Sulphur Dioxide Environmental Effects Monitoring for B.C. Works

2019 Annual Report

Prepared for:

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1 Introduction

In 2013 a technical assessment (ESSA et al. 2013) was completed for B.C. Works, to determine the potential impacts of sulphur dioxide (SO_2) emissions on human health, vegetation, terrestrial ecosystems, and aquatic ecosystems. Figure 1 shows a conceptual model of the pathways of potential effect that were considered in the technical assessment.

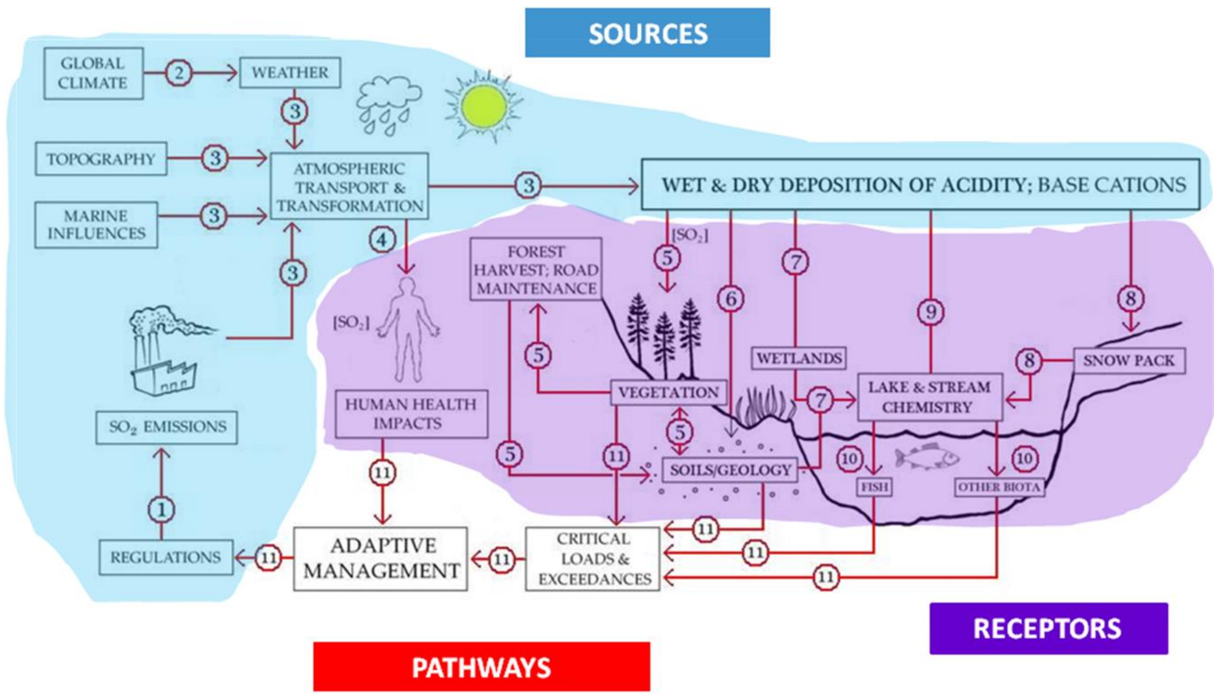


Figure 1. Source-Pathway-Receptor model of SO_2 emissions in the environment, showing linkages between sources and receptors. (Source: Figure 3.1-1 from ESSA et al. 2013)

A sulphur dioxide Environmental Effects Monitoring (EEM) Program was designed to answer questions that arose during the technical assessment, and to monitor effects of SO_2 from the modernized smelter on human health, vegetation, and terrestrial and aquatic ecosystems. Results from this Program will inform decisions regarding the need for changes to the scale or intensity of monitoring, as well as decisions regarding the need for mitigation.

The scope of the EEM Program encompasses SO_2 emissions from the modernized smelter at full production capacity. Other smelter emissions, research and development related to SO_2 impact measurement and mitigation, monitoring for non-B.C. Works' acid deposition and monitoring not specific to B.C. Works' SO_2 impacts are all outside of the scope of the SO_2 EEM Program.

