours are not valid outside of vertical brown lines (begin and end dates for seasonal sampling).

Figure 4. Depth-time distributions of isotherms of T (˚C) and isopleths of D.O (mg/L) and pH at UKL station Mid North (MN), 2017. Note: 1) brown shaded area on the abscissa denotes the bottom profile depth, and 2) contours are not valid outside of vertical brown lines (begin and end dates for seasonal sampling).

Figure 5. Water column mean dissolved oxygen values in Upper Klamath Lake in 2017.

2017 Station Distributions

The distribution of parameter values for each station for the June-September period (chosen here to encompass the major algal growing season in UKL) are shown in Figure 6 and Figure 7. Although the seasonal timing of water quality has been shown to vary among stations (see below analyses comparing individual stations by date), the season-wide distributions as indicated by the interquartile range (25th-75th percentiles or box hinges in the plots below) tend to overlap for most parameters. In addition, although the timing of sample collection can affect the distribution of these variables (particularly temperature, pH and dissolved oxygen—see Jassby and Kann 2010), the below plots reflect water column means which are less sensitive to the effect of sample timing than are surface values. Nonetheless, as with previous years, certain stations tended to stand out on a seasonal basis. For example, DO was skewed lower for ER and CP (Figure 6)[8]. Secchi depth (transparency) was somewhat lower at PM, WB, and CP and higher at AS and AN. In general and following the trend in bloom dynamics (bloom declines were not as severe in the southern region – see below), stations in the southern region (PM, NB, and ML) tended to have higher pH and DO than the northern stations (ER, SB, MN, and CP). These among-station patterns are not always consistent from year-to-year (see Kann 2011-2017).

Stations PM and WB were among the highest with respect to median and/or upper quartile CHL, while the lower quartile and inter-quartile range for CHL at AS and AN were among the lowest (Figure 7). Similar to 2012 when both AS and AN showed noticeably lower CHL relative to other stations, especially compared to previous years (Kann 2012), the 2017 values were also lower (the 2016 and 2015 pattern for AS was more similar to other years). Unlike 2010 and 2011 (but similar to 2012) when the AS and AN stations showed higher upper quartile and median values for TP, UQ values were not high relative to other stations in 2017 (Figure 7). With the exception of SB which was skewed low for SRP, SRP values were similar overall among stations.

Similar to previous years, Agency Lake stations were among the lowest for nitrogen, particularly for TN, but also for NH_4-N and NO_3-N (Figure 7; Table 2). The upper quartile value and interquartile range for TN were highest at WB, ER, and SB. Similar to 2010-16, ER and CP were among the highest for ammonia, and SB and MN in 2017 were also high (NH_4-N; Figure 7; Table 2). Un-ionized ammonia also tended to be highest at ER, SB, MN, and CP in 2017 (Figure 7). As in previous years un-ionized ammonia was also high at WB. NO_3-N was more similar among sites, but tended to be higher at AS and AN.

Median silica values (~40,000 µg/L)[9] were similar among stations, although medians and UQ values at the Agency Lake stations were lower and showed a narrower interquartile range[10] (Figure 7). See below for a description of seasonal silica dynamics.

[8] In past years the DO distribution was skewed higher for AS and AN, but in 2017 this was not the case as stations in the southern region of the lake showed high interquartile ranges that were at times higher than AS and AN.
[9] Median values were ~30,000 µg/L in 2012.
[10] The spatial pattern of lower silica medians and narrower interquartile range at the Agency Lake stations is consistent year-to-year.

Figure 6. Station distributions of T (˚C), pH, D.O (mg/L), and Secchi depth, June-September, 2017.

Chlorophyll a (µg/L)
Total Phosphorus (µg/L)
SRP (µg/L)
Total Nitrogen (µg/L)
NO3 & NH4 N (µg/L)
SiO2 (µg/L)
Un-ionized Ammonia (µg/L)
PM
NB
WB
ML
ER
SB
MN
CP
AS
AN
Station
NO3
NH4

Figure 7. Station distributions of CHL, TP, SRP, TN, NO_3+ NO_2-N, NH_4-N, SiO_2 and un-ionized ammonia, June-September, 2017.

Table 2. Water Column mean summary statistics for each UKL station for the June-September period, 2017 (LQ= Lower Quartile; UQ=Upper Quartile).

Year	Station	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2017	AS	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2017	AS	Median	21.90	8.87	8.98	1.15	22.40	139.00	71.00	915.00	33900.00	12.00	19.00	6.99
2017	AS	Arithmetic Mean	20.28	8.91	8.37	1.18	77.27	181.89	89.44	1426.89	30644.44	53.44	37.89	7.02
2017	AS	Coefficient of Variation	0.21	0.07	0.39	0.46	1.80	0.72	0.74	0.93	0.22	1.21	1.06	0.70
2017	AS	LQ	18.10	8.43	6.98	0.80	8.87	96.50	37.25	627.00	24625.00	10.50	15.50	2.33
2017	AS	UQ	22.98	9.46	10.35	1.50	78.30	218.00	121.75	1707.50	35150.00	114.75	49.75	10.99
2017	ER	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2017	ER	Median	20.92	8.64	6.24	1.03	153.00	267.00	79.00	2600.00	34200.00	14.00	182.00	41.46
2017	ER	Arithmetic Mean	19.41	8.72	6.28	1.03	124.92	250.67	107.00	2356.33	32977.78	22.78	312.89	57.93
2017	ER	Coefficient of Variation	0.20	0.04	0.37	0.61	0.89	0.38	0.54	0.49	0.26	0.92	1.05	1.15
2017	ER	LQ	17.08	8.51	4.36	0.51	20.90	160.50	58.50	1313.25	24050.00	11.50	57.75	6.97
2017	ER	UQ	22.75	8.91	7.86	1.68	162.75	339.25	175.25	3122.50	40900.00	29.00	646.50	83.59
2017	ML	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2017	ML	Median	20.03	8.89	8.24	0.88	84.90	223.00	58.00	2010.00	34100.00	13.00	23.00	6.38
2017	ML	Arithmetic Mean	18.57	8.99	8.52	1.00	99.02	214.89	95.56	1844.00	32400.00	21.22	121.00	23.44
2017	ML	Coefficient of Variation	0.23	0.04	0.17	0.42	0.62	0.34	0.67	0.37	0.26	1.11	2.11	1.67
2017	ML	LQ	16.52	8.72	7.94	0.65	58.53	152.75	45.25	1446.75	24175.00	8.50	13.75	2.96
2017	ML	UQ	22.17	9.19	8.91	1.44	131.25	281.25	152.50	2277.50	39475.00	26.25	91.25	22.89
2017	MN	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2017	MN	Median	21.07	9.03	8.29	0.89	110.00	219.00	79.00	2050.00	33900.00	12.00	177.00	31.56
2017	MN	Arithmetic Mean	19.33	8.96	8.15	0.92	106.18	230.44	110.56	2066.78	33211.11	16.00	237.78	53.57
2017	MN	Coefficient of Variation	0.21	0.04	0.27	0.44	0.92	0.45	0.62	0.50	0.27	1.08	1.20	1.05

Year	Station	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2017	MN	LQ	16.77	8.69	6.89	0.71	36.03	133.75	45.00	1313.50	24375.00	8.00	25.50	6.75
2017	MN	UQ	22.80	9.19	9.25	1.29	119.25	315.50	182.75	2535.00	41450.00	13.75	346.00	105.75
2017	NB	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2017	NB	Median	19.43	9.01	8.72	0.85	66.40	169.00	57.00	1930.00	34500.00	15.00	16.00	8.41
2017	NB	Arithmetic Mean	18.76	9.07	8.93	0.95	85.93	195.00	89.44	1645.00	32466.67	25.78	73.00	17.03
2017	NB	Coefficient of Variation	0.21	0.05	0.18	0.36	0.85	0.44	0.70	0.40	0.26	1.06	1.66	1.37
2017	NB	LQ	16.60	8.68	8.30	0.72	28.00	117.75	37.25	1288.75	24400.00	11.50	13.75	1.97
2017	NB	UQ	21.59	9.51	9.85	1.23	119.75	286.50	155.00	2107.50	40075.00	29.50	63.75	21.08
2017	PM	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2017	PM	Median	20.63	9.24	9.01	0.75	190.00	213.00	51.00	2420.00	37400.00	10.00	19.00	10.06
2017	PM	Arithmetic Mean	19.37	9.15	9.47	0.75	169.39	222.56	76.00	2210.56	33488.89	10.44	19.89	8.29
2017	PM	Coefficient of Variation	0.22	0.07	0.13	0.40	0.60	0.44	0.74	0.43	0.28	0.35	0.17	0.71
2017	PM	LQ	17.36	8.57	8.80	0.51	96.78	140.75	29.50	1737.00	24200.00	8.75	16.75	1.95
2017	PM	UQ	22.36	9.68	10.14	0.84	222.00	318.75	138.50	2802.50	41950.00	11.75	23.00	14.07
2017	SB	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2017	SB	Median	21.40	8.96	7.81	0.52	125.00	271.00	75.00	2800.00	33500.00	12.00	119.00	37.52
2017	SB	Arithmetic Mean	20.06	8.92	8.09	0.80	125.53	252.56	73.00	2402.89	32755.56	20.22	213.44	59.46
2017	SB	Coefficient of Variation	0.19	0.03	0.36	0.64	0.68	0.42	0.55	0.48	0.26	1.26	1.01	1.16
2017	SB	LQ	17.65	8.65	6.34	0.46	40.10	167.25	42.00	1260.00	24625.00	10.50	47.25	6.35
2017	SB	UQ	22.31	9.15	9.09	1.24	199.50	361.25	88.25	3390.00	41000.00	14.25	444.25	95.39
2017	WB	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2017	WB	Median	20.20	9.15	8.58	0.55	247.00	244.00	54.00	3140.00	36200.00	11.00	71.00	8.92
2017	WB	Arithmetic Mean	19.40	9.06	8.59	0.64	263.36	272.22	76.89	3107.00	33544.44	18.78	84.56	30.45
2017	WB	Coefficient of Variation	0.21	0.06	0.18	0.56	0.76	0.53	0.65	0.57	0.27	0.94	1.12	1.39

Year	Station	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2017	WB	LQ	17.19	8.73	7.76	0.43	81.88	137.75	38.00	1765.00	24950.00	9.75	18.25	5.74
2017	WB	UQ	22.60	9.37	9.65	0.81	361.25	386.75	124.50	4287.50	41200.00	21.75	97.00	49.70
2017	AN	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2017	AN	Median	20.19	8.83	8.36	1.66	11.70	141.00	82.00	536.00	33800.00	9.00	16.00	3.39
2017	AN	Arithmetic Mean	18.99	8.90	8.47	1.41	72.87	196.00	108.89	1140.33	31288.89	19.89	22.67	4.67
2017	AN	Coefficient of Variation	0.22	0.06	0.23	0.49	1.62	0.75	0.76	1.04	0.17	1.03	1.06	0.76
2017	AN	LQ	17.70	8.65	6.86	0.89	6.55	88.50	48.75	454.50	26550.00	7.00	8.50	1.06
2017	AN	UQ	22.22	9.36	9.19	1.97	100.78	250.75	133.75	1615.00	35525.00	32.25	23.00	8.63
2017	CP	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2017	CP	Median	21.17	8.89	7.64	0.66	101.00	280.00	73.00	2310.00	33800.00	13.00	117.00	20.27
2017	CP	Arithmetic Mean	19.79	8.91	7.68	0.79	333.82	430.56	113.56	4183.56	33300.00	23.78	298.33	66.87
2017	CP	Coefficient of Variation	0.19	0.05	0.39	0.86	1.97	1.30	0.61	1.46	0.26	0.94	1.27	1.30
2017	CP	LQ	17.93	8.64	5.40	0.33	59.48	168.50	58.75	1734.00	24775.00	10.75	37.75	8.56
2017	CP	UQ	22.75	9.32	10.37	1.09	213.25	349.75	188.25	2975.00	41200.00	29.25	510.25	102.81
2017	UKL OUT	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2017	UKL OUT	Median	20.63	9.24	9.01	0.75	190.00	213.00	51.00	2420.00	37400.00	10.00	19.00	10.06
2017	UKL OUT	Arithmetic Mean	19.37	9.15	9.47	0.75	169.39	222.56	76.00	2210.56	33488.89	10.44	19.89	8.29
2017	UKL OUT	Coefficient of Variation	0.22	0.07	0.13	0.40	0.60	0.44	0.74	0.43	0.28	0.35	0.17	0.71
2017	UKL OUT	LQ	17.36	8.57	8.80	0.51	96.78	140.75	29.50	1737.00	24200.00	8.75	16.75	1.95
2017	UKL OUT	UQ	22.36	9.68	10.14	0.84	222.00	318.75	138.50	2802.50	41950.00	11.75	23.00	14.07

Seasonal Chlorophyll Pattern and Climate Interaction

Seasonal differences in algal biomass (CHL) among stations in 2017 show that, unlike both the previous seven years (2008-2014) when early season CHL in Agency Lake was similar to UKL stations through the initial bloom peak, and 2006 (Kann 2011) and 2007 when AS and AN increased earlier and declined earlier in the season relative to UKL stations[11]; early season CHL in Agency Lake was slightly lower than UKL stations in 2015-2017, and was similar during the initial bloom peak in 2016 and 2017 (Figure 8). In 2015 AS remained lower through the initial bloom peak (Figure 8). The general trend towards greater similarity between Agency and UKL Lakes in terms of the June algal biomass increase and seasonal maxima and decline in the later years likely reflects greater connectivity between the two lakes due wetland restoration activities on the Williamson Delta Preserve (e.g., Wong et al. 2010; 2011). Values for Agency Lake in 2017 were notably lower during July-October than they were in UKL.

As noted in previous annual data reports (Kann 2008 to 2017), water temperature partially explained the early season CHL patterns among the years. For example, low temperatures coincided with a depressed early-June bloom in 2006, 2008, and 2011 (Kann 2017). Similar to 2013-2016, spring CHL values were also relatively low (generally <10-15 µg/L) in 2017, and while 2013, 2015, and 2016 increased in late- May/early-June, trends in 2017 were similar to 2014 when values remained low in early-June before increasing in mid- to late-June (Figure 8). However, values in 2017 remained suppressed (<100 µg/L) until early-July, whereas 2013-2016 showed relatively rapid increases to values >100-200 µg/L by mid- to late-June, and showed relatively earlier peaks than many previous years. The elevated June values during 2013-2016 were not always associated with water temperatures that were warmer than other years, but the delayed increase in 2017 appeared to be associated with suppressed June temperatures (<20 ^{o}C).

In 2015 temperature seemed to directly relate to the onset of a relatively early *Aphanizomenon* bloom, and indirectly to the earlier than usual *Microcystis* bloom in that it was timed to the *Aphanizomenon* crash and the influx of nitrogen[12] (Kann 2016). However, it was clear that factors other than temperature were also affecting bloom dynamics in previous years (see Kann 2017 for a more complete description of these dynamics).

[11] Between 1990-2007 data tend to show CHL at the Agency L. stations increasing and declining earlier than UKL stations.

[12] *Microcystis* does not typically appear in UKL until the *Aphanizomeno*n bloom crash which typically occurs between mid-July and mid-August.

Figure 8. Seasonal CHL and temperature trends for UKL stations, 2013-2017 (blue line shows the median value for UKL-only, red line shows the median value for Agency Lake-only).

Because water temperature in the above plots is measured biweekly, and due to UKL's shallow depth, a short lag-time is generally observed with respect to equilibrium with ambient air temperatures (e.g., Wood et al. 2006), it is also instructive to evaluate daily air temperatures as another indicator of water column warming.

Daily air temperature in 2017 confirm the June cooling noted above, and although late-May to early-June values were relatively high compared to other years, values were among the lowest in mid-June before rebounding to relatively high levels again towards the end of June that remained high into September (Figure 9a). In fact, July, August, and early-September values were among the highest relative to the previous 11 years (particularly in August; Figure 10).

Previous analyses of daily data obtained from the USBR AgriMet station located near Agency Lake indicated at least partial tracking of May air temperature and CHL levels (Kann 2011; 2012). For example, temperature declines in mid-May of 2006 and 2008 that remained near or below 15 ^{o}C through mid-June were associated with suppressed CHL levels in early-June (Kann 2011). In 2007 and 2009, air temperatures warmed between mid- and late-May and were associated with elevated CHL levels in early June, and in 2010, when temperatures cooled substantially in mid-May and portions of June, CHL also remained suppressed during early and mid-June. Analyses for previous years indicated a threshold temperature of ~15 for *Aphanizomenon* bloom development in Upper Klamath Lake (Kann 1998; Kann 2011). However, as noted previously (Kann 2011) high CHL levels due to spring diatom blooms can be achieved even at temperatures much cooler than 15 ^{o}C. Furthermore, there was an indication that once the 15 ^{o}C threshold was reached, cool temperatures towards the end of June and into July also had an apparent effect on suppressing continuing algal biomass development.

June air temperatures in 2015 clearly fit the trend of warmer temperatures leading to earlier bloom development, with late-May (see Kann 2016) and June values among the highest of the 2006-2017 period (Figure 10). Although there was an apparent cooling trend during May-July between 2006 and 2012, this trend was mostly reversed during 2013-2017 (Figure 10).

Analysis of wind speed as an indicator of the extent of water column mixing showed that the periods directly preceding and during the typical period of June bloom development in previous years tended to show that higher wind speeds were associated with lower algal biomass and vice versa (e.g., Kann 2016). This trend appeared to hold in 2017 when suppressed algal biomass was associated with wind speeds among the highest during the mid-June period (Figure 9b).

Also similar to previous 2006-2016 analysis of air temperature and wind speed data that showed wind and temperature to be related such that warm/calm conditions co-occur and that cool/windy conditions co-occur (Kann 2016), these parameters also tended to co-occur in 2017 (Figure 11)[13]. For example, confidence ellipses computed for the period encompassing 10 days prior to and subsequent to June 1st (the typical historical period of initial *Aphanizomenon* increase) show that 2006, 2008, and 2011 (red, green, and maroon ellipses in Figure 11) tended to be cooler and windier than during the same periods in 2009, and 2013 to 2017.

[13] The pattern was especially clear in mid-June; see Figure 9.

Figure 9. Time series of the 7-day running mean of daily air temperature (a) and 7-day running mean of the daily wind run in miles (b), April-June, 2006-2017. Data are from the Bureau of Reclamation AgriMet station located at Agency Lake (AGKO).

Figure 10. Annual distribution of Agency Lake AgriMet (AGKO) daily air temperatures, May-October, 2006-2017.

Overall, years showing lower wind speed and warmer temperatures tend to be associated with higher early- and mid-June CHL than the other years. For example, during 2011the late-May to early-June period was among the coolest and windiest of the six years portrayed (Figure 11), and as noted above also showed relatively low algal biomass levels. Both the 2013 and 2014 earlier bloom years were associated with warmer and calmer conditions during the late-May to early-June period. In this case, 2015 stands out as one of the calmest and warmest during the late-May to early June period. Although the late-May to early-June period in 2017 was intermediate with respect to wind and temperature (Figure 11), the mid-June period that likely played a role in a delayed bloom development was both windy and cool (Figure 9).

These climate data indicate that cooler and well mixed conditions during the usual early season bloom development period (e.g., Kann and Welch 2005) contribute to variability in year-to-year bloom development. Multivariate analyses performed on the longer 1990-2009 data set also showed that wind and temperature, along with lake elevation were determinants of CHL levels in UKL (Jassby and Kann 2010). As noted below these factors also interact with varying year-to-year variability in nutrient concentrations.

Figure 11. Scatter plot of the 7-day running mean of the daily wind run (miles) vs. 7-day running mean of daily air temperature (^{o}C) during May and June. Data are from the Bureau of Reclamation AgriMet station located at Agency Lake (AGKO). Data labels are day of the month. Confidence ellipses are drawn for dates occurring during the last 10 days of May and first 10 days of June; confidence ellipses are centered on the sample means of the x and y variables where the unbiased sample standard deviations of x and y determine its major axes and the sample covariance between x and y, its orientation (Systat 2013).

2016 Monthly and Seasonal Water Quality, Chlorophyll, and Nutrient Patterns

Basic statistics for monthly distributions over all sampling years are shown in Appendix 1. Peak water temperatures occurred in July of 2017 (Figure 12). Monthly distributions for pH in 2017 showed a progressive seasonal increase with seasonal maxima occurring in July that coincided with lower Secchi depth (indicating reduced transparency) and highest CHL distributions (Figure 13). Similar to 2012 through 2016, lower DO occurred during August in 2017, and although the timing of low DO was similar to other years, August DO was relatively low compared to many previous years.

Figure 12. Monthly distributions of T (˚C), pH, D.O (mg/L), and Secchi depth, 2017 (symbol "a" denotes values for Agency Lake plotted separately from the box plot distribution).

Figure 13. Monthly distributions of CHL, TP, SRP, TN, NO_3+ NO_2-N, NH_4-N, SiO_2 and un-ionized ammonia, 2017 (symbol "a" denotes values for Agency Lake plotted separately from the box plot distribution).

Although the CHL decline in 2017 was fairly pronounced relative to other years, the typical bimodal CHL peak as indicated by the monthly box plots was not as obvious as some years (Figure 13)[14]. TP tended to follow the initial trend in CHL, but then remained elevated even while the bloom declined in 2017 SRP increased gradually into June before increasing to seasonal highs in August[15]. TN remained low during June, with values then peaking in July and August. Coinciding with the decline of the *Aphanizomenon* bloom, NH_4-N increased in July and August (this was in contrast to 2015 when ammonia increased during the June bloom decline), and NO_3-N increased in September (Figure 13).

