RioTinto

B.C. Works SO_2 EEM Program – Technical Memo W09

Aquatic Ecosystems Actions and Analyses

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1 Introduction

This Technical Memo provides additional information on the data and analyses in support of the 2020 requirements for the Aquatic Ecosystems component of the B.C. Works' Sulphur Dioxide Environmental Effects Monitoring (EEM) Program (draft SO_2 EEM Phase III Plan, ESSA et al. 2021). These data and analyses thus provide the foundation for Section 3.4 in the 2020 Annual Report.

Relative to previous years, this Technical Memo is streamlined to focus primarily on the data and analyses relevant to the evaluation of the KPI.

This technical memo applies methods and approaches that have already been described in detail in other relevant documents. Most of the methods follow those employed in the SO_2 Technical Assessment Report (STAR) (ESSA et al. 2013), the Kitimat Airshed Assessment (KAA) (ESSA et al. 2014a) and the 2019 EEM Comprehensive Review Report (ESSA et al. 2020). Full details on the collection, processing and analysis of the water chemistry samples are reported in technical reports prepared by Limnotek for each year's sampling (Perrin et al. 2013; Perrin and Bennett 2015; Limnotek 2016; Bennett and Perrin 2017, 2018; Limnotek 2019, 2020, 2021). Wherever possible, the description of methods in this technical report refers to these reports instead of repeating information that is already well-documented elsewhere.

The following four documents (as described above) are listed here because they are referenced throughout this technical memo, often without their full citation:

- The STAR (ESSA *et al*. 2013)
- The KAA (ESSA *et al.* 2014a)
- 2019 EEM Comprehensive Review Report (ESSA et al. 2020)
- The EEM Phase III Plan (ESSA et al. 2021)

2 Methods

2.1 Water Chemistry Sampling

EEM Lakes

The EEM long-term sampling plan includes eleven lakes: seven sensitive lakes, one less sensitive lake, and three control lakes (ESSA et al. 2021). The three control lakes (NC184, NC194 and DCAS14A) are all located outside of the zone of sulphur deposition from B.C. Works, and have pre-KMP baseline data for 2013 from sampling as part of the KAA (ESSA et al., 2014a).

In 2020, Limnotek sampled six of the eleven EEM lakes according to the 2020 Aquatics Work Plan, which had a reduced scope due to COVID-19. Lakes not sampled in 2020 include LAK016, (a less sensitive lake), LAK022 (a sensitive lake) and the control lakes (DCAS14A, NC184, and NC194). The sampling methodology is described in detail in Limnotek's technical report on the water quality monitoring (Limnotek 2021). Table 2-1 summarizes all of the EEM sites sampled during 2012-2020. Figure 2-1 shows a map of the lakes sampled in 2020.

Table 2-1. Summary of sampling sites within the EEM Phase III Program. The rationale for lakes included in the Phase III EEM program is described in ESSA et al. 2021.

Sample Site	Year of Sampling									Role in Phase III EEM Program and sampling in 2020.
	2012	2013	2014	2015	2016	2017	2018	2019	2020	
	STAR	EEM	EEM	EEM	EEM	EEM	EEM	EEM	EEM	
Lake 006	✓	✓	✓	✓	✓	✓	✓	✓	✓	EEM sensitive lake, included in Phase III
Lake 012	✓	✓	✓	✓	✓	✓	✓	✓	✓	EEM sensitive lake, included in Phase III
Lake 022	✓	✓	✓	✓	✓	✓	✓	✓		EEM sensitive lake only accessible by helicopter, included in Phase III but not sampled in 2020 due to COVID.
Lake 023	✓	✓	✓	✓	✓	✓	✓	✓	✓	EEM sensitive lake, included in Phase III
Lake 028	✓	✓	✓	✓	✓	✓	✓	✓	✓	EEM sensitive lake, included in Phase III
Lake 042	✓	✓	✓	✓	✓	✓	✓	✓	✓	EEM sensitive lake, included in Phase III
Lake 044	✓	✓	✓	✓	✓	✓	✓	✓	✓	EEM sensitive lake, included in Phase III
Lake 016	✓	✓	✓	✓	✓	✓	✓	✓		EEM less sensitive lake, included in Phase III but not sampled in 2020.
NC184		✓†		✓	✓	✓	✓	✓		EEM control lakes added to EEM in 2015. Only accessible by helicopter, included in Phase III but not sampled in 2020 due to COVID.
NC194		✓†		✓	✓	✓	✓	✓		
DCAS14A		✓†		✓	✓	✓	✓	✓		

† Sampled as part of the Kitimat Airshed Assessment (ESSA et al. 2014a).

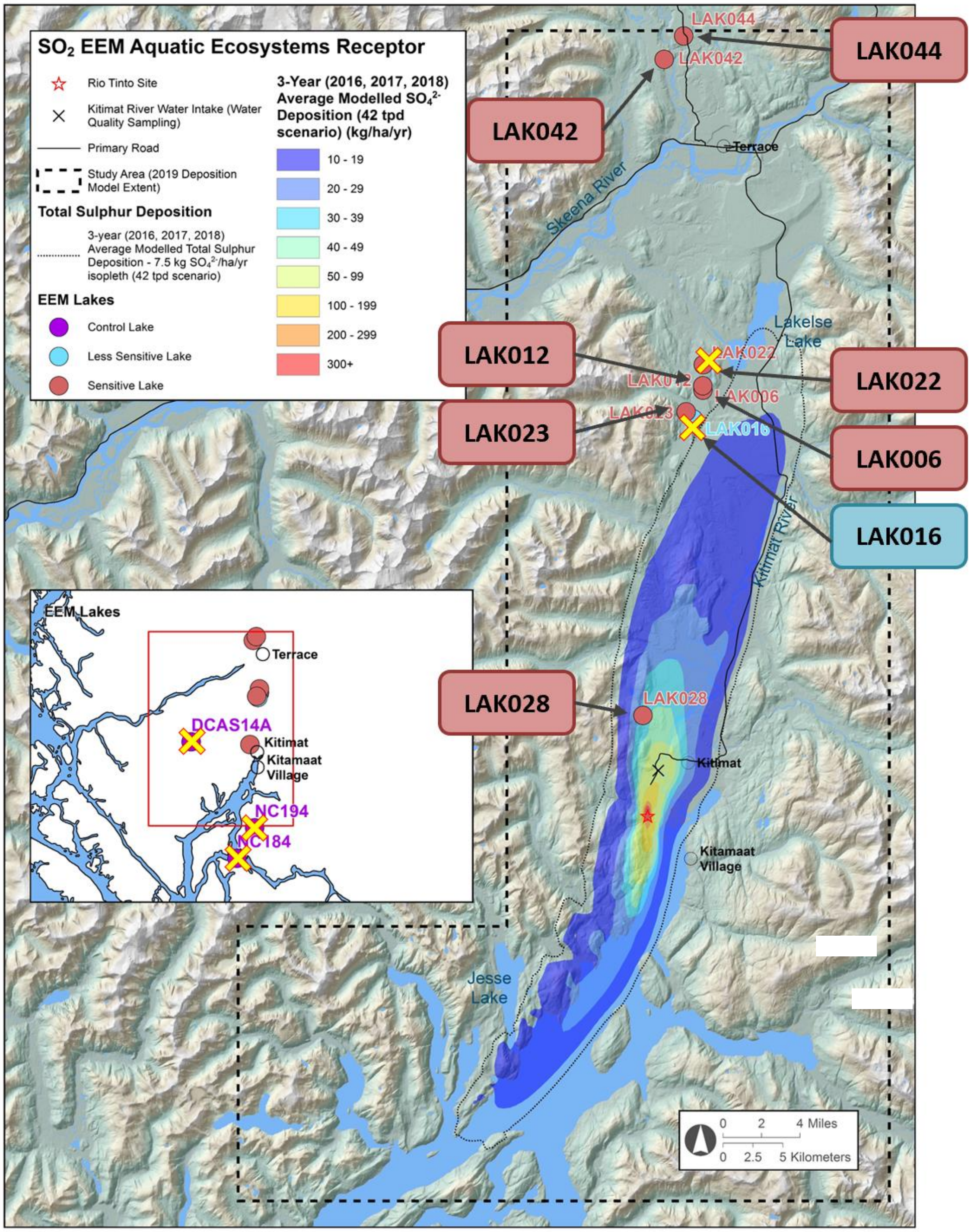


Figure 2-1. Location of the lakes in the EEM Program, including seven sensitive lakes (red), one less sensitive lake (blue) and three control lakes (purple). The 'X' symbols indicate lakes that are part of the Phase III EEM Program but were not sampled in 2020.

Sampling frequency

The only difference in sampling frequency from the last several years was a reduction in the sampling frequency of sensitive lakes, due to budgetary constraints: LAK006, LAK012, LAK023, LAK042, and LAK044 were sampled 2 times within the Fall index period, and LAK028 was sampled 3 times within the Fall index period, whereas all 6 lakes had been sampled 4 times in previous years.

Continuous monitoring

Two lakes (LAK006, LAK028) had continuous monitoring of surface water pH, temperature and lake levels. LAK028 also had a similar instrument installed at depth. This work was planned, implemented and documented by Limnotek. The methods and results for 2020 are reported in Limnotek (2021).

Water chemistry data

The only difference in the water chemistry data from the 2020 sampling compared to previous years is that the analyses of Gran ANC, pH and conductivity are now *only* performed by the BASL facility (University of Alberta). In 2019, samples taken during the fall index period had duplicate samples sent to BASL and Trent University to enable cross-lab comparisons to support this transition (see Limnotek 2020).

Integrating laboratory measurements of pH and Gran ANC from Trent and BASL laboratories

The planned transition of laboratory analysis of pH and Gran ANC from Trent University to the BASL laboratory at the University of Alberta is now complete. In 2019, duplicate samples were sent to both laboratories to facilitate cross-laboratory comparisons (see Limnotek 2020). In 2020, samples were analyzed only by BASL.

To facilitate analyses over the entire period of record, we needed to develop an “integrated” data series for each of the two metrics. Our method, described below, was advised by Dr. Carl Schwarz (retired professor of statistics from Simon Fraser University).

Given the long time series from Trent University (2012 to 2019) and only one year with only BASL data (2020), we treated this as a “missing data problem” where the “missing values” are Trent values for 2020 that must be imputed based on comparisons of data from the two labs in 2019. The same procedure could work in reverse but given that we currently have only a single year without a Trent value, the approach of converting the BASL values to *imputed* Trent values has the smallest increase in uncertainty.

The imputation of the 2020 values was based on the regression of Trent values vs. BASL values from the 2019 data. Similar to the cross-laboratory comparison conducted by Limnotek (2020), we used the full data set of all the samples from the fall index period for 2019, including all of the field duplicates, but excluding samples with Gran ANC > 4 mg/L (or ~80 μeq/L), as these waters are not sensitive to acidification. This criterion excluded all four less sensitive lakes, and deepwater samples from LAK028. Those samples were excluded so that the higher Gran ANC values (in many cases an order of magnitude higher) did not bias the functional relationship for the sensitive lakes. Four additional samples (out of 48) were excluded because the differences between the results from the two laboratories were markedly higher than the range for the remaining samples. Those four excluded samples included one field duplicate sample for LAK006 and one sample (out of 4) for each of the three control lakes (not all from the same sampling date).

After imputing the "missing" values, we needed to adjust the subsequent analysis to account for the imputation uncertainty. It is expected that the imputation uncertainty only contributes a small amount of uncertainty to the final result, given the extent of variation across years at each lake for each of the KPI and informative indicator values. Sensitivity analyses were performed to assess the sensitivity of the primary Bayesian statistical analyses used in this report (i.e., as described in Section 2.3) to the uncertainty associated with the imputation procedure. Five time series were analyzed for each "integrated" metric (i.e., pH and Gran ANC): using the predicted value for 2020, using the predicted value +/- 1 SD, and using the predicted value +/- 2 SD, where the SD is based on the prediction interval in the imputation procedure. The results of these sensitivity analyses are included in Appendix 4.

2.2 Empirical Changes in Water Chemistry

The methods applied for examining empirical changes are the same as described in the last several years. The one exception is for the analyses of inorganic aluminum, which has not been measured every year.

Inorganic Aluminum

Aluminum is of interest because of the concern for toxic effects on aquatic ecosystems.

As described in the STAR (see Section 9.4.1.2.4; based on the 2012 sampling data):

> *Levels of both dissolved aluminum and dissolved organic carbon (DOC) increased as pH decreased, consistent with other studies (Baker et al. 1991). This pattern is expected due to greater solubility of aluminum at low pH, and increased acidity (lower pH) with higher contributions of organic anions. It is likely that most of the aluminum in lower pH sites was complexed with organic anions, which renders it less toxic to fish (Baker et al. 1990). Lakes in the study area have higher levels of both aluminum and DOC than streams for a given pH.*

As described in the Comprehensive Review (see "Inorganic Aluminum" in Section 7.1.2.3.2 of Appendix 7):

> *Inorganic monomeric aluminum (Al_{im}) is strongly linked with toxicity to fish and other aquatic organisms and is therefore frequently interpreted to represent the bioavailable fraction of aqueous aluminum. Differing levels of particulate matter and aluminum complexation in natural surface waters mean that total aluminum and dissolved aluminum do not always correlate well with aquatic toxicity. As part of the EEM Program, Al_{im} was measured in 2013 for 12 of the 14 water chemistry samples taken. Al_{im} is more difficult to measure and therefore was only a one-time addition only to the water chemistry analyses. It was also added again in 2019. However, total aluminum and dissolved aluminum have been measured ever year.*

The Comprehensive Review concluded:

> *Based on these simple exploratory analyses of Al_{im} from 2013, LAK028 would be the only lake for which concerns regarding potential aluminum toxicity are strongly indicated but LAK042 might also be flagged for further observation based on these*

results. It appears from this preliminary analysis that BCS provides sufficient information on the potential for toxic conditions without the additional measurement of Al_{im} , but we can check on this preliminary conclusion with the data on Al_{im} collected in the fall of 2019.

The Comprehensive Review recommended that additional data could provide a better understanding of the patterns and relationships between Al_{im} and other water chemistry properties but did not recommend adding Al_{im} as an ongoing sampling component of the Phase III EEM Program, proposing instead that BCS be used as an indicator of Al toxicity concerns.

This Annual Report repeats the analyses conducted in the Comprehensive Review with the 2020 data and compares those results to the 2013 and 2019 data, with the primary objective of determining whether the same conclusions hold true when examined with data from an additional year. The 2020 data include a total of 23 observations of Al_{im} from surface waters, in addition to the 51 data points in 2019 and 12 in 2013.

2.3 Statistical Analyses of Changes in Water Chemistry

The 2019 Comprehensive Review performed an extensive series of statistical analyses of changes in water chemistry and concluded that the results from the Bayesian statistical analyses provided the greatest ability to assess the level of support for different hypotheses of chemical change. The 2019 Comprehensive Review further recommended that these analyses be re-run on an annual basis to assess status and detect any anomalous patterns. This annual report represents the second iteration of re-running those analyses with more recent monitoring data. These methods are described in detail in Appendix F of the 2019 Comprehensive Review Report (see Bayesian Method 1 especially). The key metrics of interest are the differences in lake chemistry between the post-KMP average for the last three years (2018-2020) and the pre-KMP baseline (2012 for the sensitive and less sensitive lakes; 2013 for the control lakes). For the lakes that were not sampled in 2020, the post-KMP period used to compute average lake chemistry was 2018-2019. Appendix 3 includes sensitivity analyses that examine: a) the effect of using an alternative baseline representing the transition period as operations at the old smelter were wound down (2012-2014); and, b) the effect of using an alternative post-KMP period, the four years from 2017 to 2020. The ideal duration used for the post-KMP period is a compromise between the benefits of using many years of the post-KMP data to assess average conditions, and the risk of not detecting recent changes if many years' data are used to compute average values. The 3-year duration used in this report for the post-KMP period represents a reasonable compromise.

The results of the Bayesian statistical analyses are expressed in terms of: a) the % belief that the post-KMP values have exceeded the *level of protection* thresholds, and b) the % belief that the changes from the baseline period to the post-KMP period have exceeded the *change limit* thresholds. As applied in the 2019 Comprehensive Review, the % belief values are classified as low (< 20%), moderate (20% to <80%), or high (≥ 80%), both for ease of interpretation and for the purpose of integrating the analyses for the two-threshold structure (i.e., the *level of protection* and the *change limit*) of the CBANC KPI and acidification informative indicators (pH, Gran ANC and BCS) into a single assessment for each indicator for each lake. As described in the Phase III Plan, these acidification indicators (CBANC, pH, Gran ANC and BCS) are only considered to be in exceedance if **both** thresholds are exceeded. The single, integrated assessment of each of those indicators is determined according to the rules:

1. If the result for **either** threshold is **"low"**, then the overall assessment is **"low"**
2. The results for **both** thresholds must be **"high"** for an overall assessment of **"high"**
3. If result for **either** threshold is **"moderate"** and the results for the other threshold are "moderate" or "high", then the overall assessment is **"moderate"**.

As described in the EEM Phase III Plan, the two-threshold structure avoids creating false positives by simultaneously considering the two dimensions of importance to aquatic organisms – the absolute level and the relative change in the water chemistry metrics used as acidification indicators.

Appendix 4 includes the results of the sensitivity analyses for the uncertainty associated with the imputation procedure associated with developing integrated data series for pH and Gran ANC following the transition of laboratories (details in Section 2.1).

The Bayesian before-after control-impact (BACI) analyses were not performed this year because the control lakes were not sampled in 2020.

2.4 Environmental Data

This section includes supplementary environmental observations or data utilized in the interpretation of the water chemistry results (see Section 4.3).

Precipitation monitoring at the Lakelse NADP site indicate that 2020 had the highest annual precipitation (183.4 cm) in the 8 years of monitoring that began in 2013; the annual precipitation in 2020 was 26% higher than the 2013-2020 average value of 145.2 cm. See section 3.1 of the main report (Atmospheric Pathways)

Higher precipitation in the late summer of 2020 (303 mm in August and September 2020, vs 173 mm in August and September 2019[1]) led to a 40-50 cm increase in lake levels in LAK042, which has no apparent inlet or outlet (C. Perrin and S. Bennett, Limnotek, pers. comm. and photographic evidence –Figure 4-2).

2.5 Episodic Acidification

We reviewed the data record from the continuous pH monitors installed in LAK006 and LAK028 to identify any notable drops in pH. If any such changes were observed, we compared those results with the lake-level data to determine if it appeared to be driven by high inflows to the lake.

[1] Source: Data from climate station *Terrace A*; accessed via Environment Canada's *Historical Climate Data* web portal (http://climate.weather.gc.ca)

2.6 Alignment of Evidentiary Framework with Phase III Indicators

The "Simple Evidentiary Framework" developed in the 2019 Comprehensive Review and subsequently built into the Phase III Plan only considers post-KMP changes in pH and ANC[2] (relative to pre-KMP conditions), especially relative to the *change limit* thresholds, but does not consider the post-KMP state of either or those metrics with respect to the *level of protection* thresholds. This is not consistent with the important advance in the EEM Phase III Plan of moving to a two-threshold structure for the KPI and the pH and ANC informative indicators that consider both relative change and the absolute level of those indicators.

To be consistent with the EEM Phase III Plan, we have revised the Evidentiary Framework by adding an assessment node associated with the *level of protection* threshold (Figure 2-2). The new node is inserted earlier in the logic sequence than the two nodes assessing the level of change. In the two-threshold structure for the KPI and informative indicators, neither of the thresholds takes precedence – an exceedance of the indicator requires that both thresholds are exceeded with a high percent belief. Therefore, there is no inherent sequence between evaluating the *change* limit and *level of protection* thresholds. However, in the Evidentiary Framework, there is an additional node that considers whether there has been any change in the indicator prior to assessing against the *change limit* threshold, which makes the framework more precautionary, so we believe it makes more sense to have the *level of protection* node earlier in the sequence than the two change-based nodes.

[2] Gran ANC in the 2019 Comprehensive Review; CBANC in the Phase III Plan (consistent with the revised KPI).

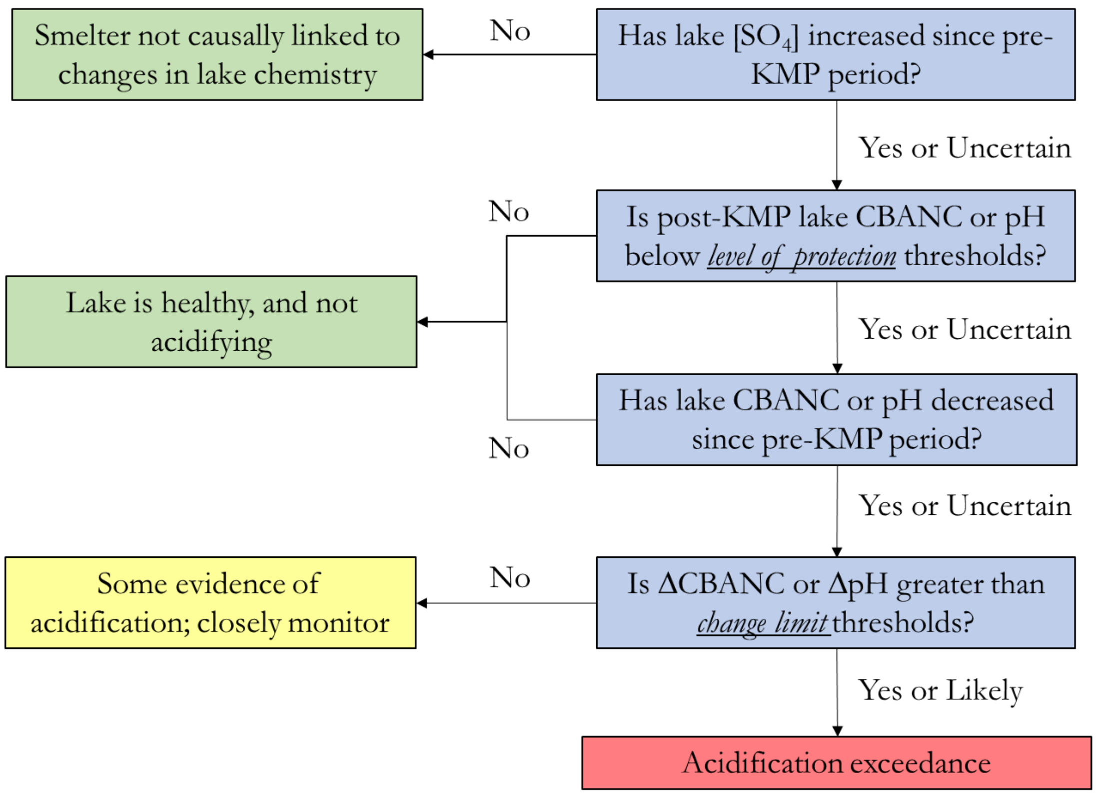


Figure 2-2. The Evidentiary Framework. The framework developed in the 2019 Comprehensive Review has been revised in order to align with the two-threshold structure for the KPI and informative indicators in the EEM Phase III Plan.

3 Results

3.1 Empirical Changes in Water Chemistry

Empirical changes in ANC, pH, SO_4^{2-}, DOC, sum of base cations, chloride, and calcium are shown in Table 3-1. Changes are reported in terms of the difference between the post-KMP average (2018-2020) and the pre-KMP baseline (2012 for the sensitive and less sensitive lakes; 2013 for the control lakes). The sensitive EEM lakes and less sensitive EEM lakes are presented separately within each of the tables. The inter-annual changes presented in this report use the mean annual values whenever multiple within-season samples were taken for a given lake in a given year.

Unlike the annual reports prior to the 2019 Comprehensive Review, the annual changes between individual years are no longer reported and analyzed. As already stated in previous years (e.g., ESSA 2018), year-to-year changes should be interpreted cautiously:

> *"... annual changes should be interpreted with substantial caution due to the combination of large natural variation (both within and between years) and limitations on measurement precision... multiple years of observations are required to reliably detect changes in mean pH, Gran ANC and SO4; it is risky to draw conclusions based only on annual changes".*

Furthermore, in the December 2018 workshop on the terms of reference for the EEM comprehensive review, the ENV external acidification expert recommended that we stop reporting annual changes because inter-annual variability in lake chemistry is too variable to make any meaningful interpretation of the changes between two years.