This document comprises the 2019 Annual Report under the SO_2 EEM Plan for the B.C. Works. It is organized into sections according to the SO_2 assessment framework illustrated in Figure 2. The Annual Report for 2020 will be prepared in the spring of 2021.

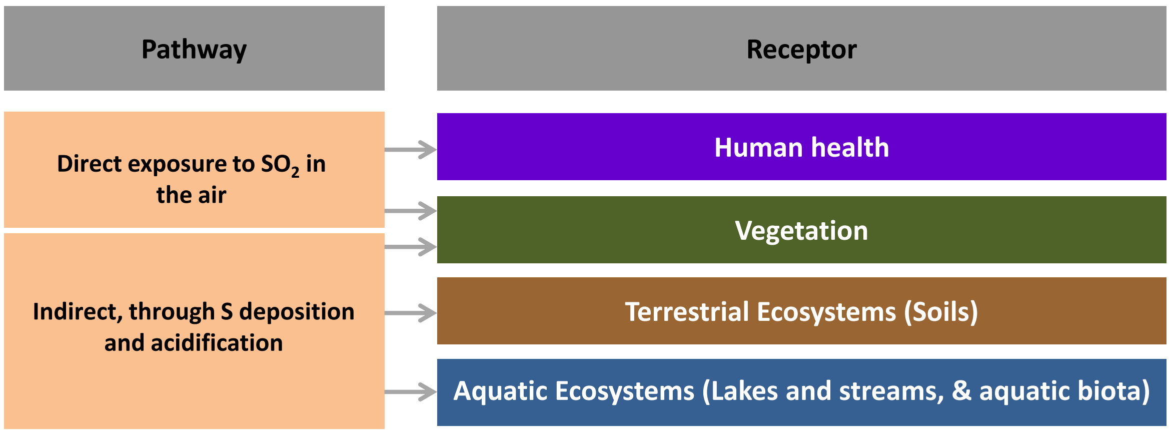


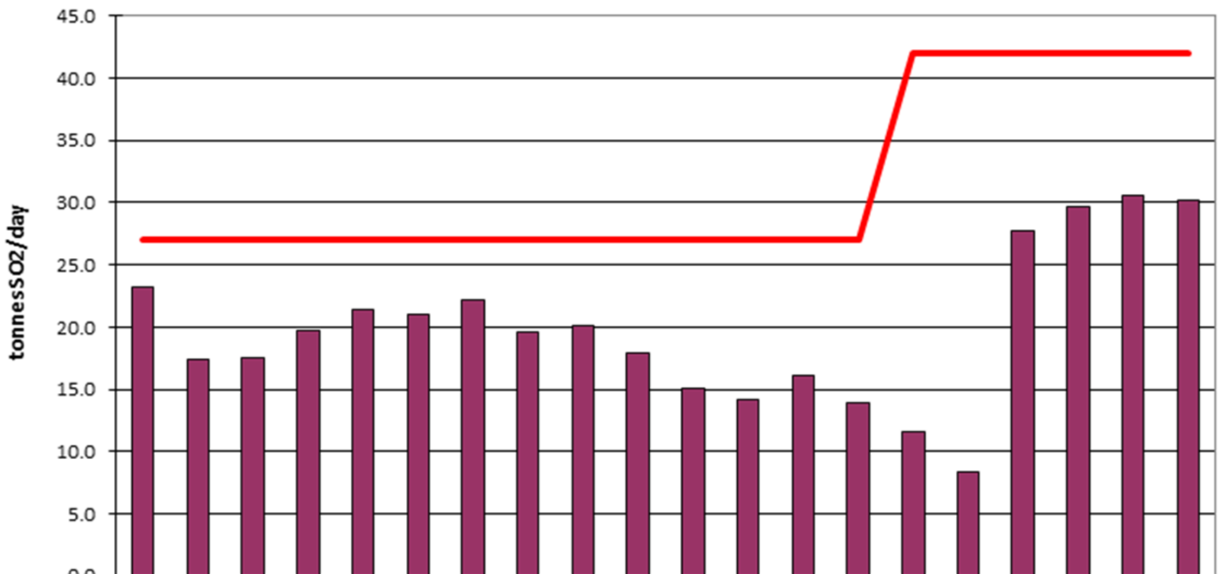
Figure 2. Framework for reporting on EEM activities.