A further look at the 2017 time-series with respect to CHL and dissolved nutrients on a lake-wide basis shows that, as in other years, SRP at the UKL stations generally remained low through the initial CHL peak even though the peak occurred in early-July instead of the typically observed June peak (Figure 14, Figure 15, and Appendix III). As noted previously, there is evidence that SRP is limiting the early season bloom in UKL, especially since SRP values remain suppressed even when internal sources of phosphorus are increasing during that time period (Kann 2010; Walker et al. 2012).

In 2017 and most previous years, TIN (the sum of NH_4-N and NO_3-N) levels were relatively low during the period leading up to and at the onset the annual *Aphanizomenon* growth period (Figure 15). TIN began to increase in early-August as algal biomass began to decline (Figure 15), but then decreased again in mid-September before increasing in October. As in earlier years, SRP in 2016 tended to decline into the fall months. Unlike 2011 when TIN declined in the fall, values of TIN also increased in 2017 (values continued to increase in 2012-2106 as well). In addition, TIN was substantially higher at the northern stations (MN, CP, ER, CP) than it was at the southern stations, and coincided with a relatively rapid chlorophyll decline (Figure 14). Spring and fall TIN tended to show an increased proportion of NO_3-N, while summer TIN was comprised predominantly of NH_4-N (Figure 15). The 2015 dynamics compared to 2016 and 2017 provides a good illustration of the effect of bloom phenology, particularly bloom onset, peak and decline, on nutrient parameters.

In previous years April TN:TP values were >15, which was associated with diatom blooms observed in spring (Kann 2012). However, in 2015 April TN:TP ratios were closer to 10 (Figure 15), but were back to ~15 in 2016, and 10 again in 2017. In most years the TN:TP and TIN:SRP ratios declined in May and June during the period preceding the rise of nitrogen-fixing *Aphanizomenon* in UKL (TN:TP ratios were generally lower than 10 and TIN:SRP<2.5) (Figure 15). April and early May TIN:SRP ratios were notably higher in 2016 and 2017 than they were in 2015. Relatively low May-June TN:TP and TIN:SRP ratios in 2015 (TN:TP <10; TIN:SRP<1) also seemed to be associated with an earlier *Aphanizomenon*-associated algal biomass rise (Figure 15). Although TIN:SRP ratios typically increase in August as TIN levels rise (as they did in 2016), this occurred in late June of 2015 due to the early *Aphanizomenon* decline and subsequent remineralization of organic N to inorganic N. Also unique to 2015 was an unusually early and large boom of *Microcystis aeruginosa* which followed the decline in *Aphanizomenon* and increase in TIN (Kann 2016).

[14] This is likely due to the regional aspect of the decline, with northern stations showing a steep decline while southern stations did not (Figure 8; Figure 14)

[15] SRP is typically slightly elevated in April and May before declining during the period of algal biomass increase (indicating uptake) in June.

Figure 14. Chlorophyll, SRP, and TIN time-series for UKL and Agency Lake Stations, 2017.

Figure 15. Lake-wide mean Chlorophyll, SRP, TIN, and nutrient ratio time-series for UKL Stations, 2015-2017.

Unlike 2016 which showed declining silica April-June and a substantial increase beginning in July, 2017 values increased in May, then declined in June, and did not substantially increase until August (Figure 13; Appendix III). These trends are likely tied to silica uptake during spring diatom blooms, and subsequent summer sediment recycling and lack of uptake due to diatom decline during periods of *Aphanizomenon* dominance. The delayed increase in 2017 silica values is apparently tied to the timing of the *Aphanizomenon* increase, which was delayed in 2017(Appendix II; Appendix III). The May silica increase followed by a June decrease in 2017 may reflect a diatom resurgence as the *Aphanizomenon* bloom was delayed (Figure 16; Appendix II). Time series graphs in Appendix III indicate that the silica increase is concomitant with initial large CHL and TP increases in July and August, and that silica concentration increases (>45,000 µg/L) continue into September before gradually declining in the fall, and continue to decline to seasonal lows in the spring. The Agency Lake sites showed a more muted pattern with somewhat higher values in the spring compared to other stations, and the magnitude of summer increases were less pronounced, especially at AN (Appendix III). Silica values in the spring and early summer of 2013 and 2014 were noticeably higher (>25,000 µg/L) than in 2012 when they were ~15,000 µg/L (Kann 2013). The reason for this is not yet clear, but TP values were also higher during this period in 2013 and 2014. Silica values in 2015 were again lower and similar to those in 2012 (Appendix III; Figure 16), values in 2016 were higher and similar to 2013 and 2014, and 2017 were again somewhat lower. Trends at the outflow station (Figure 16), which include winter data, show the seasonal silica trend that includes a spring depression likely due to diatom uptake. The outflow data also clearly show the relatively high TIN occurring in the fall of 2015, 2016, and 2017 (especially when compared to 2014), as well as the seasonal spring depression of TIN in the period preceding the rise in CHL due to diazotrophic *Aphanizomenon*.

Figure 16. Outflow Chlorophyll, SRP, TIN (nitrate and ammonia), and silica time-series, 2012 -2017.

In 2009, chlorophyll to TP ratios greater than 1 (which indicate potential P limitation- see Kann 2010) were observed at a high frequency in June during the initial bloom increase; in 2010 CHL: TP ratios >1 occurred in April, part of May, July, and part of September (Kann 2011), and in 2012 the frequency of CHL: TP ratios >1 was similar to 2011, occurring at a high frequency only in July (Kann 2013). In 2013 both June and July showed an increased frequency of CHL:TP >1 but in 2014 a relatively low frequency of CHL: TP ratios >1 occurred, with only a few stations in June and July above 1 (Kann 2014; Kann 2015). Interestingly, 2015, 2016, and now 2017 also showed a relatively low frequency of CHL: TP ratios >1(Figure 17).

Figure 17. Quantile plot (cumulative frequency) of April-October chlorophyll to TP ratios in Upper Klamath Lake, 2017.

The underwater light environment is another factor that can influence both bloom dynamics and other water quality parameters, especially those that are photosynthetically driven. Although not discussed in detail here, a plot of photic zone depth (defined as the depth where 99% of incident light is absorbed as computed from extinction coefficients) relative to the maximum depth at UKL and Agency Lake stations shows that, as in other years, despite the shallow nature of the system that the photic zone depth was at times shallower than maximum depth in 2017 (Figure 18; occurring when the blue line is above red line). The typical UKL pattern shows a relatively shallow photic zone during the spring diatom bloom, a deeper photic zone that extends the depth of the water column during much of May and early-June, a shallower photic zone during late-June to mid-July algal blooms, a decline (i.e., deeper photic zone- although not as extreme as the

May decline) during August bloom declines, and finally another shallow photic zone period during bloom rebound in late-August and September (Kann 2010-2017). The 2017 pattern was generally similar to other years; however, the percentage of the water column outside of the photic zone tended to be somewhat higher than previous years (e.g., does not have sufficient light for photosynthesis; Figure 19).

Figure 18. Photic zone depth and maximum depth at UKL and Agency Lake stations in 2017 (periods when the blue line is shallower than the red line indicate that a portion of the water column is not within the photic zone.

Light limitation was more apparent at the deeper ER station which showed a greater percentage of the water column to be light limited. To the extent that underwater light is influenced by seasonal algal dynamics (in concert with ambient light and the interaction with lake depth), decreases in available light during the early spring were likely influenced by diatom blooms (e.g., Kann 2011). These light decreases are generally followed by a "clear water" phase in May (with some variability in timing) as the diatoms decline (Kann 2014). In 2012, a reduced photic zone occurred in early-spring, with a "clear water" phase occurring in late-May, and although the photic zone was again reduced in early June, the lake was then relatively clear again in late-June prior to a sharp decrease in transparency in mid-July (Kann 2013). In both 2013 and 2014 there was a "clear water" phase in early June which preceded the algal biomass increase in July, and in 2015 and 2016 a mid-May to early-June increase in clarity preceded the June algal biomass increase. The percent of the water column in the photic zone was also somewhat reduced from late-April to mid-May in 2017 (Figure 19), and was followed by increasing clarity in early- to mid-June (but not at all sites), before decreasing in July, and increasing again in August.

Figure 19. Percent of the water column in the photic zone for UKL and Agency Lake Stations, 2017.

As is typical for many shallow lake ecosystems, the concentration of nutrients, their ratios, the underwater light climate, and climatic variables (e.g., temperature and wind speed) are important determinants of annual bloom dynamics of *Aphanizomenon* in UKL. During the 2010 and 2009 growing seasons (see Kann 2010; 2011) it appears that the late-spring decline in TN:TP (indicating more nitrogen limiting conditions), a later (June as opposed to May) "clear water" phase (nitrogen fixation generally has a high energy/light requirement) and cooler May-June temperatures were important determinants of *Aphanizomenon* bloom timing. Likewise, relatively high TIN concentrations and high TIN:SRP ratios, a late "clear water" phase, generally cooler and windier conditions during late-May and early-June, and cool temperatures in July apparently influenced bloom dynamics in 2011. The bloom pattern in 2012 fell somewhere in between the 2009-2010 and 2011 pattern, with declining TIN:SRP ratios and a "clear water" phase also preceding the summer *Aphanizomenon* increase.

The 2013-2016 bloom initiation patterns were also characterized declining TIN:SRP ratios and a "clear water" phase, as well as by warmer/calmer climatic conditions. In particular, 2015 experienced an early bloom and unusually early bloom crash (decline) of *Aphanizomenon* that was followed by an unusually early *Microcystis* bloom. Although the period preceding the bloom in 2017 was also characterized by declining TIN:SRP ratios and a "clear water" phase, it appears a windy and cool period in mid-June may have delayed the biomass increase. As shown by Jassby and Kann (2010), lake level and climate interact to determine bloom magnitude during the early season.

As noted above, this report serves as an annual data summary, and additional multivariate modelling is beyond the current scope. However, it is recommended that the interaction among these variables as well as other controlling factors such as lake level and hydrodynamic patterns be further explored further with additional multivariate statistical analyses using the long-term dataset.

Comparison of 2017 to Previous 1990-2016 Data

To facilitate inter-annual comparisons of the major water quality variables, lake-wide means and medians were computed for UKL-only and Agency Lake-only. The distributions for the June-September period are shown in Figure 20 to Figure 23, and summary statistics in Tables 3 and 4. The overall June-September temperature distribution in 2017 was similar to many previous years (but was higher than 2016; Figure 20). Dissimilar to 2010-2014 when the June-Sep UKL pH distributions were among the lowest for the period of record, values in both 2015 and 2016 were in the range of many previous years, but 2017 was again lower (Figure 20; Table 3). In contrast to 2011 when median DO concentration was higher than all other years for the period of record, median DO in 2012 and 2013 were among the lowest despite the lack of a large bloom decline, and 2014-2017 were intermediate for the June-September period. Secchi disk transparency followed that of the photic zone indication of water column light, with the large interquartile range (Figure 19) reflecting the differences in bloom patterns between the northern and southern areas of the lake (southern stations often remained blooming while the northern area was experience a bloom decline- see above).

Figure 20. June-September distribution of UKL-only lake-wide means for T (˚C), pH, D.O (mg/L), and Secchi depth, 1990-2017.

Figure 21. June-September distribution of UKL-only lake-wide means for CHL, TP, SRP, TN, NO_3+ NO_2-N, SiO_2 and NH_4-N, 1990-2017.

Table 3. Summary statistics for June-September UKL-only lake-wide means, 1990-2017 (LQ= Lower Quartile; UQ=Upper Quartile).

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1990	N of Cases	14.0	14.0	14.0	14.0	13.0	13.0	13.0	13.0	0.0	10.0	11.0	11.0
1990	Median	21.0	9.3	7.9	0.7	139.9	219.2	59.4	2916.1		9.0	52.0	49.7
1990	Arithmetic Mean	20.7	9.4	8.0	0.7	136.8	208.3	60.7	2642.6		11.1	84.7	54.0
1990	Coefficient of Variation	0.1	0.0	0.2	0.4	0.5	0.2	0.5	0.4		1.0	0.9	0.5
1990	LQ	18.8	9.2	6.6	0.6	109.5	192.8	33.8	1922.6		1.7	34.4	37.3
1990	UQ	22.9	9.5	8.9	0.8	156.0	239.4	87.3	3379.4		18.2	123.6	72.6
1991	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	0.0	3.0	7.0	7.0
1991	Median	18.0	9.4	8.8	0.7	100.5	231.6	43.1	2459.3		26.3	35.0	28.8
1991	Arithmetic Mean	18.1	9.2	8.7	0.8	95.6	202.4	47.3	2171.6		26.1	52.3	35.2
1991	Coefficient of Variation	0.1	0.1	0.2	0.3	0.7	0.4	0.5	0.4		0.8	1.1	0.9
1991	LQ	16.4	8.7	7.7	0.6	24.6	122.1	35.3	1780.0		10.3	14.3	12.7
1991	UQ	20.4	9.5	9.6	0.9	135.5	255.7	57.9	2643.1		41.9	73.1	56.7
1992	N of Cases	8.0	8.0	8.0	8.0	8.0	9.0	9.0	9.0	0.0	9.0	9.0	8.0
1992	Median	19.7	9.1	7.2	0.4	87.2	217.6	18.1	2220.0		7.2	19.0	9.8
1992	Arithmetic Mean	19.5	9.1	7.9	0.5	122.8	196.3	35.1	2532.3		11.6	25.3	13.3
1992	Coefficient of Variation	0.1	0.1	0.2	0.3	0.7	0.5	1.0	0.3		1.2	0.5	0.8
1992	LQ	17.4	9.1	6.6	0.4	64.6	131.3	11.8	2114.4		5.0	16.7	6.9
1992	UQ	21.7	9.3	9.5	0.6	173.8	236.1	44.7	3180.1		8.9	32.7	20.3
1993	N of Cases	10.0	10.0	10.0	10.0	9.0	18.0	18.0	18.0	0.0	18.0	18.0	9.0
1993	Median	18.2	8.8	8.1	0.7	82.6	108.0	16.0	1811.2		7.0	14.9	15.3
1993	Arithmetic Mean	17.9	8.8	8.2	0.8	74.9	115.2	15.0	1977.1		30.1	157.2	37.6
1993	Coefficient of Variation	0.1	0.1	0.2	0.4	0.6	0.5	0.3	0.6		1.7	2.2	2.1
1993	LQ	17.1	7.9	6.6	0.6	47.7	76.0	12.0	1540.0		5.0	6.0	2.1
1993	UQ	19.2	9.4	9.6	0.9	96.2	150.0	19.0	2368.5		14.9	128.1	20.1
1994	N of Cases	10.0	10.0	10.0	9.0	14.0	20.0	17.0	20.0	0.0	17.0	21.0	10.0
1994	Median	19.6	9.1	8.2	0.5	54.6	126.0	12.0	1626.1		8.1	28.1	4.6
1994	Arithmetic Mean	19.6	9.0	7.8	0.6	69.2	127.5	18.6	1760.7		14.9	48.8	10.7

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1994	Coefficient of Variation	0.2	0.1	0.2	0.4	0.7	0.2	0.9	0.3		1.2	1.3	1.5
1994	LQ	18.4	8.2	6.2	0.4	39.3	112.3	9.7	1434.0		5.0	11.6	1.9
1994	UQ	22.1	9.3	8.6	0.8	66.7	147.1	24.0	2160.5		14.4	52.6	9.9
1995	N of Cases	9.0	9.0	9.0	8.0	8.0	16.0	16.0	16.0	0.0	16.0	16.0	8.0
1995	Median	19.6	9.5	8.5	0.6	155.3	158.0	43.2	2500.0		5.0	13.1	29.9
1995	Arithmetic Mean	19.2	9.5	8.6	0.6	152.0	168.1	47.2	2603.6		6.4	22.9	31.3
1995	Coefficient of Variation	0.1	0.0	0.1	0.2	0.2	0.3	0.5	0.2		0.6	1.1	0.6
1995	LQ	18.4	9.5	8.0	0.5	125.4	144.3	25.0	2335.9		5.0	5.0	17.1
1995	UQ	20.0	9.7	9.3	0.8	182.1	181.6	65.0	3147.9		5.0	27.9	46.5
1996	N of Cases	10.0	10.0	10.0	7.0	10.0	10.0	10.0	10.0	0.0	10.0	10.0	10.0
1996	Median	19.8	9.0	8.0	0.9	104.2	153.6	39.8	1936.2		14.2	196.3	54.0
1996	Arithmetic Mean	19.6	9.0	7.8	0.9	106.4	142.6	41.1	1818.8		26.9	331.5	83.9
1996	Coefficient of Variation	0.1	0.0	0.2	0.3	0.5	0.4	0.8	0.3		1.0	1.0	0.9
1996	LQ	18.2	8.7	7.2	0.8	60.7	96.9	7.4	1584.5		5.0	85.4	22.8
1996	UQ	21.6	9.3	9.1	1.0	146.0	189.9	65.0	2251.7		44.4	483.1	130.4
1997	N of Cases	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	0.0	8.0	8.0	8.0
1997	Median	19.3	9.3	9.5	0.8	167.5	229.6	66.1	2468.4		6.1	761.3	302.1
1997	Arithmetic Mean	19.2	9.2	8.7	0.8	143.1	224.2	65.6	2499.5		15.6	916.0	482.1
1997	Coefficient of Variation	0.1	0.1	0.2	0.4	0.4	0.2	0.6	0.1		1.2	0.5	0.8
1997	LQ	17.7	9.0	6.9	0.5	92.1	196.6	33.4	2252.5		5.0	669.3	237.4
1997	UQ	21.5	9.5	9.8	1.0	186.4	252.1	91.9	2603.3		22.3	1124.6	843.5
1998	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	0.0	9.0	9.0	9.0
1998	Median	20.3	8.9	9.3	1.1	63.0	186.8	49.2	1940.2		5.0	471.7	170.5
1998	Arithmetic Mean	19.9	8.9	8.6	1.1	86.1	163.7	48.4	1824.4		13.7	583.0	194.9
1998	Coefficient of Variation	0.2	0.1	0.2	0.3	0.7	0.4	0.9	0.4		1.4	0.6	1.0
1998	LQ	17.0	8.7	8.0	0.9	36.7	84.0	5.7	1205.6		5.0	315.0	64.6
1998	UQ	22.4	9.3	10.1	1.2	119.9	214.9	76.4	2352.8		10.9	947.3	259.4
1999	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	0.0	9.0	9.0	9.0

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1999	Median	18.1	9.4	9.0	0.8	131.3	208.8	46.4	2248.7		12.7	254.2	120.3
1999	Arithmetic Mean	18.2	9.1	8.9	0.8	109.1	188.1	52.5	2114.6		18.1	307.0	154.9
1999	Coefficient of Variation	0.2	0.1	0.2	0.2	0.6	0.3	0.7	0.3		0.9	0.7	1.0
1999	LQ	16.7	8.7	8.0	0.7	62.2	135.1	17.1	1924.7		5.0	181.7	28.9
1999	UQ	20.3	9.5	9.7	1.0	154.6	234.8	77.1	2461.3		31.9	435.0	237.7
2000	N of Cases	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	0.0	8.0	8.0	8.0
2000	Median	19.8	9.3	7.8	0.9	118.8	185.9	81.3	2043.3		19.8	586.9	259.9
2000	Arithmetic Mean	19.7	9.3	7.4	0.9	109.6	215.0	71.7	2013.9		28.6	637.0	334.4
2000	Coefficient of Variation	0.1	0.1	0.3	0.3	0.6	0.3	0.5	0.1		1.3	0.3	0.8
2000	LQ	18.5	8.8	6.2	0.8	64.6	178.9	40.0	1820.3		9.5	511.0	107.7
2000	UQ	21.7	9.8	8.9	1.0	141.5	259.9	104.5	2204.6		21.6	674.5	550.4
2001	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	0.0	9.0	9.0	9.0
2001	Median	19.2	9.5	7.4	0.8	134.2	174.5	32.8	2967.4		13.2	613.6	264.7
2001	Arithmetic Mean	18.8	9.2	7.4	0.8	132.8	193.4	35.3	2989.5		11.0	645.5	275.9
2001	Coefficient of Variation	0.1	0.1	0.3	0.2	0.5	0.3	0.7	0.2		0.4	0.3	0.5
2001	LQ	17.3	8.8	6.5	0.7	74.7	150.9	8.7	2708.6		5.0	492.9	226.6
2001	UQ	19.9	9.7	9.4	1.0	180.3	246.2	61.9	3357.3		15.0	846.6	330.3
2002	N of Cases	8.0	8.0	7.0	8.0	8.0	8.0	8.0	8.0	0.0	8.0	8.0	8.0
2002	Median	19.6	9.2	8.1	0.9	107.4	184.2	35.5	2469.1		12.6	397.2	168.1
2002	Arithmetic Mean	19.3	9.2	8.3	0.9	105.6	173.9	32.5	2400.6		20.3	401.0	181.8
2002	Coefficient of Variation	0.1	0.0	0.2	0.2	0.4	0.3	0.6	0.2		1.2	0.5	0.6
2002	LQ	17.1	9.1	7.4	0.7	84.3	151.5	16.6	2138.1		10.0	304.5	106.3
2002	UQ	21.1	9.5	8.7	1.0	134.8	205.1	47.3	2794.9		14.5	545.9	260.6
2003	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	0.0	9.0	9.0	9.0
2003	Median	20.7	9.4	8.2	0.7	80.1	225.4	46.6	2999.8		13.0	69.1	24.1
2003	Arithmetic Mean	20.3	9.2	7.8	0.8	90.6	204.2	48.7	2475.0		17.3	141.9	93.8
2003	Coefficient of Variation	0.1	0.1	0.2	0.3	0.6	0.4	0.7	0.4		0.8	1.6	1.9
2003	LQ	18.7	8.8	7.0	0.6	61.3	115.0	18.1	1807.8		7.0	27.6	11.9