Figure 3-1 and Figure 3-2 show the changes in the same water chemistry parameters graphically. These figures allow better visualization of the distribution and variability in the observed changes between 2012 and 2018-2020.

For additional reference, Table 3-2 and Table 3-3 shows the CBANC and pH values, respectively, over the period of record for EEM lakes, average values for the post-KMP period (2018-2020) and the differences between the post-KMP period and both the pre-KMP baseline (2012) and the transition period baseline (2012-2014).

Appendix 2 provides a detailed set of figures showing the inter-annual changes in major water chemistry metrics (CBANC, Gran ANC, BCS, pH, SO_4^{2-}, base cations, calcium, chloride, and DOC) for each of the EEM lakes across the nine years of annual monitoring (2012-2020). Similar figures are also included for the three control lakes based on their six years of annual monitoring (2013 and 2015-2020).

Table 3-1. Empirical changes in CBANC, Gran ANC, BCS, pH, SO_4^{2-}, DOC, base cations, chloride, and calcium for EEM lakes, 2012-2020. These values represent the difference between the average of the post-KMP period (2018-2020) and the 2012 baseline. For lakes not sampled in 2020, the changes represent the difference between the 2018-2019 average and the 2012 baseline. Numbers shown are the value in the later period minus the value in the earlier year. Increases are shaded in green; decreases are shaded in red. The Gran ANC and pH values are based on the "integrated" time series (i.e., values from the Trent University laboratory from 2012 to 2019 with the 2020 values imputed from the 2020 values measured by the BASL laboratory ("integ"); see details in Section 2.1)

	CBANC (µeq/L)	Gran ANC (integ) (µeq/L)	BCS (µeq/L)	pH (integ)	SO4* (µeq/L)	DOC (mg/L)	∑ BC* (µeq/L)	Cl (µeq/L)	Ca* (µeq/L)
Sensitive Lakes									
Lak006	15.3	7.3	12.5	0.3	4.5	0.6	19.9	0.7	9.4
LAK012	-4.8	5.6	-12.2	0.4	8.5	1.5	3.8	3.4	-2.7
LAK022 **	7.8	5.3	5.4	0.2	16.0	0.5	23.9	1.1	13.7
LAK023	15.6	3.4	6.4	0.2	-5.2	1.8	10.5	0.6	6.3
LAK028	-9.0	6.6	-13.2	0.1	78.1	0.8	69.9	3.1	49.3
LAK042	13.5	21.0	14.2	0.4	0.9	-0.1	14.6	0.1	7.6
LAK044	6.2	2.7	4.4	0.1	-1.5	0.3	4.9	1.0	1.7
Total ↑	**5**	**7**	**5**	**7**	**5**	**6**	**7**	**7**	**6**
Total ↓	**2**	**0**	**2**	**0**	**2**	**1**	**0**	**0**	**1**
Less Sensitive Lake									
LAK016 **	6.8	23.1	2.7	0.3	12.9	0.8	19.8	1.9	10.5
Total ↑	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Total ↓	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Control Lake									
DCAS14A **	26.5	8.4	27.9	0.2	7.7	-0.3	31.0	-1.1	21.5
NC184 **	10.2	18.3	27.3	0.3	2.1	-3.4	12.1	-4.1	12.5
NC194 **	9.2	0.2	9.5	-0.1	-0.9	-0.1	8.4	-0.5	6.7
Total ↑	**3**	**3**	**3**	**2**	**2**	**0**	**3**	**0**	**3**
Total ↓	**0**	**0**	**0**	**1**	**1**	**3**	**0**	**3**	**0**

** not sampled in 2020

Table 3-2. CBANC values over period of record for EEM lakes, average CBANC values for the post-KMP period and the relative change from the pre-KMP baseline and the transition period baseline. The post-KMP averaging period applied in the 2019 comprehensive review (CR) is also shown for reference. Green represents an increase and red represents a decrease. Bolded purple values are below the 20 µeq/L *level of protection* threshold for CBANC.

	Mean CBANC values (µeq/L)									Post-KMP averaging period		Change from baseline to current post-KMP average (2018-20)	
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2016-18 (CR)	2018-20 (current)	From pre-KMP baseline (2012)	From transition period baseline (2012-14)
LAK006	49.2	43.1	52.9	55.1	56.9	58.0	59.3	63.8	70.3	58.0	64.5	15.3	16.1
LAK012	114.5	97.5	99.8	106.1	103.2	101.1	90.4	96.5	142.1	98.2	109.7	-4.8	5.7
LAK022	67.9	62.0	76.1	75.2	80.3	70.4	76.6	74.8		75.8	75.7	7.8	7.0
LAK023	46.9	37.7	59.4	58.0	59.5	59.9	61.3	59.4	66.6	60.2	62.5	15.6	14.5
LAK028	**16.0**	**-8.1**	31.2	38.6	**12.3**	**0.7**	**8.4**	**4.5**	**8.0**	**7.1**	**7.0**	-9.0	-6.0
LAK042	47.2	55.1	51.6	55.4	64.0	63.1	50.4	52.1	79.5	59.2	60.7	13.5	9.4
LAK044	**8.0**	**8.9**	**12.6**	**16.4**	**13.9**	**13.8**	**13.2**	**14.8**	**14.5**	**13.6**	**14.2**	6.2	4.3
LAK016	127.2	108.7	132.5	147.1	140.8	125.3	138.1	129.8		134.7	134.0	6.8	11.2
DCAS14A		53.5		74.9	72.7	67.8	79.0	81.1		73.2	80.1	26.5	26.5
NC184		80.4		73.0	94.6	76.3	95.0	86.1		88.6	90.6	10.2	10.2
NC194		35.6		40.9	40.0	46.5	43.1	46.7		43.2	44.9	9.2	9.2

Table 3-3. pH values over period of record for EEM lakes, average pH values for the post-KMP period and the relative change from the pre-KMP baseline and the transition period baseline. The post-KMP averaging period applied in the 2019 comprehensive review (CR) is also shown for reference. Green represents an increase and red represents a decrease. Bolded purple values are below the *level of protection* threshold for pH (6.0). As explained in the STAR, the 2012 chemistry of most of the sensitive lakes was influenced by organic acids contributed by DOC. Mean DOC has not changed much in the sensitive lakes since 2012 (Figure 3-1).

	Mean pH values									Post-KMP averaging period		Change from baseline to current post-KMP average (2018-20)	
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2016-18 (CR)	2018-20 (current)	From pre-KMP baseline (2012)	From transition period baseline (2012-14)
LAK006	**5.8**	6.2	6.1	6.0	6.0	6.0	6.1	6.1	6.0	6.0	6.1	0.3	0.1
LAK012	**5.6**	6.3	6.0	6.0	6.2	6.1	6.2	6.1	6.0	6.2	6.1	0.4	0.1
LAK022	**5.9**	6.2	6.3	6.1	6.1	6.1	6.1	6.1		6.1	6.1	0.2	0.0
LAK023	**5.7**	6.0	**5.9**	**5.9**	**5.9**	**5.9**	6.0	**5.8**	**5.9**	**5.9**	**5.9**	0.2	0.0
LAK028	**5.0**	**5.2**	**5.3**	**5.1**	**5.0**	**4.8**	**5.3**	**5.2**	**4.9**	**5.0**	**5.1**	0.1	-0.1
LAK042	**4.7**	**5.5**	**5.1**	**5.4**	**5.4**	**5.2**	**5.1**	**5.4**	**4.6**	**5.2**	**5.0**	0.4	0.0
LAK044	**5.4**	**5.7**	**5.8**	**5.8**	**5.5**	**5.6**	**5.5**	**5.5**	**5.6**	**5.6**	**5.5**	0.1	-0.1
LAK016	6.3	6.7	6.7	6.8	6.6	6.7	6.7	6.6		6.7	6.6	0.3	0.1
DCAS14A		6.5		6.6	6.6	6.6	6.8	6.6		6.6	6.7	0.2	0.2
NC184		5.7		5.5	5.8	5.4	6.2	5.7		5.8	6.0	0.3	0.3
NC194		6.6		6.5	6.4	6.4	6.5	6.4		6.4	6.4	-0.1	-0.1

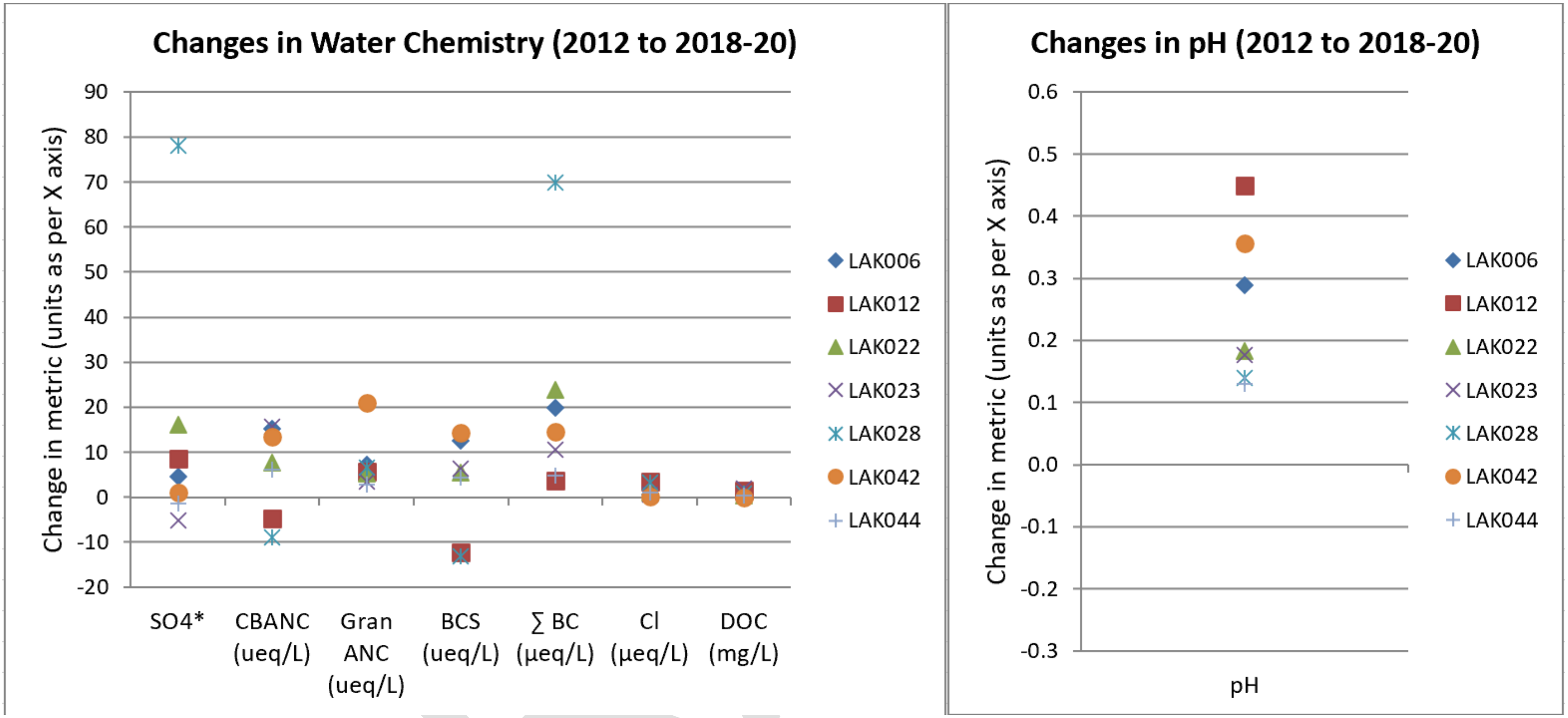


Figure 3-1. Changes in water chemistry metrics (left panel) and pH (right panel) across all of the sensitive EEM lakes, from 2012 to 2018-2020. Values shown are the mean 2018-2020 value minus the mean 2012 value. The large increase in lake SO_4^{2-} in LAK028 has been buffered by a large increase in base cations, due to cation exchange in watershed soils.

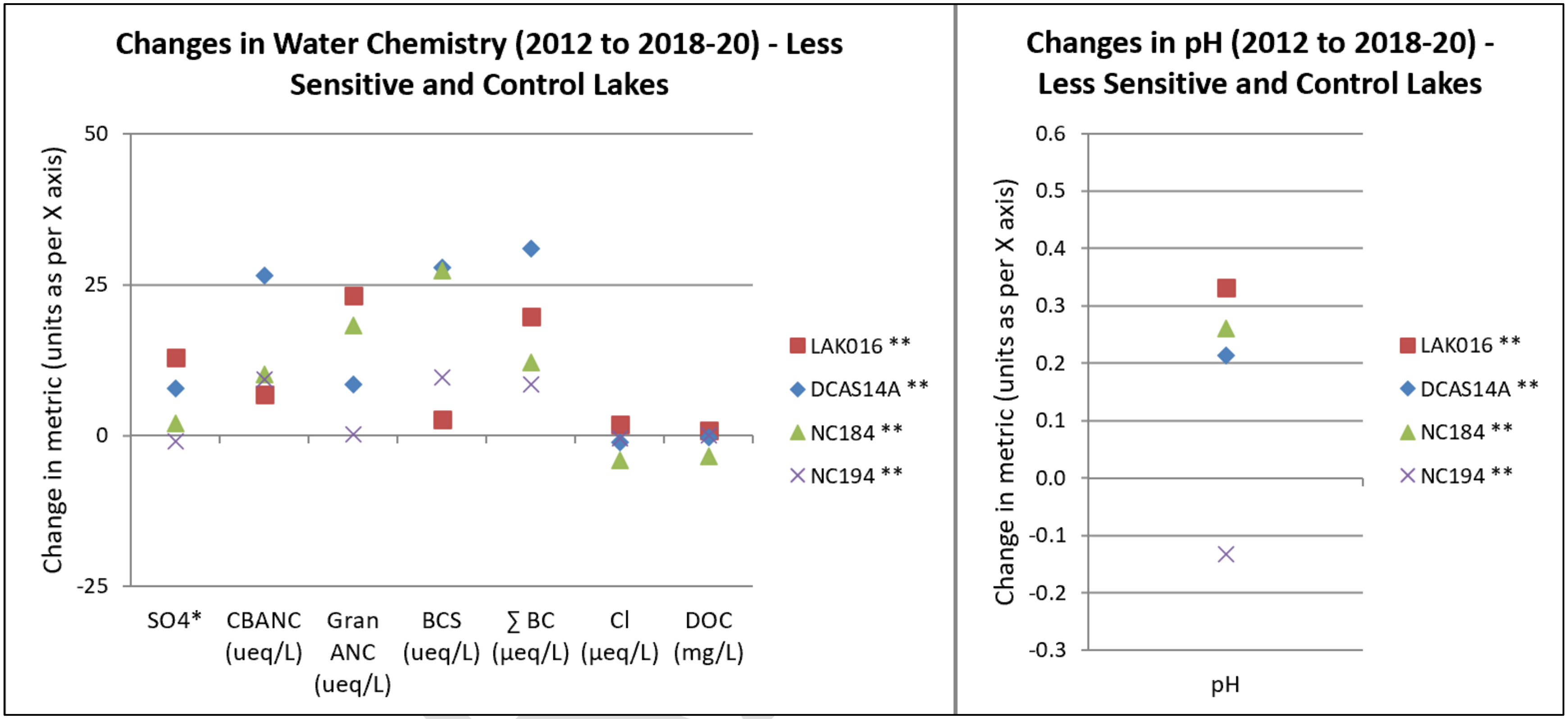
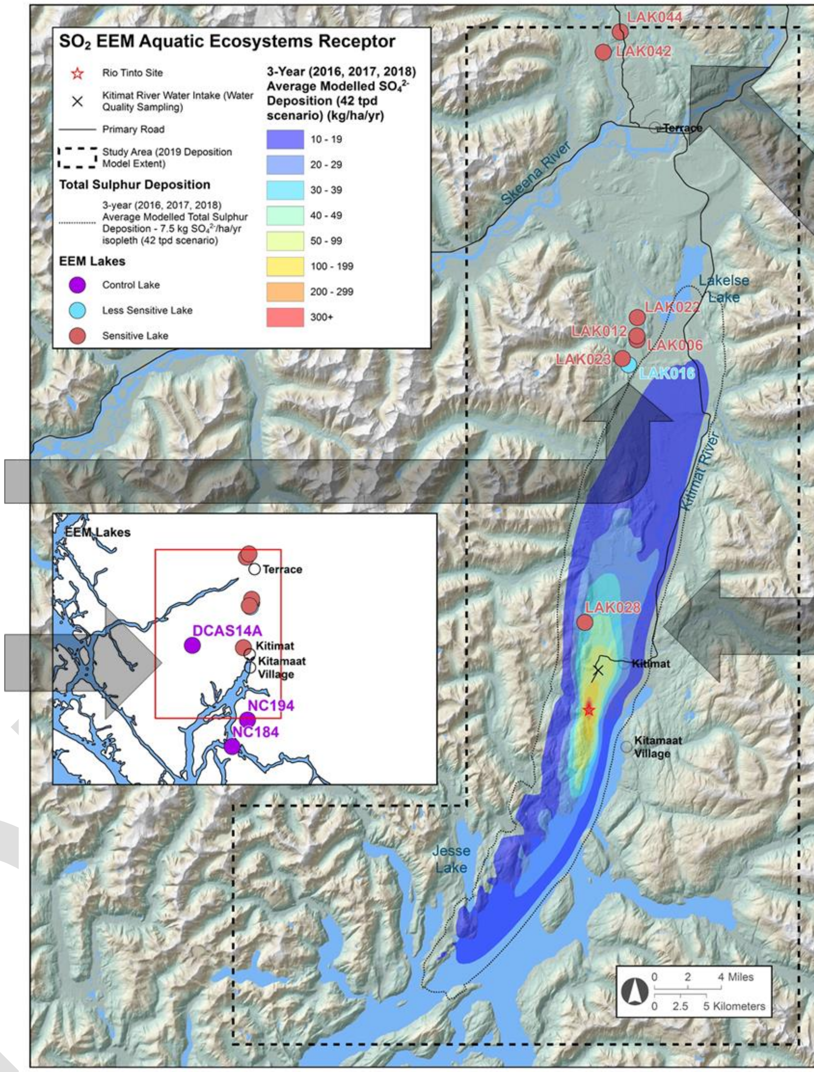


Figure 3-2. Changes in water chemistry metrics (left panel) and pH (right panel) across all of the less sensitive and control lakes, from 2012 to 2018-2020. Values shown are the mean 2018-2020 value minus the mean 2012 value.

	2012 to 2018-20		
LAKE	ΔSO_4^{2-}	Δ CBANC	ΔpH
Lak006	4.5	15.3	0.3
LAK012	8.5	-4.8	0.4
LAK022	16.0	7.8	0.2
LAK023	-5.2	15.6	0.2
LAK016	12.9	6.8	0.3

	2012 to 2018-20		
LAKE	ΔSO_4^{2-}	Δ CBANC	ΔpH
DCAS14A	7.7	26.5	0.2
NC184	2.1	10.2	0.3
NC194	-0.9	9.2	-0.1



	2012 to 2018-20		
LAKE	ΔSO_4^{2-}	Δ CBANC	ΔpH
LAK042	0.9	13.5	0.4
LAK044	-1.5	6.2	0.1

	2012 to 2018-20		
LAKE	ΔSO_4^{2-}	Δ CBANC	ΔpH
LAK028	78.1	-9.0	0.1

Figure 3-3. Observed changes in SO_4^{2-}, CBANC and pH from the baseline period (2012) to the post-KMP period (2018-2020). Green cells indicate increases and red cells indicate decreases. Note that LAK016, LAK022, DCAS14A, NC184, and NC194 were not sampled in 2020; for these lakes the post-KMP period used was 2018-2019.

Inorganic Aluminum

The following graphs show the relationship between Al_{im} and total Al (Figure 3-4), pH (Figure 3-5), and BCS (Figure 3-6). The key observations from these graphs are as follows:

General patterns:

- Figure 3-4 shows a positive, potentially non-linear relationship between Al_{im} and total Al in 2013, 2019 and 2020. Only those sites with total Al values greater than 0.1 mg/L have appreciable levels of Al_{im}.
- Figure 3-5 shows that the expected pattern of increasing Al_{im} with decreasing pH is reflected in all three years.
- Similar to 2013, the 2019 and 2020 data show the expected pattern that Al_{im} is highest for sites where BCS < 0 μeq/L and is <0.03 mg/L for sites where BCS > 50 μeq/L (Figure 3-6). One of the strengths of the BCS metric is that Al_{im} consistently increases as BCS declines below zero. The data show that DOC also plays a role, with higher concentrations of both total aluminum and Al_{im} in organically acidified lakes with pH ≤ 5.7 and DOC > 8 mg/L (Figure 3-5).

LAK028:

- With respect to key metrics related to aluminum (Total Al, Al_{im}, pH, BCS) LAK028 showed a similar status in 2020 and 2019 (Figure 3-4, Figure 3-5, Figure 3-6).
- With BCS < 0 μeq/L and Al_{im} > 0.30 mg/l in both 2019 and 2020, there is evidence of chronic toxic levels of Al_{im} in LAK028 (Figure 3-6, middle and top panels).
- The conditions in 2019 and 2020 appear to be generally similar to those in 2013 during the transition to the new smelter (2013 also had BCS <0 μeq/L and Al_{im} > 0.30 mg/l; bottom panel of Figure 3-6), though there was only one sample from LAK028 in 2013 so we have no estimate of within season variability.
- There has been considerable variability in mean BCS over time in LAK028 (Table 3-4). Section 3.3 includes statistical analyses of the changes in BCS between the pre-KMP baseline and the post-KMP period.

LAK042:

- LAK042 showed a 10 mg/L increase in DOC between 2019 and 2020 (Appendix 1, from 9.2 mg/L to 19.2 mg/L).
- This resulted in a 0.7 unit decrease in pH (Appendix 1, from 5.4 to 4.7), increases in both total Al and Al_{im}, and a decrease in BCS (from 9.1 to -13.2 μeq/L; Figure 3-4, Figure 3-5, Figure 3-6).
- The changes in LAK042 between 2019 and 2020 are most likely related to flooding of the shoreline of LAK042 in the two months prior to the 2020 sampling, dissolving organic acids from the surrounding Sphagnum moss and soils (see Sections 2.4 and 4.3).
- The changes in LAK042 between 2019 and 2020 are not attributable to sulphate deposition, as [SO_4] did not change (constant at 7.6 ueq/L in both 2019 and 2020, Appendix 1).

Other lakes:

- None of the other lakes show levels of BCS < 0 or chronic toxic levels of Al_{im}.

Inorganic monomeric aluminum has been measured in several individual years as a pilot to determine whether there are any lakes experiencing elevated levels of biologically-available aluminum that have not already been identified by the existing suite of lake chemistry metrics and analyses. Similar to the preliminary conclusions expressed in the 2019 Comprehensive Review and the 2019 Annual Report, the 2020 results show that the Al_{im} data align as expected with the BCS data and do not contribute novel information about lake chemistry. Therefore, discontinuing the measurement of Al_{im} would not have any adverse impact on the monitoring program.