An EEM Plan (ESSA et al. 2014a) focused on the first 6 years (2013-2018) of the EEM Program. A comprehensive review of the EEM Program was conducted in 2019 (ESSA et al. 2020a), and the results of that review will inform updates to the next phase of the EEM Program.

Because 2019 was same year as the comprehensive review, this Annual Report focuses on KPI monitoring and analyses done in 2019.

2 Facility Emissions

SO_2 emissions have increased above pre-KMP emissions due to the commissioning of the smelter and full operation of the potline. During 2019 average emissions of SO_2 decreased from the 30.6 t/d average rate in 2018 to 30.2 t/d in 2019 (Figure 3). 2019 SO_2 emissions remained below the 42 t/d permit limit.



	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
Average	23.3	17.4	17.5	19.8	21.4	21.0	22.2	19.6	20.1	18.0	15.1	14.2	16.1	13.9	11.6	8.3	27.7	29.7	30.6	30.2
Limit	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	42.0	42.0	42.0	42.0	42.0	42.0

Figure 3. Annual SO_2 emissions from the Kitimat smelter from 2000 to 2019. (Source: Rio Tinto)

3 EEM Activities

3.1 Atmospheric Pathways

SO_2 Concentrations

SO_2 monitoring data were collected from five existing continuous analysers: Haul Road (fenceline), Riverlodge (lower Kitimat), Whitesail (upper Kitimat), Kitamaat Village, and Lakelse Lake[1][2] (Figure 4). A sixth station (not pictured) was established by ENV in Terrace that can also be used to help assess SO_2 emissions from the smelter. All SO_2 analyzers passed ENV's[3] audits and had greater than 90% data capture for SO_2 in 2019.

Figure 5 shows the pattern of the monthly average SO_2 concentrations at the six[4] continuous monitoring stations from 2013 through 2019, along with monthly SO_2 emissions over the same period. Figure 6 presents the same data without the Haul Road station in order to show the detailed changes at the lower concentrations. Figure 5 shows that the Haul Road concentrations generally trend closely with SO_2 emissions from the smelter. Figure 6 (without Haul Road) shows that stations north of the smelter change more noticeably due to seasonal weather patterns than due to changes related to SO_2 emissions. The continuous air quality monitoring stations record hourly observations of SO_2. They provide information on air quality in the area on an ongoing basis, and will provide important data for many EEM activities over the next several years.

Figure 7 shows a histogram depicting the relative frequency of hourly averaged concentrations of SO_2 at Haul Road, Riverlodge and Kitamaat Village and Whitesail. Low concentrations (below 4 ppb) occur most of the time (high frequency), and higher concentrations occur infrequently.

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[1] The sole purpose of the Lakelse SO_2 analyzer is for estimating dry deposition and is not included in air quality monitoring network for British Columbia.

[2] A seventh continuous SO_2 monitoring station was established in Service Centre (Industrial Avenue) in May 2020, outside the time period discussed in this report.

[3] BC Ministry of Environment and Climate Change Strategy (ENV) conducts audits on all monitoring stations within the network; however, since the Lakelse Lake monitor's purpose is for estimating dry deposition, it is not within the network and not audited by ENV.

[4] Since the purpose of the Lakelse Lake monitor is for estimating dry deposition, it is not included in Figure 5 comparing SO_2 concentrations to the smelter's SO_2 emissions. The Terrace monitor is also not included because of its greater distance from the smelter.