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2003	UQ	21.2	9.6	8.5	1.0	133.0	266.9	79.2	3175.8		21.1	143.0	82.0
2004	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	0.0	9.0	9.0	9.0
2004	Median	20.2	9.2	8.1	0.9	85.9	172.7	23.5	2317.7		15.8	40.7	19.6
2004	Arithmetic Mean	19.3	9.2	7.7	0.9	85.1	148.8	29.1	2114.2		17.6	113.6	37.2
2004	Coefficient of Variation	0.2	0.0	0.2	0.2	0.7	0.3	0.8	0.2		0.6	1.5	1.2
2004	LQ	15.9	9.0	6.6	0.8	36.8	119.2	11.1	2050.0		9.2	22.0	11.4
2004	UQ	21.4	9.6	8.8	1.0	109.7	173.9	38.0	2351.3		23.0	110.9	41.5
2005	N of Cases	18.0	18.0	18.0	9.0	16.0	18.0	18.0	18.0	0.0	18.0	18.0	18.0
2005	Median	18.3	9.1	8.0	0.8	93.2	152.8	25.1	2170.0		9.0	24.3	10.0
2005	Arithmetic Mean	18.8	9.1	8.0	0.9	98.7	159.6	29.7	2332.4		12.7	44.3	16.3
2005	Coefficient of Variation	0.2	0.1	0.2	0.2	0.6	0.4	0.8	0.4		0.7	1.2	1.2
2005	LQ	16.1	8.9	7.0	0.8	63.1	112.0	8.7	1890.0		6.3	19.0	5.0
2005	UQ	21.7	9.5	8.8	1.0	130.4	213.9	41.7	2815.0		18.0	35.0	22.5
2006	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	0.0	9.0	9.0	9.0
2006	Median	20.4	9.4	8.2	0.7	108.2	238.3	75.7	2416.3		5.0	56.3	51.2
2006	Arithmetic Mean	19.7	9.2	8.1	0.9	95.8	198.4	61.5	2256.0		17.4	115.0	50.8
2006	Coefficient of Variation	0.1	0.1	0.2	0.5	0.7	0.5	0.7	0.5		1.1	1.6	0.7
2006	LQ	18.2	8.4	7.0	0.7	24.6	102.9	14.7	1523.0		5.0	49.8	24.3
2006	UQ	21.5	9.9	9.0	1.4	129.4	255.2	99.4	2786.7		28.5	61.5	87.4
2007	N of Cases	9.0	9.0	9.0	9.0	8.0	9.0	9.0	9.0	0.0	9.0	9.0	9.0
2007	Median	19.8	9.3	7.4	0.7	97.1	225.5	73.6	2794.1		8.2	48.5	41.8
2007	Arithmetic Mean	19.1	9.4	7.6	0.7	107.4	234.9	72.7	2513.6		12.8	85.2	40.3
2007	Coefficient of Variation	0.2	0.1	0.2	0.3	0.5	0.4	0.6	0.4		1.0	1.5	0.9
2007	LQ	17.9	9.1	6.6	0.6	75.5	169.5	35.7	2139.4		5.5	17.2	11.4
2007	UQ	21.1	9.9	8.7	0.8	154.2	309.7	103.4	3115.5		12.9	82.5	53.3
2008	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
2008	Median	19.8	9.2	7.9	0.7	112.0	205.1	59.4	2507.3	32881.0	10.0	58.6	25.1
2008	Arithmetic Mean	19.0	9.2	8.1	0.8	105.6	182.2	53.5	2232.8	33614.9	9.8	57.7	32.4
2008	Coefficient of	0.1	0.1	0.1	0.3	0.5	0.4	0.6	0.4	0.3	0.8	0.6	0.8

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
	Variation												
2008	LQ	17.1	9.0	7.5	0.7	85.6	123.2	20.7	2001.0	23578.4	4.0	25.8	13.7
2008	UQ	21.2	9.5	8.3	0.9	128.7	239.0	76.6	2756.4	43138.3	10.9	84.3	55.9
2009	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
2009	Median	19.1	9.3	7.5	0.7	122.8	164.2	46.8	2132.8	27713.5	5.6	39.4	27.1
2009	Arithmetic Mean	19.1	9.2	7.7	0.9	102.8	156.5	44.2	2162.0	25708.8	9.1	134.2	52.4
2009	Coefficient of Variation	0.1	0.1	0.2	0.5	0.5	0.5	0.8	0.3	0.5	0.8	1.3	1.1
2009	LQ	17.7	8.7	7.0	0.6	49.9	95.4	6.5	1945.8	14134.8	4.3	23.9	11.3
2009	UQ	20.0	9.7	8.2	1.1	139.7	210.7	77.8	2448.6	37038.8	11.2	193.7	81.3
2010	N of Cases	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
2010	Median	19.8	9.4	8.9	0.9	81.0	112.2	16.8	1763.0	20693.8	6.0	24.3	14.7
2010	Arithmetic Mean	18.9	9.1	8.7	0.9	86.1	118.1	22.1	1657.0	24176.7	7.3	55.5	25.2
2010	Coefficient of Variation	0.2	0.1	0.1	0.2	0.8	0.6	0.9	0.5	0.6	0.6	1.1	1.2
2010	LQ	16.7	8.5	7.7	0.8	22.8	51.2	5.2	684.1	9317.1	4.0	14.0	1.4
2010	UQ	21.6	9.6	9.4	1.0	115.5	175.4	35.6	2353.1	38837.9	8.0	99.0	44.4
2011	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
2011	Median	19.3	9.0	9.3	0.9	63.4	114.4	10.5	1668.0	27439.3	20.1	48.0	12.7
2011	Arithmetic Mean	18.4	8.8	8.5	1.0	55.6	127.0	31.0	1412.9	29191.3	17.1	87.6	24.8
2011	Coefficient of Variation	0.2	0.1	0.2	0.3	0.7	0.6	1.2	0.4	0.3	0.6	1.0	1.1
2011	LQ	16.5	8.3	7.2	0.8	12.7	52.7	4.4	709.0	20683.5	8.0	31.3	1.6
2011	UQ	20.9	9.2	9.6	1.1	94.6	208.1	71.8	1870.0	36432.5	23.3	108.6	35.1
2012	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
2012	Median	19.3	8.8	7.2	0.9	46.7	110.9	31.7	1773.1	29618.5	13.8	62.9	14.6
2012	Arithmetic Mean	19.2	8.8	7.8	0.8	69.3	153.5	50.3	1661.5	30558.3	33.0	75.1	26.5
2012	Coefficient of Variation	0.1	0.1	0.2	0.3	0.9	0.6	0.9	0.5	0.4	1.1	0.7	1.0
2012	LQ	17.6	8.2	6.9	0.6	25.4	83.1	15.6	967.2	17643.1	9.6	39.7	1.6
2012	UQ	21.4	9.4	8.5	1.0	107.3	211.9	70.1	2391.9	44039.1	63.8	101.8	45.6
2013	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
2013	Median	19.8	8.8	7.4	0.9	49.1	147.1	32.1	2008.0	41729.5	7.5	47.4	15.7

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2013	Arithmetic Mean	19.7	8.9	7.3	0.8	72.8	183.0	58.0	1910.9	38043.5	115.8	67.3	29.9
2013	Coefficient of Variation	0.1	0.1	0.3	0.3	0.8	0.5	0.7	0.4	0.2	1.3	0.9	1.1
2013	LQ	17.8	7.7	5.8	0.5	14.8	104.2	28.3	1263.7	28323.7	5.4	32.3	2.0
2013	UQ	22.6	9.9	8.2	0.9	132.0	256.5	93.0	2593.9	46135.5	296.7	83.8	62.3
2014	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
2014	Median	18.9	8.6	8.3	0.9	24.0	195.3	75.7	2091.9	41019.7	10.6	50.7	6.1
2014	Arithmetic Mean	19.6	8.9	8.0	0.9	53.7	212.3	89.6	1824.0	37933.5	43.6	52.4	29.2
2014	Coefficient of Variation	0.1	0.1	0.2	0.2	0.9	0.5	0.7	0.4	0.2	1.7	0.8	1.3
2014	LQ	18.3	8.2	6.9	0.8	21.6	122.7	35.6	1075.3	29841.1	7.7	22.2	2.1
2014	UQ	21.3	9.6	9.5	1.0	97.4	287.1	128.9	2359.7	45192.8	34.4	66.0	49.4
2015	N of Cases	10.0	10.0	10.0	8.0	10.0	10.0	10.0	10.0	8.0	10.0	10.0	10.0
2015	Median	20.9	9.2	8.3	0.7	71.4	239.7	99.5	1881.0	38943.9	22.3	65.1	35.8
2015	Arithmetic Mean	19.9	9.2	8.0	0.8	74.8	220.4	90.2	1902.4	37345.9	34.9	66.5	37.1
2015	Coefficient of Variation	0.2	0.0	0.2	0.3	0.4	0.3	0.6	0.2	0.3	0.9	0.6	0.7
2015	LQ	18.0	8.9	6.6	0.7	43.5	161.6	46.5	1601.6	31521.4	13.4	30.7	12.2
2015	UQ	22.0	9.6	9.1	1.0	105.8	267.4	125.2	2294.8	45916.8	49.4	93.7	51.4
2016	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
2016	Median	19.9	9.2	8.3	0.6	79.9	236.6	30.9	2179.5	38938.6	7.0	32.1	11.8
2016	Arithmetic Mean	19.3	9.2	8.2	0.6	85.3	213.1	47.6	2125.4	37489.4	9.7	46.8	26.9
2016	Coefficient of Variation	0.1	0.1	0.2	0.3	0.6	0.4	0.9	0.3	0.2	0.5	1.0	1.2
2016	LQ	16.5	8.8	6.5	0.5	35.7	147.5	7.8	1779.7	30580.1	5.5	18.8	4.8
2016	UQ	21.3	9.7	8.9	0.7	135.1	280.1	88.9	2738.1	44621.4	13.0	51.7	44.4
2017	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
2017	Median	20.6	8.9	8.0	0.8	105.5	241.4	60.0	2619.7	34502.8	13.2	59.2	32.5
2017	Arithmetic Mean	19.3	9.0	8.1	0.9	93.8	238.9	90.1	2222.1	32976.3	16.5	116.7	41.7
2017	Coefficient of Variation	0.2	0.0	0.2	0.4	0.5	0.4	0.6	0.4	0.3	0.5	1.1	1.1
2017	LQ	17.3	8.6	6.5	0.6	56.9	164.8	40.4	1697.1	24428.3	10.9	27.1	6.5
2017	UQ	22.5	9.2	9.1	1.3	125.8	310.4	146.0	2892.4	40548.7	20.7	171.9	60.9

As expected due to its controlling effect on pH, median and lower quartile CHL in 2014 (as in 2013) also tended to be among the lowest for the period of record, but rebounded in 2015, 206, and 2017 (Figure 21). Overall CHL levels were lower for the 2010-2014 period compared to the earlier period. TP in 2017 was relatively high compared to other years, as was SRP (this is in contrast to 206 which was among the lowest for median and lower quartile[16]) (Figure 21). While TN was low between 2010 and 2014, and followed the trend in TP and CHL during those years, TN increased in 2015, 2016, and 2017. TN values in 2017 were intermediate overall when compared to the period of record. For the 28 years of record, the ammonia distribution was similar from 1990-1995, was elevated from 1996-2002, and then decreased to pre-1996 levels during the past 14 years (2003-2016). The ammonia distribution was intermediate and the nitrate distribution low in 2017. Inter-annual silica variability is indicated, with 2009 and 2010 showing reduced lower quartile values, possibly due to enhanced diatom blooms in spring of those years (Figure 21). Silica values in 2013-2016 were similar, and showed the highest median, upper and lower quartiles, and inter-quartile range compared to the previous five years. The median and lower quartile values in 2017 were somewhat lower compared to 2013-2016. As expected given lower pH values in recent years, un-ionized ammonia was notably lower during 2010-2014 (especially lower quartile values), and then rebounded somewhat in 2015 and 2016. Although total ammonia was somewhat higher in 2017, un-ionized ammonia remained in the range of 2015 and 2016 due to lower pH occurring in 2017 (Figure 22; Figure 23)

Although for Agency Lake in 2013 both pH and DO were noticeably lower compared to many previous years, median values (LQ values were higher) in both 2014 and 2015 were low for pH but intermediate for DO. For 2016 pH was skewed high and DO low, and both were skewed low for 2017 (Figure 22; Table 4). Secchi depth was skewed somewhat high in 2017. Lower quartile and median values of CHL in Agency Lake in 2014 were also among the lowest for the period of record, and while 2015 and 2016 values rebounded they were still somewhat low relative to previous years, and 2017 was again relatively low (Figure 23; Table 4). TP, SRP, and TN values were also relatively low in 2017 (especially TN). NO_3-NO_2-N was similar to other years, and NH_4-N tended to follow the overall 28 year cyclical pattern described above (Figure 23). Both Agency and UKL Lakes continued to show several periods of apparent sub-decadal cyclical increases and decreases for nutrient parameters over the period of record (Figure 21 and Figure 23). Inter-annual silica variability and overall values in Agency Lake are lower relative to UKL.

2017 Microcystin Sampling

Beginning in 2016 the Klamath Tribes initiated data collection for the cyanotoxin, microcystin. In 2017 a total of 108 samples were collected, with 15 surface grabs (SG) at Agency Lake Boat Launch (ALBL), and 15 each of depth-integrated (DI) and SG samples at stations PM, ER, MN, and AS. Seasonal trends indicated relatively low values in May and June (<0.5 µg/L except for MN which exceeded 1 µg/L in June). Values increased in July with several stations then exceeding 1 µg/L in mid- to late-July (Figure 24). The first instance of a station exceeding the recent draft EPA[17] and Oregon Health Authority (OHA) recreational criteria[18] of 4 µg/L occurred

[16] in contrast 2014-2015 were among the highest

[17] Draft Human Health Recreational Ambient Water Quality Criteria and/or Swimming Advisories for Microcystins and Cylindrospermopsin. https://www.epa.gov/sites/production/files/2016-12/documents/draft-hh-rec-ambient-water-swimming-document.pdf

in late July at ALBL. Overall values continued to increase in August (ALBL showed a very high level of 3128 µg/L) and in mid- to late-September many of the stations exceeded the 4 µg/L recreational criteria in both the SG and DI samples (Figure 24). Some of the samples from PM (KL0002), MN (KL0008), ER (KL0006), and ALBL were well over 10 µg/L during this period, including a value of 153 µg/L at ER. Microcystin values then generally declined below the OHA public health advisory levels in October (the exception was ER which remained slightly above 4 µg/L in early October (Figure 24). Microcystin concentrations were higher overall at stations PM, ER, and MN in 2017 (higher medians and upper quartile) than in 2016 (Figure 24). However, ALBL was higher overall in 2016, and the lower quartile for AS (KL0010) in 2016 was also higher that the lower quartile in 2017. Overall there were 14 exceedances of the OHA advisory level in 2017 compared to 10 in 2016.

SUMMARY

With the addition of 2017 data, the UKL water quality/limnological database now includes 28 years of data and includes the years 1990-2017. Given the dynamic and variable nature of shallow, high productivity lakes such as UKL, a long-term monitoring program is essential for assessing change relative to management programs, as well as for understanding lake dynamics.

For example, as noted in earlier reports, ongoing wetland restoration is occurring in vast areas of the periphery of UKL (e.g., Wong et al. 2010; 2011), riparian and nutrient management plans (e.g., Oregon 1010 and TMDL plans) have been developed, and water use plans have been implemented (e.g., KBRT Wood River Valley programs).

Continued monitoring is recommended to accommodate the restoration time-frame (restoration of ecological function can be a multi-decade process) for Klamath Basin activities and to increase statistical power (sample size) for multi-variable analyses. Such a long-term database allows for statistical time series or trend analysis, as well as multi-variable assessment of the relationship between controlling variables (e.g., climate) and important water quality parameters (e.g., see Jassby and Kann 2010).

Further analysis (beyond the scope of the current data summary report) of the noticeable differences in algal biomass (CHL), as well as other water quality parameters among years will provide an opportunity to gain further insight into annual controlling factors of bloom dynamics. Additional multivariate analyses, time-series and trend analyses such as Seasonal Kendal Tests, as well as integration with current lake literature on shallow lakes and *Aphanizomenon* bloom dynamics are recommended. The analysis of the long-term Upper Klamath Lake phytoplankton and zooplankton datasets will also significantly aid in understanding annual water quality variability. A comprehensive statistical analysis of the type provided in Jassby and Kann (2010) is recommended at five year intervals[19].

---

[18] Oregon Harmful Algae Bloom Surveillance (HABS) Program Public Health Advisory Guidelines Harmful Algae Blooms in Freshwater Bodies https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/RECREATION/HARMFULALGAEBLOOMS/Documents/Advisory%20Guidelines%20for%20Harmful%20Cyanobacteria%20Blooms%20in%20Recreational%20Waters.pdf

[19] The next 5-year interval occurred with the addition of 2014 sampling data.

Figure 22. June-September distribution of Agency Lake means for T (˚C), pH, D.O (mg/L), and Secchi depth, 1990-2017.

Figure 23. June-September distribution of Agency Lake means for CHL, TP, SRP, TN, NO_3+ NO_2-N, SiO_2 and NH_4-N, 1990-2017.

Table 4. Summary statistics for June-September Agency Lake means, 1990-2017 (LQ=Lower Quartile; UQ=Upper Quartile).

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1990	N of Cases	14.0	14.0	14.0	10.0	13.0	13.0	13.0	13.0	0.0	9.0	11.0	11.0
1990	Median	21.0	9.6	7.9	0.6	143.1	249.0	79.0	2374.0		20.5	58.2	13.6
1990	Arithmetic Mean	21.1	9.3	9.0	0.7	150.5	222.8	99.1	2411.1		41.2	95.3	20.3
1990	Coefficient of Variation	0.1	0.1	0.5	0.4	0.8	0.2	0.7	0.4		1.4	1.0	0.9
1990	LQ	20.6	9.0	6.4	0.5	31.9	178.4	34.9	2008.9		0.0	25.7	4.6
1990	UQ	22.8	10.0	11.4	0.9	224.1	270.4	172.4	2706.3		55.0	136.0	33.7
1991	N of Cases	9.0	8.0	9.0	9.0	9.0	9.0	9.0	9.0	0.0	3.0	7.0	6.0
1991	Median	18.6	9.0	9.3	1.0	50.0	325.6	205.9	1276.4		5.0	18.6	14.7
1991	Arithmetic Mean	19.2	9.1	8.9	1.0	56.3	270.6	175.2	1328.0		20.7	43.1	13.1
1991	Coefficient of Variation	0.1	0.1	0.2	0.4	0.9	0.4	0.6	0.4		1.3	1.6	0.8
1991	LQ	17.2	8.6	8.2	0.7	15.3	139.7	55.1	986.8		5.0	8.3	2.3
1991	UQ	21.8	9.7	9.6	1.5	97.4	359.1	237.6	1731.5		40.4	32.3	19.6
1992	N of Cases	8.0	8.0	8.0	8.0	8.0	7.0	8.0	7.0	0.0	8.0	8.0	8.0
1992	Median	21.6	8.9	10.0	0.9	19.4	115.9	40.5	797.3		5.0	8.0	3.5
1992	Arithmetic Mean	21.4	8.9	9.5	0.9	85.7	180.2	60.7	1419.3		13.6	11.7	7.1
1992	Coefficient of Variation	0.1	0.1	0.3	0.3	1.7	0.8	0.9	0.9		1.7	0.9	1.6
1992	LQ	19.1	8.0	7.0	0.9	7.0	80.7	33.3	502.6		5.0	5.0	0.3
1992	UQ	23.5	9.7	11.1	1.0	96.8	293.0	61.8	1755.7		7.0	12.7	7.9
1993	N of Cases	10.0	10.0	10.0	10.0	9.0	9.0	9.0	9.0	0.0	9.0	9.0	9.0
1993	Median	19.4	8.9	8.4	1.1	33.2	220.6	113.6	1206.8		20.8	11.0	3.1
1993	Arithmetic Mean	19.2	8.8	8.3	1.0	66.5	255.6	160.1	1450.5		54.0	70.2	4.0
1993	Coefficient of Variation	0.1	0.1	0.3	0.5	1.0	0.5	0.6	0.6		1.3	1.6	0.8
1993	LQ	18.2	7.8	6.9	0.5	6.0	130.7	88.3	761.5		7.4	5.0	2.1
1993	UQ	20.6	9.7	10.4	1.6	127.6	370.7	219.7	2053.1		81.0	108.1	4.7
1994	N of Cases	8.0	8.0	8.0	6.0	7.0	7.0	7.0	7.0	0.0	7.0	7.0	7.0