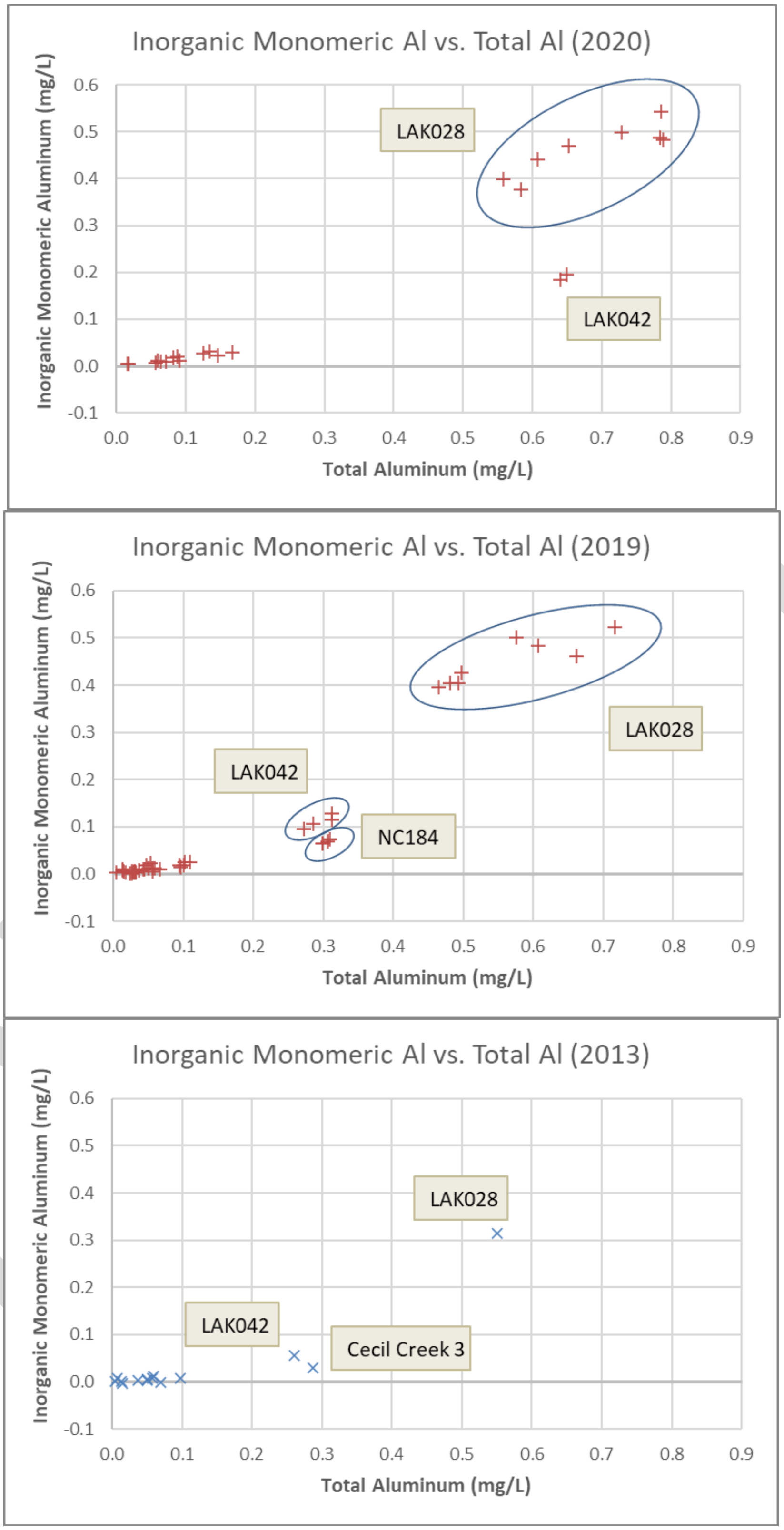


Figure 3-4. Inorganic monomeric aluminum versus total aluminum for 2020 samples (top), 2019 samples (middle) and 2013 samples (bottom). Lakes with higher aluminum values are indicated.

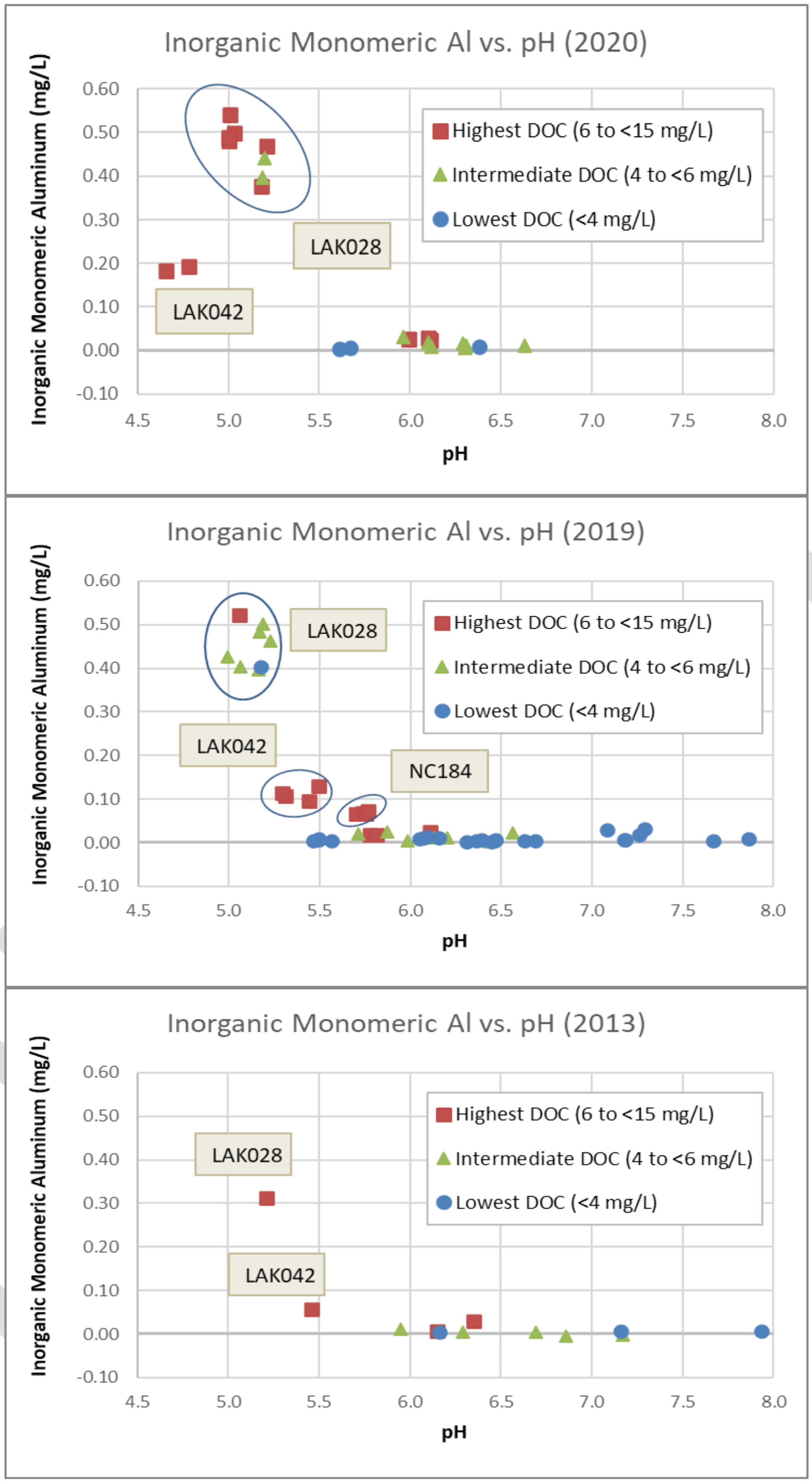


Figure 3-5. Inorganic monomeric aluminum versus pH for 2020 samples (top), 2019 samples (middle) and 2013 samples (bottom). The sites are stratified into three classes of DOC, which were applied in the Comprehensive Review based on natural breaks in the 2013 data. Note the different X-axis on the top panel.

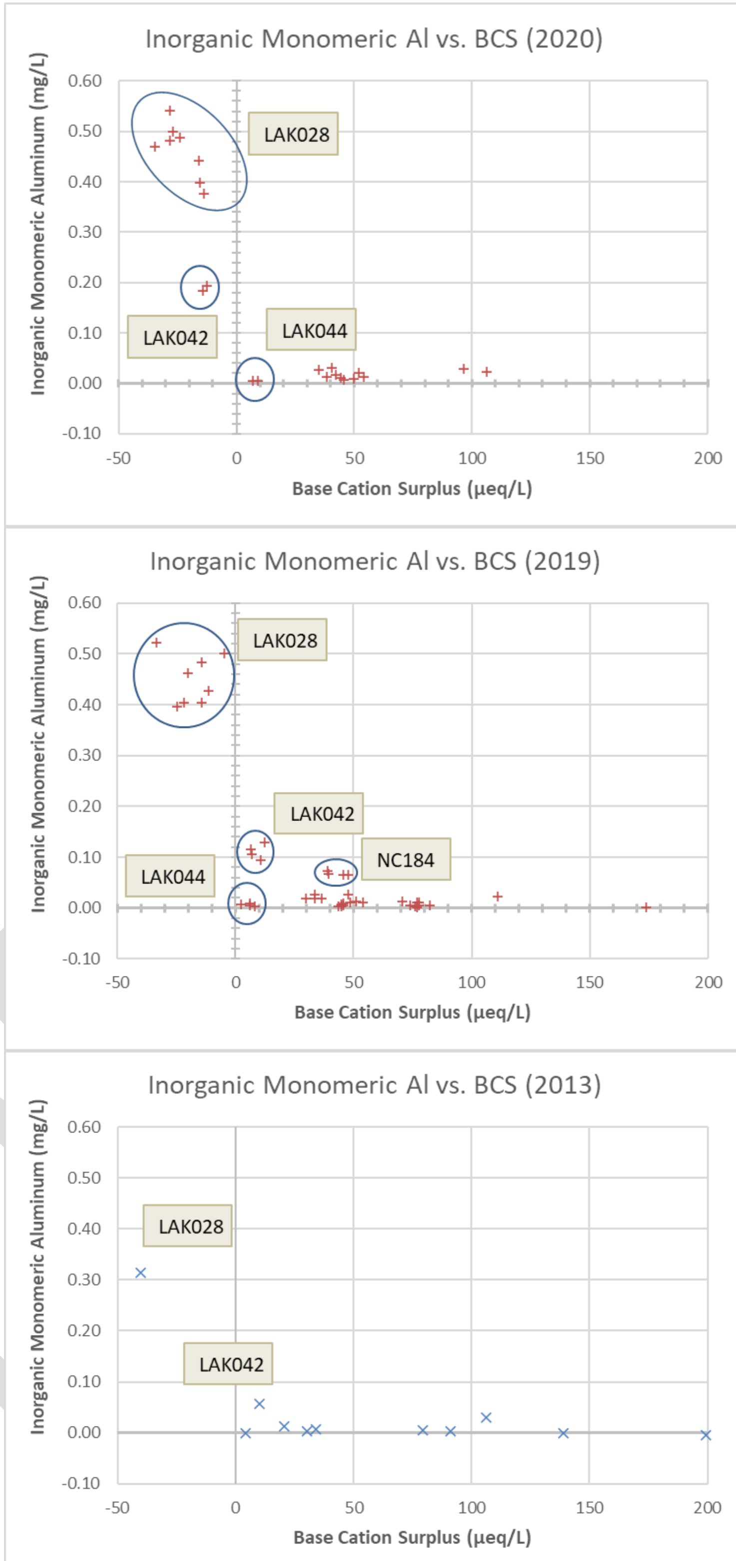


Figure 3-6. Inorganic monomeric aluminum versus Base Cation Surplus (BCS) for 2020 samples (top), 2019 samples (middle) and 2013 samples (bottom). The 2013 and 2019 data are limited to samples <200 µeq/L.

Table 3-4. Mean values of BCS in LAK028 by year. Units are μeq/L. Data from Appendix 1.

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020
BCS (μeq/L)	-5.1	-40.2	4.8	1.5	-24.9	-32.5	-8.4	-18.1	-26.7

3.2 Water Chemistry Sampling Results

Appendix 1 reports the results of the water chemistry sampling for the EEM lakes and control lakes from the sampling conducted in 2020 (with the data from 2012-2020 included for reference), for major water chemistry metrics (ANC, pH, DOC, base cations, and major anions).

3.3 Statistical Analysis of Changes in Water Chemistry

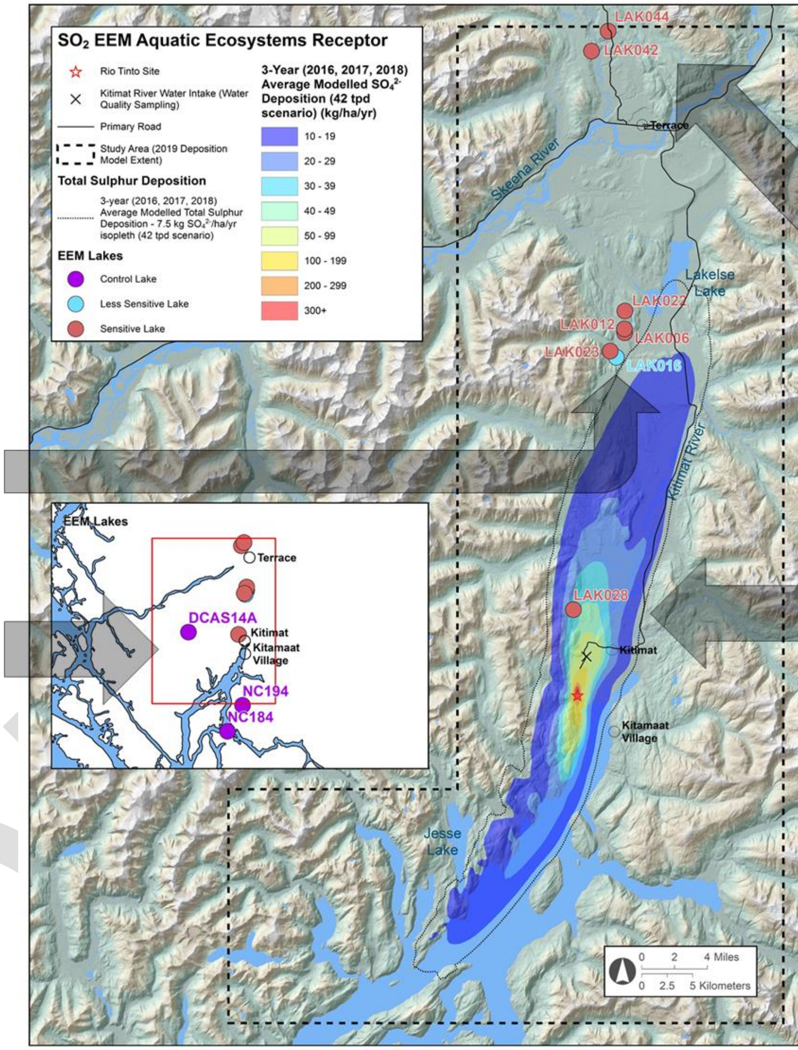
The key results of the statistical analyses of changes in lake chemistry across all the lakes in the EEM Program are summarized in Table 3-5 and Figure 3-7. These results applied Bayesian Method 1, described in Appendix F of the 2019 Comprehensive Review Report.

Table 3-5. Summary of findings across all lakes monitored in the EEM program. The % belief values are derived from the Bayesian version of Method 1, as described in Aquatic Appendix F of the 2019 Comprehensive Review Report. Values of % belief < 20% are coloured green, 20-80% yellow, and >80% red.

	Changes in SO4	Exceedance of *CHANGE LIMIT*				Exceedance of *LEVEL OF PROTECTION*				KPI and Informative Indicator Evaluation			
	(% belief that threshold exceeded; from Bayesian analysis method 1)	(% belief that metric value has decreased by more than the threshold; from Bayesian analysis method 1)				(% belief that metric value is below threshold; from Bayesian analysis method 1)				(Classification of % belief that both the *change limit* and *level of protection* thresholds are exceeded)			
Metric	SO4	CBANC	Gran ANC (integ)	BCS	pH (integ)	CBANC	Gran ANC (integ)	BCS	pH (integ)	CBANC	Gran ANC (integ)	BCS	pH (integ)
Thresholds	Increase > 0	Lake-spec.	Lake-spec.	Δ 13 ueq/L	Δ 0.3 pH units	20 ueq/L	30.7 ueq/L	0 ueq/L	6.0 pH units	**KPI**	Inform. Indic.	Inform. Indic.	Inform. Indic.
Sensitive Lakes													
LAK006	98%	2%	5%	0%	1%	0%	45%	0%	2%	LOW	LOW	LOW	LOW
LAK012	99%	40%	19%	49%	1%	0%	0%	0%	10%	LOW	LOW	LOW	LOW
LAK022	89%	2%	10%	5%	0%	0%	29%	0%	13%	LOW	LOW	LOW	LOW
LAK023	0%	2%	3%	1%	3%	0%	100%	0%	100%	LOW	LOW	LOW	LOW
LAK028	94%	13%	0%	49%	9%	100%	100%	100%	100%	LOW	LOW	MOD	LOW
LAK042	81%	9%	2%	9%	13%	0%	100%	55%	100%	LOW	LOW	LOW	LOW
LAK044	4%	0%	3%	0%	0%	100%	100%	0%	100%	LOW	LOW	LOW	LOW
Less Sensitive Lakes													
LAK016	81%	7%	1%	12%	6%	0%	0%	0%	0%	LOW	LOW	LOW	LOW
Control Lakes													
DCAS14A	99%	1%	1%	0%	12%	0%	0%	0%	0%	LOW	LOW	LOW	LOW
NC184	86%	10%	17%	12%	19%	0%	53%	0%	89%	LOW	LOW	LOW	LOW
NC194	2%			1%	17%	0%	96%	0%	0%	n/a	n/a	LOW	LOW

	% belief in change		
LAKE	↑ SO_4^{2-}	↓ CBANC	↓ pH
LAK006	98%	2%	1%
LAK012	99%	40%	1%
LAK022	89%	2%	0%
LAK023	0%	2%	3%
LAK016	81%	7%	6%

	% belief in change		
LAKE	↑ SO_4^{2-}	↓ CBANC	↓ pH
DCAS14A	99%	1%	12%
NC184	86%	10%	19%
NC194	2%	TBD	17%



	% belief in change		
LAKE	↑ SO_4^{2-}	↓ CBANC	↓ pH
LAK042	81%	9%	13%
LAK044	4%	0%	0%

	% belief in change		
LAKE	↑ SO_4^{2-}	↓ CBANC	↓ pH
LAK028	94%	13%	9%

Figure 3-7. Spatial distribution of percent belief in chemical change. Numbers show % belief in: a) SO4 increase (no threshold), b) CBANC decrease below lake-specific threshold, and c) pH decrease below 0.3 threshold. The % belief values are derived from the Bayesian version of Method 1, as described in Aquatic Appendix F of the 2019 Comprehensive Review Report. NC194 does not have an estimated ANC threshold because it did not have appropriate titration data available.

3.4 Episodic Acidification

We reviewed the data from the continuous pH monitors installed in LAK006 and LAK028 to identify any acidic episodes.

LAK006 did not have any notable drops in pH. There was a decrease between mid-August and early September (≤0.3 pH units), which corresponds with a time of increased lake levels (indicating higher precipitation), but by mid-September the pH had returned to the same level. The pH level declined from mid-September through mid-October, which is consistent with the pattern observed in previously years of pH decreasing during the end of the monitoring season as precipitation events increase in frequency and magnitude.

LAK028 showed pronounced but small drops (~0.2) pH units) on/near August 17th and September 24th. These observations align with two significant precipitation events (as indicated by rapid, short-lived increases in lake-level. The timing of these events aligns with the patterns seen in LAK006 too, but LAK028 shows a more "flashy" response to storm events.

None of these changes represent acidic episodes of a magnitude that would be of concern for ecological communities.

4 Discussion

4.1 Empirical Changes in Lake Chemistry with respect to the Aquatic Key Performance Indicator

This section only addresses the CBANC KPI and the pH informative indicator (of specific interest as the prior KPI) as the statistical analyses represent the primary assessment of the KPI and informative indicators.

The mean values of CBANC indicate that there have been no exceedances of the KPI.

For the CBANC KPI, only 2 of the 7 sensitive lakes (LAK028 and LAK042) have post-KMP values below the *level of protection* threshold. Both of those lakes were already below that threshold in 2012 (and the alternate, transition period baseline) and neither of those lakes have exceeded the *change limit* threshold. None of the 7 sensitive lakes exceeded the *change limit* threshold and only 2 show any decrease in CBANC at all. In the sensitivity analyses with the alternate, transition period baseline (2012-2014), there is only 1 lake with a decrease in CBANC (LAK028), but the magnitude of this decrease (6 µeq/L) is less than the lake-specific threshold (13.4 µeq/L; see Appendix 5). The empirical data therefore indicate that none of the lakes exceeded the KPI.

For the pH informative indicator, 4 of the 7 sensitive lakes (LAK023, LAK028, LAK042, and LAK044) have post-KMP values below the *level of protection* threshold. All four of these lakes have been below that threshold throughout the entire period of record (LAK023 had a pH of 6.0 in two years, but never higher). None of those lakes have exceeded the *change limit* threshold. None of the 7 sensitive lakes show any decrease in pH at all. In the sensitivity analyses with the alternate, transition period baseline (2012-2014), 2 lakes show decreases of <0.05 pH units and 2 lakes show decreases <0.1 pH units. The empirical data therefore indicate that none of the lakes have exceeded the pH informative indicator.

The following section utilizes the statistical analyses to the same data to assess the percent belief that CBANC KPI and the pH, Gran ANC and BCS informative indicators could have been exceeded.

4.2 Statistical Analysis of Changes in Lake Chemistry

Table 4-1 shows the results from 2020 compared to the results reported in the 2019 Annual Report and in 2019 comprehensive review. The 2020 results are generally quite similar to the previous results, which shows that the conclusions of the previous analyses continue to be supported with additional years of monitoring data.

For SO_4^{2-}, three lakes increased from moderate to high % belief. LAK042 increased from 44% belief in SO_4 increase to 81%, DCAS14A increased from 75% belief to 99% belief, and NC184 increased from 69% belief to 86%; however, all three lakes show strong support for only relatively small increases in SO_4 (+0.9 μeq/L, +7.7 μeq/L and +2.1 μeq/L, respectively). All three control lakes are located well outside the area of deposition from the smelter and therefore the increases in SO_4 in two of the control lakes are unrelated to the smelter. However, because the control lakes were not sampled in 2020, the 2020 results do not reflect any newer data but rather the changes from the 2019 report reflect the influence dropping earlier years from post-KMP averaging period (i.e., 2016-2019 to 2018-2019).

The Bayesian analyses were not performed on CBANC in previous years, so there are no comparisons for the CBANC results.

For Gran ANC and pH, four lakes had changes in % belief of greater than 10% (LAK012 and NC184 for Gran ANC, and LAK042 and NC194 for pH), but none of those changes were large enough to shift those lakes from the low to moderate classifications. As discussed above, the changes seen in the control lakes are not based on any newer data but rather the removal of 2016 and 2017 from the calculation of the post-KMP average.

Sensitive lake LAK012 increased from 0% belief to 19% belief for a decrease in Gran ANC. However, the Gran ANC in 2020 was substantially higher than any previous year, so the increased support for a decrease beyond the *change limit* threshold appears to be driven by the removal of 2016 (a relatively high year) from the post-KMP period and the increasing relative influence of 2018 (the lowest year) with the shift from a 4-year average to a 3-year average.

Sensitive lake LAK042 increased from 0% belief to 13% belief for a decrease in pH. This change was influenced by a value in 2020 that was lower than any of the observed values from 2013 to 2019 (driven by a flood-induced increase in DOC, as discussed in section 4.3), and the removal of a relatively high value in 2016 from the post-KMP period; however, none of the observed values have been below the 2012 baseline, so the 13% belief is simply accounting for some degree of uncertainty around the observed values.

Out of 11 total lakes, the number that showed differences in % belief of ≤5% were 7 for SO_4^{2-}, all 8 for Gran ANC, and 10 for pH.

Table 4-1. Comparison of the results of the updated statistical analyses of the changes relative to the *change limit* to the results in the previous two reporting periods (i.e., 2019 Annual Report and the 2019 comprehensive review (CR)). The 2020 results are the same as Table 3-5. The % belief values are derived from the Bayesian version of Method 1, as described in Aquatic Appendix F of the 2019 Comprehensive Review Report. Values of % belief < 20% are coloured green, 20-80% yellow, and >80% red.