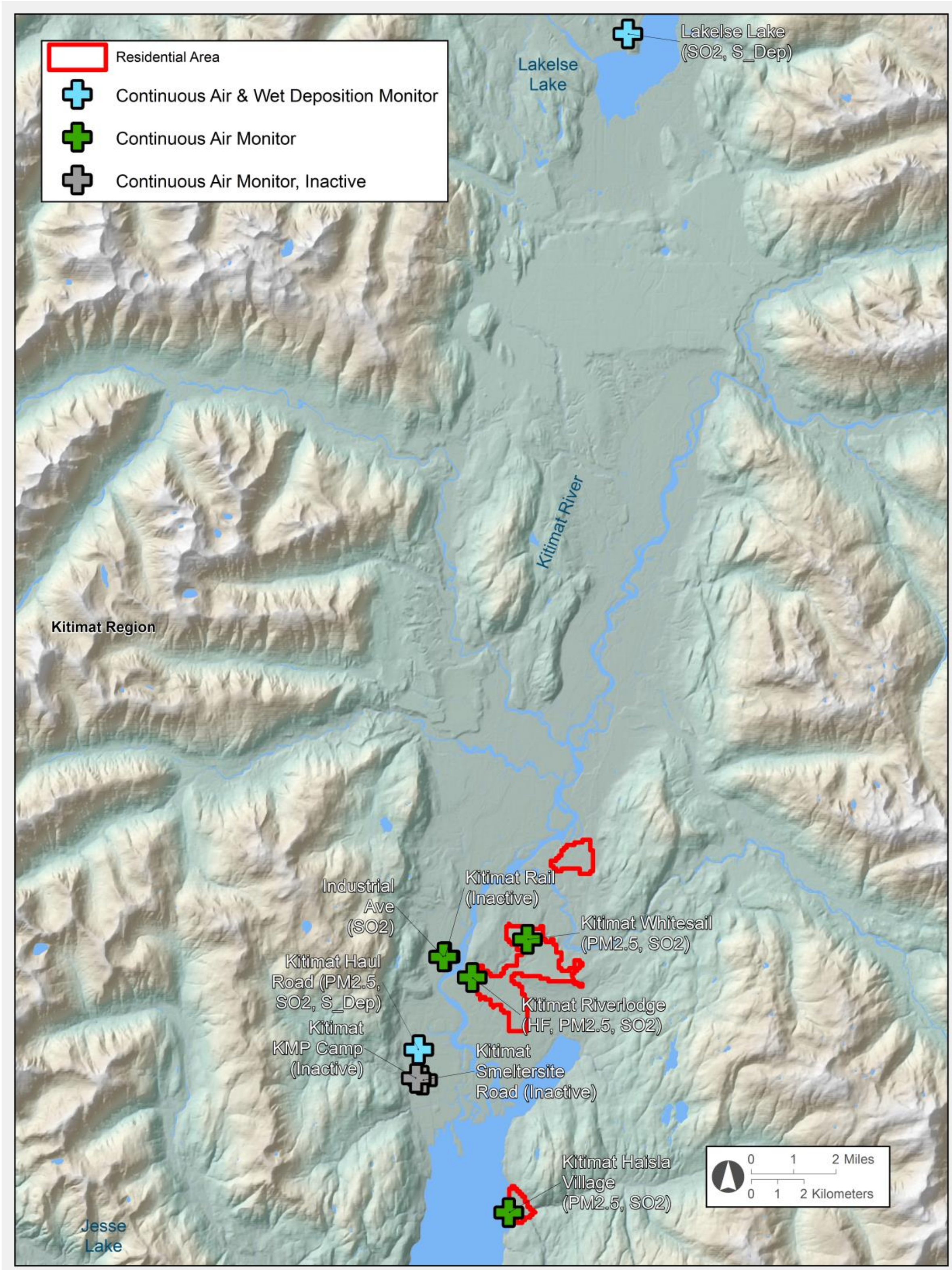


Figure 4. Locations of the four continuous SO_2 analysers (Haul Road, Whitesail, Riverlodge, Kitamaat Village).