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1994	Median	22.0	9.5	8.7	0.7	125.2	386.5	147.3	1763.6		10.5	21.5	10.7
1994	Arithmetic Mean	21.8	9.1	8.7	0.7	157.8	350.6	198.8	2155.6		18.4	26.8	11.9
1994	Coefficient of Variation	0.1	0.1	0.2	0.4	0.9	0.6	0.8	0.6		0.8	0.6	0.6
1994	LQ	20.6	8.7	7.4	0.6	35.2	153.5	82.1	1583.7		8.1	14.6	8.6
1994	UQ	23.6	9.7	10.1	0.9	273.8	497.7	335.2	2893.9		30.8	37.3	18.2
1995	N of Cases	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	0.0	8.0	8.0	8.0
1995	Median	19.8	9.5	9.6	0.8	130.6	401.3	227.9	1878.0		5.0	19.1	9.5
1995	Arithmetic Mean	19.8	9.5	9.6	0.8	128.9	383.5	207.8	1988.9		8.0	22.1	10.1
1995	Coefficient of Variation	0.1	0.0	0.1	0.2	0.4	0.3	0.5	0.2		0.8	0.8	0.6
1995	LQ	19.4	9.3	9.1	0.6	88.5	305.3	143.3	1695.7		5.0	7.4	4.4
1995	UQ	20.7	9.6	10.2	0.9	157.9	449.7	286.6	2376.4		7.4	30.7	13.5
1996	N of Cases	8.0	8.0	8.0	6.0	8.0	8.0	8.0	8.0	0.0	8.0	8.0	8.0
1996	Median	19.6	9.5	10.2	0.9	78.5	264.5	143.0	1325.0		8.0	254.8	39.3
1996	Arithmetic Mean	19.7	9.2	9.2	0.8	158.8	285.9	133.9	1871.9		44.1	279.6	146.1
1996	Coefficient of Variation	0.1	0.1	0.3	0.5	1.4	0.5	0.5	0.5		1.2	1.0	1.4
1996	LQ	18.1	8.9	8.3	0.5	36.8	208.0	87.0	1202.5		5.0	61.0	14.0
1996	UQ	21.4	9.7	11.0	0.9	175.5	333.5	177.0	2545.0		99.5	359.5	232.6
1997	N of Cases	8.0	8.0	8.0	4.0	8.0	8.0	8.0	8.0	0.0	8.0	8.0	8.0
1997	Median	20.6	9.3	9.3	1.3	46.0	166.9	82.3	1234.5		13.3	485.0	133.7
1997	Arithmetic Mean	20.2	8.8	8.8	1.4	80.1	167.0	76.9	1376.6		50.7	494.3	177.0
1997	Coefficient of Variation	0.1	0.1	0.5	0.3	1.2	0.6	0.7	0.4		1.2	0.5	1.0
1997	LQ	18.8	8.0	6.0	1.0	11.9	60.5	30.5	941.5		5.0	318.7	30.4
1997	UQ	21.7	9.4	11.5	1.8	128.6	257.6	120.7	1782.2		103.6	643.4	293.7
1998	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	0.0	9.0	9.0	9.0
1998	Median	21.8	8.6	8.4	1.5	14.7	71.9	34.9	642.6		5.0	143.0	20.9
1998	Arithmetic Mean	20.8	8.8	8.6	1.4	66.9	107.9	37.7	1144.3		7.6	353.2	186.9
1998	Coefficient of	0.2	0.1	0.3	0.4	1.2	0.6	1.0	0.7		0.9	1.1	1.4

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
	Variation												
1998	LQ	18.2	8.4	7.0	0.7	7.5	58.3	10.7	546.4		5.0	90.9	6.3
1998	UQ	23.0	9.4	10.4	2.0	167.5	160.8	42.4	2027.4		5.6	749.7	456.8
1999	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	0.0	9.0	9.0	9.0
1999	Median	19.2	9.3	9.6	1.3	47.4	290.3	106.0	1253.3		9.2	200.2	14.1
1999	Arithmetic Mean	19.1	9.1	9.5	1.2	91.1	254.0	125.0	1514.6		28.4	198.3	117.6
1999	Coefficient of Variation	0.2	0.1	0.3	0.5	1.5	0.5	0.7	0.8		1.2	0.9	1.5
1999	LQ	17.0	8.4	7.9	0.8	5.9	145.7	57.2	656.9		5.0	69.7	11.8
1999	UQ	20.8	9.7	10.5	1.8	116.4	354.2	190.7	1619.4		59.7	238.9	172.8
2000	N of Cases	8.0	8.0	8.0	7.0	8.0	8.0	8.0	8.0	0.0	8.0	8.0	8.0
2000	Median	20.6	9.0	7.6	1.4	44.4	365.1	190.4	1079.1		23.9	221.3	84.8
2000	Arithmetic Mean	20.3	9.0	7.5	1.4	42.4	339.5	198.0	1184.7		27.0	286.7	192.2
2000	Coefficient of Variation	0.2	0.1	0.2	0.2	0.6	0.4	0.5	0.3		0.6	0.7	1.7
2000	LQ	18.8	8.6	7.1	1.2	21.5	196.0	128.1	996.0		13.8	167.1	28.7
2000	UQ	22.7	9.6	8.7	1.5	66.4	429.0	272.4	1249.0		34.1	321.2	146.9
2001	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	0.0	9.0	9.0	9.0
2001	Median	20.5	8.5	7.7	1.3	30.5	250.6	151.4	1255.5		14.5	238.4	67.3
2001	Arithmetic Mean	19.7	8.8	8.1	1.3	58.6	288.1	171.7	1309.8		21.1	305.6	140.6
2001	Coefficient of Variation	0.1	0.1	0.3	0.5	0.9	0.5	0.7	0.4		1.3	0.6	1.0
2001	LQ	17.5	8.3	6.9	0.8	16.4	209.3	71.5	918.6		5.0	128.2	34.6
2001	UQ	21.4	9.5	9.6	1.8	101.5	358.5	246.3	1697.3		20.9	503.6	266.2
2002	N of Cases	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	0.0	7.0	7.0	7.0
2002	Median	21.7	9.2	8.7	0.9	51.3	293.5	166.8	1844.5		13.8	137.5	64.4
2002	Arithmetic Mean	20.9	9.3	8.7	0.9	60.8	298.2	159.0	1698.5		15.1	236.4	132.1
2002	Coefficient of Variation	0.1	0.0	0.2	0.3	0.5	0.3	0.5	0.2		0.3	0.8	1.0
2002	LQ	19.1	9.0	8.2	0.7	32.5	255.5	122.3	1458.9		11.6	104.0	52.8
2002	UQ	22.4	9.5	9.7	1.2	93.4	372.4	190.9	1901.9		17.8	348.8	208.0

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2003	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	0.0	9.0	9.0	9.0
2003	Median	21.8	9.5	9.0	0.9	78.1	316.9	182.3	2102.3		11.5	26.2	15.9
2003	Arithmetic Mean	21.4	9.3	9.1	1.1	83.5	364.7	227.8	2078.2		14.8	121.4	83.6
2003	Coefficient of Variation	0.1	0.1	0.2	0.7	0.7	0.5	0.6	0.5		0.8	1.7	2.2
2003	LQ	19.9	8.9	7.8	0.5	30.4	205.8	99.2	1251.6		6.6	22.4	15.1
2003	UQ	22.5	9.7	10.6	1.4	124.8	548.7	346.8	2821.1		18.7	103.4	35.0
2004	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	0.0	9.0	9.0	9.0
2004	Median	21.2	8.7	8.2	1.3	8.3	101.0	19.8	750.9		15.1	21.7	5.5
2004	Arithmetic Mean	20.4	8.8	8.4	1.2	47.4	106.3	38.4	1105.1		29.4	37.2	7.6
2004	Coefficient of Variation	0.2	0.1	0.3	0.3	1.4	0.6	1.1	0.6		1.2	0.9	0.9
2004	LQ	17.0	8.2	6.5	0.9	5.4	54.5	11.5	583.9		5.0	13.6	3.1
2004	UQ	23.0	9.6	10.8	1.5	96.4	138.0	56.3	1593.9		41.3	49.4	9.9
2005	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	0.0	9.0	9.0	9.0
2005	Median	19.5	8.8	8.4	1.2	41.0	190.4	100.5	1557.3		14.0	16.5	3.1
2005	Arithmetic Mean	19.4	8.7	8.6	1.1	68.5	218.2	119.2	1783.3		17.1	18.4	5.7
2005	Coefficient of Variation	0.2	0.1	0.3	0.4	0.9	0.6	0.8	0.5		0.8	0.5	1.1
2005	LQ	15.4	8.0	6.6	0.8	29.2	129.2	36.3	1233.5		5.0	10.9	0.6
2005	UQ	22.9	9.4	10.4	1.3	99.9	303.6	171.0	2305.2		24.4	23.4	12.6
2006	N of Cases	9.0	9.0	9.0	8.0	9.0	9.0	9.0	9.0	0.0	9.0	9.0	9.0
2006	Median	21.7	8.9	7.4	1.3	29.9	155.5	80.0	1327.0		10.5	21.2	9.5
2006	Arithmetic Mean	20.8	9.0	8.2	1.1	60.2	205.8	115.7	1303.1		13.4	22.2	9.9
2006	Coefficient of Variation	0.1	0.1	0.3	0.3	1.1	0.5	0.7	0.5		0.9	0.6	0.7
2006	LQ	19.7	8.8	6.6	0.8	12.7	131.1	50.6	838.7		5.0	13.1	5.6
2006	UQ	22.6	9.5	9.7	1.4	113.5	304.1	188.7	1685.8		17.2	27.2	13.0
2007	N of Cases	9.0	9.0	9.0	9.0	8.0	9.0	9.0	9.0	0.0	9.0	9.0	9.0
2007	Median	22.1	9.2	9.3	0.9	88.9	420.6	189.4	1421.5		8.5	26.3	9.8
2007	Arithmetic Mean	20.5	9.4	8.9	0.9	133.8	403.2	256.3	2144.5		18.1	55.9	17.1

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2007	Coefficient of Variation	0.2	0.1	0.2	0.6	1.0	0.6	0.6	0.6		1.3	1.2	1.0
2007	LQ	19.1	9.0	7.7	0.5	37.3	176.7	120.1	1216.3		5.0	11.7	5.3
2007	UQ	22.7	10.0	10.4	1.1	192.5	615.2	406.1	2797.0		19.5	83.7	25.6
2008	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
2008	Median	20.4	9.1	9.3	1.0	61.7	257.0	175.2	1488.8	31635.7	15.2	26.4	11.0
2008	Arithmetic Mean	19.8	9.1	9.2	1.1	62.6	263.1	180.2	1419.3	33174.9	14.9	28.7	10.7
2008	Coefficient of Variation	0.2	0.1	0.1	0.4	0.6	0.4	0.5	0.4	0.2	0.6	0.2	0.7
2008	LQ	17.8	8.8	8.3	0.8	31.6	157.2	107.2	1041.8	28531.8	7.1	25.8	5.7
2008	UQ	22.4	9.6	9.9	1.4	94.5	339.8	235.2	1799.8	38602.1	18.5	33.1	17.4
2009	N of Cases	8.0	8.0	8.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	8.0
2009	Median	19.9	9.3	9.3	1.0	56.1	168.7	92.2	1341.1	31716.7	9.2	26.6	18.1
2009	Arithmetic Mean	20.1	9.2	8.1	0.9	84.5	185.6	86.3	1645.4	29927.1	25.6	65.8	20.6
2009	Coefficient of Variation	0.1	0.1	0.3	0.5	0.7	0.3	0.4	0.4	0.3	1.2	1.3	0.6
2009	LQ	18.0	8.5	6.1	0.5	30.5	139.0	58.2	1286.6	23854.6	7.9	18.3	11.1
2009	UQ	21.3	9.9	9.6	1.2	149.5	234.4	114.3	2130.3	36475.2	37.0	83.4	28.0
2010	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
2010	Median	19.9	9.6	9.7	1.0	90.8	184.3	91.2	1681.7	30752.6	6.4	14.0	9.0
2010	Arithmetic Mean	19.3	9.2	10.5	1.0	116.7	221.9	109.6	1644.4	30044.6	20.7	17.6	8.1
2010	Coefficient of Variation	0.2	0.1	0.2	0.5	0.9	0.7	0.8	0.6	0.3	2.1	0.6	0.8
2010	LQ	17.0	8.4	9.0	0.7	26.1	72.1	21.6	643.2	21777.2	4.0	10.1	2.0
2010	UQ	22.3	9.8	12.7	1.5	190.3	338.5	196.3	2430.6	40493.5	8.8	24.8	12.9
2011	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
2011	Median	20.2	9.3	9.8	1.0	38.3	257.8	117.8	1608.5	30943.2	10.6	16.7	4.3
2011	Arithmetic Mean	19.2	9.1	10.2	1.0	55.0	250.3	131.3	1513.5	31138.2	16.1	21.6	8.4
2011	Coefficient of Variation	0.2	0.1	0.2	0.3	0.8	0.4	0.5	0.3	0.2	1.0	0.7	0.9
2011	LQ	17.6	8.4	8.5	0.8	16.8	163.7	64.5	1105.8	26653.5	6.9	11.5	1.6
2011	UQ	22.2	9.6	11.7	1.1	110.0	358.9	201.9	1993.2	35506.6	18.8	28.0	15.8

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2012	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
2012	Median	20.1	8.8	8.8	1.2	16.7	124.3	84.8	882.8	31998.6	14.2	19.9	4.6
2012	Arithmetic Mean	20.2	8.6	9.2	1.1	34.9	155.4	85.3	1118.7	29775.7	27.6	28.0	8.0
2012	Coefficient of Variation	0.1	0.1	0.3	0.3	1.6	0.4	0.5	0.6	0.2	1.0	0.8	1.1
2012	LQ	18.6	8.1	7.6	1.1	8.8	112.8	49.0	637.1	24522.2	11.6	13.3	1.2
2012	UQ	22.4	8.8	11.2	1.4	35.2	191.6	107.8	1386.9	34240.1	38.3	30.5	13.2
2013	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
2013	Median	20.2	9.0	8.9	1.1	33.8	230.8	77.3	1210.2	35544.1	7.4	19.1	4.3
2013	Arithmetic Mean	20.1	9.0	9.0	1.0	66.7	298.6	142.4	1917.2	34999.4	19.1	20.6	9.0
2013	Coefficient of Variation	0.1	0.1	0.2	0.4	1.1	0.8	0.8	0.8	0.2	0.9	0.6	1.3
2013	LQ	19.2	8.0	7.2	0.6	9.1	106.4	61.5	790.5	29821.4	5.6	12.8	0.7
2013	UQ	22.4	10.0	10.4	1.3	122.0	492.7	226.1	2708.2	40404.4	37.0	24.4	11.7
2014	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
2014	Median	20.5	8.8	10.1	1.1	21.2	182.0	67.3	972.2	33233.4	11.4	22.0	6.6
2014	Arithmetic Mean	20.5	9.1	9.7	1.2	36.7	201.3	104.5	1198.8	32560.4	15.2	23.6	11.0
2014	Coefficient of Variation	0.1	0.1	0.2	0.3	1.1	0.5	0.7	0.6	0.1	0.7	0.5	0.8
2014	LQ	19.1	8.7	8.2	0.9	11.5	116.9	59.9	600.6	29100.8	9.3	14.9	4.4
2014	UQ	21.4	9.5	10.7	1.3	46.2	232.1	132.4	1784.5	36046.5	19.3	28.0	20.1
2015	N of Cases	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
2015	Median	20.8	9.1	9.6	1.1	32.3	194.0	102.3	877.9	34534.6	14.9	16.1	7.1
2015	Arithmetic Mean	19.4	9.0	9.7	1.1	40.8	198.0	102.3	1183.3	33284.7	34.8	28.3	7.0
2015	Coefficient of Variation	0.2	0.0	0.2	0.4	0.6	0.3	0.5	0.5	0.1	1.0	1.0	0.6
2015	LQ	16.9	8.7	9.0	0.8	22.2	153.0	59.9	815.9	32527.3	8.5	13.5	4.2
2015	UQ	22.1	9.3	10.8	1.5	61.3	242.9	137.9	1459.6	35765.1	63.5	32.7	7.6
2016	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
2016	Median	21.1	9.1	9.0	0.7	37.1	219.8	90.5	1298.5	33849.7	16.5	19.7	8.4
2016	Arithmetic Mean	20.2	9.2	9.1	0.8	67.6	205.4	89.6	1525.8	34127.2	19.3	27.5	9.4

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2016	Coefficient of Variation	0.1	0.1	0.3	0.4	0.9	0.4	0.8	0.4	0.1	0.8	0.7	0.8
2016	LQ	18.0	8.7	7.0	0.6	21.9	120.0	26.7	1069.8	31290.3	5.6	13.1	4.2
2016	UQ	22.6	9.9	10.6	0.9	122.0	276.0	152.7	2218.8	37671.2	30.0	50.1	11.1
2017	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
2017	Median	21.3	8.9	8.7	1.4	15.0	138.0	83.0	641.7	33850.0	10.0	16.5	6.5
2017	Arithmetic Mean	19.6	8.9	8.4	1.3	59.6	188.4	98.3	1253.9	30948.9	31.7	27.3	5.8
2017	Coefficient of Variation	0.2	0.1	0.3	0.5	1.5	0.7	0.7	1.0	0.2	1.1	0.9	0.7
2017	LQ	17.9	8.6	7.1	0.9	10.8	91.8	41.6	552.5	25323.4	9.3	10.6	1.6
2017	UQ	22.6	9.4	9.5	1.8	82.7	224.7	120.9	1622.9	35255.8	61.3	40.3	9.0

Figure 24. Microcystin concentration in Upper Klamath and Agency Lakes in 2017 (top panel) and compared between 2016 and 2017 for the June-October period (bottom panel).

LITERATURE CITED

Eldridge, S.L.C., Wherry, S.A., and Wood, T.M., 2014, Statistical analysis of the water-quality monitoring program, Upper Klamath Lake, Oregon, and optimization of the program for 2013 and beyond: U.S. Geological Survey Open File Report 2014-1009, 82 p., http://dx.doi.org/10.3133/ofr20141009

Eldridge, S.L.C, T. M. Wood , K.R. Echols & B.R. Topping (2013) Microcystins, nutrient dynamics, and other environmental factors during blooms of non-microcystin-producing Aphanizomenon flos-aquae in Upper Klamath Lake, Oregon, 2009, Lake and Reservoir Management, 29:1, 68-81

Jassby, A., and J. Kann. 2010. Upper Klamath Lake Monitoring Program: preliminary analysis of status and trends for 1990-2009. Technical Memorandum prepared by Aquatic Ecosystem Sciences LLC for the Klamath Tribes Natural Resources Department, Chiloquin, OR. 55 p.

Kann, J. 1998. Ecology and water quality dynamics of a shallow hypertrophic lake dominated by Cyanobacteria (*Aphanizomenon flos-aquae*). Doctoral Dissertation. University of North Carolina. Curriculum in Ecology. Chapel Hill, North Carolina.

Kann, J., and V. H. Smith. 1999. Chlorophyll as a predictor of elevated pH in a hypereutrophic lake: estimating the probability of exceeding critical values for fish success using parametric and nonparametric models. Can. J. Fish Aquat. Sci. 56: 2262-2270

Kann, J. and E. B. Welch. 2005. Wind control on water quality in shallow, hypereutrophic Upper Klamath Lake, Oregon. Lake Reserv. Manage. 21(2):149-158

Kann, J. 2007. Upper Klamath Lake 2006 Data Summary Report. Technical Memorandum Prepared for the Klamath Tribes Natural Resources Department, Chiloquin Oregon. April 2007.

Kann, J. 2008. Upper Klamath Lake 2007 Data Summary Report. Technical Memorandum Prepared for the Klamath Tribes Natural Resources Department, Chiloquin Oregon. June 2008.

Kann, J. 2009. Upper Klamath Lake 2008 Data Summary Report. Technical Memorandum Prepared for the Klamath Tribes Natural Resources Department, Chiloquin Oregon. June 2009.

Kann, J. 2010. Upper Klamath Lake 2009 Data Summary Report. Technical Memorandum Prepared for the Klamath Tribes Natural Resources Department, Chiloquin Oregon. June 2010.

Kann, J. 2011. Upper Klamath Lake 2010 Data Summary Report. Technical Memorandum Prepared for the Klamath Tribes Natural Resources Department, Chiloquin Oregon. June 2011.

Kann, J. 2012. Upper Klamath Lake 2011 Data Summary Report. Technical Memorandum Prepared for the Klamath Tribes Natural Resources Department, Chiloquin Oregon. July 2012.

Kann, J. 2013. Upper Klamath Lake 2012 Data Summary Report. Technical Memorandum Prepared for the Klamath Tribes Natural Resources Department, Chiloquin Oregon. May 2013

Kann, J. 2014. Upper Klamath Lake 2013 Data Summary Report. Technical Memorandum Prepared for the Klamath Tribes Natural Resources Department, Chiloquin Oregon. May 2014

Kann, J. 2015. Upper Klamath Lake 2014 Data Summary Report. Technical Memorandum Prepared for the Klamath Tribes Natural Resources Department, Chiloquin Oregon. Aug 2016

Kann, J. 2016. Upper Klamath Lake 2014 Data Summary Report. Technical Memorandum Prepared for the Klamath Tribes Natural Resources Department, Chiloquin Oregon. June 2017

J. Kann, J.E. Asarian, A. St. Amand. 2014. Initial Analysis of 1990-2013 Phytoplankton and Zooplankton Data for Upper Klamath Lake (Phase I). Prepared by Aquatic Ecosystem Sciences LLC. for the Klamath Tribes Natural Resources Department. 100p. + appendices.

Klamath Tribes 2013a. Standard Operating Procedures (SOP) for Upper Klamath Lake Water Quality Field Sampling. Revision: 2013 v). Klamath Tribes Research Station, Klamath Tribes Natural Resources Department, Chiloquin, OR.