LAKE	Changes in CBANC (% belief that CBANC *change limit* threshold exceeded)	Changes in SO_4 (% belief in SO_4 increase)			Changes in Gran ANC (% belief that Gran ANC *change limit* threshold exceeded)			Changes in pH (% belief that pH *change limit* threshold exceeded)		
	2020 Results	CR Results	2019 Results[1]	2020 Results	CR Results	2019 Results[1]	2020 Results	CR Results	2019 Results[1]	2020 Results
Sensitive Lakes										
LAK006	2%	83% belief in increase	85% belief in increase	98% belief in increase	0%	0%	5%	1%	0%	1%
LAK012	40%	91% belief in increase	95% belief in increase	99% belief in increase	1%	0%	19%	1%	0%	1%
LAK022 [2]	2%	88% belief in increase	89% belief in increase	89% belief in increase	0%	0%	10%	0%	0%	0%
LAK023	2%	5% belief in increase	2% belief in increase	0% belief in increase	0%	0%	3%	1%	0%	3%
LAK028	13%	96% belief in increase	97% belief in increase	94% belief in increase	2%	1%	0%	18%	6%	9%
LAK042	9%	36% belief in increase	44% belief in increase	81% belief in increase	0%	0%	2%	2%	0%	13%
LAK044	0%	1% belief in increase	0% belief in increase	4% belief in increase	0%	0%	3%	0%	0%	0%
Less Sensitive Lakes										
LAK016 [2]	7%	97% belief in increase	81% belief in increase	81% belief in increase	0%	0%	1%	1%	0%	6%
Control Lakes										
DCAS14A [2]	1%	68% belief in increase	75% belief in increase	99% belief in increase	0%	0%	1%	6%	0%	12%
NC184 [2]	10%	58% belief in negligible increase	69% belief in negligible increase	86% belief in increase	5%	4%	17%	28%	14%	19%
NC194 [2]	n/a	1% belief in increase	1% belief in increase	2% belief in increase	n/a	n/a	n/a	12%	4%	17%

[1] The 2019 Annual Report applied a 4-year post-KMP averaging period (i.e., 2016-2019; adding the new year of observations to the post-KMP period used in the CR), whereas the present 2020 Annual Report applies a 3-year post-KMP averaging period. Comparing the 2019 and 2020 results is thus comparing the difference between applying a 2016-2019 post-KMP averaging period versus a 2018-2020 post-KMP averaging period.

[2] For lakes not sampled in 2020, the comparison of 2019 and 2020 results represents a more significant difference – i.e., post-KMP averaging periods of 2016-2019 vs. 2018-2019.

4.3 Separating Natural and Anthropogenic Factors: the Environmental Context

Environmentally mediated one-year decrease in pH in LAK042

The 2020 monitoring data show that LAK042 had a notable 1-year decrease in pH that warranted further exploration (Figure 4-1, lower left). The lake also had large decreases in Gran ANC and BCS, large increases in CBANC and DOC, but no change in SO_4. However, LAK042 does not show any decreases in CBANC, pH, Gran ANC, or BCS when looking at longer-term changes from the pre-KMP baseline to the post-KMP average, so the exploration here focuses on understanding the 2019 to 2020 annual change.

SO_4 increased by small amount in the past 2 years, but current SO_4 is only marginally higher than in 2012, and shows no change from 2019 to 2020. Chemical changes from 2019 to 2020 are therefore not related to smelter (Figure 4-1, lower left).

For 2020, Gran ANC and BCS are both the lowest in post-KMP, and lowest over 2013 to 2020, but still higher than 2012, and CBANC is notably higher than any other year in the period of record (Figure 4-1, lower right). Similar to CBANC, there is a substantial increase in BC in 2020, above all other previous values (Figure 4-1, upper left).

There was a substantial decrease in pH in 2020, but still not below 2012 (Figure 4-1, lower left). However, LAK042 does have history of large swings in pH.

In 2020, LAK042 experienced an unprecedented increase in DOC (near doubling) from 2019 levels (and from the average value across 2013-2019). This suggests that the annual changes in 2020 in pH and ANC are due to increases in organic acids. Although such a large change in DOC had not previously been observed, the responses of the other metrics aligned with this change (i.e., corroborating the DOC observations and indicating that the increase was not a measurement or analysis issue). However, the fact that such a large change in DOC had not previously been observed indicated that something was markedly different about 2020. The field crew observed that lake conditions during the sampling period were in fact notably different than previous years – specifically, the lake level was significantly higher than previously observed. As reported in Section 2.3, precipitation was much higher in August and September 2020 than the same period in 2019 (i.e., approximately 75% higher) and this resulted in a roughly 40-50 cm increase in the water level at LAK042. This change is consistent with the expectation that LAK042 would be very sensitive to changes in precipitation because it has no apparent inlet or outlet. A substantial increase in lake level would therefore result in a flooding of the Sphagnum moss and soils along the shoreline of the lake (as observed by the field crew, and shown in Figure 4-2). This flooding of the shoreline would be expected to increase dissolution of organic matter and base cations into the lake, which is consistent with the empirical data. The evidence supports the conclusion that this single-year drop in pH was driven by anomalous environmental conditions.

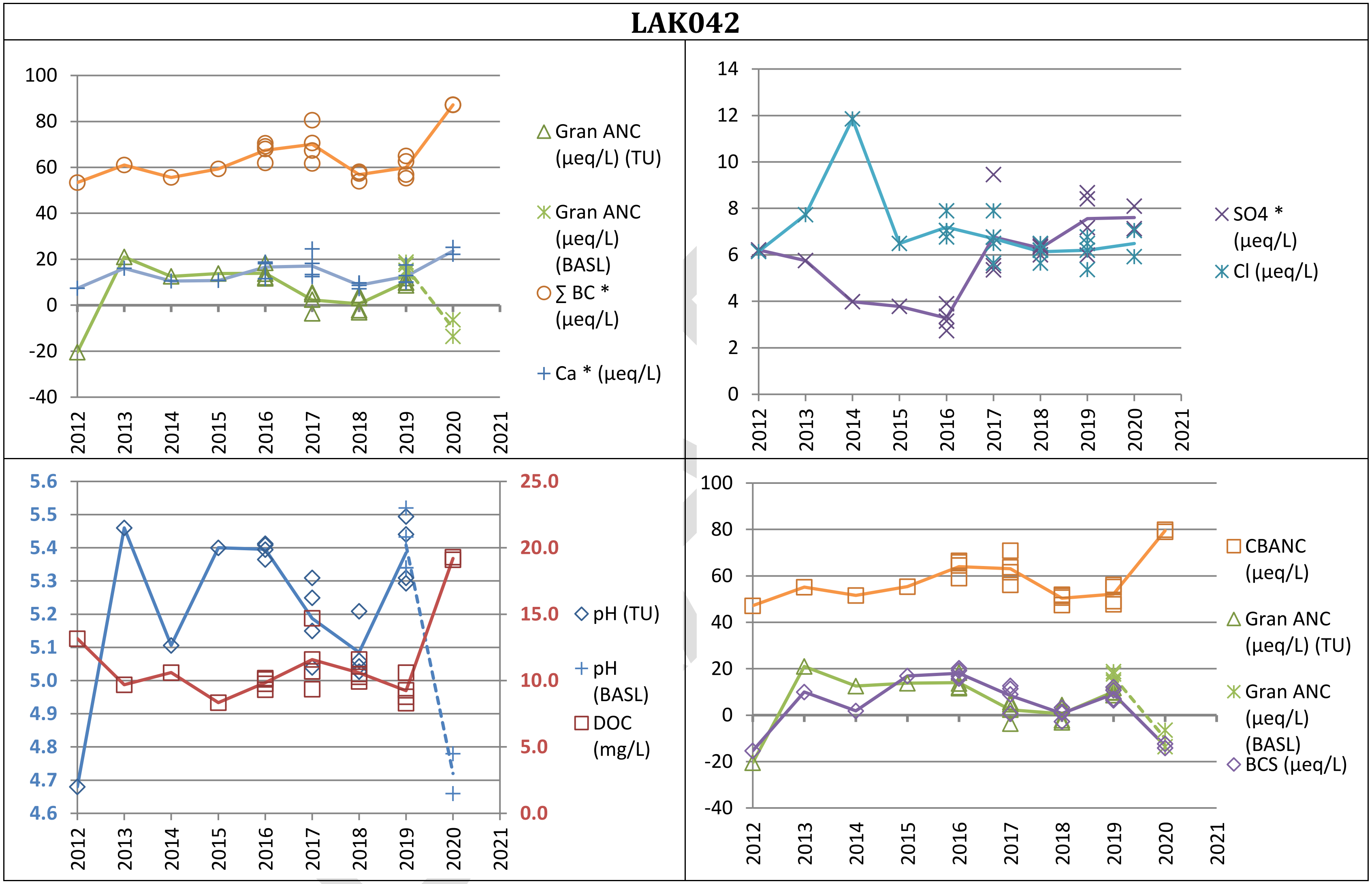


Figure 4-1. LAK042 lake chemistry over time. BC = total base cations; Ca = Calcium; Cl = chlorine; DOC = dissolved organic carbon; BCS = base cation surplus. Note: see Appendix 2 for similar figures for the full set of lakes.

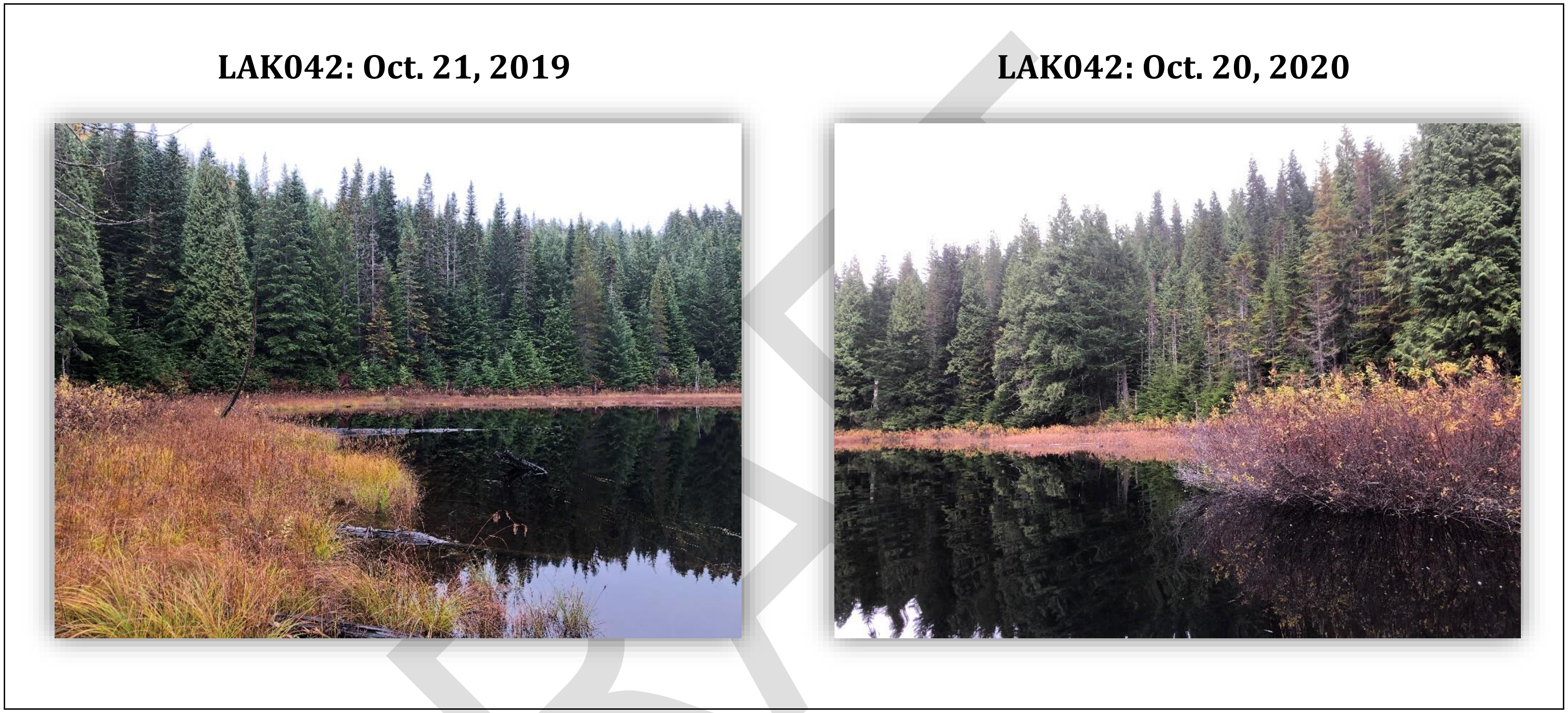


Figure 4-2. Comparison of photos of LAK042 during sampling visits in 2019 (left) and 2020 (right).

4.4 Application of the Evidentiary Framework

We have applied the revised evidentiary framework, as described in Section 2.6, using the updated results of the statistical analyses. The results are shown in Figure 4-3. The underlying results are compiled in Table 4-2. The updated application of the simplified evidentiary framework show that: a) 2 sensitive lakes and 3 control lakes[3] land within the first box, "smelter not causally linked to changes in lake chemistry"; b) 2 sensitive lakes and 1 less sensitive lakes land within the second box, "lake is healthy, and not acidifying"; and c) 2 sensitive lakes (LAK028 and LAK042) land within the third box, "some evidence of acidification".

For LAK028, this classification is based on: a) average post-KMP values below the *level of protection* for both CBANC and pH, and b) strong support for a decline in CBANC (96% belief) and low-intermediate support for declines in pH (31% belief), but with low support for exceedance of either *change limit* threshold (13% belief for CBANC and 9% belief for pH).

For LAK042, this classification is based on: a) average post-KMP values below the *level of protection* for pH only, and b) low-intermediate support for declines in pH (24% belief), with low support for exceedance of the *change limit* threshold (13% belief).

There are no lakes that have acidification exceedances.

[3] All of the control lakes are classified in the first box regardless of increases in sulphate because any such increases cannot be causally linked to the smelter due to their location well outside the smelter plume.

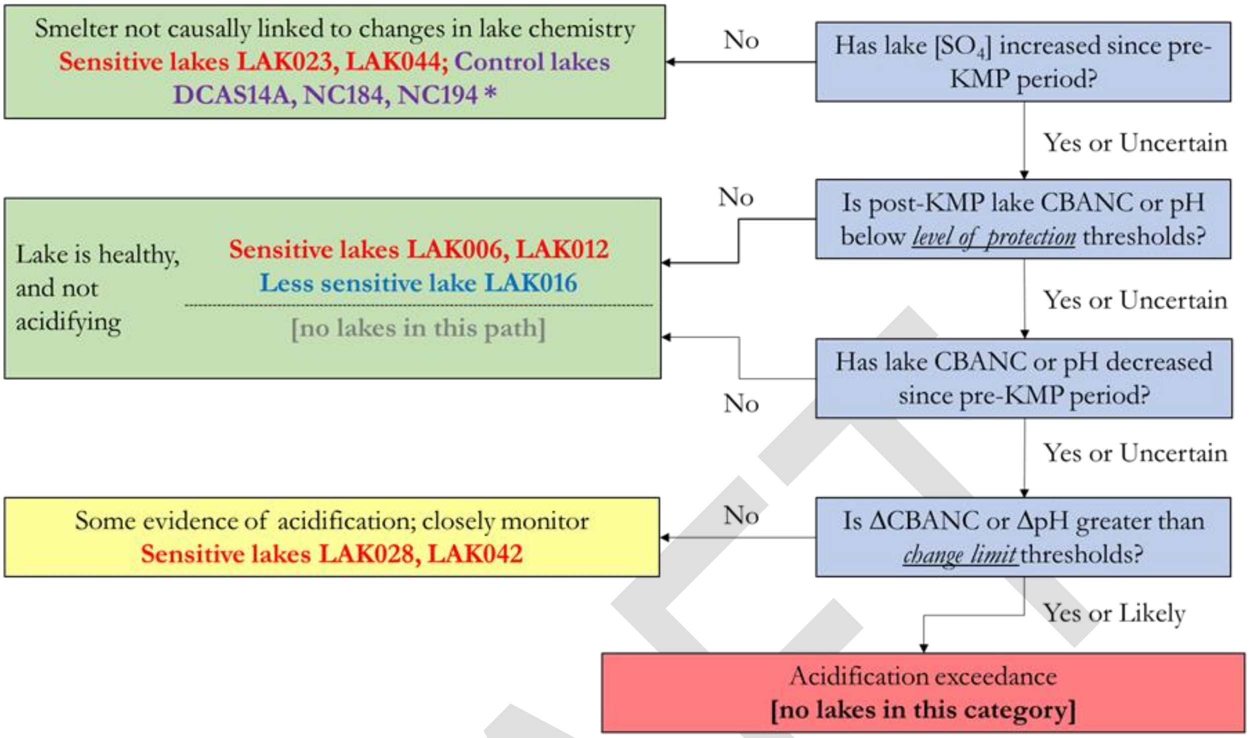


Figure 4-3. Classification of EEM lakes according to the simplified evidentiary framework. LAK028 has strong support for a decline in CBANC and low-intermediate support for a decline in pH but low support for exceeding the *change limit* thresholds. LAK042 has low-intermediate support for declines in CBANC and pH but low support for exceeding the *change limit* thresholds. The control lakes (*) are all classified in the first box regardless of increases in sulphate because any such increases cannot be causally linked to the smelter due to their location well outside the smelter plume.

Table 4-2. Results used in the application of the simple evidentiary framework. The first four columns are identical to Table 3-5 but the last two show the results for the % belief of *any* change in Gran ANC and pH. The % belief values are derived from the Bayesian version of Method 1, as described in Aquatic Appendix F of the 2019 Comprehensive Review Report. Values of % belief < 20% are coloured green, 20-80% yellow, and >80% red.

LAKE	**Changes in SO_4** (% belief in SO_4 increase / decrease)	**State of post-KMP CBANC** (% belief that CBANC *level of protection* threshold exceeded)	**State of post-KMP pH** (% belief that pH *level of protection* threshold exceeded)	**Changes in CBANC** (% belief that CBANC *change limit* threshold exceeded)	**Changes in pH** (% belief that pH *change limit* threshold exceeded)	**Change in CBANC (no threshold)** (% belief that CBANC decreased)	**Change in pH (no threshold)** (% belief that pH decreased)
Threshold type	**Any change (increase)**	**Level of Protection**	**Level of Protection**	**Change Limit**	**Change Limit**	**Any change (decrease)**	**Any change (decrease)**
Sensitive Lakes							
LAK006	98% belief in increase	0%	2%	2%	1%	6%	2%
LAK012	99% belief in increase	0%	10%	40%	1%	55%	2%
LAK022	89% belief in increase	0%	13%	2%	0%	6%	1%
LAK023	0% belief in increase	0%	100%	2%	3%	4%	11%
LAK028	94% belief in increase	100%	100%	13%	9%	96%	31%
LAK042	81% belief in increase	0%	100%	9%	13%	28%	24%
LAK044	4% belief in increase	100%	100%	0%	0%	1%	2%
Less Sensitive Lakes							
LAK016	81% belief in increase	0%	0%	7%	6%	26%	12%
Control Lakes							
DCAS14A	99% belief in increase	0%	0%	1%	12%	2%	27%
NC184	86% belief in increase	0%	89%	10%	19%	21%	33%
NC194	2% belief in increase	0%	0%	TBD [3]	17%	11%	79%

5 Recommendations

We recommend discontinuing the measurement of inorganic monomeric Aluminum. The ongoing use of BCS as an informative indicator will be sufficient for evaluating risks to biota without additional monitoring of inorganic monomeric Aluminum. However, it is being measured in 2021 because the planning for the 2021 field season occurred earlier than the analyses presented in this Technical Memo, so this recommendation would come into effect for the 2022 field season.

We do not recommend any other changes or adjustments to next year's program.

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Appendix 1: Water Chemistry Data from Annual Sampling, 2012-2020

The two tables below shows the sample results for each of the EEM lakes and control lakes from annual monitoring conducted from 2012 to 2020, including charge balance ANC (CBANC), Gran ANC, base cation surplus (BCS), pH, dissolved organic carbon (DOC), and the concentration of major anions and cations, as well as the sum of all base cations (BC). The pH of the water samples has been measured by three different laboratories with (Trent University, 2012-2019; ALS, 2013-2020; BASL, 2019-2020). Gran ANC also transitioned from Trent University to BASL, overlapping in 2019.

The first table provides the mean annual value and standard error for each metric for lakes with multiple within-season samples, as calculated from all the within-season samples. Lakes with only a single annual sample will show the same value in both tables and no measure of variability. The second table presents the sampling data in its "raw" units, as measured, without converting concentration values to charge equivalents. Although acidification studies require converting measured concentrations to charge equivalents, these unconverted values may be more familiar and therefore easier to interpret for some audiences.

Mean Annual Values

The mean annual values and standard error have been calculated for all lakes with multiple within-season samples. Sample values with no standard error indicate that only a single annual sample was taken for that particular lake in that particular year.