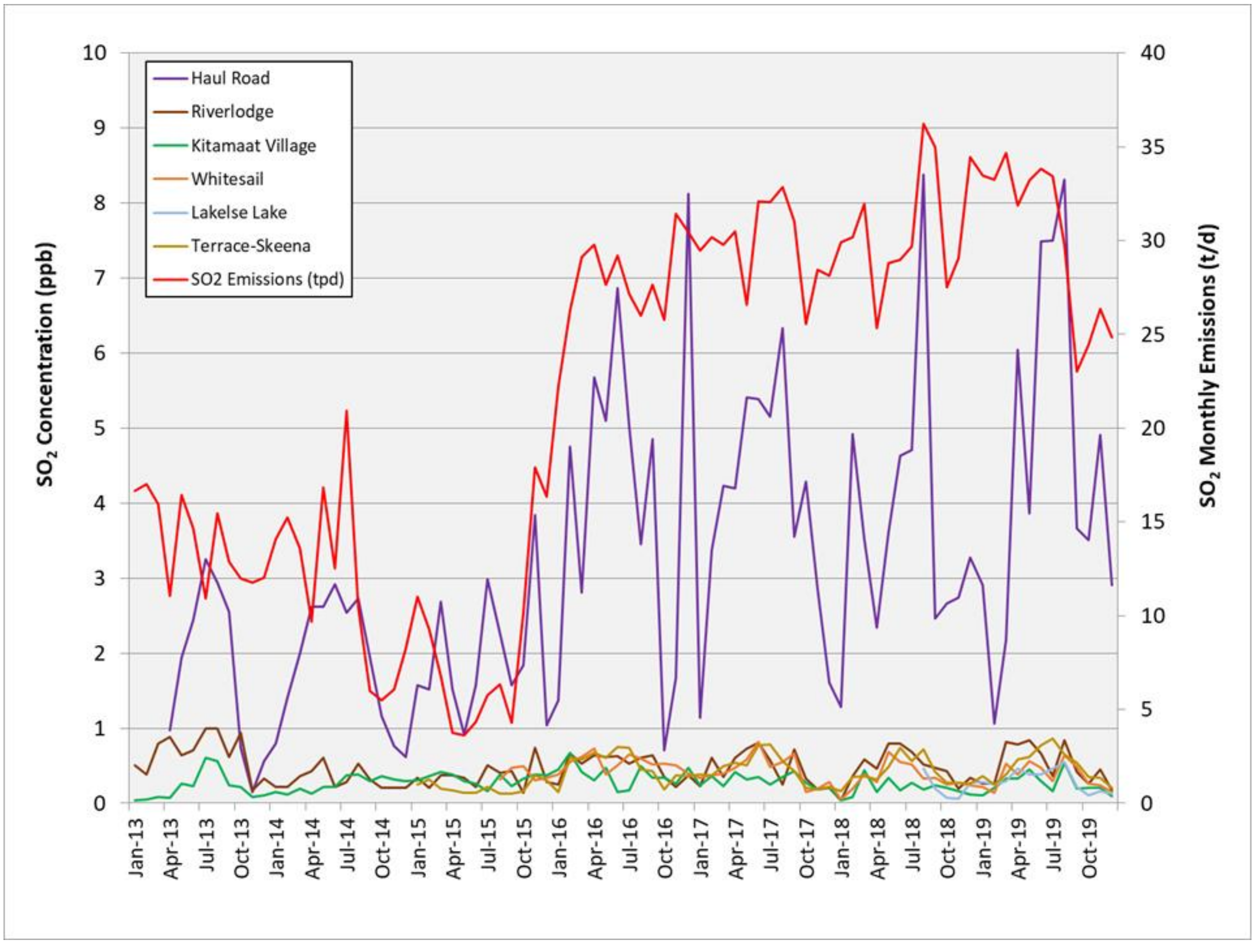


Figure 5. Monthly SO_2 emissions (red line) and monthly average ambient SO_2 concentrations at the six continuous monitoring stations (purple, brown, green. orange, blue and gold lines) for 2013 to 2019. (Source: Rio Tinto)