Klamath Tribes 2013b. Quality Assurance Project Plan (QAPP). Revision: 2013 v 0. Klamath Tribes Research Station, Klamath Tribes Natural Resources Department, Chiloquin, OR.

Lindenberg, M.K., Hoilman, Gene, and Wood, T.M., 2009, Water quality conditions in Upper Klamath and Agency Lakes, Oregon, 2006: U.S. Geological Survey Scientific Investigations Report 2008-5201, 54 p.

Walker, W.W., J. D. Walker, and J. Kann. 2012. Evaluation of Water and Nutrient Balances for the Upper Klamath Lake Basin in Water Years 1992-2010. Technical Report to the Klamath Tribes Natural Resources Department, Chiloquin, OR. 49 pp. +Appendices.

Wood, T.M., Hoilman, G.R., and Lindenberg, M.K., 2006, Water-quality conditions in Upper Klamath Lake, Oregon, 2002–04: U.S. Geological Survey Scientific Investigations Report 2006-5209, 52 p.

Wood, T.M., Cheng, R.T., Gartner, J.W., Hoilman, G.R., Lindenberg, M.K., and Wellman, R.E., 2008, Modeling hydrodynamics and heat transport in Upper Klamath Lake, Oregon, and implications for water quality: U.S. Geological Survey Scientific Investigations Report 2008–5076, 48 p.

Wong, S.W., Barry, M.J., Aldous, A.R., Rudd, N.T., Hendrixson, H.A., and C.M. Doehring (2011). Nutrient Release from a Recently Flooded Delta Wetland: Comparison of Field Measurements to Laboratory Results. Wetlands 31(2): 433-443.

Wong, S.W., Hendrixson, H.A., and Doehring, C.M., 2010, Post-restoration water quality conditions at the Williamson River Delta, Upper Klamath Basin, Oregon, 2007-2009: The Nature Conservancy. (Internet access at: http://conserveonline.org/workspaces/Williamson.River.Delta.Preserve/documents/postrestoration-water-quality-conditions-at-the/view.html).

APPENDIX I: Summary statistics of monthly distributions for the June-September period, Upper Klamath Lake Stations; 1990-2017 (LQ= Lower Quartile; UQ=Upper Quartile).

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1990	6	N of Cases	14.0	14.0	14.0	13.0	12.0	12.0	13.0	12.0	2.0	2.0	2.0
1990	6	Median	16.1	9.2	8.7	1.0	50.8	118.5	18.0	795.0	25.0	62.2	50.2
1990	6	Arithmetic Mean	17.8	9.3	9.1	1.0	91.5	129.3	19.7	1084.6	25.0	62.2	50.2
1990	6	Coefficient of Variation	0.2	0.1	0.2	0.3	1.2	0.3	0.4	0.6	0.2	0.3	0.3
1990	6	LQ	15.6	8.9	8.1	0.8	29.9	106.0	14.8	694.0	22.0	47.9	39.7
1990	6	UQ	20.7	9.5	9.3	1.2	116.0	139.0	20.0	1543.0	28.0	76.4	60.6
1990	7	N of Cases	18.0	18.0	18.0	16.0	16.0	16.0	16.0	16.0	8.0	16.0	16.0
1990	7	Median	22.5	9.5	6.9	0.6	118.6	216.0	67.0	2452.0	14.1	57.2	40.3
1990	7	Arithmetic Mean	22.4	9.5	7.3	0.6	165.4	222.1	67.1	2654.3	13.0	93.7	48.8
1990	7	Coefficient of Variation	0.0	0.0	0.3	0.4	0.6	0.2	0.3	0.4	0.9	1.0	0.8
1990	7	LQ	21.7	9.3	6.3	0.4	95.9	194.5	53.0	2185.0	2.8	34.2	22.0
1990	7	UQ	23.0	9.6	8.7	0.8	268.7	246.0	81.0	3248.0	19.0	125.4	60.0
1990	8	N of Cases	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
1990	8	Median	23.3	9.3	7.8	0.5	191.2	240.9	95.3	3428.4	20.6	100.1	48.4
1990	8	Arithmetic Mean	22.1	9.2	7.4	0.7	201.2	242.8	94.2	3897.0	16.8	96.1	38.4
1990	8	Coefficient of Variation	0.1	0.0	0.3	0.7	0.7	0.3	0.1	0.5	0.9	0.9	0.9
1990	8	LQ	19.1	9.0	5.3	0.4	82.5	171.4	87.4	2533.4	0.0	13.8	5.7
1990	8	UQ	23.5	9.4	9.1	1.0	276.1	306.9	103.7	4316.9	29.3	159.0	69.0
1990	9	N of Cases	16.0	16.0	16.0	16.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
1990	9	Median	18.4	9.4	9.7	0.6	149.6	228.0	57.7	3459.1	0.0	73.3	44.8
1990	9	Arithmetic Mean	18.5	9.4	9.0	0.7	167.3	235.2	66.6	3495.6	5.7	167.1	64.2
1990	9	Coefficient of Variation	0.1	0.0	0.3	0.5	0.8	0.2	0.3	0.3	2.0	1.1	0.8
1990	9	LQ	17.8	9.2	7.4	0.5	88.5	207.0	52.5	2856.0	0.0	36.1	20.6
1990	9	UQ	19.1	9.6	10.9	1.0	231.9	246.8	72.5	3722.2	8.0	231.7	97.3
1991	6	N of Cases	18.0	18.0	18.0	18.0	16.0	16.0	16.0	16.0	16.0	8.0	8.0

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1991	6	Median	15.9	8.4	8.1	0.9	16.8	88.7	19.5	681.0	39.0	5.0	0.6
1991	6	Arithmetic Mean	15.6	8.4	8.1	0.8	19.3	90.2	21.7	686.1	44.8	6.9	0.7
1991	6	Coefficient of Variation	0.1	0.0	0.1	0.7	0.5	0.1	0.7	0.2	0.9	0.8	0.6
1991	6	LQ	14.8	8.2	7.3	0.7	11.7	81.5	6.5	588.4	10.0	5.0	0.5
1991	6	UQ	16.3	8.7	8.9	1.2	25.4	95.8	38.9	788.5	66.8	5.0	0.8
1991	7	N of Cases	13.0	13.0	13.0	13.0	11.0	11.0	11.0	11.0	3.0	11.0	11.0
1991	7	Median	19.9	9.5	8.7	0.7	119.3	157.0	40.1	2317.3	5.0	46.0	30.3
1991	7	Arithmetic Mean	19.5	9.5	8.7	0.7	124.8	163.1	35.7	2549.5	5.0	131.1	68.0
1991	7	Coefficient of Variation	0.1	0.0	0.2	0.4	0.5	0.2	0.4	0.3	0.0	1.3	1.1
1991	7	LQ	18.6	9.4	7.7	0.6	80.2	141.7	20.9	2145.5	5.0	34.0	22.8
1991	7	UQ	20.3	9.7	10.4	0.8	177.0	176.0	48.1	3072.4	5.0	185.9	110.5
1991	8	N of Cases	25.0	21.0	25.0	27.0	24.0	24.0	24.0	24.0	0.0	24.0	21.0
1991	8	Median	20.3	9.3	9.2	0.7	115.4	225.5	55.0	2548.8		24.5	9.0
1991	8	Arithmetic Mean	20.0	9.1	8.6	0.7	130.7	248.8	65.2	2833.1		78.7	19.3
1991	8	Coefficient of Variation	0.1	0.1	0.2	0.6	0.9	0.3	0.5	0.5		1.2	1.1
1991	8	LQ	18.1	8.7	6.7	0.5	33.9	200.5	41.0	1959.5		15.7	8.0
1991	8	UQ	21.8	9.5	10.1	1.1	185.5	288.0	101.0	3320.0		156.8	26.4
1991	9	N of Cases	17.0	17.0	17.0	17.0	16.0	16.0	15.0	16.0	0.0	8.0	8.0
1991	9	Median	16.2	9.6	9.0	0.7	133.8	249.4	56.8	2384.8		17.0	11.9
1991	9	Arithmetic Mean	16.5	9.6	8.8	0.7	177.8	299.6	61.6	2804.9		98.9	26.0
1991	9	Coefficient of Variation	0.1	0.0	0.2	0.5	1.1	0.4	0.3	0.4		2.1	1.2
1991	9	LQ	15.9	9.5	8.0	0.5	87.8	214.7	48.4	2017.6		11.0	7.5
1991	9	UQ	17.2	9.8	9.9	0.9	157.9	319.2	76.3	3339.1		51.0	31.0
1992	6	N of Cases	16.0	16.0	16.0	16.0	16.0	18.0	18.0	18.0	18.0	18.0	16.0
1992	6	Median	18.2	9.6	10.1	0.4	247.6	165.0	17.0	2500.0	5.0	33.5	22.3
1992	6	Arithmetic Mean	18.1	9.6	10.1	0.5	256.2	193.8	25.3	2825.6	10.0	34.5	20.4
1992	6	Coefficient of	0.1	0.0	0.1	0.6	0.7	0.5	1.3	0.4	1.5	0.5	0.6

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
		Variation											
1992	6	LQ	15.9	9.3	9.3	0.3	105.8	123.0	10.0	2010.0	5.0	19.0	9.2
1992	6	UQ	20.0	10.0	10.8	0.6	362.2	271.0	18.0	3600.0	5.0	49.0	30.0
1992	7	N of Cases	24.0	24.0	24.0	24.0	24.0	21.0	24.0	21.0	24.0	24.0	24.0
1992	7	Median	21.0	9.3	7.2	0.6	125.9	239.0	38.3	2840.0	5.0	11.8	4.9
1992	7	Arithmetic Mean	20.3	9.2	6.9	0.6	166.9	301.5	48.5	3106.0	11.2	129.5	15.1
1992	7	Coefficient of Variation	0.1	0.0	0.3	0.5	0.9	0.4	0.7	0.3	1.5	3.1	1.5
1992	7	LQ	17.9	9.1	6.2	0.3	67.5	220.8	25.0	2412.5	5.0	5.0	2.4
1992	7	UQ	21.9	9.4	8.4	0.8	229.1	394.5	60.5	3666.3	7.8	46.5	16.8
1992	8	N of Cases	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
1992	8	Median	20.6	9.2	8.7	0.3	72.4	121.0	11.3	2362.5	6.3	15.5	6.3
1992	8	Arithmetic Mean	20.9	9.1	8.4	0.4	74.4	136.1	11.5	2436.6	7.5	20.1	6.8
1992	8	Coefficient of Variation	0.1	0.0	0.3	0.3	0.4	0.7	0.2	0.2	0.4	0.8	0.6
1992	8	LQ	19.5	9.1	7.0	0.3	49.3	54.0	9.5	1935.0	5.0	9.0	3.8
1992	8	UQ	23.1	9.2	10.1	0.4	96.7	207.0	13.0	2880.0	10.3	22.5	10.3
1992	9	N of Cases	8.0	8.0	8.0	8.0	6.0	8.0	8.0	8.0	8.0	8.0	8.0
1992	9	Median	17.5	8.0	5.6	0.4	40.6	126.5	13.0	1585.0	5.0	12.5	0.4
1992	9	Arithmetic Mean	17.3	8.1	5.7	0.4	43.2	131.8	14.3	1616.9	14.3	13.1	0.9
1992	9	Coefficient of Variation	0.0	0.1	0.2	0.2	0.5	0.2	0.3	0.1	1.5	0.5	1.5
1992	9	LQ	16.9	7.8	5.0	0.3	34.1	112.5	12.0	1460.0	5.0	8.5	0.2
1992	9	UQ	17.9	8.5	6.4	0.5	58.4	154.3	16.5	1797.5	12.0	16.0	0.8
1993	6	N of Cases	24.0	24.0	24.0	24.0	24.0	28.0	28.0	28.0	28.0	28.0	24.0
1993	6	Median	17.3	8.7	9.7	1.0	66.0	78.0	8.8	1540.0	5.0	6.5	0.6
1993	6	Arithmetic Mean	16.7	8.6	9.7	1.1	67.0	78.3	10.7	1516.2	5.9	13.4	1.3
1993	6	Coefficient of Variation	0.1	0.1	0.1	0.5	0.9	0.4	0.5	0.6	0.4	0.9	0.8
1993	6	LQ	14.7	7.8	8.5	0.7	6.5	53.0	7.0	584.0	5.0	5.0	0.5
1993	6	UQ	18.1	9.4	10.7	1.4	115.8	101.3	13.0	2200.0	5.0	17.0	2.3

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1993	7	N of Cases	17.0	17.0	17.0	17.0	16.0	20.0	20.0	20.0	20.0	20.0	16.0
1993	7	Median	18.1	9.4	8.4	0.8	109.0	150.0	14.0	2055.0	5.0	7.3	7.4
1993	7	Arithmetic Mean	18.2	9.4	8.4	0.7	135.5	139.9	13.5	2627.0	8.5	40.6	17.6
1993	7	Coefficient of Variation	0.0	0.0	0.2	0.4	0.7	0.3	0.2	0.6	1.1	2.1	1.8
1993	7	LQ	17.7	9.2	7.7	0.5	71.0	105.5	11.0	1620.0	5.0	5.0	2.3
1993	7	UQ	18.8	9.7	9.5	0.8	146.0	161.0	15.5	2720.0	5.0	26.8	12.8
1993	8	N of Cases	16.0	16.0	16.0	16.0	16.0	22.0	22.0	22.0	22.0	22.0	16.0
1993	8	Median	18.9	9.0	7.8	0.7	84.5	137.0	20.0	1840.0	11.0	12.0	6.8
1993	8	Arithmetic Mean	18.8	8.9	7.2	0.7	101.4	148.8	19.4	1863.9	11.9	114.0	15.8
1993	8	Coefficient of Variation	0.1	0.0	0.3	0.3	0.6	0.4	0.2	0.2	0.8	1.8	1.5
1993	8	LQ	16.9	8.6	5.7	0.6	71.8	101.0	15.0	1710.0	5.0	5.0	1.9
1993	8	UQ	20.6	9.2	8.8	0.8	136.5	159.0	22.0	2250.0	15.0	100.5	22.0
1993	9	N of Cases	16.0	16.0	16.0	16.0	16.0	20.0	20.0	20.0	20.0	20.0	16.0
1993	9	Median	18.1	8.1	7.3	1.1	34.0	98.3	16.5	1730.0	98.5	518.3	21.0
1993	9	Arithmetic Mean	17.7	8.0	6.3	1.0	82.8	115.5	16.8	2439.6	117.0	1271.9	208.6
1993	9	Coefficient of Variation	0.2	0.1	0.4	0.4	1.6	0.6	0.4	0.9	0.9	1.4	2.4
1993	9	LQ	14.8	7.3	4.6	0.7	21.0	76.0	13.0	1412.5	32.0	368.5	8.5
1993	9	UQ	20.6	8.6	8.2	1.2	63.5	124.5	18.0	2430.0	184.5	942.8	62.2
1994	6	N of Cases	18.0	18.0	18.0	18.0	18.0	22.0	18.0	22.0	18.0	22.0	18.0
1994	6	Median	16.9	9.6	9.8	0.7	103.5	85.5	5.0	1525.0	5.0	9.0	3.9
1994	6	Arithmetic Mean	17.1	9.6	10.1	0.7	146.6	92.3	6.2	1954.8	5.0	23.7	4.0
1994	6	Coefficient of Variation	0.1	0.0	0.1	0.2	0.6	0.4	0.4	0.6	0.0	1.4	0.3
1994	6	LQ	15.7	9.3	9.5	0.6	72.0	67.0	5.0	1030.0	5.0	5.0	3.2
1994	6	UQ	18.2	9.9	11.1	0.8	206.0	112.0	7.0	2330.0	5.0	18.0	4.5
1994	7	N of Cases	15.0	15.0	15.0	14.0	15.0	19.0	17.0	19.0	17.0	19.0	15.0
1994	7	Median	20.8	9.9	8.1	0.9	109.0	163.0	35.0	2350.0	11.0	13.0	9.3
1994	7	Arithmetic Mean	21.1	9.6	7.5	0.8	151.4	152.9	45.1	2325.5	14.2	74.5	27.6

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1994	7	Coefficient of Variation	0.1	0.1	0.2	0.4	0.6	0.2	0.5	0.2	1.1	1.8	1.3
1994	7	LQ	19.1	9.3	6.0	0.5	78.3	117.3	28.0	1957.5	9.4	5.0	4.2
1994	7	UQ	23.3	10.0	8.5	1.1	216.9	180.0	68.5	2700.0	13.3	49.8	41.4
1994	8	N of Cases	17.0	17.0	17.0	16.0	17.0	21.0	19.0	21.0	19.0	21.0	16.0
1994	8	Median	21.4	8.7	6.2	0.4	54.0	143.0	13.0	1840.0	5.0	20.0	5.7
1994	8	Arithmetic Mean	21.3	8.8	5.9	0.4	59.5	149.4	13.9	1859.3	16.6	39.4	10.8
1994	8	Coefficient of Variation	0.1	0.0	0.3	0.2	0.2	0.1	0.4	0.1	1.3	1.3	1.9
1994	8	LQ	21.0	8.6	5.3	0.4	50.4	131.6	10.3	1640.0	5.0	10.4	1.3
1994	8	UQ	22.1	9.1	6.5	0.5	67.3	164.1	15.5	2087.5	13.0	47.3	8.5
1994	9	N of Cases	16.0	16.0	16.0	16.0	22.0	25.0	24.0	25.0	24.0	26.0	16.0
1994	9	Median	18.7	8.2	7.8	0.4	34.5	121.0	10.0	1380.0	5.0	17.8	0.7
1994	9	Arithmetic Mean	17.9	8.1	7.9	0.4	37.9	119.3	9.9	1454.0	8.0	38.4	1.1
1994	9	Coefficient of Variation	0.1	0.0	0.1	0.1	0.3	0.1	0.2	0.1	1.1	1.5	0.8
1994	9	LQ	16.4	8.0	7.3	0.4	30.0	114.8	9.0	1370.0	5.0	5.0	0.5
1994	9	UQ	19.2	8.3	8.4	0.4	45.5	125.0	11.0	1575.0	6.3	43.5	1.5
1995	6	N of Cases	16.0	16.0	16.0	16.0	16.0	18.0	18.0	18.0	18.0	18.0	16.0
1995	6	Median	17.0	9.6	10.2	0.6	200.0	124.0	14.0	2040.0	10.0	5.0	5.6
1995	6	Arithmetic Mean	17.5	9.6	9.9	0.6	267.4	161.8	13.9	2685.8	11.6	23.4	15.7
1995	6	Coefficient of Variation	0.1	0.0	0.1	0.4	1.0	1.0	0.4	0.7	0.6	1.6	1.5
1995	6	LQ	15.2	9.5	9.5	0.5	186.5	101.0	8.0	1850.0	5.0	5.0	2.4
1995	6	UQ	20.0	9.7	10.8	0.8	250.0	158.0	20.0	3020.0	16.0	25.0	20.2
1995	7	N of Cases	16.0	16.0	16.0	16.0	16.0	20.0	20.0	20.0	20.0	20.0	16.0
1995	7	Median	21.0	9.7	8.8	0.6	165.3	152.5	39.5	2475.0	5.0	5.0	3.9
1995	7	Arithmetic Mean	20.8	9.7	8.6	0.6	174.2	163.7	41.4	2496.3	27.9	33.0	19.3
1995	7	Coefficient of Variation	0.1	0.0	0.2	0.5	0.4	0.2	0.5	0.2	2.5	2.8	2.4
1995	7	LQ	19.8	9.5	8.4	0.5	126.0	140.5	24.0	2195.0	5.0	5.0	3.4
1995	7	UQ	21.9	9.9	9.3	0.7	231.0	182.5	58.8	2615.0	5.0	14.0	7.4

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1995	8	N of Cases	19.0	19.0	19.0	16.0	16.0	22.0	22.0	22.0	22.0	22.0	16.0
1995	8	Median	20.2	9.6	9.0	0.7	149.8	162.0	56.0	2557.5	5.0	13.5	10.7
1995	8	Arithmetic Mean	19.9	9.6	8.4	0.7	150.0	182.1	58.5	2708.2	5.0	57.2	36.6
1995	8	Coefficient of Variation	0.1	0.0	0.2	0.5	0.5	0.5	0.3	0.3	0.0	1.6	1.3
1995	8	LQ	19.1	9.4	7.8	0.5	82.5	145.5	46.0	2380.0	5.0	5.0	3.5
1995	8	UQ	20.7	9.7	9.9	1.0	204.0	177.5	72.0	3220.0	5.0	49.0	53.9
1995	9	N of Cases	16.0	16.0	16.0	16.0	16.0	20.0	20.0	20.0	20.0	20.0	16.0
1995	9	Median	18.5	9.3	8.1	0.6	144.0	264.0	76.8	3077.5	5.0	21.0	15.9
1995	9	Arithmetic Mean	18.7	9.3	7.6	0.6	149.5	262.1	87.8	3126.5	5.0	136.7	42.0
1995	9	Coefficient of Variation	0.0	0.0	0.3	0.4	0.4	0.3	0.4	0.3	0.0	1.6	1.1
1995	9	LQ	18.4	9.0	6.4	0.5	120.0	187.5	63.0	2300.0	5.0	18.0	9.0
1995	9	UQ	18.9	9.6	9.3	0.7	195.5	319.5	99.5	3680.0	5.0	197.3	74.8
1996	6	N of Cases	12.0	12.0	12.0	6.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
1996	6	Median	17.6	8.6	8.2	0.9	54.0	57.0	8.0	848.0	5.0	232.5	36.4
1996	6	Arithmetic Mean	18.0	8.6	8.3	0.8	58.0	61.6	7.8	943.1	8.7	267.7	65.7
1996	6	Coefficient of Variation	0.1	0.1	0.1	0.1	0.6	0.3	0.1	0.3	0.9	0.8	1.2
1996	6	LQ	16.6	8.2	7.6	0.7	26.0	52.0	7.0	750.0	5.0	63.0	3.6
1996	6	UQ	19.5	9.1	9.0	1.0	84.5	66.0	8.5	1045.0	10.0	449.0	112.5
1996	7	N of Cases	12.0	12.0	12.0	8.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
1996	7	Median	21.7	9.4	9.0	0.8	138.5	115.3	6.0	1800.0	5.0	194.0	96.5
1996	7	Arithmetic Mean	22.3	9.4	9.3	0.8	157.2	116.8	6.5	1850.4	5.0	275.0	127.7
1996	7	Coefficient of Variation	0.1	0.0	0.2	0.4	0.4	0.3	0.1	0.3	0.0	1.0	0.9
1996	7	LQ	21.0	9.3	8.3	0.6	109.0	102.0	6.0	1580.0	5.0	32.5	20.4
1996	7	UQ	23.7	9.5	10.3	1.1	202.0	122.5	7.0	1890.0	5.0	544.5	235.6
1996	8	N of Cases	12.0	12.0	12.0	7.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
1996	8	Median	20.3	8.9	7.0	0.8	108.0	188.5	58.5	2165.0	33.0	242.5	73.9
1996	8	Arithmetic Mean	20.4	9.0	7.0	0.8	110.7	178.3	63.3	2144.2	46.6	471.2	96.6