Lake	Year	CBANC (µeq/L)	SE	Gran ANC (µeq/L) (Trent)	SE	Gran ANC (µeq/L) (BASL)	SE	BCS (µeq/L)	SE	pH (Trent)	SE	pH (ALS)	SE	pH (BASL)	SE	DOC (mg/L)	SE	SO4 * (µeq/L)	SE	Cl (µeq/L)	SE	F (µeq/L)	SE	Ca * (µeq/L)	SE	Mg * (µeq/L)	SE	K * (µeq/L)	SE	Na * (µeq/L)	SE	∑ BC * (µeq/L)	∑ Anions (µeq/L)
Lak006	2012	49.2		25.7				34.6		5.8						3.6		11.4		5.8		4.5		30.3		12.5		2.9		14.9		60.6	66.2
LAK007	2012	1452.4		1437.6				1452.5		8.0						0.6		51.4		24.6		2.8		1272.2		157.0		19.3		55.4		1503.9	1552.5
LAK012	2012	114.5		57.0				94.5		5.6						4.6		6.1		4.2		5.0		74.5		20.8		5.2		20.0		120.6	115.9
LAK016	2012	127.2		68.7				112.0		6.3						3.7		39.0		6.3		7.8		117.7		20.5		7.3		20.8		166.3	166.4
LAK022	2012	67.9		27.8				44.5		5.9						5.3		30.2		6.9		6.1		58.1		16.0		3.2		20.8		98.1	99.4
LAK023	2012	46.9		19.8				29.3		5.7						4.2		19.0		4.5		5.6		39.4		12.0		3.7		10.8		65.9	72.2
LAK024	2012	315.4		299.5				311.7		7.1						1.4		24.8		27.3		1.6		273.2		33.0		4.2		29.6		340.0	376.5
LAK028	2012	16.0		-4.0				-5.1		5.0						4.9		56.9		6.1		20.7		47.5		9.5		3.1		12.8		72.9	95.7
LAK034	2012	177.6		99.4				158.1		6.7						4.5		24.1		5.8		5.8		119.3		31.6		5.8		44.9		201.7	221.4
LAK042	2012	47.2		-20.4				-15.4		4.7						13.2		6.2		6.1		3.2		7.4		22.7		3.1		20.3		53.4	73.4
LAK044	2012	8.0		1.3				2.5		5.4						1.7		6.2		5.6		2.9		6.8		3.2		4.1		0.0		14.2	27.7
Lak006	2013	43.1		29.0				30.3		6.2		6.1				3.2		14.4		8.7		5.6		27.1		13.0		5.3		12.2		57.6	80.1
LAK007	2013	1385.6		1462.1				1388.3		7.9		8.1				0.1		66.5		36.3		3.7		1226.0		156.5		21.9		47.6		1452.0	1598.9
LAK012	2013	97.5		63.5				79.5		6.3		6.1				4.2		11.3		14.7		8.2		64.8		20.3		9.2		14.6		108.9	168.1
LAK016	2013	108.7		96.9				90.9		6.7		7.2				4.2		56.9		12.3		11.5		114.4		23.9		11.2		17.6		167.1	206.6
LAK022	2013	62.0		36.4				33.9		6.2		6.1				6.2		47.1		12.4		8.7		65.1		19.2		6.0		18.8		109.1	145.9
LAK023	2013	37.7		23.8				20.7		6.0		6.0				4.0		24.1		7.5		7.4		37.1		13.3		5.1		8.3		63.9	89.7
LAK024	2013																																		
LAK028	2013	-8.1		4.8				-40.2		5.2		5.5				7.1		128.1		17.7		32.0		85.1		18.3		5.0		13.0		121.3	184.0
LAK034	2013	219.5		210.4				199.4		6.9		7.4				4.7		38.1		8.2		10.0		152.7		41.7		9.2		54.1		257.7	287.0
LAK042	2013	55.1		21.0				10.0		5.5		5.4				9.7		5.7		7.7		3.2		16.0		22.3		3.4		19.3		61.0	87.4
LAK044	2013	8.9		8.6				4.5		5.7		6.0				1.5		6.2		8.9		3.8		7.8		3.6		5.9		-2.0		15.3	35.0
Lak006	2014	52.9	2.0	38.8	0.6			37.2	2.6	6.1	0.1	6.6	0.2			3.8	0.3	12.1	0.6	8.1	1.2	4.8	0.1	31.7	0.5	14.6	0.4	4.7	0.3	14.5	1.2	65.5	84.2
LAK007	2014	1484.8		1445.7				1484.5		8.1		8.0				0.7		30.7		19.2		1.9		1276.8		156.7		20.2		61.8		1515.5	1527.8
LAK012	2014	99.8	3.1	68.8	6.8			71.8	7.9	6.0	0.1	6.7	0.2			6.3	1.0	15.8	5.2	10.3	2.2	5.2	0.2	69.3	1.6	21.3	0.6	7.3	0.5	18.3	1.6	116.1	135.7
LAK016	2014	132.5		105.7				115.6		6.7		6.7				4.0		48.2		9.3		9.5		122.4		25.0		10.1		23.3		180.8	194.2
LAK022	2014	76.1		46.9				51.0		6.3		6.4				5.7		37.8		9.0		6.9		68.5		18.9		5.2		21.4		114.0	133.0
LAK023	2014	59.4	3.3	32.1	1.1			34.3	2.1	5.9	0.1	6.7	0.3			5.7	0.4	18.9	1.0	6.1	0.3	6.2	0.2	49.3	3.9	14.9	0.4	4.0	0.1	10.8	0.3	79.0	93.0
LAK024	2014	473.4		472.1				468.1		7.6		7.5				1.7		37.2		65.7		2.3		402.3		50.1		7.8		50.2		510.4	617.9

Lake	Year	CBANC (µeq/L)	SE	Gran ANC (µeq/L) (Trent)	SE	Gran ANC (µeq/L) (BASL)	SE	BCS (µeq/L)	SE	pH (Trent)	SE	pH (ALS)	SE	pH (BASL)	SE	DOC (mg/L)	SE	SO4 * (µeq/L)	SE	Cl (µeq/L)	SE	F (µeq/L)	SE	Ca * (µeq/L)	SE	Mg * (µeq/L)	SE	K * (µeq/L)	SE	Na * (µeq/L)	SE	∑ BC * (µeq/L)	∑ Anions (µeq/L)
LAK028	2014	31.2		22.6				4.8		5.3		5.7				5.9		94.4		11.0		23.3		85.9		17.7		4.4		17.6		125.7	156.6
LAK034	2014	249.1		205.0				217.2		6.7		7.0				7.0		17.0		6.5		7.7		161.4		43.6		9.4		51.9		266.3	270.9
LAK042	2014	51.6		12.5				1.8		5.1		5.4				10.6		4.0		11.8		2.6		10.5		23.6		3.7		17.9		55.7	89.4
LAK044	2014	12.6		5.9				6.8		5.8		5.6				1.8		4.6		5.9		2.8		7.8		3.9		5.3		0.4		17.3	28.5
Lak006	2015	55.1	0.8	32.4	0.4			38.7	1.5	6.0	0.1	6.4	0.3			3.9	0.2	11.5	0.3	6.6	0.3	4.4	0.1	32.3	0.3	14.8	0.2	3.9	0.1	15.7	0.3	66.7	77.0
LAK007	2015	1461.9		1565.6				1463.9		8.0		7.9				0.3		45.6		24.0		2.6		1266.6		161.5		21.0		58.6		1507.7	1666.8
LAK012	2015	106.1	2.0	65.9	2.1			71.8	3.9	6.0	0.1	6.3	0.2			7.5	1.0	17.6	3.1	11.1	1.7	4.7	0.1	74.8	3.9	23.2	0.9	8.1	0.8	18.0	0.8	124.2	140.3
LAK016	2015	147.1		113.1				128.8		6.8		6.9				4.3		40.9		8.7		8.6		130.9		25.0		9.8		22.9		188.6	192.1
LAK022	2015	75.2		35.6				47.0		6.1		6.2				6.3		32.5		7.9		5.9		64.1		18.1		4.4		21.2		107.8	117.3
LAK023	2015	58.0	1.0	30.0	1.0			34.4	0.9	5.9	0.1	6.2	0.1			5.4	0.4	15.1	0.7	6.2	0.3	5.2	0.2	46.1	1.5	13.9	0.3	3.8	0.1	9.7	0.1	73.5	83.0
LAK024	2015	472.8		443.0				465.0		7.4		7.5				2.2		34.7		59.0		2.1		400.5		49.3		8.7		49.0		507.6	580.6
LAK028	2015	38.6		10.8				1.5		5.1		5.3				8.1		71.1		9.0		20.5		76.5		15.7		3.2		14.4		109.8	122.1
LAK034	2015	233.0		177.8				198.5		6.6		6.7				7.6		0.9		6.2		4.7		146.5		37.1		5.3		45.1		234.0	231.8
LAK042	2015	55.4		13.8				16.9		5.4		5.5				8.3		3.8		6.5		2.3		10.7		23.1		2.5		23.0		59.3	70.7
LAK044	2015	16.4		6.2				11.6		5.8		5.8				1.6		3.7		5.9		2.7		9.8		4.4		5.5		0.5		20.3	28.0
Lak006	2016	56.9	2.4	26.9	1.0			38.9	2.4	6.0	0.0	6.3	0.1			4.2	0.1	11.8	0.2	5.6	0.2	4.2	0.1	32.6	0.5	14.8	0.7	4.2	0.6	17.2	0.9	68.8	74.0
LAK007	2016	1495.8		1368.6				1495.2		8.0		8.1				0.8		46.7		25.4		2.6		1301.5		162.8		20.2		58.3		1542.8	1474.0
LAK012	2016	103.2	1.6	65.8	1.2			81.0	2.1	6.2	0.0	6.5	0.1			5.1	0.3	9.5	0.5	5.6	0.2	4.6	0.1	64.7	0.8	20.8	0.6	6.0	0.6	21.6	0.8	113.0	115.7
LAK016	2016	140.8		93.9				118.3		6.6		6.9				5.2		44.9		8.5		8.2		127.4		26.4		8.9		23.7		186.5	189.4
LAK022	2016	80.3		34.4				50.1		6.1		6.4				6.7		34.2		7.9		5.8		68.1		19.2		4.2		23.1		114.6	119.0
LAK023	2016	59.5	1.4	27.9	1.9			33.6	1.0	5.9	0.0	6.2	0.1			5.8	0.1	12.7	0.2	4.9	0.2	5.1	0.1	42.5	0.9	14.1	0.4	4.7	0.5	11.0	0.8	72.3	80.8
LAK024	2016	525.1		463.1				514.8		7.5		7.6				2.7		39.2		70.0		2.3		446.5		55.3		9.5		53.9		565.3	619.2
LAK028	2016	12.3	3.8	-4.9	6.2			-24.9	5.2	5.0	0.1	5.1	0.1			8.1	0.3	127.8	8.1	10.0	0.5	26.8	0.8	94.7	8.3	23.8	1.7	3.7	0.2	19.5	1.6	141.6	179.1
LAK034	2016	212.2		151.6				177.6		6.5		7.1				7.6		0.0		5.4		4.4		130.0		34.3		3.8		44.1		212.3	215.4
LAK042	2016	64.0	1.7	14.0	1.5			18.0	1.1	5.4	0.0	5.7	0.0			9.8	0.2	3.3	0.2	7.2	0.2	2.2	0.1	16.7	1.7	24.7	0.4	2.7	0.2	23.3	0.2	67.4	78.8
LAK044	2016	13.9	0.6	4.1	1.3			7.0	0.6	5.5	0.0	6.0	0.1			2.0	0.1	4.1	0.1	6.1	0.1	2.3	0.1	8.2	0.4	4.1	0.0	5.5	0.1	0.3	0.2	18.2	27.7
Lak006	2017	58.0	0.6	27.9	2.7			42.1	1.0	6.0	0.1	6.4	0.1			3.8	0.1	14.4	0.3	5.4	0.2	4.2	0.0	34.8	0.5	15.6	0.2	4.1	0.1	18.0	0.4	72.5	71.4
LAK007	2017	1402.3		1381.6				1404.3		8.0		8.0				0.3		47.1		25.9		2.4		1201.7		165.2		19.9		62.6		1449.4	1492.4
LAK012	2017	101.1	3.7	58.2	3.2			78.2	1.9	6.1	0.1	6.5	0.1			5.2	0.5	14.6	2.6	7.0	1.2	4.4	0.1	65.4	4.5	21.7	1.2	7.7	1.0	21.5	0.9	116.3	117.5
LAK016	2017	125.3		82.7				107.8		6.7		6.8				4.1		43.2		7.3		7.7		114.0		24.7		6.9		22.9		168.6	167.5
LAK022	2017	70.4		34.2				44.2		6.1		6.3				5.9		39.0		7.1		5.4		64.1		19.5		3.8		22.2		109.6	112.4
LAK023	2017	59.9	1.5	28.5	2.4			36.0	1.3	5.9	0.0	6.2	0.0			5.4	0.1	10.1	1.7	4.2	0.3	4.6	0.0	43.2	2.1	13.8	0.3	2.3	0.2	11.2	0.3	70.5	71.3
LAK024	2017	479.2		416.6				472.3		7.4		7.6				2.0		34.9		57.5		2.0		399.6		52.2		8.5		54.2		514.4	557.5
LAK028	2017	0.7	5.3	-9.9	4.5			-32.5	7.8	4.8	0.1	5.1	0.1			7.3	0.6	150.0	13.0	8.7	1.0	27.2	1.7	102.5	11.0	26.5	2.5	3.5	0.4	19.9	1.6	152.4	199.2
LAK034	2017	177.6		136.5				150.7		6.4		6.8				6.0		0.1		4.5		3.4		105.6		30.3		2.7		39.1		177.8	179.1
LAK042	2017	63.1	3.0	2.3	2.1			8.4	2.7	5.2	0.1	5.4	0.1			11.6	1.1	6.8	0.9	6.7	0.5	2.4	0.0	17.1	2.7	26.9	1.1	2.8	0.3	23.2	0.5	70.0	80.8
LAK044	2017	13.8	0.3	7.0	2.2			9.1	0.3	5.6	0.1	6.0	0.1			1.6	0.0	4.5	0.2	5.9	0.1	2.2	0.0	7.9	0.1	4.2	0.1	5.6	0.1	0.7	0.2	18.4	26.2
Lak006	2018	59.3	1.2	28.3	1.2			43.6	1.5	6.1	0.0	6.4	0.0			3.8	0.1	15.7	0.2	6.1	0.1	4.2	0.1	36.2	0.3	16.1	0.5	4.3	0.3	18.5	0.6	75.1	82.1
LAK007	2018	1443.8		1407.6				1445.7		8.1		8.1				0.3		47.1		27.9		2.6		1251.5		157.4		20.6		61.3		1490.8	1518.7
LAK012	2018	90.4	1.2	50.9	4.3			70.5	0.9	6.2	0.1	6.6	0.1			4.6	0.1	14.6	0.7	6.2	0.3	4.6	0.1	58.3	0.4	19.7	0.6	6.2	0.3	21.1	0.8	105.2	112.3
LAK016	2018	138.1		92.8				118.4		6.7		6.9				4.6		45.3		7.3		8.1		128.5		23.3		7.3		24.3		183.5	195.3

Lake	Year	CBANC (μeq/L)	SE	Gran ANC (μeq/L) (Trent)	SE	Gran ANC (μeq/L) (BASL)	SE	BCS (μeq/L)	SE	pH (Trent)	SE	pH (ALS)	SE	pH (BASL)	SE	DOC (mg/L)	SE	SO4 * (μeq/L)	SE	Cl (μeq/L)	SE	F (μeq/L)	SE	Ca * (μeq/L)	SE	Mg * (μeq/L)	SE	K * (μeq/L)	SE	Na * (μeq/L)	SE	∑ BC * (μeq/L)	∑ Anions (μeq/L)
LAK022	2018	76.6		30.3				51.8		6.1		6.3				5.6		43.2		7.3		5.8		72.1		19.3		4.2		24.4		119.9	120.1
LAK023	2018	61.3	0.7	23.0	0.7			36.3	1.6	6.0	0.1	6.4	0.1			5.6	0.2	14.1	0.9	4.9	0.2	4.9	0.1	45.9	0.3	15.0	0.3	3.3	0.2	11.4	0.4	75.5	78.6
LAK024	2018	553.5		509.9				548.8		7.6		7.6				1.6		42.6		77.3		2.4		472.7		56.4		9.4		57.2		595.7	680.2
LAK028	2018	8.4	1.8	4.2	1.6			-10.2	1.9	5.3	0.0	5.5	0.0			4.4	0.1	107.5	2.0	6.6	0.2	20.9	0.3	76.4	0.9	19.0	0.5	2.8	0.1	17.9	0.7	116.0	147.4
LAK034	2018	183.4		130.6				161.0		6.5		6.6				5.1		0.1		3.7		3.7		113.1		27.7		2.1		40.8		183.7	176.3
LAK042	2018	50.4	1.0	0.6	1.9			0.7	1.3	5.1	0.0	5.3	0.0			10.6	0.4	6.3	0.1	6.1	0.2	2.3	0.1	8.8	0.6	23.9	0.5	2.3	0.1	21.8	0.1	56.8	74.4
LAK044	2018	13.2	0.3	3.9	0.9			7.0	0.2	5.5	0.0	5.9	0.0			1.9	0.1	4.5	0.1	6.4	0.1	2.2	0.0	8.3	0.1	4.1	0.2	5.5	0.1	-0.2	0.3	17.7	27.5
Lak006	2019	63.8	2.2	31.6	2.7	40.0	1.1	49.7	1.8	6.1	0.0	6.5	0.1	6.2	0.0	3.5	0.2	16.8	0.6	6.7	0.6	4.0	0.2	38.0	0.6	17.8	0.4	5.1	0.2	19.9	0.9	80.8	74.1
LAK007	2019	1443.5		1374.5		1496.3		1445.4		8.1		8.1		8.0		0.3		43.0		27.1		2.4		1246.6		158.4		20.4		61.2		1486.5	1469.6
LAK012	2019	96.5	0.4	55.3	0.9	64.1	2.6	74.8	1.6	6.1	0.0	6.6	0.1	6.2	0.0	5.0	0.3	13.5	0.9	7.1	0.2	4.4	0.2	59.7	0.5	21.3	0.2	6.5	0.2	22.6	0.6	110.1	121.4
LAK016	2019	129.8		90.8		100.9		111.2		6.6		7.1		6.6		4.4		58.6		9.0		7.9		127.9		26.5		9.7		24.4		188.6	219.5
LAK022	2019	74.8		35.9		44.4		47.8		6.1		6.4		6.2		6.0		49.3		8.7		5.6		71.5		22.4		5.0		25.3		124.2	123.4
LAK023	2019	59.4	1.6	20.7	2.4	26.8	1.5	33.4	1.3	5.8	0.0	6.3	0.1	6.0	0.0	5.9	0.2	13.5	0.8	5.4	0.2	4.8	0.2	42.2	0.4	15.4	0.6	3.3	0.2	12.1	1.1	73.1	79.4
LAK024	2019	570.7		496.9		548.7		566.0		7.7		7.7		7.3		1.6		40.8		75.3		2.1		478.3		58.1		8.7		66.3		611.4	662.5
LAK028	2019	4.5	4.4	3.3	0.7	4.0	3.1	-18.1	6.0	5.2	0.0	5.4	0.0	5.1	0.0	5.2	0.3	148.5	4.0	11.3	0.6	25.8	1.1	103.5	1.2	26.6	0.5	3.7	0.2	20.0	0.9	153.7	200.1
LAK034	2019	196.8		148.9		166.9		173.8		6.4		7.0		6.6		5.3		0.9		4.5		4.1		122.1		30.4		1.8		43.5		197.8	195.9
LAK042	2019	52.1	2.1	10.1	0.6	16.5	1.0	9.1	1.4	5.4	0.0	5.6	0.1	5.4	0.0	9.2	0.5	7.6	0.6	6.2	0.3	2.3	0.1	12.6	1.8	23.1	0.6	2.2	0.3	22.0	0.3	59.9	77.1
LAK044	2019	14.8	0.6	6.1	0.4	6.6	0.3	5.7	1.2	5.5	0.0	5.9	0.1	5.7	0.0	2.5	0.3	4.7	0.3	6.5	0.3	2.3	0.1	8.9	0.2	4.5	0.2	6.0	0.2	0.3	0.2	19.6	32.0
Lak006	2020	70.3	1.5			44.7	1.3	48.1	3.8			6.3	0.0	6.1	0.0	5.1	0.5	15.3	0.5	6.5	0.6	4.0	0.1	44.9	1.3	17.6	0.7	4.7	0.4	18.6	0.4	85.7	91.4
LAK012	2020	142.1	6.4			93.1	9.0	101.4	4.9			6.4		6.1	0.0	8.8		15.6		9.3		5.0		97.5		28.1		7.8		24.5		157.9	165.7
LAK016	2020																																
LAK022	2020																																
LAK023	2020	66.6	0.5			29.6	1.6	37.6	2.8			6.1		6.0	0.0	6.4		13.9		5.1		4.8		49.0		15.7		3.7		12.2		80.6	80.5
LAK028	2020	8.0	1.4			0.5	0.6	-26.7	1.5			5.0	0.0	5.0	0.0	7.6	0.2	149.1	4.2	9.8	0.2	24.3	0.9	110.6	3.2	24.5	0.6	3.4	0.2	20.3	0.9	158.8	193.3
LAK042	2020	79.5	0.4			-10.0	3.6	-13.2	0.9			4.8		4.7	0.1	19.2		7.6		6.5		2.5		23.6		33.2		2.9		27.5		87.2	102.9
LAK044	2020	14.5	0.9			2.4	1.6	8.1	1.1			5.7	0.1	5.6	0.0	1.9	0.0	5.2	0.2	6.9	0.1	2.1	0.1	8.4	0.2	4.6	0.1	6.6	0.0	0.3	0.5	19.9	21.8
NC184	2012																																
NC194	2012																																
DCAS14A	2012																																
NC184	2013	80.4		16.2				25.6		5.7						11.6		5.7		24.0		0.3		50.5		17.5		4.4		13.8		86.2	132.0
NC194	2013	35.6		28.0				35.3		6.6						0.7		3.6		7.6		0.3		23.2		3.4		5.2		7.4		39.2	59.3
DCAS14A	2013	53.5		50.6				49.9		6.5						1.4		33.4		9.2		0.6		63.9		10.3		10.3		6.1		90.6	115.6
NC184	2014																																
NC194	2014																																
DCAS14A	2014																																
NC184	2015	73.0		18.4				27.2		5.5		5.6				9.8		5.7		21.7		0.5		48.8		16.1		2.9		10.8		78.7	104.6
NC194	2015	40.9		33.0				40.2		6.5		6.5				0.8		2.3		7.3		0.5		26.9		4.4		4.3		7.9		43.4	56.3
DCAS14A	2015	74.9						73.6		6.6		6.7				0.9		35.7		7.3		0.5		77.6		12.4		11.2		9.9		111.0	49.0
NC184	2016	94.6		27.3				44.9		5.8		6.2				10.6		5.5		21.2		0.5		62.6		19.3		2.7		15.5		100.1	120.5
NC194	2016	40.0		28.7				35.1		6.4		6.6				1.6		2.3		7.9		0.5		26.4		4.3		3.8		7.9		42.4	55.4
DCAS14A	2016	72.7		57.5				68.3		6.6		6.8				1.5		36.8		8.5		0.5		77.5		11.8		10.5		9.7		109.6	116.1

Lake	Year	CBANC (µeq/L)	SE	Gran ANC (µeq/L) (Trent)	SE	Gran ANC (µeq/L) (BASL)	SE	BCS (µeq/L)	SE	pH (Trent)	SE	pH (ALS)	SE	pH (BASL)	SE	DOC (mg/L)	SE
NC184	2017	76.3		9.8				13.0		5.4		6.0				13.3	
NC194	2017	46.5		12.4				44.8		6.4		6.4				1.0	
DCAS14A	2017	67.8		51.0				63.3		6.6		6.7				1.5	
NC184	2018	95.0		44.0				63.1		6.2		6.4				7.0	
NC194	2018	43.1		26.1				45.0		6.5		6.7				0.3	
DCAS14A	2018	79.0		59.3				77.3		6.8		6.8				1.0	
NC184	2019	86.1	1.7	24.9	1.5	47.3	14.2	42.9	2.2	5.7	0.0	6.1	0.1	5.9	0.0	9.3	0.3
NC194	2019	46.7	0.6	30.4	5.3	41.4	0.2	44.7	0.4	6.4	0.0	6.6	0.1	6.5	0.0	1.0	0.2
DCAS14A	2019	81.1	1.5	58.6	5.9	73.0	0.3	78.3	1.4	6.6	0.1	6.8	0.0	6.6	0.0	1.2	0.0
NC184	2020																
NC194	2020																
DCAS14A	2020																

Lake	Year	SO4 * (µeq/L)	SE	Cl (µeq/L)	SE	F (µeq/L)	SE	Ca * (µeq/L)	SE	Mg * (µeq/L)	SE	K * (µeq/L)	SE	Na * (µeq/L)	SE	∑ BC * (µeq/L)	∑ Anions (µeq/L)
NC184	2017	4.7		14.7		0.5		45.2		17.4		2.5		15.9		81.0	104.6
NC194	2017	2.5		4.8		0.5		29.9		5.7		3.6		9.9		49.1	39.4
DCAS14A	2017	31.1		5.6		0.5		68.2		11.8		9.1		9.9		99.0	99.0
NC184	2018	8.3		16.6		0.5		67.8		17.3		3.1		15.3		103.4	113.3
NC194	2018	2.6		5.1		0.5		28.3		4.3		4.1		9.1		45.8	45.6
DCAS14A	2018	41.3		7.3		0.5		85.6		12.6		11.5		10.7		120.4	124.2
NC184	2019	7.1	0.2	23.2	1.0	0.5	0.0	58.3	0.3	19.0	0.6	2.6	0.1	13.5	1.1	93.3	114.5
NC194	2019	2.7	0.3	9.2	0.4	0.5	0.0	31.4	0.6	4.8	0.1	4.7	0.2	8.5	0.3	49.4	50.0
DCAS14A	2019	41.0	0.9	8.8	1.0	0.5	0.0	85.3	1.2	13.7	0.2	11.9	0.3	11.9	0.3	122.8	138.6
NC184	2020																
NC194	2020																
DCAS14A	2020																

[1] SE = standard error

Sampling Data in 'Raw' Units

The annual or mean annual values (depending on whether the lake had multiple within-season samples) are presented in their "raw" units, as measured, without converting concentration values to charge equivalents.