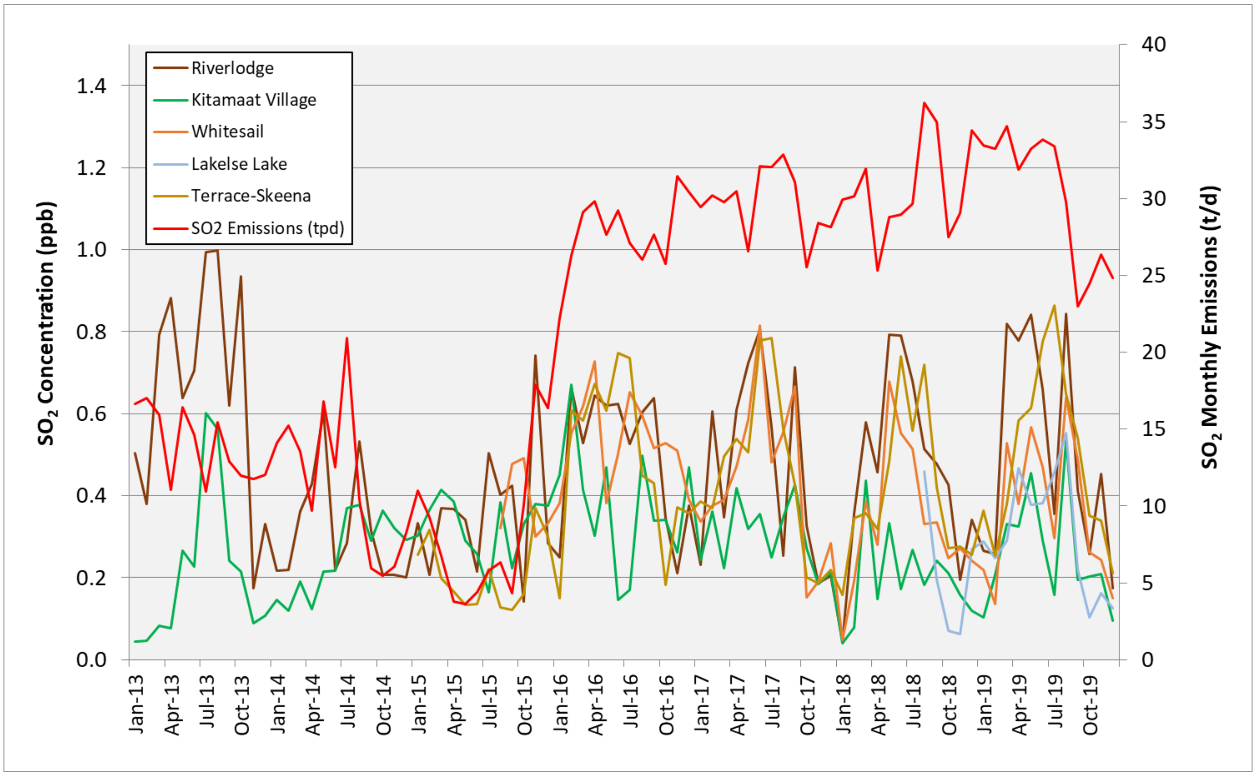


Figure 6. Low concentration scale monthly SO_2 emissions (red line) and monthly average ambient SO_2 concentrations at the five lower concentration continuous monitoring stations (brown, green, orange, blue, and gold lines) for 2013 to 2019. (Source: Rio Tinto)