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1996	8	Coefficient of Variation	0.1	0.0	0.3	0.3	0.6	0.2	0.4	0.2	0.8	0.9	0.6
1996	8	LQ	19.5	8.7	5.7	0.6	62.0	155.0	43.0	1955.0	22.5	121.0	48.8
1996	8	UQ	21.2	9.3	8.4	1.1	153.5	202.0	86.5	2440.0	68.5	885.0	145.1
1996	9	N of Cases	12.0	12.0	12.0	8.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
1996	9	Median	15.8	8.8	7.9	1.1	89.0	182.5	71.0	2085.0	16.0	129.0	17.1
1996	9	Arithmetic Mean	16.0	8.8	8.2	1.2	128.7	194.1	73.0	2290.4	31.7	188.8	25.4
1996	9	Coefficient of Variation	0.1	0.0	0.2	0.4	0.7	0.2	0.3	0.3	1.3	0.9	0.7
1996	9	LQ	14.3	8.7	7.3	0.8	70.0	169.0	62.0	1835.0	5.0	46.5	12.2
1996	9	UQ	18.5	9.0	9.5	1.3	170.5	227.5	77.5	2550.0	45.5	279.5	38.8
1997	6	N of Cases	8.0	8.0	8.0	7.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
1997	6	Median	18.9	9.6	9.9	0.5	200.0	133.5	9.0	2225.0	5.0	338.0	173.7
1997	6	Arithmetic Mean	18.7	9.5	9.6	0.5	245.5	145.6	8.6	2486.9	5.0	454.4	263.4
1997	6	Coefficient of Variation	0.0	0.0	0.1	0.5	0.5	0.4	0.3	0.3	0.0	0.6	0.8
1997	6	LQ	18.5	9.4	8.6	0.3	182.0	103.8	7.0	2002.5	5.0	272.5	154.5
1997	6	UQ	19.0	9.7	10.7	0.7	323.5	190.0	10.0	3120.0	5.0	718.0	415.7
1997	7	N of Cases	26.0	26.0	26.0	24.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
1997	7	Median	21.1	9.5	8.9	0.5	185.0	232.0	52.0	2240.0	5.0	1685.0	681.8
1997	7	Arithmetic Mean	20.0	9.5	8.4	0.6	260.0	270.6	55.0	2759.4	7.1	1654.9	915.3
1997	7	Coefficient of Variation	0.1	0.0	0.3	0.5	1.0	0.6	0.6	0.6	0.7	0.8	0.7
1997	7	LQ	16.9	9.3	6.0	0.3	127.0	182.0	26.0	1940.0	5.0	762.0	392.8
1997	7	UQ	21.5	9.8	10.2	0.8	300.0	328.0	82.0	3310.0	5.0	1940.0	1533.8
1997	8	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
1997	8	Median	20.3	8.5	6.6	1.2	63.0	248.5	112.5	2650.0	51.0	903.5	85.7
1997	8	Arithmetic Mean	20.4	8.4	6.7	1.1	120.6	268.5	117.4	3222.8	60.0	852.9	139.1
1997	8	Coefficient of Variation	0.1	0.1	0.3	0.3	1.8	0.5	0.3	0.7	0.6	0.4	1.7
1997	8	LQ	19.4	7.8	5.2	1.0	32.0	202.0	81.0	2370.0	29.0	640.0	21.1
1997	8	UQ	21.2	8.8	7.4	1.3	79.0	269.5	149.0	3090.0	92.0	1000.0	129.4

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1997	9	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
1997	9	Median	17.5	9.3	10.4	0.9	155.0	216.0	73.5	2135.0	5.0	649.0	253.0
1997	9	Arithmetic Mean	17.2	9.3	10.6	0.9	174.3	229.4	69.6	2350.8	6.1	773.4	311.3
1997	9	Coefficient of Variation	0.1	0.0	0.2	0.4	0.8	0.3	0.2	0.3	0.7	0.6	0.7
1997	9	LQ	15.3	9.2	9.8	0.7	60.0	173.0	58.5	1710.0	5.0	476.0	151.6
1997	9	UQ	19.0	9.4	12.0	1.1	224.0	282.0	84.0	2720.0	5.0	960.0	421.9
1998	6	N of Cases	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
1998	6	Median	17.3	8.8	9.8	1.2	47.0	62.0	6.0	894.0	5.0	319.0	52.7
1998	6	Arithmetic Mean	17.3	8.9	9.6	1.1	62.4	83.0	7.4	1113.7	5.0	358.8	88.6
1998	6	Coefficient of Variation	0.1	0.0	0.1	0.3	0.6	0.6	0.5	0.4	0.0	0.6	1.3
1998	6	LQ	15.5	8.7	9.3	0.9	34.6	48.9	5.0	847.0	5.0	183.0	28.2
1998	6	UQ	19.4	9.0	10.1	1.2	77.8	104.5	8.4	1333.8	5.0	462.0	98.2
1998	7	N of Cases	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
1998	7	Median	23.9	9.4	9.5	0.8	172.0	193.5	49.0	2330.0	5.0	963.0	450.9
1998	7	Arithmetic Mean	23.4	9.3	8.3	0.8	191.1	205.1	40.3	2505.0	5.0	939.0	500.1
1998	7	Coefficient of Variation	0.1	0.0	0.3	0.6	0.4	0.3	0.9	0.3	0.0	0.3	0.4
1998	7	LQ	22.3	9.1	6.6	0.5	146.9	179.0	4.0	2055.0	5.0	633.6	335.9
1998	7	UQ	24.5	9.5	10.2	0.9	231.8	242.5	71.6	2815.0	5.0	1141.3	678.8
1998	8	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
1998	8	Median	21.7	8.1	6.8	1.8	11.5	224.5	102.0	2150.0	63.0	979.3	59.0
1998	8	Arithmetic Mean	21.7	8.1	6.4	1.6	74.2	240.6	109.6	2468.9	76.8	1059.1	117.1
1998	8	Coefficient of Variation	0.1	0.0	0.5	0.4	2.1	0.4	0.3	0.5	1.1	0.6	2.0
1998	8	LQ	20.3	7.8	3.2	1.5	5.9	183.0	78.0	2060.0	16.0	820.0	21.3
1998	8	UQ	23.3	8.2	8.3	2.1	30.0	245.0	146.0	2440.0	88.5	1080.0	68.8
1998	9	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
1998	9	Median	18.9	9.3	10.0	0.9	96.0	181.5	55.5	1847.5	5.0	287.5	89.2
1998	9	Arithmetic Mean	18.7	9.2	9.5	0.9	116.9	198.2	61.9	1898.2	5.9	281.9	111.3

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1998	9	Coefficient of Variation	0.2	0.0	0.2	0.3	0.5	0.3	0.4	0.3	0.3	0.9	1.0
1998	9	LQ	15.1	9.0	8.7	0.7	77.0	163.0	48.0	1500.0	5.0	26.0	7.6
1998	9	UQ	21.9	9.4	10.6	1.1	162.0	222.0	66.0	2270.0	5.0	521.0	220.7
1999	6	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
1999	6	Median	16.8	8.8	10.1	1.1	46.0	87.0	12.0	1070.0	5.0	205.0	32.8
1999	6	Arithmetic Mean	16.9	8.8	10.4	0.9	88.5	108.1	14.0	1307.5	5.0	261.4	81.9
1999	6	Coefficient of Variation	0.2	0.1	0.1	0.4	1.3	0.6	0.5	0.6	0.0	0.7	1.6
1999	6	LQ	14.3	8.3	9.1	0.8	21.0	73.5	7.0	740.0	5.0	151.0	8.9
1999	6	UQ	19.3	9.4	11.0	1.1	110.5	105.0	21.0	1530.0	5.0	302.0	128.7
1999	7	N of Cases	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
1999	7	Median	20.1	9.8	9.1	0.6	227.0	177.5	29.0	2490.0	5.0	263.0	167.7
1999	7	Arithmetic Mean	19.5	9.8	9.2	0.6	236.4	201.3	27.2	2838.2	9.6	419.8	300.0
1999	7	Coefficient of Variation	0.1	0.0	0.2	0.6	0.5	0.5	0.8	0.4	0.6	0.9	0.9
1999	7	LQ	18.3	9.7	8.7	0.3	127.0	146.0	5.0	1997.5	5.0	162.3	118.8
1999	7	UQ	20.8	9.9	10.5	0.9	317.9	238.3	48.3	3452.5	15.5	602.4	399.6
1999	8	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
1999	8	Median	21.3	9.4	7.6	0.7	166.0	289.3	81.5	2480.0	11.0	165.0	67.8
1999	8	Arithmetic Mean	21.2	9.4	7.8	0.7	211.9	308.0	81.7	2842.8	12.6	433.1	243.7
1999	8	Coefficient of Variation	0.1	0.0	0.2	0.5	0.9	0.5	0.1	0.5	1.0	1.3	1.4
1999	8	LQ	20.2	9.3	6.7	0.5	84.0	190.0	77.0	1930.0	5.0	43.0	21.4
1999	8	UQ	22.4	9.6	8.9	0.9	234.0	371.0	87.0	3150.0	14.0	854.0	435.1
1999	9	N of Cases	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
1999	9	Median	16.9	8.7	8.7	1.2	48.0	197.0	66.0	1950.0	43.0	358.0	31.4
1999	9	Arithmetic Mean	16.3	8.7	8.7	1.0	83.1	224.6	77.7	2294.3	44.4	407.0	63.5
1999	9	Coefficient of Variation	0.1	0.0	0.3	0.4	1.2	0.5	0.5	0.4	0.7	0.8	1.3
1999	9	LQ	14.7	8.5	7.0	0.7	21.5	157.3	47.5	1787.5	16.0	85.3	11.0
1999	9	UQ	17.9	9.0	10.6	1.3	106.8	241.3	113.8	2405.0	62.0	750.8	58.8

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2000	6	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2000	6	Median	20.5	9.9	9.7	0.6	188.0	193.5	8.5	2385.0	14.3	793.3	609.7
2000	6	Arithmetic Mean	20.2	9.8	9.2	0.6	233.0	194.3	21.3	2451.7	17.9	1010.8	703.9
2000	6	Coefficient of Variation	0.1	0.0	0.2	0.5	0.6	0.4	0.9	0.3	0.9	0.6	0.6
2000	6	LQ	17.7	9.6	8.0	0.4	124.5	128.0	7.0	1620.0	5.0	616.0	473.9
2000	6	UQ	22.0	10.0	10.5	0.8	282.0	233.0	29.0	3030.0	22.0	1370.0	765.8
2000	7	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2000	7	Median	21.2	9.6	7.5	1.0	101.0	233.0	90.5	1660.0	10.0	521.3	314.8
2000	7	Arithmetic Mean	21.0	9.7	7.7	0.9	170.2	460.8	89.4	2047.6	9.6	728.3	504.9
2000	7	Coefficient of Variation	0.0	0.0	0.2	0.5	1.0	1.2	0.1	0.5	0.2	0.7	0.9
2000	7	LQ	20.3	9.5	7.1	0.5	71.0	208.0	86.0	1410.0	10.0	399.0	288.6
2000	7	UQ	21.5	9.8	8.2	1.2	204.0	396.0	96.0	2540.0	10.5	1090.0	493.5
2000	8	N of Cases	18.0	18.0	18.0	12.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2000	8	Median	21.5	8.5	4.5	1.4	21.5	226.0	141.3	2277.5	66.5	870.0	71.2
2000	8	Arithmetic Mean	21.2	8.5	4.7	1.4	33.7	222.6	126.7	2192.2	79.9	749.0	86.3
2000	8	Coefficient of Variation	0.1	0.0	0.5	0.2	1.1	0.3	0.3	0.2	0.9	0.5	0.6
2000	8	LQ	18.4	8.3	2.8	1.2	17.0	174.0	113.0	1780.0	22.0	554.0	57.3
2000	8	UQ	23.5	8.7	6.3	1.6	39.0	286.5	153.0	2410.0	153.0	911.0	114.4
2000	9	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2000	9	Median	16.7	9.1	9.0	0.8	130.5	194.0	67.0	1795.0	17.5	514.5	132.9
2000	9	Arithmetic Mean	16.5	9.1	8.5	0.8	148.8	184.4	63.8	1972.5	22.7	523.1	169.2
2000	9	Coefficient of Variation	0.2	0.0	0.2	0.3	0.6	0.1	0.2	0.3	0.6	0.3	0.7
2000	9	LQ	13.8	9.0	7.5	0.7	70.0	170.0	49.0	1470.0	13.0	363.0	88.5
2000	9	UQ	18.8	9.3	9.7	1.1	172.0	201.0	75.0	2180.0	28.0	679.0	234.9
2001	6	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2001	6	Median	16.6	9.6	9.3	0.6	160.3	132.0	7.0	2490.0	5.0	501.0	258.0
2001	6	Arithmetic Mean	16.8	9.6	9.4	0.6	184.6	142.9	6.9	2556.1	5.0	485.6	264.5

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2001	6	Coefficient of Variation	0.1	0.0	0.1	0.3	0.4	0.4	0.1	0.3	0.0	0.5	0.6
2001	6	LQ	15.9	9.5	9.0	0.6	128.0	99.0	6.0	1910.0	5.0	263.0	176.1
2001	6	UQ	17.6	9.7	9.6	0.8	227.0	163.0	7.0	2990.0	5.0	553.0	318.5
2001	7	N of Cases	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
2001	7	Median	19.6	9.7	7.9	0.7	199.0	249.0	54.0	3410.0	13.0	639.0	362.2
2001	7	Arithmetic Mean	19.6	9.7	8.3	0.7	206.6	237.2	43.6	3364.5	12.9	611.7	390.1
2001	7	Coefficient of Variation	0.0	0.0	0.2	0.4	0.4	0.3	0.6	0.3	0.2	0.5	0.5
2001	7	LQ	19.4	9.6	7.4	0.6	142.8	183.0	11.3	2710.0	11.3	346.3	267.9
2001	7	UQ	19.9	9.9	9.4	0.9	241.0	279.8	65.4	3990.0	15.0	714.0	492.0
2001	8	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2001	8	Median	22.2	8.9	5.5	0.7	75.3	226.5	70.8	3150.0	8.0	861.0	231.1
2001	8	Arithmetic Mean	21.5	8.9	5.5	0.9	81.8	238.3	65.4	3409.7	10.3	925.9	254.4
2001	8	Coefficient of Variation	0.1	0.0	0.5	0.5	0.7	0.3	0.6	0.3	0.7	0.4	0.5
2001	8	LQ	19.7	8.7	3.6	0.6	38.0	180.0	30.0	2960.0	5.0	745.0	108.5
2001	8	UQ	23.0	9.2	8.0	1.0	102.5	293.0	92.0	4020.0	13.0	1080.0	389.5
2001	9	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2001	9	Median	16.7	8.8	7.4	1.0	96.5	173.0	22.5	2765.0	13.0	970.0	93.6
2001	9	Arithmetic Mean	16.9	8.6	6.4	1.0	114.8	169.8	33.8	2961.1	16.6	861.2	155.9
2001	9	Coefficient of Variation	0.1	0.1	0.4	0.5	0.7	0.3	0.7	0.3	0.6	0.6	1.5
2001	9	LQ	16.0	8.3	3.7	0.5	67.0	133.0	16.5	2340.0	11.0	414.0	25.2
2001	9	UQ	17.9	9.0	8.2	1.3	167.0	192.0	57.5	3740.0	23.0	1100.0	103.0
2002	6	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2002	6	Median	19.5	9.3	9.2	0.7	147.5	101.0	6.0	1847.5	6.3	249.0	125.3
2002	6	Arithmetic Mean	19.5	9.2	9.7	0.8	167.7	119.6	6.9	1812.5	7.8	369.1	186.1
2002	6	Coefficient of Variation	0.1	0.0	0.2	0.4	0.7	0.6	0.4	0.3	0.4	1.0	1.0
2002	6	LQ	17.5	9.0	8.6	0.6	97.5	74.5	5.0	1435.0	5.0	41.0	7.0
2002	6	UQ	20.8	9.4	11.0	1.0	182.0	126.0	8.0	2200.0	10.0	625.0	348.5

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2002	7	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2002	7	Median	21.8	9.6	7.3	0.8	147.5	177.5	41.0	2435.0	11.5	398.8	266.0
2002	7	Arithmetic Mean	21.7	9.6	7.1	0.8	140.7	187.2	41.6	2345.8	22.7	424.7	261.7
2002	7	Coefficient of Variation	0.1	0.0	0.3	0.3	0.4	0.2	0.4	0.2	1.3	0.3	0.4
2002	7	LQ	21.1	9.5	5.5	0.6	82.0	157.5	30.0	2125.0	10.0	328.0	186.5
2002	7	UQ	22.6	9.7	8.4	1.0	192.0	199.0	53.5	2580.0	13.5	526.0	342.9
2002	8	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2002	8	Median	19.6	9.0	8.3	0.9	67.5	170.0	39.0	2695.0	54.8	570.5	111.9
2002	8	Arithmetic Mean	19.8	8.8	8.0	1.0	84.2	201.6	46.8	2761.7	78.1	578.5	149.7
2002	8	Coefficient of Variation	0.1	0.1	0.3	0.4	0.8	0.3	0.6	0.3	1.1	0.4	0.8
2002	8	LQ	18.3	8.5	6.7	0.7	38.5	162.0	27.0	2240.0	8.0	420.0	46.4
2002	8	UQ	21.0	9.2	9.2	1.2	123.0	245.0	67.0	2955.0	100.0	639.0	215.6
2002	9	N of Cases	18.0	18.0	9.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2002	9	Median	16.5	9.3	8.9	0.9	100.0	190.3	39.0	2652.5	12.0	309.5	94.0
2002	9	Arithmetic Mean	16.5	9.3	8.2	0.9	109.9	211.1	42.9	2874.4	12.5	328.9	122.1
2002	9	Coefficient of Variation	0.0	0.0	0.1	0.3	0.5	0.3	0.4	0.3	0.2	0.4	0.6
2002	9	LQ	15.9	9.1	7.1	0.7	80.0	155.0	31.0	2300.0	11.0	207.0	69.0
2002	9	UQ	17.1	9.4	9.0	1.1	115.0	264.0	56.0	3340.0	13.0	448.0	165.6
2003	6	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2003	6	Median	20.1	8.4	8.0	1.2	16.0	90.8	18.5	1000.0	14.5	69.5	5.4
2003	6	Arithmetic Mean	20.0	8.4	8.1	1.1	27.6	99.7	16.5	1157.3	33.3	61.0	7.2
2003	6	Coefficient of Variation	0.0	0.0	0.1	0.2	1.0	0.5	0.4	0.4	0.9	0.4	0.9
2003	6	LQ	18.9	8.2	7.8	1.0	12.0	68.5	11.5	782.0	12.0	53.0	2.2
2003	6	UQ	20.6	8.5	8.1	1.3	26.0	109.0	21.0	1305.0	56.0	76.0	9.3
2003	7	N of Cases	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
2003	7	Median	22.4	9.5	8.5	0.7	94.0	202.0	44.0	2760.0	8.0	347.0	71.3
2003	7	Arithmetic Mean	22.8	9.4	7.6	0.8	118.9	215.6	52.4	2846.5	8.7	422.2	211.6