Lake	Year	Gran Alkalinity (mg/L) (Trent)	Gran Alkalinity (mg/L) (BASL)	pH (Trent)	pH (ALS)	pH (BASL)	DOC (mg/L)	Conductivity (µS/s)	SO4 (mg/L)	Cl (mg/L)	F (mg/L)	NO3 (µg/L)	NH4 (µg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)
Lak006	2012	1.3		5.8			3.6	6.7	0.6	0.2	0.1	0.1	3.0	0.6	0.2	0.1	0.5	0.0	0.1	0.0
Lak007	2012	71.9		8.0			0.6	148.9	2.6	0.9	0.1	4.7	1.8	25.5	2.0	0.8	1.8	0.0	0.0	0.0
LAK012	2012	2.9		5.6			4.6	12.7	0.3	0.1	0.1	0.7	3.4	1.5	0.3	0.2	0.5	0.7	0.1	0.2
LAK016	2012	3.4		6.3			3.7	17.9	1.9	0.2	0.1	0.8	3.9	2.4	0.3	0.3	0.6	0.0	0.1	0.0
LAK022	2012	1.4		5.9			5.3	10.7	1.5	0.2	0.1	0.7	3.7	1.2	0.2	0.1	0.6	0.0	0.1	0.0
LAK023	2012	1.0		5.7			4.2	7.5	0.9	0.2	0.1	0.3	3.3	0.8	0.2	0.1	0.3	0.0	0.1	0.0
LAK024	2012	15.0		7.1			1.4	40.0	1.3	1.0	0.0	0.4	2.4	5.5	0.5	0.2	1.2	0.0	0.0	0.0
LAK028	2012	-0.2		5.0			4.9	12.2	2.8	0.2	0.4	1.5	3.4	1.0	0.1	0.1	0.4	0.1	0.4	0.0
LAK034	2012	5.0		6.7			4.5	22.4	1.2	0.2	0.1	1.6	4.9	2.4	0.4	0.2	1.1	0.0	0.0	0.0
LAK042	2012	-1.0		4.7			13.2	11.9	0.3	0.2	0.1	0.7	8.5	0.2	0.3	0.1	0.6	0.6	0.4	0.0
LAK044	2012	0.1		5.4			1.7	3.1	0.3	0.2	0.1	0.4	3.0	0.1	0.1	0.2	0.1	0.0	0.0	0.0
Lak006	2013	1.5		6.2	6.1		3.2	7.0	0.7	0.3	0.1	2.5	2.5	0.5	0.2	0.2	0.5	0.0	0.0	0.0
Lak007	2013	73.2		7.9	8.1		0.1	147.0	3.4	1.3	0.1	2.5	2.5	24.6	2.0	0.9	1.8	0.0	0.0	0.0
LAK012	2013	3.2		6.3	6.1		4.2	12.8	0.6	0.5	0.2	2.5	2.5	1.3	0.3	0.4	0.6	0.4	0.1	0.0
LAK016	2013	4.9		6.7	7.2		4.2	20.3	2.8	0.4	0.2	22.7	7.1	2.3	0.3	0.4	0.6	0.0	0.0	0.0
LAK022	2013	1.8		6.2	6.1		6.2	13.8	2.3	0.4	0.2	2.5	2.5	1.3	0.3	0.2	0.7	0.1	0.1	0.0
LAK023	2013	1.2		6.0	6.0		4.0	9.6	1.2	0.3	0.1	30.1	2.5	0.7	0.2	0.2	0.3	0.0	0.1	0.0
LAK024	2013																			
LAK028	2013	0.2		5.2	5.5		7.1	20.3	6.2	0.6	0.6	20.4	2.5	1.7	0.3	0.2	0.6	0.2	0.6	0.0
LAK034	2013	10.5		6.9	7.4		4.7	28.3	1.9	0.3	0.2	2.5	2.5	3.1	0.5	0.4	1.4	0.0	0.0	0.0
LAK042	2013	1.1		5.5	5.4		9.7	8.0	0.3	0.3	0.1	2.5	2.5	0.3	0.3	0.1	0.6	0.3	0.3	0.0
LAK044	2013	0.4		5.7	6.0		1.5	3.3	0.3	0.3	0.1	2.5	2.5	0.2	0.1	0.2	0.1	0.0	0.0	0.0
Lak006	2014	1.9		6.1	6.6		3.8	8.5	0.6	0.3	0.1	7.7	40.5	0.6	0.2	0.2	0.5	0.0	0.1	0.0
Lak007	2014	72.4		8.1	8.0		0.7	154.2	1.6	0.7	0.0	2.5	2.5	25.6	2.0	0.8	1.8	0.0	0.0	0.0
LAK012	2014	3.4		6.0	6.7		6.3	13.9	0.8	0.4	0.1	7.6	5.3	1.4	0.3	0.3	0.6	0.3	0.1	0.0
LAK016	2014	5.3		6.7	6.7		4.0	21.5	2.4	0.3	0.2	2.5	6.7	2.5	0.3	0.4	0.7	0.0	0.1	0.0
LAK022	2014	2.3		6.3	6.4		5.7	14.4	1.9	0.3	0.1	2.5	2.5	1.4	0.3	0.2	0.7	0.1	0.1	0.0
LAK023	2014	1.6		5.9	6.7		5.7	9.3	0.9	0.2	0.1	10.9	5.3	1.0	0.2	0.2	0.4	0.0	0.1	0.0
LAK024	2014	23.6		7.6	7.5		1.7	63.1	2.1	2.3	0.0	5.1	2.5	8.1	0.8	0.4	2.5	0.0	0.0	0.0
LAK028	2014	1.1		5.3	5.7		5.9	20.2	4.6	0.4	0.4	2.5	2.5	1.7	0.2	0.2	0.6	0.1	0.5	0.0
LAK034	2014	10.3		6.7	7.0		7.0	27.5	0.9	0.2	0.1	2.5	2.5	3.2	0.5	0.4	1.3	0.1	0.0	0.0
LAK042	2014	0.6		5.1	5.4		10.6	10.8	0.3	0.4	0.1	2.5	2.5	0.2	0.3	0.2	0.6	0.4	0.3	0.0
LAK044	2014	0.3		5.8	5.6		1.8	3.6	0.3	0.2	0.1	2.5	2.5	0.2	0.1	0.2	0.1	0.0	0.0	0.0
Lak006	2015	1.6		6.0	6.4		3.9	5.6	0.6	0.2	0.1	3.4	5.4	0.7	0.2	0.2	0.5	0.1	0.1	0.0
Lak007	2015	78.4		8.0	7.9		0.3	151.2	2.3	0.9	0.0	5.6	2.5	25.4	2.0	0.8	1.8	0.0	0.0	0.0
LAK012	2015	3.3		6.0	6.3		7.5	10.1	0.9	0.4	0.1	8.3	8.0	1.5	0.3	0.3	0.6	0.3	0.1	0.0
LAK016	2015	5.7		6.8	6.9		4.3	20.7	2.0	0.3	0.2	7.9	2.5	2.6	0.3	0.4	0.7	0.0	0.1	0.0
LAK022	2015	1.8		6.1	6.2		6.3	12.8	1.6	0.3	0.1	2.5	2.5	1.3	0.2	0.2	0.6	0.1	0.1	0.0
LAK023	2015	1.5		5.9	6.2		5.4	5.9	0.8	0.2	0.1	6.3	2.5	0.9	0.2	0.2	0.3	0.0	0.1	0.0

Lake	Year	Gran Alkalinity (mg/L) (Trent)	Gran Alkalinity (mg/L) (BASL)	pH (Trent)	pH (ALS)	pH (BASL)	DOC (mg/L)	Conductivity (µS/s)	SO4 (mg/L)	Cl (mg/L)	F (mg/L)	NO3 (µg/L)	NH4 (µg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)
LAK024	2015	22.2		7.4	7.5		2.2	58.7	2.0	2.1	0.0	8.1	2.5	8.1	0.7	0.4	2.3	0.1	0.0	0.0
LAK028	2015	0.5		5.1	5.3		8.1	17.8	3.5	0.3	0.4	2.5	2.5	1.5	0.2	0.1	0.5	0.2	0.6	0.0
LAK034	2015	8.9		6.6	6.7		7.6	22.3	0.1	0.2	0.1	2.5	2.5	2.9	0.5	0.2	1.2	0.1	0.0	0.0
LAK042	2015	0.7		5.4	5.5		8.3	8.1	0.2	0.2	0.0	2.5	2.5	0.2	0.3	0.1	0.7	0.2	0.3	0.0
LAK044	2015	0.3		5.8	5.8		1.6	3.5	0.2	0.2	0.1	2.5	2.5	0.2	0.1	0.2	0.1	0.0	0.0	0.0
Lak006	2016	1.3		6.0	6.3		4.2	7.8	0.6	0.2	0.1	2.5	2.5	0.7	0.2	0.2	0.5	0.0	0.1	0.0
Lak007	2016	68.5		8.0	8.1		0.8	153.7	2.4	0.9	0.1	6.5	2.5	26.1	2.0	0.8	1.8	0.0	0.0	0.0
LAK012	2016	3.3		6.2	6.5		5.1	12.4	0.5	0.2	0.1	5.0	4.7	1.3	0.3	0.2	0.6	0.3	0.1	0.0
LAK016	2016	4.7		6.6	6.9		5.2	20.8	2.2	0.3	0.2	10.9	2.5	2.6	0.3	0.4	0.7	0.0	0.1	0.0
LAK022	2016	1.7		6.1	6.4		6.7	13.7	1.7	0.3	0.1	2.5	2.5	1.4	0.3	0.2	0.7	0.1	0.1	0.0
LAK023	2016	1.4		5.9	6.2		5.8	9.1	0.6	0.2	0.1	2.5	5.1	0.9	0.2	0.2	0.4	0.0	0.1	0.0
LAK024	2016	23.2		7.5	7.6		2.7	66.3	2.2	2.5	0.0	20.7	2.5	9.0	0.8	0.4	2.6	0.1	0.0	0.0
LAK028	2016	-0.2		5.0	5.1		8.1	23.7	6.2	0.4	0.5	21.5	2.5	1.9	0.3	0.2	0.6	0.1	0.7	0.0
LAK034	2016	7.6		6.5	7.1		7.6	22.1	0.0	0.2	0.1	2.5	2.5	2.6	0.4	0.2	1.1	0.1	0.0	0.0
LAK042	2016	0.7		5.4	5.7		9.8	8.8	0.2	0.3	0.0	2.5	3.7	0.3	0.3	0.1	0.7	0.2	0.3	0.0
LAK044	2016	0.2		5.5	6.0		2.0	3.9	0.2	0.2	0.0	2.5	2.5	0.2	0.1	0.2	0.1	0.0	0.0	0.0
Lak006	2017	1.4		6.0	6.4		3.8	8.8	0.7	0.2	0.1	2.5	2.5	0.7	0.2	0.2	0.5	0.0	0.1	0.0
Lak007	2017	69.1		8.0	8.0		0.3	149.0	2.4	0.9	0.0	2.5	2.5	24.1	2.1	0.8	2.0	0.0	0.0	0.0
LAK012	2017	2.9		6.1	6.5		5.2	12.9	0.7	0.2	0.1	9.7	5.6	1.3	0.3	0.3	0.6	0.3	0.1	0.0
LAK016	2017	4.1		6.7	6.8		4.1	18.5	2.1	0.3	0.1	2.5	2.5	2.3	0.3	0.3	0.7	0.0	0.1	0.0
LAK022	2017	1.7		6.1	6.3		5.9	12.8	1.9	0.3	0.1	2.5	2.5	1.3	0.3	0.2	0.6	0.0	0.1	0.0
LAK023	2017	1.4		5.9	6.2		5.4	7.9	0.5	0.2	0.1	7.7	2.5	0.9	0.2	0.1	0.3	0.0	0.1	0.0
LAK024	2017	20.9		7.4	7.6		2.0	57.4	2.0	2.0	0.0	11.2	2.5	8.1	0.8	0.4	2.4	0.1	0.0	0.0
LAK028	2017	-0.5		4.8	5.1		7.3	26.9	7.2	0.3	0.5	25.3	3.3	2.1	0.3	0.1	0.6	0.1	0.7	0.0
LAK034	2017	6.8		6.4	6.8		6.0	17.6	0.0	0.2	0.1	2.5	2.5	2.1	0.4	0.1	1.0	0.1	0.0	0.0
LAK042	2017	0.1		5.2	5.4		11.6	9.8	0.4	0.2	0.0	2.5	5.4	0.3	0.3	0.1	0.7	0.3	0.4	0.0
LAK044	2017	0.4		5.6	6.0		1.6	4.4	0.2	0.2	0.0	2.5	2.5	0.2	0.1	0.2	0.1	0.0	0.0	0.0
Lak006	2018	1.4		6.1	6.4		3.8	8.8	0.8	0.2	0.1	2.5	2.5	0.7	0.2	0.2	0.5	0.0	0.1	0.0
Lak007	2018	70.4		8.1	8.1		0.3	147.4	2.4	1.0	0.0	2.5	2.5	25.1	2.0	0.8	2.0	0.0	0.0	0.0
LAK012	2018	2.5		6.2	6.6		4.6	11.5	0.7	0.2	0.1	2.5	2.5	1.2	0.3	0.2	0.6	0.3	0.1	0.0
LAK016	2018	4.6		6.7	6.9		4.6	20.0	2.2	0.3	0.2	2.5	2.5	2.6	0.3	0.3	0.7	0.0	0.1	0.0
LAK022	2018	1.5		6.1	6.3		5.6	13.4	2.1	0.3	0.1	2.5	2.5	1.5	0.3	0.2	0.7	0.0	0.1	0.0
LAK023	2018	1.1		6.0	6.4		5.6	9.4	0.7	0.2	0.1	2.5	2.5	0.9	0.2	0.1	0.4	0.0	0.1	0.0
LAK024	2018	25.5		7.6	7.6		1.6	70.2	2.4	2.7	0.0	2.5	2.5	9.5	0.9	0.4	2.8	0.0	0.0	0.0
LAK028	2018	0.2		5.3	5.5		4.4	17.7	5.2	0.2	0.4	2.5	3.3	1.5	0.2	0.1	0.5	0.1	0.5	0.0
LAK034	2018	6.5		6.5	6.6		5.1	17.8	0.0	0.1	0.1	2.5	2.5	2.3	0.3	0.1	1.0	0.0	0.0	0.0
LAK042	2018	0.0		5.1	5.3		10.6	8.6	0.3	0.2	0.0	2.5	2.5	0.2	0.3	0.1	0.6	0.3	0.4	0.0
LAK044	2018	0.2		5.5	5.9		1.9	3.6	0.2	0.2	0.0	2.5	2.5	0.2	0.1	0.2	0.1	0.0	0.0	0.0
Lak006	2019	1.6	2.0	6.1	6.5	6.2	1.1	8.3	0.8	0.2	0.1	2.5	2.5	0.8	0.2	0.2	0.6	0.0	0.0	0.0
Lak007	2019	68.8	74.9	8.1	8.1	8.0	0.3	147.2	2.2	1.0	0.0	2.5	2.5	25.0	2.0	0.8	1.9	0.0	0.0	0.0
LAK012	2019	2.8	3.2	6.1	6.6	6.2	1.8	11.0	0.7	0.3	0.1	3.2	2.5	1.2	0.3	0.3	0.7	0.2	0.0	0.0

Lake	Year	Gran Alkalinity (mg/L) (Trent)	Gran Alkalinity (mg/L) (BASL)	pH (Trent)	pH (ALS)	pH (BASL)	DOC (mg/L)	Conductivity (µS/s)	SO4 (mg/L)	Cl (mg/L)	F (mg/L)	NO3 (µg/L)	NH4 (µg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)
LAK016	2019	4.5	5.1	6.6	7.1	6.6	2.5	19.8	2.9	0.3	0.2	2.5	6.2	2.6	0.3	0.4	0.7	0.0	0.1	0.0
LAK022	2019	1.8	2.2	6.1	6.4	6.2	1.3	13.6	2.4	0.3	0.1	2.5	2.5	1.4	0.3	0.2	0.8	0.1	0.1	0.0
LAK023	2019	1.0	1.3	5.8	6.3	6.0	1.0	7.1	0.7	0.2	0.1	2.5	3.6	0.9	0.2	0.1	0.4	0.0	0.1	0.0
LAK024	2019	24.9	27.5	7.7	7.7	7.3	6.9	66.8	2.3	2.7	0.0	8.0	2.5	9.6	0.9	0.4	3.0	0.0	0.0	0.0
LAK028	2019	0.2	0.2	5.2	5.4	5.1	5.4	24.0	7.2	0.4	0.5	11.9	5.2	2.1	0.4	0.2	0.7	0.1	0.6	0.0
LAK034	2019	7.5	8.4	6.4	7.0	6.6	3.0	17.8	0.1	0.2	0.1	2.5	2.5	2.5	0.4	0.1	1.1	0.0	0.0	0.0
LAK042	2019	0.5	0.8	5.4	5.6	5.4	1.5	6.6	0.4	0.2	0.0	4.3	2.5	0.3	0.3	0.1	0.6	0.2	0.3	0.0
LAK044	2019	0.3	0.3	5.5	5.9	5.7	1.5	2.4	0.3	0.2	0.0	2.5	2.5	0.2	0.1	0.2	0.1	0.0	0.0	0.0
Lak006	2020		2.2		6.3	6.1	5.1	8.5	0.8	0.2	0.1	2.5	2.5	0.9	0.2	0.2	0.6	0.1	0.1	0.0
LAK012	2020		4.7		6.4	6.1	8.8	15.1	0.8	0.3	0.1	2.5	2.5	2.0	0.4	0.3	0.7	0.5	0.1	0.1
LAK016	2020																			
LAK022	2020																			
LAK023	2020		1.5		6.1	6.0	6.4	7.3	0.7	0.2	0.1	2.5	2.5	1.0	0.2	0.1	0.4	0.0	0.1	0.0
LAK028	2020		0.0		5.0	5.0	7.6	25.0	7.2	0.3	0.5	25.4	3.8	2.2	0.3	0.1	0.7	0.1	0.7	0.0
LAK042	2020		-0.5		4.8	4.7	19.2	14.2	0.4	0.2	0.0	2.5	2.5	0.5	0.4	0.1	0.8	0.6	0.6	0.0
LAK044	2020		0.2		5.6	5.6	1.9	2.5	0.1	0.1	0.0	2.5	2.5	0.2	0.1	0.2	0.1	0.0	0.0	0.0
NC184	2012																			
NC194	2012																			
DCAS14A	2012																			
NC184	2013	0.8		5.7			11.6	10.0	0.4	0.9	0.0	5.0	1.0	1.0	0.3	0.2	0.8			
NC194	2013	1.4		6.6			0.7	3.9	0.2	0.3	0.0	1.0	1.0	0.5	0.1	0.2	0.3			
DCAS14A	2013	2.5		6.5			1.4	10.6	1.7	0.3	0.0	52.6	2.5	1.3	0.1	0.4	0.3	0.0	0.0	0.0
NC184	2014																			
NC194	2014																			
DCAS14A	2014																			
NC184	2015	0.9		5.5	5.6		9.8	11.6	0.4	0.8	0.0	2.5	2.5	1.0	0.2	0.1	0.7	0.2	0.3	0.0
NC194	2015	1.7		6.5	6.5		0.8	5.4	0.1	0.3	0.0	2.5	2.5	0.5	0.1	0.2	0.3	0.0	0.0	0.0
DCAS14A	2015			6.6	6.7		0.9	14.0	1.8	0.3	0.0	6.8	2.5	1.6	0.2	0.4	0.4	0.0	0.0	0.0
NC184	2016	1.4		5.8	6.2		10.6	12.8	0.4	0.8	0.0	2.5	2.5	1.3	0.3	0.1	0.8	0.1	0.3	0.0
NC194	2016	1.4		6.4	6.6		1.6	5.9	0.1	0.3	0.0	2.5	2.5	0.5	0.1	0.2	0.3	0.0	0.0	0.0
DCAS14A	2016	2.9		6.6	6.8		1.5	14.8	1.8	0.3	0.0	2.5	2.5	1.6	0.2	0.4	0.4	0.0	0.0	0.0
NC184	2017	0.5		5.4	6.0		13.3	11.4	0.3	0.5	0.0	2.5	2.5	0.9	0.2	0.1	0.7	0.2	0.3	0.0
NC194	2017	0.6		6.4	6.4		1.0	4.9	0.1	0.2	0.0	2.5	2.5	0.6	0.1	0.1	0.3	0.0	0.0	0.0
DCAS14A	2017	2.6		6.6	6.7		1.5	11.7	1.5	0.2	0.0	2.5	2.5	1.4	0.2	0.4	0.3	0.0	0.0	0.0
NC184	2018	2.2		6.2	6.4		7.0	12.3	0.5	0.6	0.0	2.5	2.5	1.4	0.3	0.1	0.7	0.1	0.2	0.0
NC194	2018	1.3		6.5	6.7		0.3	5.4	0.2	0.2	0.0	2.5	2.5	0.6	0.1	0.2	0.3	0.0	0.0	0.0
DCAS14A	2018	3.0		6.8	6.8		1.0	14.7	2.0	0.3	0.0	2.5	2.5	1.7	0.2	0.5	0.4	0.0	0.0	0.0
NC184	2019	1.2	2.4	5.7	6.1	5.9	1.1	11.1	0.5	0.8	0.0	3.7	2.5	1.2	0.3	0.1	0.8	0.1	0.3	0.0
NC194	2019	1.5	2.1	6.4	6.6	6.5	0.9	5.3	0.2	0.3	0.0	2.5	2.5	0.6	0.1	0.2	0.4	0.0	0.0	0.0
DCAS14A	2019	2.9	3.7	6.6	6.8	6.6	1.4	13.7	2.0	0.3	0.0	10.3	2.5	1.7	0.2	0.5	0.4	0.0	0.0	0.0
NC184	2020																			
NC194	2020																			

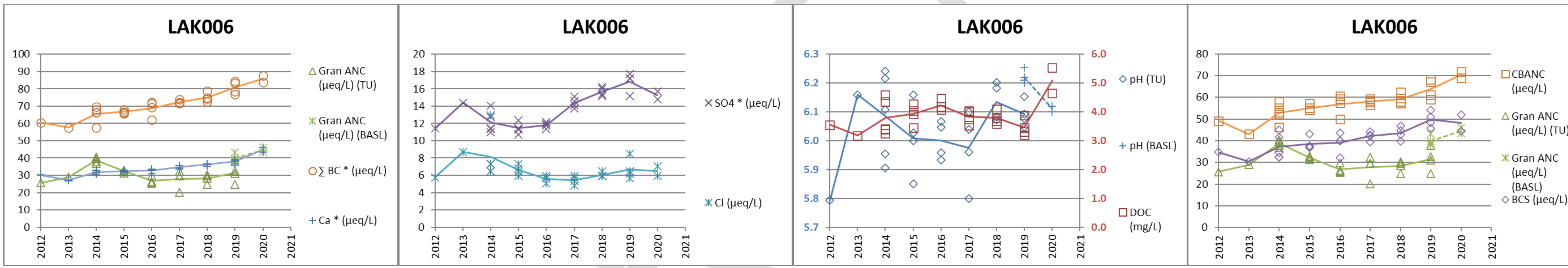
Lake	Year	Gran Alkalinity (mg/L) (Trent)	Gran Alkalinity (mg/L) (BASL)	pH (Trent)	pH (ALS)	pH (BASL)	DOC (mg/L)	Conductivity (µS/s)	SO4 (mg/L)	Cl (mg/L)	F (mg/L)	NO3 (µg/L)	NH4 (µg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)
DCAS14A	2020																			

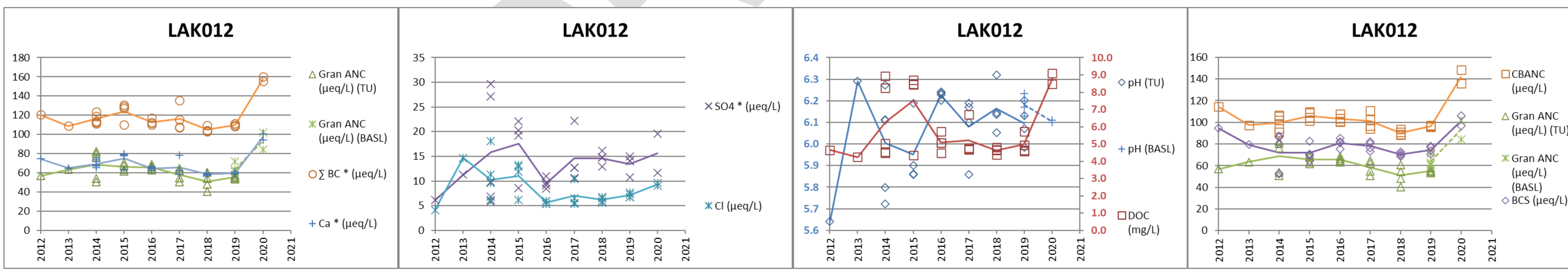
Appendix 2: Changes in Ion Concentrations from 2012 to 2020