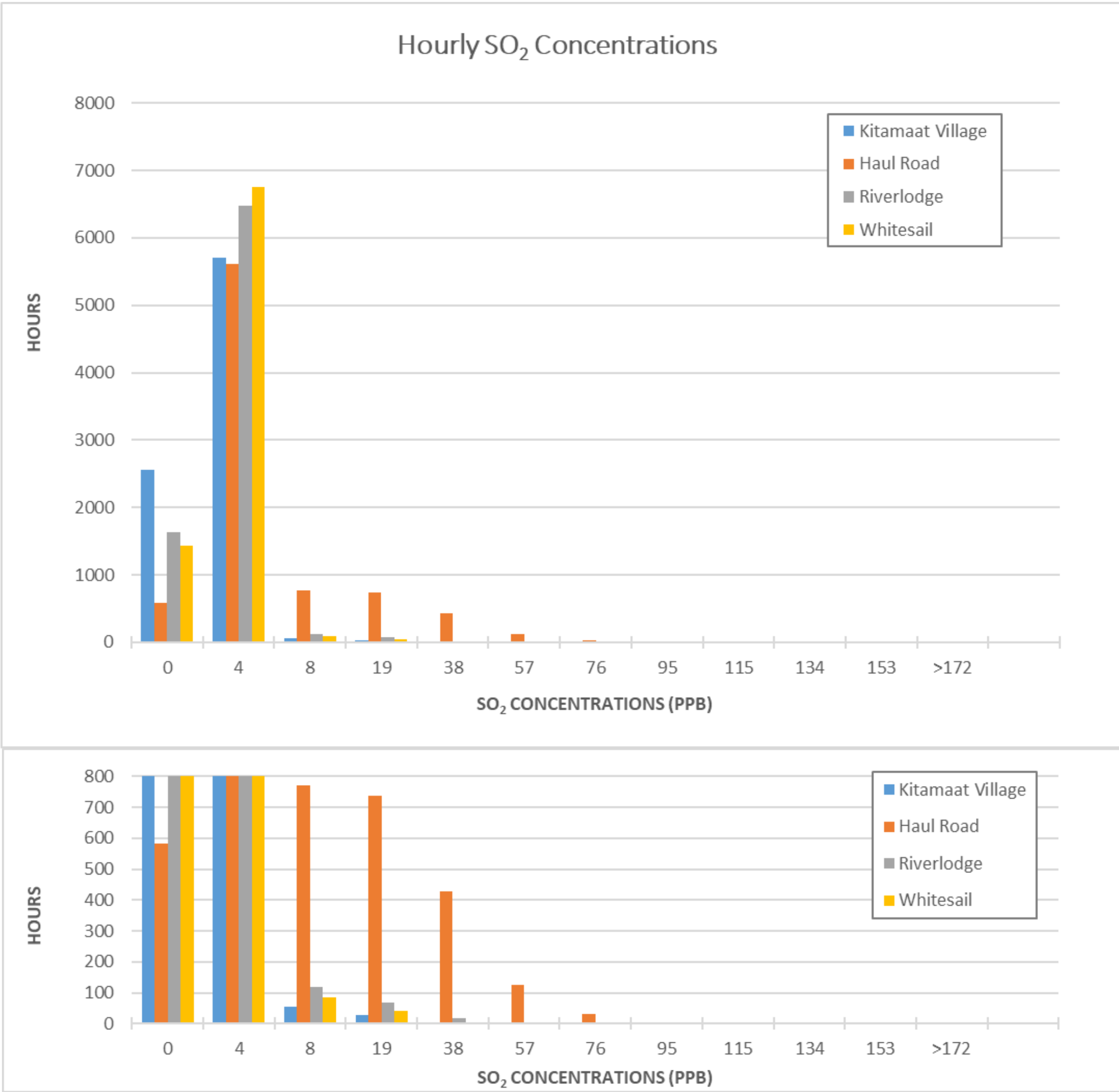


Figure 7. SO_2 hourly concentrations at the Haul Road, Riverlodge, Whitesail and Kitamaat Village continuous monitoring stations (top graph). The bottom graph zooms in on the subset of the data showing lower frequencies (800 hours and less) of higher concentrations. (Source: Rio Tinto)

Comparison to the Model Output

Monitoring data collected at the four monitor stations are compared to the air dispersion modelling results prepared for the EEM 2019 Comprehensive Review (ESSA et al. 2020a). Table 1 and Figure 8 and Figure 9 show the comparison between monitored concentrations in 2019 and the predicted SO_2 concentrations from the air dispersion modelling analysis for 1-hour and annual averaging periods. All results are in the form of the Canadian Ambient Air Quality Standards (CAAQS), which are used as the BC Air Quality Objectives for SO_2. Note that the predicted concentrations from the air dispersion modelling analysis include the more realistic background concentrations that were applied in the 2019 Comprehensive Review for the model evaluation.

As shown in Table 1, annual average monitored concentrations were approximately half of the modelled concentrations (ranging from 29% at Kitamaat Village for local scale to 62% at Whitesail for local scale and Haul Road for regional scale). The 1-hour monitored concentrations align closer with model results other than at Kitamaat Village (23% of the modelled concentration for the local scale). The remaining 1-hour monitor to model comparison ranges from 63% (Whitesail regional scale) to 111% (Riverlodge regional scale). These model results represent actual emissions applying a more realistic background used for model performance evaluation. When applying the effects assessment background (5.53 ppb based on the Terrace-Skeena Middle School monitor), the Riverlodge regional scale 1-hour model concentration is equal to the monitored concentration (39 ppb) and all other model results are higher than the monitored concentrations.

Overall, these comparisons support the discussion in the 2019 Comprehensive Review (ESSA et al. 2020a) that predicted modelled concentrations in most areas are higher than measured concentrations, resulting in cautious risk assessments. In addition, the comparison supports the 2019 Comprehensive Review conclusions related to model performance, consistently predicting 100% to 200% of measured concentrations.

Table 1. 2019 Monitored Data Compared to Modelled Concentrations.