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2003	7	Coefficient of Variation	0.1	0.0	0.4	0.5	0.9	0.4	1.0	0.3	0.5	1.3	1.5
2003	7	LQ	21.0	9.4	7.3	0.6	53.8	140.0	5.0	2177.5	5.0	22.9	13.2
2003	7	UQ	24.5	9.6	9.5	1.0	150.0	280.5	82.0	3402.5	12.0	634.5	288.0
2003	8	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2003	8	Median	20.5	9.5	8.5	0.6	178.5	261.5	72.5	3092.5	13.5	16.0	8.5
2003	8	Arithmetic Mean	20.4	9.5	8.4	0.6	171.2	272.6	73.4	3152.2	13.7	40.1	16.5
2003	8	Coefficient of Variation	0.0	0.0	0.2	0.3	0.3	0.2	0.2	0.2	0.6	2.6	2.0
2003	8	LQ	20.1	9.4	7.9	0.5	150.0	229.5	63.0	2950.0	5.0	10.0	6.6
2003	8	UQ	20.8	9.6	8.8	0.7	207.0	286.0	79.0	3620.0	18.5	24.5	13.7
2003	9	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2003	9	Median	17.1	9.4	7.4	0.7	93.5	216.0	63.5	2480.0	16.5	98.3	29.6
2003	9	Arithmetic Mean	17.0	9.4	7.7	0.7	134.3	261.9	57.9	2990.3	27.9	162.4	65.3
2003	9	Coefficient of Variation	0.0	0.0	0.3	0.4	1.3	0.7	0.5	0.6	0.9	1.2	1.4
2003	9	LQ	16.4	9.3	6.1	0.5	80.0	178.0	29.0	2025.0	13.5	31.0	16.3
2003	9	UQ	17.7	9.6	9.1	0.8	119.0	252.0	73.0	2970.0	32.0	229.0	94.6
2004	6	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2004	6	Median	17.4	9.3	9.0	1.0	65.5	69.5	7.0	1325.0	5.0	21.5	4.3
2004	6	Arithmetic Mean	17.4	9.2	9.4	0.8	92.7	93.9	8.0	1470.4	7.1	25.9	10.2
2004	6	Coefficient of Variation	0.2	0.0	0.1	0.3	0.8	0.6	0.2	0.4	0.4	0.9	1.4
2004	6	LQ	14.4	8.8	8.8	0.6	49.0	61.0	7.0	1050.0	5.0	12.0	3.3
2004	6	UQ	20.1	9.6	10.1	1.0	123.0	112.0	9.0	1680.0	10.0	34.0	7.2
2004	7	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2004	7	Median	21.7	9.6	7.1	0.7	132.3	172.5	26.5	2180.0	19.0	22.0	13.4
2004	7	Arithmetic Mean	21.7	9.6	7.1	0.7	185.4	183.9	27.1	2442.8	29.1	32.2	19.4
2004	7	Coefficient of Variation	0.0	0.0	0.2	0.5	0.9	0.5	0.6	0.4	0.8	0.9	0.8
2004	7	LQ	20.7	9.5	6.4	0.5	109.0	130.0	13.0	1790.0	12.0	14.0	10.4
2004	7	UQ	22.7	9.7	8.1	0.7	229.0	189.5	37.0	2480.0	54.0	41.0	25.7

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2004	8	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2004	8	Median	21.9	9.0	5.9	1.0	85.0	178.3	53.5	2495.0	33.0	115.5	31.0
2004	8	Arithmetic Mean	22.0	9.0	5.7	1.0	84.8	192.3	64.1	2434.4	36.1	190.8	45.9
2004	8	Coefficient of Variation	0.0	0.0	0.3	0.3	0.7	0.2	0.3	0.1	0.6	1.0	0.7
2004	8	LQ	20.9	8.9	4.6	0.7	34.0	169.0	48.5	2170.0	20.5	48.0	17.5
2004	8	UQ	23.1	9.3	6.5	1.3	109.5	198.0	86.0	2640.0	45.0	322.0	80.7
2004	9	N of Cases	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
2004	9	Median	16.3	9.1	8.6	1.0	52.0	144.0	22.0	2060.0	14.0	96.0	22.8
2004	9	Arithmetic Mean	17.3	9.1	8.5	0.9	86.0	159.0	26.3	2535.9	16.6	226.2	57.6
2004	9	Coefficient of Variation	0.1	0.0	0.2	0.3	1.3	0.4	0.7	0.4	0.9	1.1	1.2
2004	9	LQ	15.7	9.0	7.9	0.8	16.0	123.0	10.3	1910.0	8.0	22.3	9.3
2004	9	UQ	19.5	9.2	9.2	1.1	85.5	188.5	32.8	2693.8	20.5	421.5	113.1
2005	6	N of Cases	24.0	24.0	24.0	18.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
2005	6	Median	16.1	9.1	9.6	1.0	60.5	85.0	6.0	1420.0	7.5	27.0	3.6
2005	6	Arithmetic Mean	15.9	8.9	9.5	0.8	59.7	92.4	6.8	1434.3	9.0	24.1	5.9
2005	6	Coefficient of Variation	0.1	0.0	0.1	0.4	0.5	0.4	0.4	0.3	0.6	0.4	0.8
2005	6	LQ	14.5	8.8	9.4	0.7	33.5	60.5	5.0	1030.0	5.0	15.5	2.4
2005	6	UQ	16.8	9.2	10.0	1.1	71.5	123.0	7.5	1830.0	11.5	33.0	11.2
2005	7	N of Cases	22.0	22.0	22.0	18.0	20.0	22.0	22.0	22.0	22.0	22.0	22.0
2005	7	Median	22.0	9.5	7.6	1.0	70.0	175.5	36.0	2090.0	10.5	36.0	22.3
2005	7	Arithmetic Mean	22.3	9.4	6.9	1.0	77.7	181.8	36.3	2428.2	10.7	96.1	43.1
2005	7	Coefficient of Variation	0.1	0.0	0.2	0.5	0.9	0.4	0.8	0.4	0.6	1.2	1.0
2005	7	LQ	21.1	9.3	5.8	0.6	30.5	112.0	8.0	1890.0	5.0	15.0	10.2
2005	7	UQ	23.7	9.6	8.1	1.4	100.0	260.0	53.0	3150.0	14.0	122.0	70.8
2005	8	N of Cases	31.0	31.0	31.0	26.0	29.0	31.0	31.0	31.0	31.0	31.0	31.0
2005	8	Median	21.1	9.3	7.6	0.9	117.0	171.0	45.0	2400.0	13.0	19.0	8.5
2005	8	Arithmetic Mean	20.8	9.2	7.4	0.9	132.8	196.3	51.1	2796.8	17.9	106.3	18.0

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2005	8	Coefficient of Variation	0.1	0.1	0.2	0.5	0.7	0.3	0.6	0.4	0.7	1.9	1.1
2005	8	LQ	19.2	9.1	6.7	0.7	61.5	147.0	31.1	2070.0	5.0	10.0	5.7
2005	8	UQ	22.4	9.5	8.5	1.2	172.8	220.3	66.5	3335.0	23.8	117.0	29.0
2005	9	N of Cases	22.0	22.0	22.0	18.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
2005	9	Median	14.1	8.9	8.2	0.7	149.5	196.0	40.0	2870.0	10.0	47.5	6.7
2005	9	Arithmetic Mean	14.3	8.9	8.3	0.8	145.6	201.2	37.5	3010.9	10.3	79.4	12.7
2005	9	Coefficient of Variation	0.1	0.0	0.1	0.2	0.4	0.2	0.4	0.2	0.6	1.1	1.0
2005	9	LQ	13.2	8.8	7.7	0.7	94.0	162.0	24.0	2510.0	5.0	18.0	4.2
2005	9	UQ	15.3	9.1	9.0	0.9	169.0	237.0	47.0	3480.0	13.0	100.0	16.5
2006	6	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2006	6	Median	18.3	8.0	7.2	1.6	12.0	54.0	15.0	714.5	22.5	51.5	1.8
2006	6	Arithmetic Mean	18.2	8.0	7.3	1.6	13.6	71.7	14.6	799.4	22.5	57.2	2.0
2006	6	Coefficient of Variation	0.0	0.0	0.1	0.1	0.7	0.7	0.3	0.2	0.4	0.4	0.5
2006	6	LQ	17.6	7.8	6.9	1.5	5.3	49.0	12.0	672.0	18.0	50.0	1.2
2006	6	UQ	18.8	8.2	7.8	1.7	22.0	59.0	16.0	961.0	26.0	71.0	2.7
2006	7	N of Cases	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
2006	7	Median	22.2	9.3	7.2	0.9	102.0	190.0	48.0	1990.0	22.0	112.0	31.2
2006	7	Arithmetic Mean	22.2	9.1	7.1	1.0	106.6	214.1	59.3	2153.3	47.4	281.3	54.0
2006	7	Coefficient of Variation	0.0	0.1	0.3	0.4	1.0	0.5	0.9	0.4	1.2	1.3	0.9
2006	7	LQ	21.6	8.8	5.2	0.7	34.0	132.3	7.0	1817.5	5.0	43.0	24.2
2006	7	UQ	22.8	9.5	9.3	1.3	139.5	244.3	110.8	2307.5	65.0	447.0	66.8
2006	8	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2006	8	Median	20.7	9.7	8.6	0.7	107.0	258.5	87.0	3665.0	5.0	26.5	14.8
2006	8	Arithmetic Mean	20.7	9.8	8.7	0.7	153.3	279.1	87.1	3495.0	5.0	106.6	64.1
2006	8	Coefficient of Variation	0.0	0.0	0.2	0.4	0.8	0.4	0.3	0.4	0.0	1.9	1.7
2006	8	LQ	20.1	9.4	7.9	0.4	77.0	198.0	63.0	2000.0	5.0	12.0	6.5
2006	8	UQ	21.4	10.2	9.7	0.9	190.0	305.0	103.0	5040.0	5.0	69.0	33.5

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2006	9	N of Cases	18.0	18.0	18.0	14.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2006	9	Median	16.9	10.0	10.0	0.6	145.5	255.0	94.0	2510.0	5.0	61.5	37.3
2006	9	Arithmetic Mean	16.6	10.0	10.0	0.6	205.3	287.7	90.7	3426.7	5.0	89.3	65.8
2006	9	Coefficient of Variation	0.2	0.0	0.2	0.5	0.9	0.4	0.5	0.6	0.0	1.1	1.2
2006	9	LQ	13.9	9.8	8.4	0.4	95.0	231.0	71.0	2410.0	5.0	17.0	14.7
2006	9	UQ	19.0	10.2	11.6	0.7	244.0	324.0	99.0	3870.0	5.0	121.0	96.6
2007	6	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2007	6	Median	17.8	8.9	8.6	1.2	27.5	117.5	35.5	899.0	5.0	19.5	2.8
2007	6	Arithmetic Mean	17.9	8.8	8.5	1.2	63.6	140.4	32.4	1213.3	30.4	27.4	3.9
2007	6	Coefficient of Variation	0.1	0.0	0.1	0.4	1.5	0.6	0.5	0.7	1.0	0.9	0.9
2007	6	LQ	16.6	8.5	7.4	1.0	13.0	93.0	15.0	796.0	5.0	5.0	1.5
2007	6	UQ	19.1	9.0	9.6	1.5	57.0	126.0	48.0	1080.0	63.0	40.0	3.7
2007	7	N of Cases	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
2007	7	Median	21.8	9.9	7.3	0.6	144.0	310.0	111.0	3230.0	5.0	21.0	16.5
2007	7	Arithmetic Mean	21.6	9.9	7.3	0.6	162.0	316.0	93.9	3028.9	8.3	49.9	37.8
2007	7	Coefficient of Variation	0.1	0.0	0.3	0.4	0.5	0.3	0.6	0.3	0.6	1.2	1.2
2007	7	LQ	20.3	9.8	5.7	0.4	99.8	262.3	27.3	2332.5	5.0	5.0	4.4
2007	7	UQ	22.6	10.0	8.8	0.8	230.3	355.0	133.8	3722.5	13.0	69.5	51.1
2007	8	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2007	8	Median	20.3	9.4	7.4	0.6	149.5	256.0	103.5	3090.0	5.0	28.0	19.0
2007	8	Arithmetic Mean	20.2	9.4	6.6	0.6	140.5	288.7	98.0	3286.7	8.4	90.8	39.3
2007	8	Coefficient of Variation	0.0	0.0	0.2	0.5	0.5	0.3	0.2	0.4	0.5	1.1	1.0
2007	8	LQ	19.4	9.3	5.2	0.5	72.0	233.0	77.0	2430.0	5.0	19.0	11.5
2007	8	UQ	21.0	9.6	7.7	0.8	211.0	284.0	114.0	3910.0	12.0	184.0	75.4
2007	9	N of Cases	18.0	18.0	18.0	18.0	9.0	18.0	18.0	18.0	18.0	18.0	18.0
2007	9	Median	15.0	9.2	9.2	0.6	89.0	215.0	49.5	2726.6	12.0	295.2	73.5
2007	9	Arithmetic Mean	15.3	9.2	8.5	0.6	124.0	212.8	61.7	2907.3	14.5	324.7	73.5

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2007	9	Coefficient of Variation	0.2	0.0	0.2	0.2	0.7	0.2	0.6	0.2	0.8	1.0	0.8
2007	9	LQ	12.2	9.1	7.7	0.5	85.0	178.1	39.0	2430.0	5.0	53.0	29.9
2007	9	UQ	18.1	9.4	9.6	0.7	140.3	252.0	76.0	3274.9	19.0	439.0	113.4
2008	6	N of Cases	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
2008	6	Median	18.2	9.0	9.3	1.0	50.0	76.5	17.0	1120.0	4.0	24.5	5.3
2008	6	Arithmetic Mean	18.3	8.8	9.2	1.0	64.7	98.8	18.5	1449.4	12.3	29.1	7.8
2008	6	Coefficient of Variation	0.2	0.1	0.1	0.4	1.1	0.7	0.2	0.7	1.3	0.4	0.9
2008	6	LQ	15.4	8.1	8.2	0.8	13.0	59.0	16.0	733.0	4.0	20.0	0.9
2008	6	UQ	21.3	9.5	10.2	1.3	85.0	115.0	20.0	1760.0	4.0	36.0	14.5
2008	7	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2008	7	Median	21.2	9.6	8.3	0.7	178.5	202.0	51.0	2830.0	6.5	19.0	14.2
2008	7	Arithmetic Mean	21.3	9.6	8.1	0.7	271.1	204.9	56.3	2703.9	7.1	84.7	39.9
2008	7	Coefficient of Variation	0.0	0.0	0.2	0.4	1.0	0.3	0.4	0.3	0.5	1.7	1.3
2008	7	LQ	20.7	9.5	7.2	0.5	132.0	177.0	39.0	1860.0	4.0	16.0	11.2
2008	7	UQ	21.4	9.9	9.2	0.8	260.0	234.0	66.0	3090.0	10.0	49.0	28.7
2008	8	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2008	8	Median	20.4	9.3	7.3	0.8	125.0	230.0	91.0	2975.0	6.5	118.5	47.9
2008	8	Arithmetic Mean	20.3	9.3	7.5	0.8	148.9	263.7	88.2	2917.8	9.2	171.2	55.8
2008	8	Coefficient of Variation	0.0	0.0	0.3	0.3	0.7	0.3	0.3	0.3	0.8	1.2	0.8
2008	8	LQ	19.7	9.2	7.1	0.7	65.0	215.0	66.0	2080.0	4.0	25.0	11.8
2008	8	UQ	21.0	9.5	8.5	0.9	206.0	285.0	100.0	3170.0	12.0	276.0	98.1
2008	9	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2008	9	Median	16.6	9.4	8.6	0.7	114.5	220.0	66.0	2635.0	10.0	27.5	11.8
2008	9	Arithmetic Mean	16.5	9.2	7.6	0.7	163.1	256.0	70.1	3176.7	10.2	281.8	27.9
2008	9	Coefficient of Variation	0.1	0.1	0.3	0.3	1.2	0.5	0.5	0.5	0.3	2.8	1.2
2008	9	LQ	15.2	9.1	6.2	0.6	67.0	184.0	49.0	2060.0	9.0	22.0	10.4
2008	9	UQ	17.5	9.5	9.2	0.9	182.0	292.0	82.0	3460.0	12.0	103.0	25.8

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2009	6	N of Cases	27.0	27.0	27.0	27.0	26.0	27.0	27.0	27.0	27.0	27.0	27.0
2009	6	Median	18.4	9.3	8.4	0.9	82.3	65.0	6.0	1720.0	4.0	16.0	7.7
2009	6	Arithmetic Mean	19.0	9.1	8.3	0.9	109.0	80.4	5.6	1717.6	4.5	24.4	8.4
2009	6	Coefficient of Variation	0.1	0.1	0.1	0.3	0.7	0.6	0.3	0.5	0.4	0.7	0.8
2009	6	LQ	18.1	8.7	7.7	0.7	56.6	46.0	4.0	964.8	4.0	12.0	2.4
2009	6	UQ	19.8	9.4	9.0	1.1	140.7	93.0	7.0	1962.5	4.0	27.3	10.8
2009	7	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2009	7	Median	21.8	8.6	5.8	1.5	49.9	154.5	53.5	2070.0	18.0	372.5	30.3
2009	7	Arithmetic Mean	21.7	8.4	5.9	1.6	49.7	152.1	67.3	2021.1	26.5	503.0	38.9
2009	7	Coefficient of Variation	0.1	0.1	0.3	0.4	0.8	0.2	0.6	0.2	0.8	0.8	0.7
2009	7	LQ	19.6	7.8	4.8	1.1	19.8	131.0	40.0	1640.0	12.0	150.0	13.9
2009	7	UQ	23.5	9.0	7.3	1.9	56.8	166.0	97.0	2320.0	37.0	685.0	55.9
2009	8	N of Cases	17.0	17.0	17.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	17.0
2009	8	Median	19.6	9.7	8.9	0.7	146.5	191.5	41.0	2170.0	6.0	20.5	11.6
2009	8	Arithmetic Mean	19.5	9.8	9.0	0.6	153.0	200.4	47.1	2451.7	6.6	62.3	42.3
2009	8	Coefficient of Variation	0.0	0.1	0.3	0.4	0.4	0.3	0.6	0.3	0.4	2.1	2.1
2009	8	LQ	19.1	9.3	8.0	0.4	118.5	164.0	27.0	1880.0	4.0	17.0	9.0
2009	8	UQ	20.1	10.3	10.9	0.8	189.1	213.0	66.0	2860.0	9.0	25.0	21.5
2009	9	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2009	9	Median	16.1	9.8	7.9	0.6	142.5	240.5	86.0	2810.0	4.0	108.0	77.2
2009	9	Arithmetic Mean	16.3	9.8	7.5	0.6	147.5	250.8	78.0	3103.3	7.3	238.8	123.6
2009	9	Coefficient of Variation	0.1	0.0	0.2	0.3	0.3	0.2	0.3	0.3	0.7	1.5	1.1
2009	9	LQ	15.7	9.6	7.1	0.5	119.6	215.0	59.0	2450.0	4.0	27.0	19.7
2009	9	UQ	17.0	9.9	8.3	0.8	174.3	306.0	95.0	3760.0	9.0	337.0	204.7
2010	6	N of Cases	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
2010	6	Median	16.6	8.3	8.5	1.1	13.6	47.0	4.0	596.0	4.0	10.0	0.4
2010	6	Arithmetic Mean	16.9	8.2	8.6	1.1	14.6	49.0	5.0	620.1	5.3	11.8	0.7

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2010	6	Coefficient of Variation	0.2	0.1	0.1	0.3	0.9	0.2	0.7	0.2	0.4	0.6	1.0
2010	6	LQ	14.0	7.7	8.1	1.0	4.3	41.5	3.0	551.3	4.0	7.0	0.2
2010	6	UQ	20.1	8.6	9.0	1.2	17.4	53.8	5.8	633.3	8.0	17.0	0.8
2010	7	N of Cases	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
2010	7	Median	22.5	9.6	9.1	1.0	93.3	81.0	8.0	1550.0	4.0	24.0	12.1
2010	7	Arithmetic Mean	22.1	9.5	8.5	0.9	103.9	103.9	18.7	1773.6	6.1	75.7	39.7
2010	7	Coefficient of Variation	0.0	0.0	0.2	0.4	0.5	0.6	1.1	0.4	0.9	1.3	1.1
2010	7	LQ	21.2	9.4	7.3	0.6	55.7	67.0	5.3	1400.0	4.0	14.0	9.2
2010	7	UQ	22.8	9.7	9.6	1.1	124.4	141.0	21.0	2137.5	4.0	120.5	70.3
2010	8	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2010	8	Median	20.4	9.4	8.6	0.7	124.6	180.5	44.5	2120.0	9.5	34.5	19.6
2010	8	Arithmetic Mean	20.3	9.3	8.5	0.8	132.4	183.7	49.4	2326.7	17.9	158.1	34.7
2010	8	Coefficient of Variation	0.1	0.0	0.2	0.5	0.6	0.2	0.5	0.3	1.2	1.4	0.9
2010	8	LQ	18.8	8.9	7.8	0.5	91.8	160.0	37.0	1930.0	4.0	25.0	13.5
2010	8	UQ	21.5	9.6	9.6	0.9	154.8	201.0	70.0	2710.0	21.0	239.0	63.2
2010	9	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2010	9	Median	15.9	9.5	9.0	0.7	170.6	168.5	30.5	2370.0	9.0	31.0	17.9
2010	9	Arithmetic Mean	15.9	9.5	9.0	0.7	163.2	199.7	33.2	2772.8	13.4	116.3	30.9
2010	9	Coefficient of Variation	0.1	0.0	0.3	0.4	0.5	0.5	0.5	0.4	1.0	2.0	0.8
2010	9	LQ	14.8	9.4	7.7	0.6	89.5	141.0	25.0	2190.0	4.0	27.0	14.1
2010	9	UQ	16.8	9.6	10.5	0.8	216.3	220.0	34.0	2760.0	12.0	86.0	35.9
2011	6	N of Cases	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
2011	6	Median	16.1	8.1	8.3	1.1	14.2	48.0	5.0	657.0	13.0	49.0	1.3
2011	6	Arithmetic Mean	15.2	8.1	8.4	1.2	15.2	49.5	5.1	664.3	17.9	47.3	1.4
2011	6	Coefficient of Variation	0.2	0.0	0.1	0.3	0.3	0.3	0.4	0.2	0.6	0.6	0.5
2011	6	LQ	10.6	8.0	7.9	0.9	12.0	42.0	4.0	603.0	8.3	24.0	0.8
2011	6	UQ	19.0	8.3	9.4	1.5	17.3	52.0	6.0	696.0	27.0	68.0	1.9