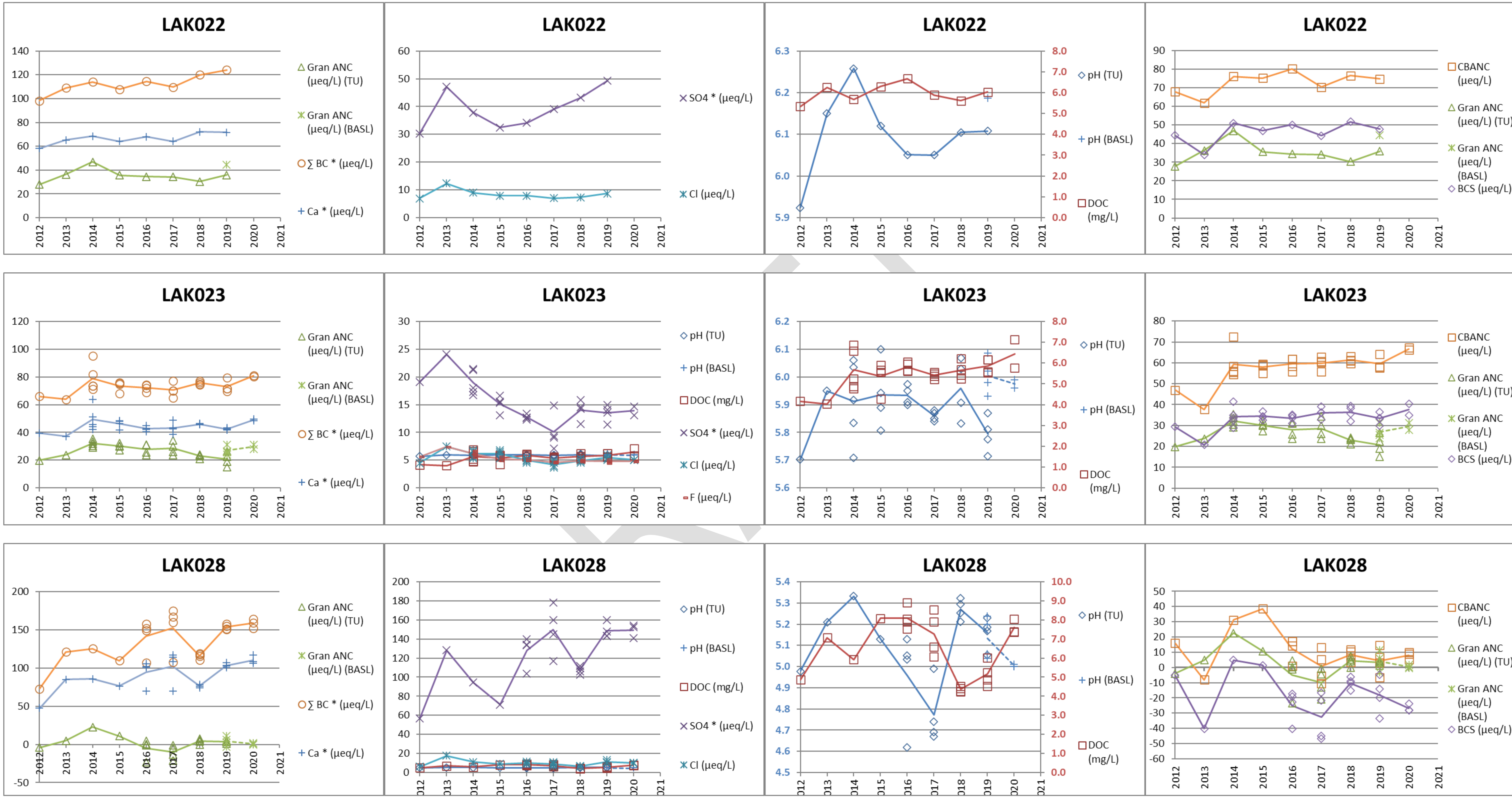
For each of the EEM lakes, the figures in this appendix show the inter-annual changes in six major water chemistry metrics from 2012 to 2020: Gran ANC, base cations and calcium (left panel), sulfate and chloride (centre panel), and pH and dissolved organic carbon (right panel). The selection of each pair of metrics is solely based on optimizing graphical representation across all metrics and lakes (i.e., metrics with somewhat similar numeric ranges are shown together). The right panel has two Y-axes. The axis for pH does not start at zero – be aware that this can make relatively minor changes appear to be much more substantial than they are. Due to large variation among the lakes for some of the metrics, the Y-axis is not consistent across the lakes, therefore extra caution is required for making comparisons among lakes with respect to the magnitude of changes. However, these graphs are especially useful for looking at the patterns of changes for individual lakes across the sampling record and determining whether similar patterns are observed across lakes and/or metrics.

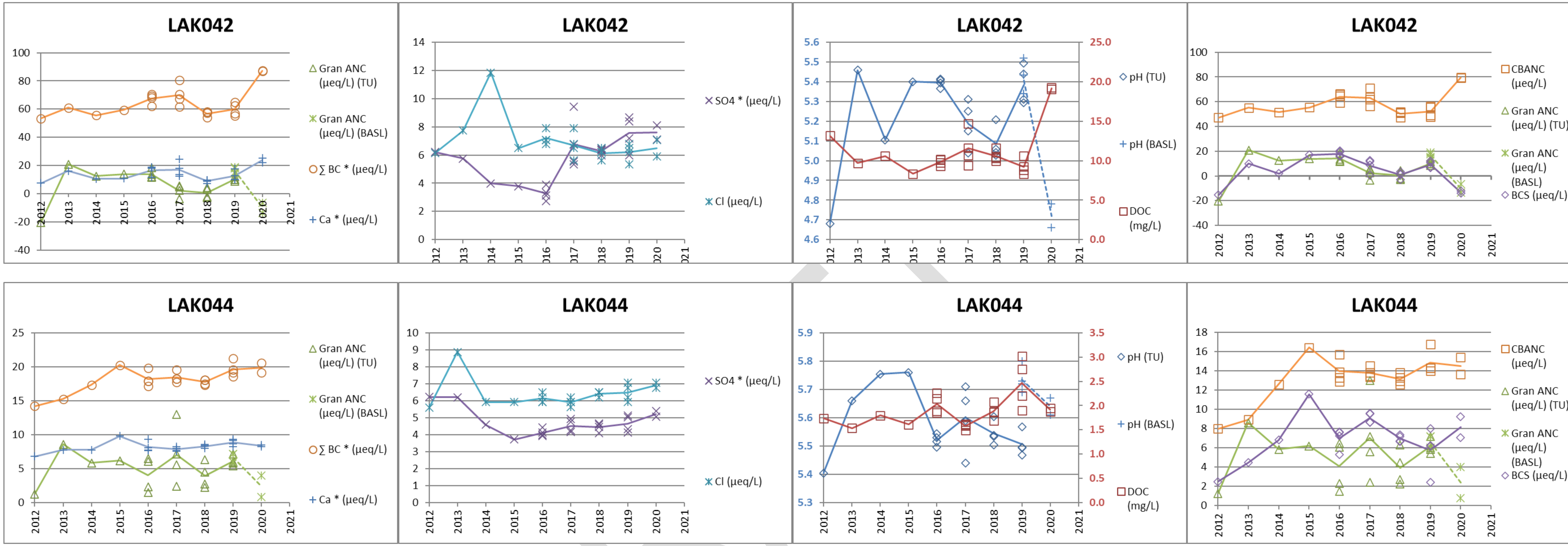
These figures show the results for all of the sampling events for each lake in each year, whether that included multiple within-season samples or only a single annual sample. The points represent the values for individual sampling events. The solid lines represent the annual trend, based on either the single annual sample or the average of all the within-season samples, as appropriate for the lake and year. For the sensitive lakes (the only lakes where intensive, within-season sampling was conducted), the point markers have been made hollow so that it is possible to see if there were multiple within-season samples with similar values.

Sensitive Lakes

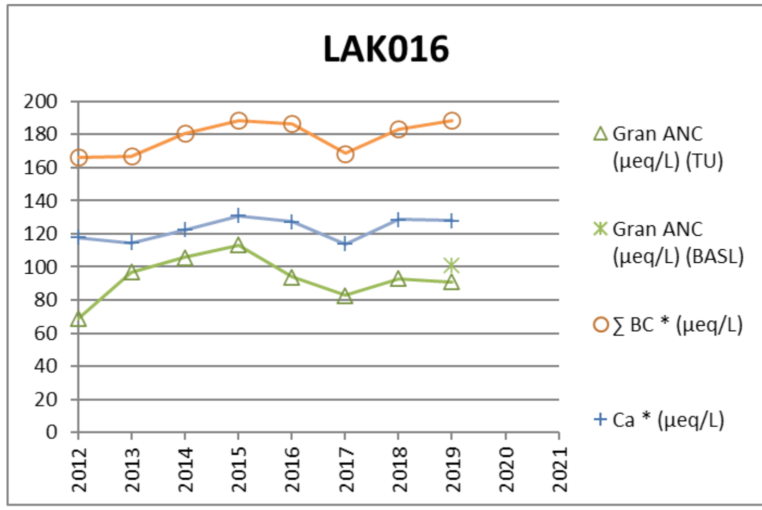


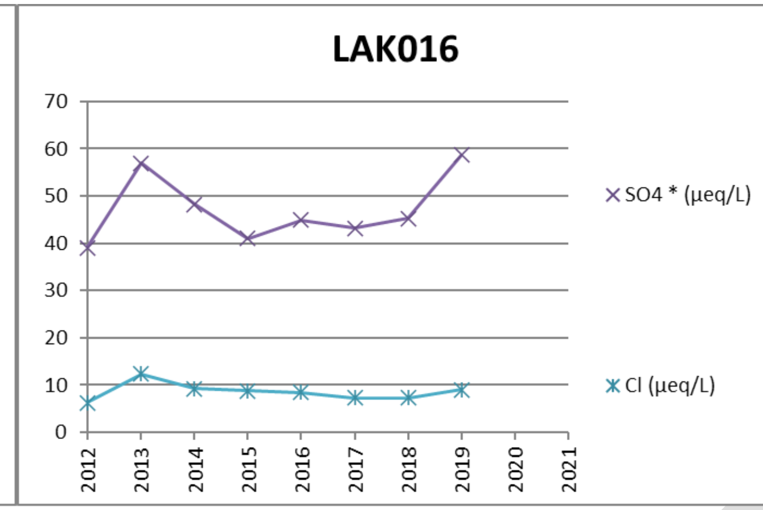


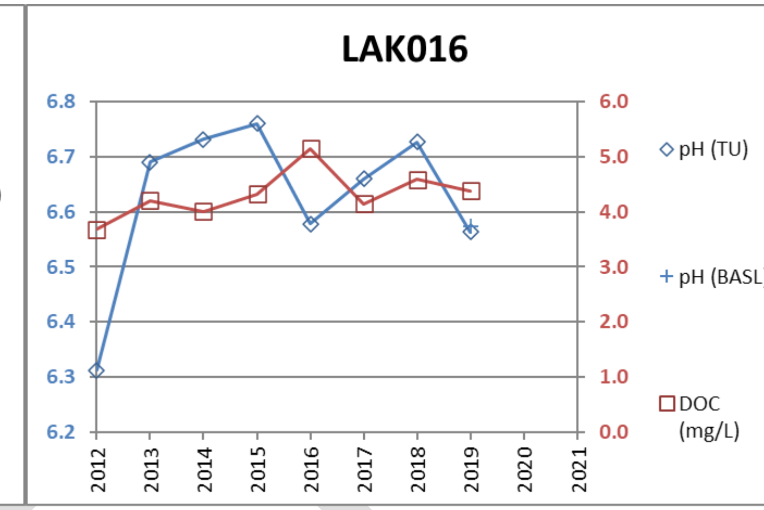

LAK022
Gran ANC (μeq/L) (TU)
Gran ANC (μeq/L) (BASL)
∑ BC * (μeq/L)
Ca * (μeq/L)
LAK022
SO4 * (μeq/L)
Cl (μeq/L)
LAK022
pH (TU)
pH (BASL)
DOC (mg/L)
LAK022
CBANC (μeq/L)
Gran ANC (μeq/L) (TU)
Gran ANC (μeq/L) (BASL)
BCS (μeq/L)
LAK023
Gran ANC (μeq/L) (TU)
Gran ANC (μeq/L) (BASL)
∑ BC * (μeq/L)
Ca * (μeq/L)
LAK023
pH (TU)
pH (BASL)
DOC (mg/L)
SO4 * (μeq/L)
Cl (μeq/L)
F (μeq/L)
LAK023
pH (TU)
pH (BASL)
DOC (mg/L)
LAK023
CBANC (μeq/L)
Gran ANC (μeq/L) (TU)
Gran ANC (μeq/L) (BASL)
BCS (μeq/L)
LAK028
Gran ANC (μeq/L) (TU)
Gran ANC (μeq/L) (BASL)
∑ BC * (μeq/L)
Ca * (μeq/L)
LAK028
pH (TU)
pH (BASL)
DOC (mg/L)
SO4 * (μeq/L)
Cl (μeq/L)
LAK028
pH (TU)
pH (BASL)
DOC (mg/L)
LAK028
CBANC (μeq/L)
Gran ANC (μeq/L) (TU)
Gran ANC (μeq/L) (BASL)
BCS (μeq/L)

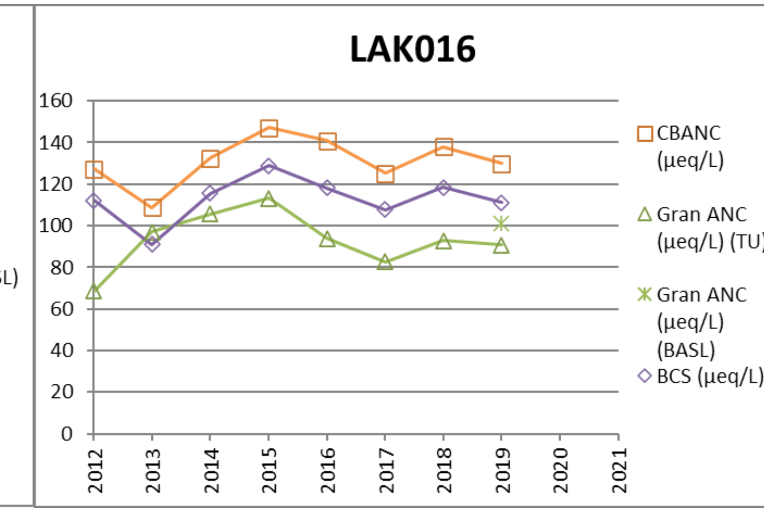

LAK042
Gran ANC (μeq/L) (TU)
Gran ANC (μeq/L) (BASL)
∑ BC * (μeq/L)
Ca * (μeq/L)
LAK042
SO4 * (μeq/L)
Cl (μeq/L)
LAK042
pH (TU)
pH (BASL)
DOC (mg/L)
LAK042
CBANC (μeq/L)
Gran ANC (μeq/L) (TU)
Gran ANC (μeq/L) (BASL)
BCS (μeq/L)
LAK044
Gran ANC (μeq/L) (TU)
Gran ANC (μeq/L) (BASL)
∑ BC * (μeq/L)
Ca * (μeq/L)
LAK044
SO4 * (μeq/L)
Cl (μeq/L)
LAK044
pH (TU)
pH (BASL)
DOC (mg/L)
LAK044
CBANC (μeq/L)
Gran ANC (μeq/L) (TU)
Gran ANC (μeq/L) (BASL)
BCS (μeq/L)

Less Sensitive Lakes

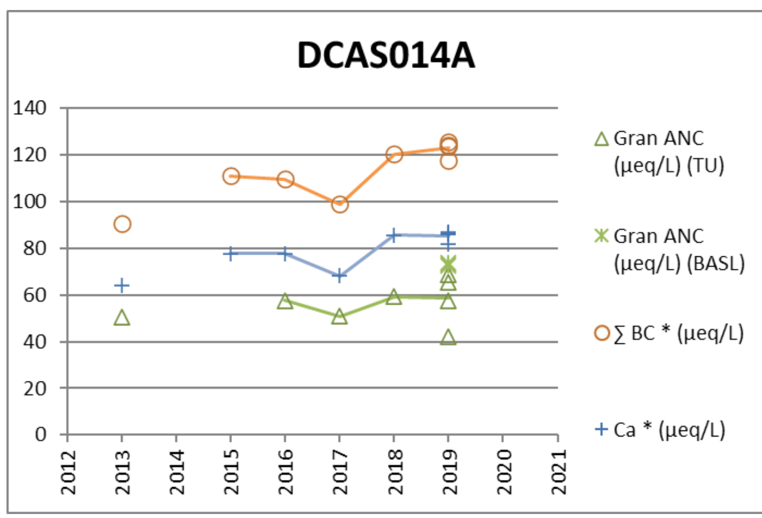


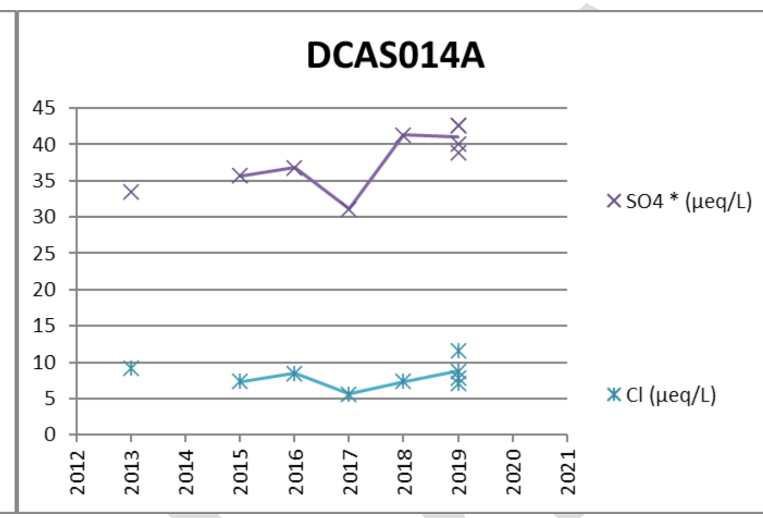


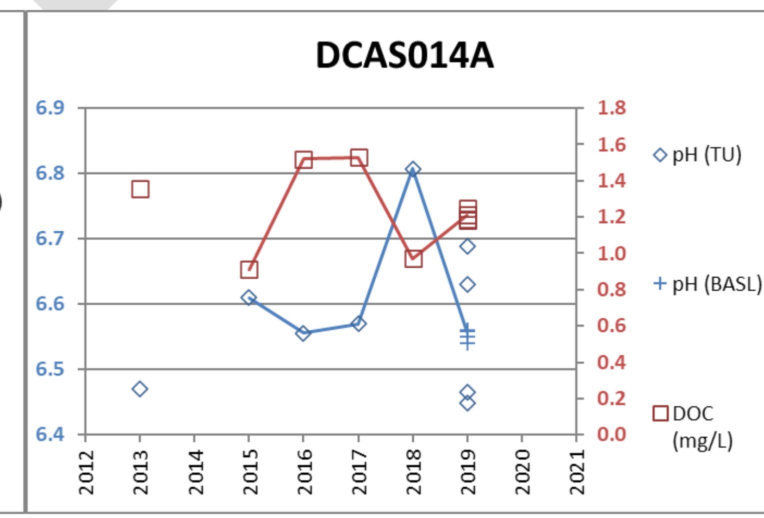


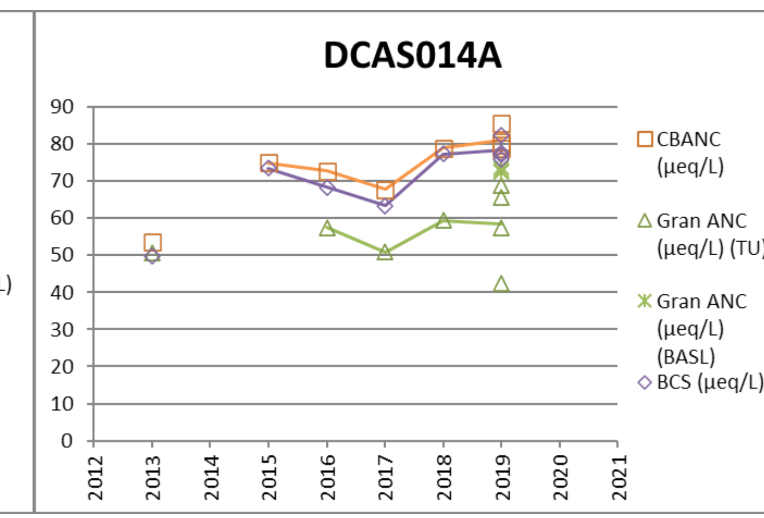


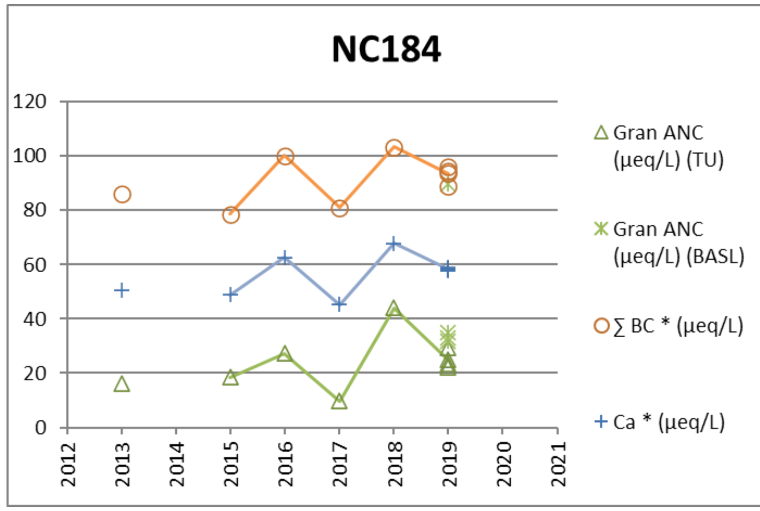
Control Lakes

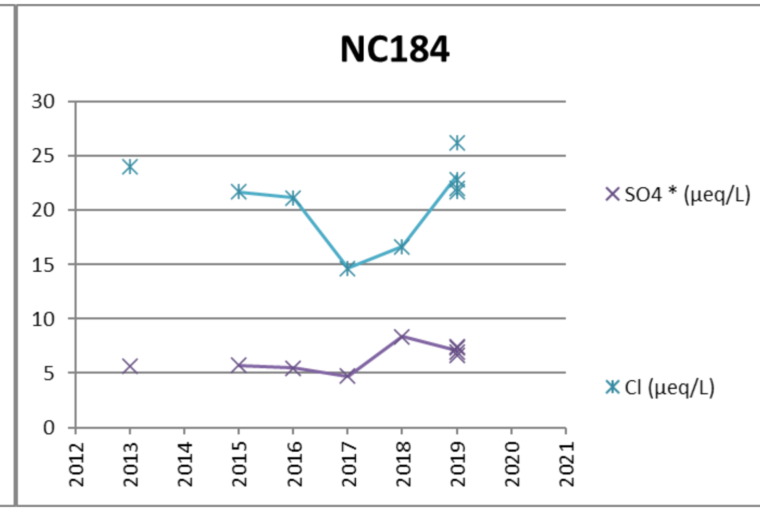


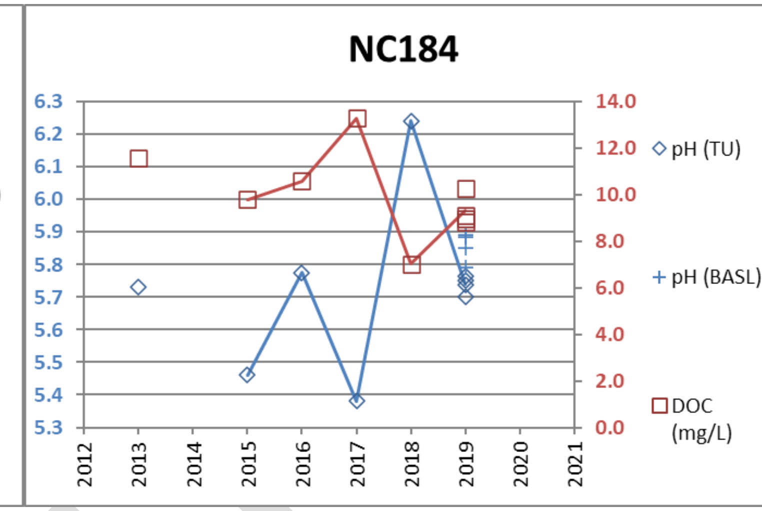


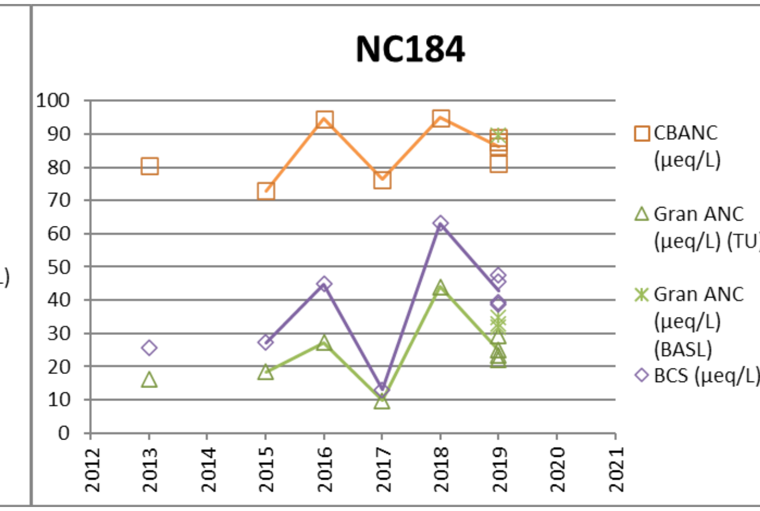


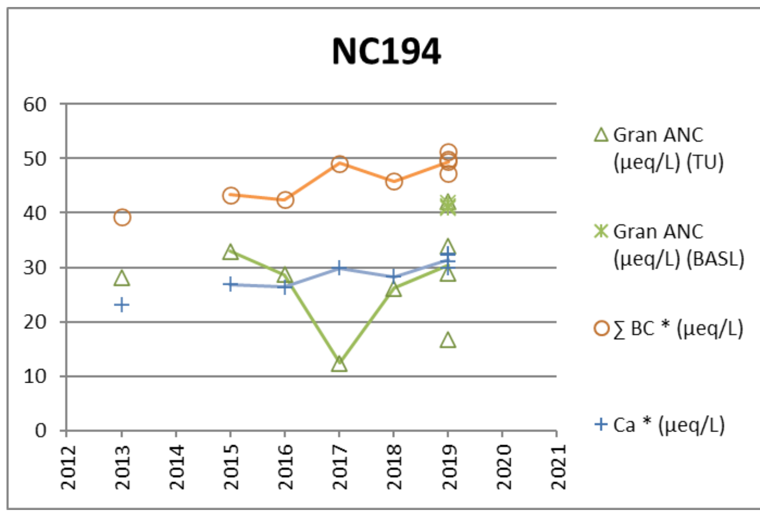


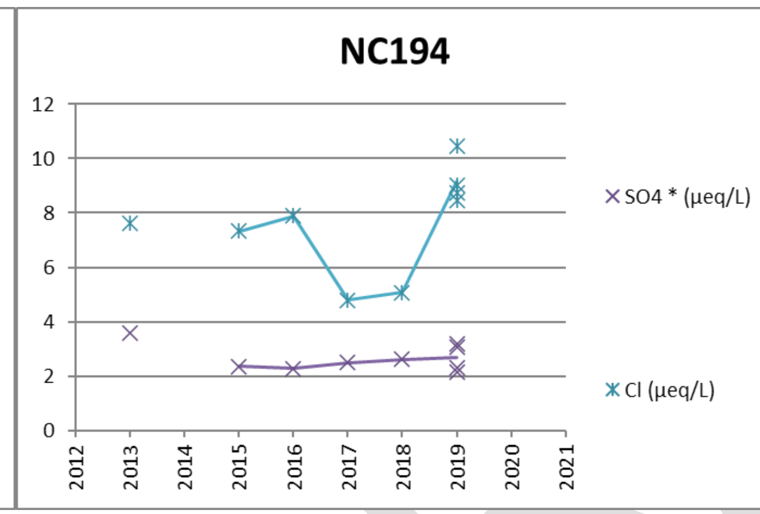

NC184
120
100
80
60
40
20
0
2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Gran ANC (μeq/L) (TU)
Gran ANC (μeq/L) (BASL)
∑ BC * (μeq/L)
Ca * (μeq/L)

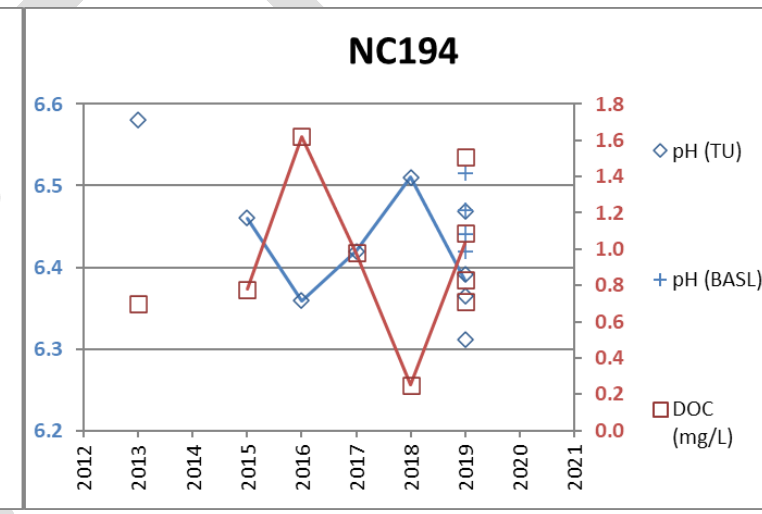

NC184
30
25
20
15
10
5
0
2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
SO4 * (μeq/L)
Cl (μeq/L)

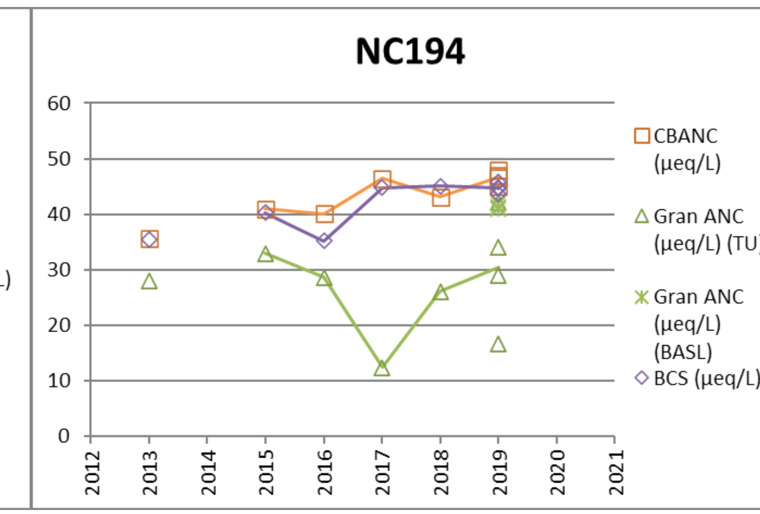

NC184
6.3 6.2 6.1 6.0 5.9 5.8 5.7 5.6 5.5 5.4 5.3
14.0 12.0 10.0 8.0 6.0 4.0 2.0 0.0
2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
pH (TU)
pH (BASL)
DOC (mg/L)


NC184
100 90 80 70 60 50 40 30 20 10 0
2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
CBANC (μeq/L)
Gran ANC (μeq/L) (TU)
Gran ANC (μeq/L) (BASL)
BCS (μeq/L)


NC194
60
50
40
30
20
10
0
2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Gran ANC (μeq/L) (TU)
Gran ANC (μeq/L) (BASL)
∑ BC * (μeq/L)
Ca * (μeq/L)


NC194
12
10
8
6
4
2
0
2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
SO4 * (μeq/L)
Cl (μeq/L)


NC194
6.6 6.5 6.4 6.3 6.2
1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4 0.2 0.0
2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
pH (TU)
pH (BASL)
DOC (mg/L)


NC194
60 50 40 30 20 10 0
2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
CBANC (μeq/L)
Gran ANC (μeq/L) (TU)
Gran ANC (μeq/L) (BASL)
BCS (μeq/L)

Appendix 3: Sensitivity Analyses for Statistical Analyses of Post-KMP Changes in Lake Chemistry

This appendix includes the results of the primary statistical analyses presented in Section 3.3 alongside the results of the sensitivity analyses performed using a) the alternate transition period baseline (2012-2014, as compared to the 2012 pre-KMP baseline applied in the base case), and b) an alternate 4-year post-KMP averaging period (2017-2020, as compared to 2018-2020 applied in the base case).

SUMMARY OF EXCEEDANCES - *of CHANGE LIMIT* (from statistical analyses)

Scenario	BASE CASE				SENSITIVITY - alternative baseline				SENSITIVITY - alternative post-KMP			
Post-KMP	2018-2020				2018-2020				2017-2020			
Baseline	2012				2012-2014				2012			
Metric	CBANC	Gran ANC	BCS	pH (imputed)	CBANC	Gran ANC	BCS	pH (imputed)	CBANC	Gran ANC	BCS	pH (imputed)
Thresholds	Lake-spec	Lake-spec	Δ 13 ueq/L	Δ 0.3 pH units	Lake-spec	Lake-spec	Δ 13 ueq/L	Δ 0.3 pH units	Lake-spec	Lake-spec	Δ 13 ueq/L	Δ 0.3 pH units
LAK006	2%	5%	0%	1%	0%	4%	0%	1%	2%	2%	0%	0%
LAK012	40%	19%	49%	1%	13%	9%	16%	5%	38%	14%	51%	0%
LAK022	2%	10%	5%	0%	2%	20%	2%	4%	2%	2%	3%	0%
LAK023	2%	3%	1%	3%	1%	6%	0%	1%	0%	1%	0%	0%
LAK028	13%	0%	49%	9%	29%	19%	32%	10%	25%	5%	62%	13%
LAK042	9%	2%	9%	13%	1%	10%	13%	23%	5%	0%	4%	7%
LAK044	0%	3%	0%	0%	0%	5%	0%	4%	0%	2%	0%	0%
LAK016	7%	1%	12%	6%	2%	8%	6%	7%	3%	1%	9%	1%
DCAS14A	1%	1%	0%	12%	1%	1%	1%	14%	1%	2%	3%	6%
NC184	10%	17%	12%	19%	12%	17%	14%	21%	15%	21%	21%	27%
NC194			1%	17%			0%	19%			0%	8%

SUMMARY OF EXCEEDANCES - *of LEVEL OF PROTECTION* (from statistical analyses)

Scenario	BASE CASE				SENSITIVITY - alternative post-KMP			
Post-KMP	2018-2020				2017-2020			
Metric	CBANC	Gran ANC	BCS	pH (imputed)	CBANC	Gran ANC	BCS	pH (imputed)
Thresholds	20 ueq/L	30.7 ueq/L	0 ueq/L	6.0 pH units	20 ueq/L	30.7 ueq/L	0 ueq/L	6.0 pH units
LAK006	0%	45%	0%	2%	0%	41%	0%	5%
LAK012	0%	0%	0%	10%	0%	0%	0%	6%
LAK022	0%	29%	0%	13%	0%	11%	0%	4%
LAK023	0%	100%	0%	100%	0%	100%	0%	100%
LAK028	100%	100%	100%	100%	100%	100%	100%	100%
LAK042	0%	100%	55%	100%	0%	100%	24%	100%
LAK044	100%	100%	0%	100%	100%	100%	0%	100%
LAK016	0%	0%	0%	0%	0%	0%	0%	0%
DCAS14A	0%	0%	0%	0%	0%	0%	0%	0%
NC184	0%	53%	0%	89%	0%	80%	0%	90%
NC194	0%	96%	0%	0%	0%	93%	0%	0%

<u>Note</u>: This row of tables (i.e., *level of protection*) is not missing a table – there is no "alternative baseline" scenario because the *level of protection* is solely based on the post-KMP status. Therefore, the overall assessment under the alternative baseline scenario (i.e., middle table in last row of tables) is based on the alternative baseline scenario the *change limit* assessment and the base case scenario for the *level of protection* assessment.

KPI & INFORM. INDICATOR EVALUATION - Exceedance of Level of Protection AND Change Limit

Scenario	BASE CASE				SENSITIVITY - alternative baseline				SENSITIVITY - alternative post-KMP			
Post-KMP	2018-2020				2018-2020				2017-2020			
Baseline	2012				2012-2014				2012			
Metric	CBANC	Gran ANC	BCS	pH (imputed)	CBANC	Gran ANC	BCS	pH (imputed)	CBANC	Gran ANC	BCS	pH (imputed)
Thresholds	Lake-spec	Lake-spec	Δ 13 ueq/L	Δ 0.3 pH units	Lake-spec	Lake-spec	Δ 13 ueq/L	Δ 0.3 pH units	Lake-spec	Lake-spec	Δ 13 ueq/L	Δ 0.3 pH units
LAK006	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW
LAK012	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW
LAK022	LOW	LOW	LOW	LOW	LOW	MOD	LOW	LOW	LOW	LOW	LOW	LOW
LAK023	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW
LAK028	LOW	LOW	MOD	LOW	MOD	LOW	MOD	LOW	MOD	LOW	MOD	LOW
LAK042	LOW	LOW	LOW	LOW	LOW	LOW	LOW	MOD	LOW	LOW	LOW	LOW
LAK044	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW
LAK016	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW
DCAS14A	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW
NC184	LOW	LOW	LOW	LOW	LOW	LOW	LOW	MOD	LOW	MOD	LOW	MOD
NC194	noRel	noRel	LOW	LOW	noRel	noRel	LOW	LOW	noRel	noRel	LOW	LOW

Appendix 4: Sensitivity Analyses on Imputation of Gran ANC and pH Values for Integrated Time Series

This appendix includes the results of the Bayesian statistical analyses for Gran ANC and pH using alternate values for the imputed 2020 value in order to explore the sensitivity of the results to the uncertainty in the imputation process (see description in Section 2.1). Results are shown for the range of data series for Gran ANC and pH across the base case scenario, the alternative baseline scenario, and the alternative post-KMP period scenario. For each scenario, the tables below show the results across all lakes for each data series and the range of results across all of the permutations of a particular metric for each lake.

SUMMARY OF EXCEEDANCES - *of CHANGE LIMIT* (from statistical analyses)

Scenario	BASE CASE											
Post-KMP	2018-2020										2018-2020	
Baseline	2012										2012	
Metric	Gran ANC (imputed)	Gran ANC (imp+1SD)	Gran ANC (imp+2SD)	Gran ANC (imp-1SD)	Gran ANC (imp-2SD)	pH (imputed)	pH (imp+1SD)	pH (imp+2SD)	pH (imp-1SD)	pH (imp-2SD)	Gran ANC	pH
Thresholds	Lake-spec	Lake-spec	Lake-spec	Lake-spec	Lake-spec	Δ 0.3 pH units	Δ 0.3 pH units	Δ 0.3 pH units	Δ 0.3 pH units	Δ 0.3 pH units	Range (max-min)	
LAK006	5%	6%	5%	4%	3%	1%	0%	0%	2%	6%	3%	6%
LAK012	19%	19%	20%	18%	18%	1%	0%	0%	2%	4%	2%	4%
LAK022	10%	8%	8%	10%	9%	0%	0%	0%	0%	0%	2%	0%
LAK023	3%	2%	2%	2%	2%	3%	3%	4%	3%	4%	1%	1%
LAK028	0%	0%	1%	1%	1%	9%	4%	2%	15%	20%	1%	18%
LAK042	2%	2%	2%	2%	3%	13%	10%	7%	17%	20%	1%	13%
LAK044	3%	2%	3%	4%	4%	0%	1%	3%	0%	4%	2%	4%
LAK016	1%	1%	1%	2%	1%	6%	6%	9%	6%	7%	1%	3%
DCAS14A	1%	1%	0%	1%	1%	12%	13%	12%	15%	14%	1%	3%
NC184	17%	15%	17%	17%	17%	19%	23%	19%	20%	22%	2%	4%
NC194						17%	19%	19%	18%	18%	0%	2%

Scenario	SENSITIVITY - alternative baseline											
Post-KMP	2018-2020										2018-2020	
Baseline	2012-2014										2012-2014	
Metric	Gran ANC (imputed)	Gran ANC (imp+1SD)	Gran ANC (imp+2SD)	Gran ANC (imp-1SD)	Gran ANC (imp-2SD)	pH (imputed)	pH (imp+1SD)	pH (imp+2SD)	pH (imp-1SD)	pH (imp-2SD)	Gran ANC	pH
Thresholds	Lake-spec	Lake-spec	Lake-spec	Lake-spec	Lake-spec	Δ 0.3 pH units	Δ 0.3 pH units	Δ 0.3 pH units	Δ 0.3 pH units	Δ 0.3 pH units	Range (max-min)	
LAK006	4%	3%	5%	3%	4%	1%	1%	1%	3%	6%	2%	5%
LAK012	9%	12%	10%	9%	10%	5%	5%	3%	6%	8%	3%	5%
LAK022	20%	19%	21%	19%	21%	4%	5%	6%	7%	6%	2%	3%
LAK023	6%	6%	4%	4%	5%	1%	1%	1%	2%	4%	2%	3%
LAK028	19%	19%	18%	18%	17%	10%	5%	3%	14%	24%	2%	21%
LAK042	10%	10%	11%	11%	9%	23%	18%	16%	28%	31%	2%	15%
LAK044	5%	8%	5%	6%	5%	4%	3%	4%	7%	11%	3%	8%
LAK016	8%	8%	8%	6%	9%	7%	7%	6%	9%	7%	3%	3%
DCAS14A	1%	0%	1%	0%	1%	14%	13%	13%	15%	12%	1%	3%
NC184	17%	18%	15%	18%	17%	21%	21%	20%	23%	22%	3%	3%
NC194						19%	20%	19%	19%	17%	0%	3%

Scenario	SENSITIVITY - alternative post-KMP											
Post-KMP	2017-2020										2017-2020	
Baseline	2012										2012	
Metric	Gran ANC (imputed)	Gran ANC (imp+1SD)	Gran ANC (imp+2SD)	Gran ANC (imp-1SD)	Gran ANC (imp-2SD)	pH (imputed)	pH (imp+1SD)	pH (imp+2SD)	pH (imp-1SD)	pH (imp-2SD)	Gran ANC	pH
Thresholds	Lake-spec	Lake-spec	Lake-spec	Lake-spec	Lake-spec	Δ 0.3 pH units	Δ 0.3 pH units	Δ 0.3 pH units	Δ 0.3 pH units	Δ 0.3 pH units	Range (max-min)	
LAK006	2%	3%	4%	3%	2%	0%	0%	1%	1%	2%	2%	2%
LAK012	14%	13%	14%	15%	12%	0%	0%	0%	0%	1%	3%	1%
LAK022	2%	2%	2%	2%	2%	0%	0%	1%	0%	0%	0%	1%
LAK023	1%	1%	1%	2%	1%	0%	0%	1%	1%	2%	1%	2%
LAK028	5%	5%	5%	5%	5%	13%	12%	9%	18%	20%	0%	11%
LAK042	0%	1%	0%	0%	1%	7%	6%	3%	10%	12%	1%	9%
LAK044	2%	2%	2%	2%	2%	0%	0%	1%	0%	1%	0%	1%
LAK016	1%	1%	1%	0%	1%	1%	1%	2%	1%	1%	1%	1%
DCAS14A	2%	1%	2%	2%	2%	6%	3%	5%	5%	5%	1%	3%
NC184	21%	22%	21%	18%	20%	27%	30%	28%	26%	27%	4%	4%
NC194						8%	9%	8%	9%	9%	0%	1%

SUMMARY OF EXCEEDANCES - *of LEVEL OF PROTECTION* (from statistical analyses)

Scenario	BASE CASE												
Post-KMP	2018-2020											2018-2020	
Metric	Gran ANC (imputed)	Gran ANC (imp+1SD)	Gran ANC (imp+2SD)	Gran ANC (imp-1SD)	Gran ANC (imp-2SD)		pH (imputed)	pH (imp+1SD)	pH (imp+2SD)	pH (imp-1SD)	pH (imp-2SD)	Gran ANC	pH
Thresholds	30.7 ueq/L	30.7 ueq/L	30.7 ueq/L	30.7 ueq/L	30.7 ueq/L		6.0 pH units	6.0 pH units	6.0 pH units	6.0 pH units	6.0 pH units	Range (max-min)	
LAK006	45%	45%	45%	45%	42%		2%	2%	2%	8%	15%	3%	13%
LAK012	0%	0%	0%	0%	0%		10%	10%	10%	19%	7%	0%	12%
LAK022	29%	29%	29%	29%	24%		13%	13%	13%	10%	9%	5%	4%
LAK023	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	0%	0%
LAK028	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	0%	0%
LAK042	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	0%	0%
LAK044	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	0%	0%
LAK016	0%	0%	0%	0%	0%		0%	0%	0%	0%	0%	0%	0%
DCAS14A	0%	0%	0%	0%	0%		0%	0%	0%	0%	0%	0%	0%
NC184	53%	53%	53%	53%	62%		89%	89%	89%	85%	87%	9%	4%
NC194	96%	96%	96%	96%	99%		0%	0%	0%	0%	0%	3%	0%

Scenario	SENSITIVITY - alternative post-KMP											2017-2020	
Post-KMP	2017-2020												
Metric	Gran ANC (imputed)	Gran ANC (imp+1SD)	Gran ANC (imp+2SD)	Gran ANC (imp-1SD)	Gran ANC (imp-2SD)		pH (imputed)	pH (imp+1SD)	pH (imp+2SD)	pH (imp-1SD)	pH (imp-2SD)	Gran ANC	pH
Thresholds	30.7 ueq/L	30.7 ueq/L	30.7 ueq/L	30.7 ueq/L	30.7 ueq/L		6.0 pH units	6.0 pH units	6.0 pH units	6.0 pH units	6.0 pH units	Range (max-min)	
LAK006	41%	80%	61%	64%	62%		5%	4%	3%	9%	10%	39%	7%
LAK012	0%	0%	0%	0%	0%		6%	4%	5%	5%	9%	0%	5%
LAK022	11%	13%	9%	8%	11%		4%	5%	6%	1%	4%	5%	5%
LAK023	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	0%	0%
LAK028	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	0%	0%
LAK042	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	0%	0%
LAK044	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	0%	0%
LAK016	0%	0%	0%	0%	0%		0%	0%	0%	0%	0%	0%	0%
DCAS14A	0%	0%	0%	0%	0%		0%	0%	0%	0%	0%	0%	0%
NC184	80%	79%	76%	76%	78%		90%	89%	94%	89%	94%	4%	5%
NC194	93%	88%	94%	89%	91%		0%	0%	0%	0%	0%	6%	0%

Appendix 5: Lake-specific thresholds for change limits for CBANC

The lake-specific CBANC thresholds for the *change limit* are shown in the table below. The table and caption below are directly copied from Table 5-1 in EEM Phase III Plan.

Lake-specific thresholds for change limits in CBANC. Values calculated from analyses of the titration data, showing the change in CBANC associated with a pH decline of 0.3 pH units from the 2012 (or 2013 for control lakes) pH value for each lake. A lake-specific threshold cannot be estimated for control lake NC194 given limited data.

	EEM Group	Lake-specific CBANC threshold (μeq/L)
LAK006	Sensitive Lake	-10.8
LAK012	Sensitive Lake	-16.3
LAK022	Sensitive Lake	-11.5
LAK023	Sensitive Lake	-10.5
LAK028	Sensitive Lake	-13.4
LAK042	Sensitive Lake	-24.4
LAK044	Sensitive Lake	-6.2
LAK016	Less Sensitive Lake	-25.6
DCAS14A	Control Lake	-21.7
NC184	Control Lake	-10.8
NC194	Control Lake	n.a.