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2011	7	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2011	7	Median	20.1	9.6	10.1	0.8	98.6	97.0	7.0	1665.0	4.0	21.5	13.2
2011	7	Arithmetic Mean	19.8	9.6	9.7	0.8	114.4	108.4	7.6	1770.0	5.1	31.2	18.4
2011	7	Coefficient of Variation	0.1	0.0	0.1	0.2	0.5	0.3	0.5	0.3	0.4	0.9	0.8
2011	7	LQ	18.5	9.5	8.5	0.7	79.0	88.0	4.0	1470.0	4.0	16.0	11.2
2011	7	UQ	20.9	9.7	10.4	0.8	152.7	136.0	9.0	1830.0	4.0	32.0	21.1
2011	8	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2011	8	Median	22.0	9.1	7.4	1.0	41.1	205.5	69.5	1870.0	20.0	114.0	47.4
2011	8	Arithmetic Mean	21.8	9.1	7.3	1.0	67.7	215.1	73.3	2083.3	29.1	190.9	53.0
2011	8	Coefficient of Variation	0.0	0.0	0.3	0.4	1.3	0.3	0.2	0.5	0.8	1.0	0.8
2011	8	LQ	21.7	8.9	5.5	0.8	12.4	183.0	63.0	1480.0	17.0	44.0	18.9
2011	8	UQ	22.5	9.2	9.8	1.4	67.0	222.0	83.0	2500.0	30.0	253.0	57.6
2011	9	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2011	9	Median	18.1	9.0	8.8	0.8	68.2	186.0	34.5	1615.0	23.5	165.5	24.0
2011	9	Arithmetic Mean	18.3	8.9	8.4	0.9	77.5	183.6	52.6	1742.2	33.1	170.2	32.3
2011	9	Coefficient of Variation	0.1	0.0	0.3	0.3	0.6	0.2	0.8	0.3	0.8	0.8	0.8
2011	9	LQ	16.6	8.7	6.2	0.7	44.0	144.0	14.0	1520.0	13.0	20.0	6.1
2011	9	UQ	19.9	9.1	10.2	1.0	98.6	207.0	90.0	1830.0	49.0	295.0	61.6
2012	6	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2012	6	Median	16.4	8.1	8.5	1.0	12.0	80.0	32.0	670.5	6.0	25.0	1.0
2012	6	Arithmetic Mean	16.3	8.1	8.5	1.0	15.7	81.9	31.8	683.1	10.9	36.4	1.2
2012	6	Coefficient of Variation	0.1	0.0	0.0	0.1	0.5	0.1	0.1	0.1	0.9	0.7	0.5
2012	6	LQ	15.1	7.9	8.2	0.9	9.5	73.0	29.0	616.0	4.0	20.0	0.8
2012	6	UQ	17.6	8.3	8.7	1.2	24.0	86.0	35.0	719.0	13.0	47.0	1.6
2012	7	N of Cases	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
2012	7	Median	21.1	9.7	8.4	0.6	129.0	187.0	51.0	2120.0	9.0	32.0	21.3
2012	7	Arithmetic Mean	20.7	9.6	8.8	0.6	146.9	202.3	67.5	2188.7	10.3	58.6	36.2

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2012	7	Coefficient of Variation	0.1	0.0	0.2	0.6	0.7	0.5	0.8	0.6	0.4	1.1	1.1
2012	7	LQ	19.5	9.3	7.0	0.4	61.4	99.8	19.0	1097.5	8.0	23.3	13.3
2012	7	UQ	21.8	10.0	10.6	0.9	211.1	276.3	138.5	2800.0	11.8	60.0	43.6
2012	8	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2012	8	Median	21.0	9.1	6.7	0.8	64.6	214.0	84.5	2085.0	34.5	87.5	31.4
2012	8	Arithmetic Mean	21.1	9.1	6.6	0.8	83.9	233.2	91.3	2208.9	44.2	241.2	50.7
2012	8	Coefficient of Variation	0.1	0.0	0.4	0.4	0.8	0.4	0.5	0.3	0.9	1.1	0.9
2012	8	LQ	19.7	8.9	4.4	0.6	43.2	171.0	66.0	1970.0	11.0	55.0	20.3
2012	8	UQ	22.3	9.4	9.5	1.0	103.9	265.0	129.0	2260.0	61.0	454.0	67.4
2012	9	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2012	9	Median	18.1	8.2	7.6	0.8	51.2	92.0	6.5	1520.0	73.0	89.5	3.1
2012	9	Arithmetic Mean	17.8	8.1	7.2	0.8	49.1	88.9	12.3	1519.4	89.7	125.6	4.5
2012	9	Coefficient of Variation	0.1	0.1	0.2	0.3	0.6	0.3	1.1	0.2	0.6	1.0	0.8
2012	9	LQ	16.8	7.8	6.3	0.7	24.9	64.0	4.0	1170.0	41.0	32.0	1.9
2012	9	UQ	18.6	8.4	7.9	1.0	67.8	118.0	14.0	1830.0	146.0	181.0	7.1
2013	6	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2013	6	Median	17.6	9.3	9.5	0.7	64.6	128.0	19.5	1365.0	8.0	16.0	6.6
2013	6	Arithmetic Mean	17.7	9.3	9.9	0.7	78.6	127.7	20.7	1440.7	7.6	19.1	9.3
2013	6	Coefficient of Variation	0.0	0.1	0.1	0.3	0.7	0.2	0.6	0.4	0.3	0.7	1.1
2013	6	LQ	17.3	8.8	9.1	0.6	30.9	107.0	9.0	880.0	4.0	11.0	1.9
2013	6	UQ	18.1	9.8	10.6	0.8	129.0	154.0	31.0	1990.0	9.0	23.0	12.9
2013	7	N of Cases	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
2013	7	Median	22.5	10.0	8.6	0.6	129.0	279.0	109.0	2580.0	4.0	44.0	32.3
2013	7	Arithmetic Mean	22.8	10.0	7.9	0.5	175.3	296.6	103.0	3009.3	5.5	84.5	64.5
2013	7	Coefficient of Variation	0.0	0.0	0.2	0.4	0.7	0.4	0.4	0.5	0.6	1.2	1.1
2013	7	LQ	22.1	9.8	6.8	0.3	99.4	246.0	71.8	2230.0	4.0	12.3	10.8
2013	7	UQ	23.3	10.2	8.9	0.6	226.4	321.8	135.5	3445.0	4.0	142.0	117.6

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2013	8	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2013	8	Median	19.8	8.0	4.5	1.0	24.1	174.0	49.5	1775.0	253.0	260.0	7.8
2013	8	Arithmetic Mean	19.8	8.1	4.6	1.1	36.0	202.3	60.9	1842.8	245.8	271.4	16.1
2013	8	Coefficient of Variation	0.0	0.1	0.5	0.2	1.0	0.7	0.5	0.2	0.7	0.9	1.3
2013	8	LQ	19.3	7.4	2.1	0.9	8.3	105.0	45.0	1450.0	73.0	48.0	2.7
2013	8	UQ	20.3	8.7	6.2	1.3	52.0	225.0	96.0	2140.0	351.0	392.0	19.9
2013	9	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2013	9	Median	16.8	7.6	6.7	0.9	11.0	88.5	29.0	1210.0	313.0	49.5	0.6
2013	9	Arithmetic Mean	16.7	7.6	6.6	0.9	15.6	89.2	29.2	1232.8	306.3	49.9	0.7
2013	9	Coefficient of Variation	0.2	0.0	0.2	0.2	0.7	0.1	0.3	0.1	0.3	0.5	0.6
2013	9	LQ	13.9	7.6	6.4	0.8	9.4	78.0	21.0	1130.0	241.0	33.0	0.4
2013	9	UQ	18.6	7.8	7.5	1.1	16.0	98.0	37.0	1330.0	368.0	58.0	0.7
2014	6	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2014	6	Median	16.7	9.0	9.5	0.7	59.6	160.5	58.5	1313.5	4.0	11.0	4.1
2014	6	Arithmetic Mean	16.8	9.0	9.6	0.8	66.5	162.7	56.2	1398.3	6.6	19.1	3.8
2014	6	Coefficient of Variation	0.1	0.1	0.1	0.4	0.8	0.2	0.4	0.5	0.7	0.8	0.6
2014	6	LQ	15.6	8.3	8.7	0.5	14.0	130.0	42.0	676.0	4.0	9.0	1.6
2014	6	UQ	18.1	9.7	10.5	1.0	112.1	195.0	75.0	2070.0	11.0	26.0	5.4
2014	7	N of Cases	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
2014	7	Median	21.3	9.8	9.6	0.7	79.2	338.0	182.0	2530.0	9.0	36.0	28.7
2014	7	Arithmetic Mean	21.7	9.7	8.8	0.8	116.8	338.6	159.8	2862.6	10.4	125.5	66.9
2014	7	Coefficient of Variation	0.1	0.0	0.3	0.4	1.0	0.3	0.3	0.4	0.8	1.2	1.1
2014	7	LQ	20.1	9.4	7.4	0.5	36.3	247.5	109.8	2000.0	4.0	18.0	14.5
2014	7	UQ	23.6	10.0	10.7	1.0	174.2	396.0	192.3	3270.0	12.0	188.8	95.0
2014	8	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2014	8	Median	20.8	8.2	6.2	0.9	27.8	177.0	66.5	1560.0	174.5	58.0	3.8
2014	8	Arithmetic Mean	20.2	8.3	5.5	0.9	41.7	192.3	82.7	1880.0	195.7	146.4	14.7

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2014	8	Coefficient of Variation	0.1	0.1	0.4	0.3	1.0	0.4	0.6	0.4	0.6	1.4	1.6
2014	8	LQ	18.8	8.0	3.2	0.7	15.4	128.0	47.0	1390.0	100.0	30.0	1.1
2014	8	UQ	21.5	8.7	7.5	1.0	68.9	230.0	116.0	2300.0	313.0	116.0	12.8
2014	9	N of Cases	18.0	18.0	18.0	18.0	17.0	18.0	18.0	18.0	18.0	18.0	18.0
2014	9	Median	18.3	8.0	7.9	1.0	21.7	109.0	30.0	1110.0	14.0	20.0	0.9
2014	9	Arithmetic Mean	18.4	8.1	7.9	1.0	22.1	105.8	27.9	1087.1	17.4	23.7	1.5
2014	9	Coefficient of Variation	0.0	0.1	0.1	0.1	0.4	0.2	0.3	0.2	0.5	0.6	1.1
2014	9	LQ	18.1	7.8	7.7	0.9	13.7	94.0	21.0	956.0	11.0	14.0	0.4
2014	9	UQ	18.8	8.5	8.5	1.1	27.0	113.0	32.0	1200.0	19.0	24.0	2.1
2015	6	N of Cases	13.0	13.0	13.0	9.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
2015	6	Median	20.9	9.0	8.4	1.4	64.7	132.0	53.0	1280.0	12.0	34.0	8.5
2015	6	Arithmetic Mean	20.9	9.0	9.1	1.4	86.0	171.8	48.8	1731.5	12.0	45.8	18.8
2015	6	Coefficient of Variation	0.0	0.0	0.1	0.3	0.9	0.5	0.2	0.7	0.4	0.7	1.3
2015	6	LQ	20.5	8.8	8.3	1.2	37.8	122.3	39.5	935.8	10.3	30.0	6.9
2015	6	UQ	21.5	9.5	10.3	1.5	104.7	186.8	57.0	2007.5	16.1	45.8	18.0
2015	7	N of Cases	22.0	22.0	22.0	18.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
2015	7	Median	21.7	9.3	10.5	0.8	70.8	254.0	126.0	1580.0	16.0	18.0	11.9
2015	7	Arithmetic Mean	22.2	9.3	9.6	0.9	76.9	258.4	137.5	1703.4	31.1	128.7	33.9
2015	7	Coefficient of Variation	0.1	0.0	0.3	0.3	0.5	0.2	0.2	0.3	0.9	1.5	1.3
2015	7	LQ	21.4	8.9	8.6	0.7	49.6	226.0	116.0	1420.0	12.0	16.0	10.1
2015	7	UQ	22.2	9.6	11.2	1.3	96.4	275.0	159.0	1880.0	53.0	176.0	44.8
2015	8	N of Cases	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
2015	8	Median	19.6	9.8	8.6	0.5	112.8	255.0	103.0	2280.0	12.0	21.0	15.0
2015	8	Arithmetic Mean	20.0	9.6	7.5	0.6	126.5	264.6	110.9	2415.9	38.7	97.9	47.2
2015	8	Coefficient of Variation	0.1	0.0	0.3	0.4	0.5	0.2	0.3	0.3	2.0	1.4	1.4
2015	8	LQ	18.7	9.5	5.4	0.5	75.6	237.0	85.5	1857.5	5.0	16.0	11.5
2015	8	UQ	21.9	9.9	9.1	0.8	195.7	277.3	138.0	2697.5	23.3	156.5	64.6

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2015	9	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2015	9	Median	14.4	8.8	6.9	0.7	48.6	124.0	27.0	1550.0	76.0	72.0	6.4
2015	9	Arithmetic Mean	14.7	8.7	6.7	0.7	70.7	156.2	25.5	1973.9	114.1	144.5	14.6
2015	9	Coefficient of Variation	0.1	0.1	0.2	0.3	1.0	0.5	0.5	0.4	0.9	2.1	1.5
2015	9	LQ	13.6	8.3	5.2	0.5	25.2	107.0	18.0	1470.0	34.0	23.0	3.6
2015	9	UQ	16.1	9.2	8.1	0.8	71.2	173.0	34.0	2140.0	160.0	127.0	11.4
2016	6	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2016	6	Median	18.4	9.4	10.5	0.8	68.4	125.0	20.0	1415.0	9.0	17.0	7.8
2016	6	Arithmetic Mean	18.8	9.3	10.8	0.9	67.1	134.3	19.7	1413.1	8.7	20.1	7.4
2016	6	Coefficient of Variation	0.1	0.0	0.1	0.4	0.6	0.3	0.7	0.5	0.5	0.4	0.4
2016	6	LQ	17.1	8.9	9.6	0.6	40.7	101.0	7.0	742.0	4.0	14.0	4.7
2016	6	UQ	21.0	9.6	12.0	1.1	98.6	168.0	27.0	2040.0	13.0	24.0	9.7
2016	7	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2016	7	Median	20.5	10.2	8.8	0.6	145.2	270.0	93.0	2750.0	4.0	16.0	14.2
2016	7	Arithmetic Mean	20.4	10.1	8.5	0.5	176.0	286.5	87.3	3152.2	5.8	33.7	25.7
2016	7	Coefficient of Variation	0.0	0.0	0.2	0.5	0.5	0.2	0.3	0.4	0.4	1.2	1.0
2016	7	LQ	20.0	9.9	8.0	0.3	98.6	246.0	75.0	2120.0	4.0	15.0	12.4
2016	7	UQ	20.8	10.3	9.4	0.7	245.8	343.0	105.0	4780.0	8.0	22.0	19.5
2016	8	N of Cases	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	25.0	25.0
2016	8	Median	22.0	9.1	6.9	0.5	86.4	270.0	84.0	2320.0	9.0	44.0	13.7
2016	8	Arithmetic Mean	21.5	9.2	6.2	0.6	100.7	274.9	78.3	2531.9	15.2	161.3	51.5
2016	8	Coefficient of Variation	0.1	0.0	0.3	0.4	0.5	0.2	0.7	0.3	1.0	1.3	1.2
2016	8	LQ	19.8	8.9	6.1	0.5	65.3	241.5	42.0	2190.0	8.0	24.3	9.8
2016	8	UQ	22.7	9.4	7.2	0.6	125.3	294.3	130.8	2750.0	15.8	323.5	122.7
2016	9	N of Cases	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2016	9	Median	14.9	8.4	8.6	0.6	29.7	132.5	4.5	1585.0	10.0	16.5	1.1
2016	9	Arithmetic Mean	15.1	8.4	8.5	0.6	30.3	137.7	5.8	1626.1	19.1	30.9	1.6

Year	Month	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2016	9	Coefficient of Variation	0.1	0.0	0.1	0.2	0.3	0.3	0.5	0.2	1.3	0.9	0.6
2016	9	LQ	14.6	8.2	8.3	0.5	21.4	98.0	4.0	1280.0	4.0	14.0	0.9
2016	9	UQ	15.5	8.5	9.1	0.7	38.3	173.0	6.0	1860.0	17.0	33.0	1.9
2017	6	N of Cases	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0
2017	6	Median	18.8	8.7	8.3	1.4	20.0	113.0	51.0	730.0	11.0	23.0	5.4
2017	6	Arithmetic Mean	18.8	8.8	8.6	1.3	29.5	112.5	49.7	784.6	10.6	28.4	5.1
2017	6	Coefficient of Variation	0.0	0.0	0.1	0.2	0.7	0.2	0.2	0.3	0.4	0.6	0.5
2017	6	LQ	18.2	8.5	7.8	1.2	15.7	98.0	41.0	676.0	8.0	17.0	2.6
2017	6	UQ	19.1	9.0	8.9	1.4	43.8	123.0	57.0	888.0	14.0	31.0	6.6
2017	7	N of Cases	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0
2017	7	Median	22.6	9.4	8.8	0.6	153.4	256.0	100.5	2280.0	11.0	40.0	20.3
2017	7	Arithmetic Mean	22.6	9.4	8.6	0.6	145.9	240.2	93.3	2408.2	11.4	70.3	32.7
2017	7	Coefficient of Variation	0.0	0.0	0.2	0.4	0.4	0.3	0.6	0.3	0.3	0.9	0.8
2017	7	LQ	22.3	9.3	7.3	0.5	99.4	169.0	43.0	2040.0	10.0	16.0	10.5
2017	7	UQ	22.9	9.7	10.4	0.8	180.7	291.0	142.0	2810.0	12.0	115.0	44.6
2017	8	N of Cases	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0
2017	8	Median	21.5	9.0	6.5	0.6	110.6	327.0	158.0	2800.0	13.0	358.0	59.4
2017	8	Arithmetic Mean	21.8	9.0	6.5	0.8	146.6	332.5	150.8	3056.1	21.1	374.8	83.4
2017	8	Coefficient of Variation	0.1	0.1	0.3	0.7	0.7	0.2	0.3	0.3	1.0	0.9	0.8
2017	8	LQ	20.9	8.7	5.3	0.5	65.3	288.5	123.0	2420.0	11.0	37.8	14.5
2017	8	UQ	22.9	9.4	8.4	1.1	232.4	368.0	182.0	3580.0	16.0	612.0	148.5
2017	9	N of Cases	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0
2017	9	Median	13.0	8.7	9.9	0.7	102.8	213.0	38.0	2255.0	22.0	26.0	4.0
2017	9	Arithmetic Mean	13.0	8.7	10.2	0.7	176.8	302.7	43.8	3299.1	33.3	64.8	7.1
2017	9	Coefficient of Variation	0.1	0.0	0.2	0.4	1.6	1.3	0.5	1.3	0.8	1.2	1.1
2017	9	LQ	11.9	8.6	9.0	0.5	91.8	169.0	25.0	2000.0	9.0	19.0	1.8
2017	9	UQ	14.1	8.9	11.5	0.8	152.0	228.0	58.0	2600.0	56.0	71.0	7.4

PPENDIX II: 2017 Seasonal trends in silica and other nutrient parameters in UKL and UKL Outflow (lake-wide mean shown with standard error).

2017 Seasonal trends in silica and other nutrient parameters by station in UKL

NB
ER
WB
AS
AN
TP, SRP, Chl, NO3, NH4 (ug/L)
SiO2 (ug/L)
DATE
05/01/2017
06/01/2017
07/01/2017
08/01/2017
09/01/2017
10/01/2017
11/01/2017
SiO2
TP
SRP
MCHL
NO3
NH4

APPENDIX III: Chlorophyll-a adjustment to account for method change from spectrophotometric to fluorometric in 2009.

Chlorophyll-a was adjusted to account for a change from spectrophotometric method to fluorometric method beginning in 2009. Between 1990 and 2008 the spectrophotometric method was used by the Aquatic Research Inc. laboratory (ARI) and beginning in 2009 the Sprague River Water Quality Lab (SRWQL) used the fluorometric method. The fluorometric method is more sensitive so values beginning in 2009 are higher relative to years prior to 2009- especially at higher Chl levels. The adjustment is based on 225 split samples collected between 2007 and 2008 that were analyzed by both labs). The adjusted values are used for all time-series comparisons that include data prior to 2009, and the un-adjusted values are used when evaluating individual years.

Comparison of Spectrophotometric Chl-a performed at ARI Lab and Fluorometric Chl-a performed at SRWQL

```
##
## Call:
## lm(formula = LOG_MCHL_DUP ~ LOG_MCHL, data = filter(df_ari, !OUTLIER))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.41490 -0.06147  0.01417  0.06789  0.30471
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.18283    0.01904   9.601   <2e-16 ***
## LOG_MCHL     0.87895    0.01070  82.135   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1106 on 224 degrees of freedom
## Multiple R-squared:  0.9679, Adjusted R-squared:  0.9677
## F-statistic:  6746 on 1 and 224 DF,  p-value: < 2.2e-16
```