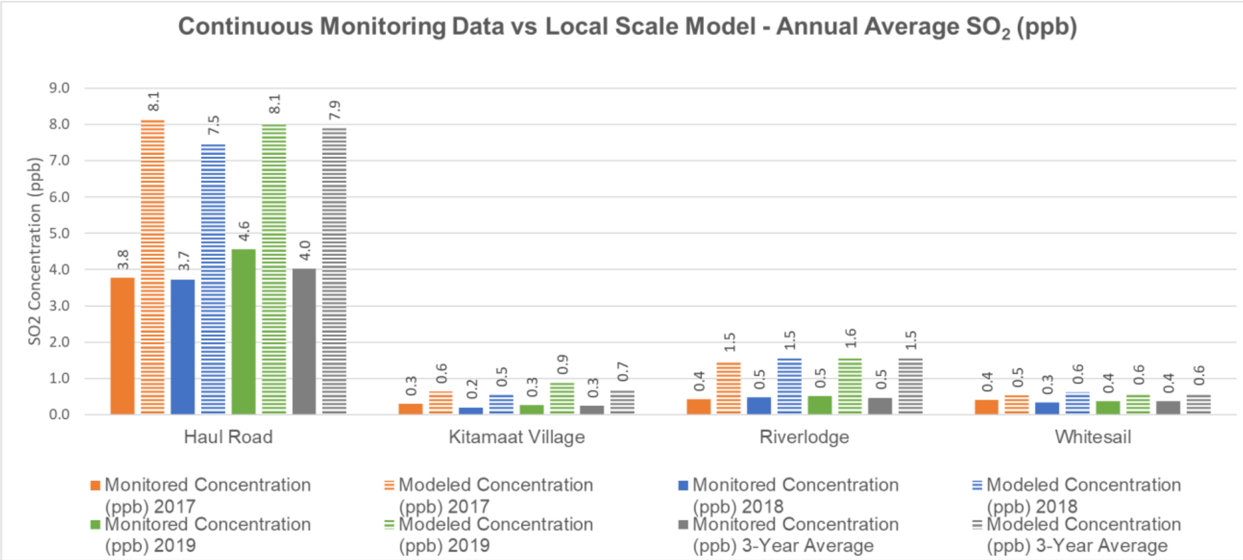
Site	Averaging Period [a] / Model	Monitored Concentration (ppb)	Modelled Concentration [b] (ppb)	Monitored Concentration (ppb)	Modelled Concentration [b] (ppb)
		2019		3-Year Average	
Haul Road	Annual/Local	4.55	8.06	4.02	7.89
Kitamaat Village	Annual/Local	0.26	0.89	0.25	0.69
Riverlodge	Annual/Local	0.51	1.59	0.47	1.54
Whitesail	Annual/Local	0.37	0.60	0.37	0.58
Haul Road	Annual/Regional	4.55	7.35	4.02	7.23
Kitamaat Village	Annual/Regional	0.26	0.55	0.25	0.53
Riverlodge	Annual/Regional	0.51	1.61	0.47	1.61
Whitesail	Annual/Regional	0.37	0.91	0.37	0.92
Haul Road	99% 1HDM/Local	82	113	74	115
Kitamaat Village	99% 1HDM/Local	18	80	16	52
Riverlodge	99% 1HDM/Local	39	43	32	42
Whitesail	99% 1HDM/Local	22	28	21	30
Haul Road	99% 1HDM/Rgnl	82	97	74	94
Kitamaat Village	99% 1HDM/Rgnl	18	20	16	18
Riverlodge	99% 1HDM/Rgnl	39	35	32	35
Whitesail	99% 1HDM/Rgnl	22	35	21	36

[a] Averaging periods and forms of results correspond to the CAAQS. 1HDM = 1-hour averaging period, daily maximum

[b] Modelled concentrations are based on results from the actual scenario using actual emissions for 2016, 2017, 2018. For 2019 forward, the 3-year average actual model results are scaled from 2016-2018 average emissions to current year emission.

The following background value from Williams Lake is added to account for non-modelled sources of SO_2 (for 2019 forward, note the background is added after scaling model results).

Annual Average	0.26	ppb
99th% 1-hour Daily Max	1.80	ppb



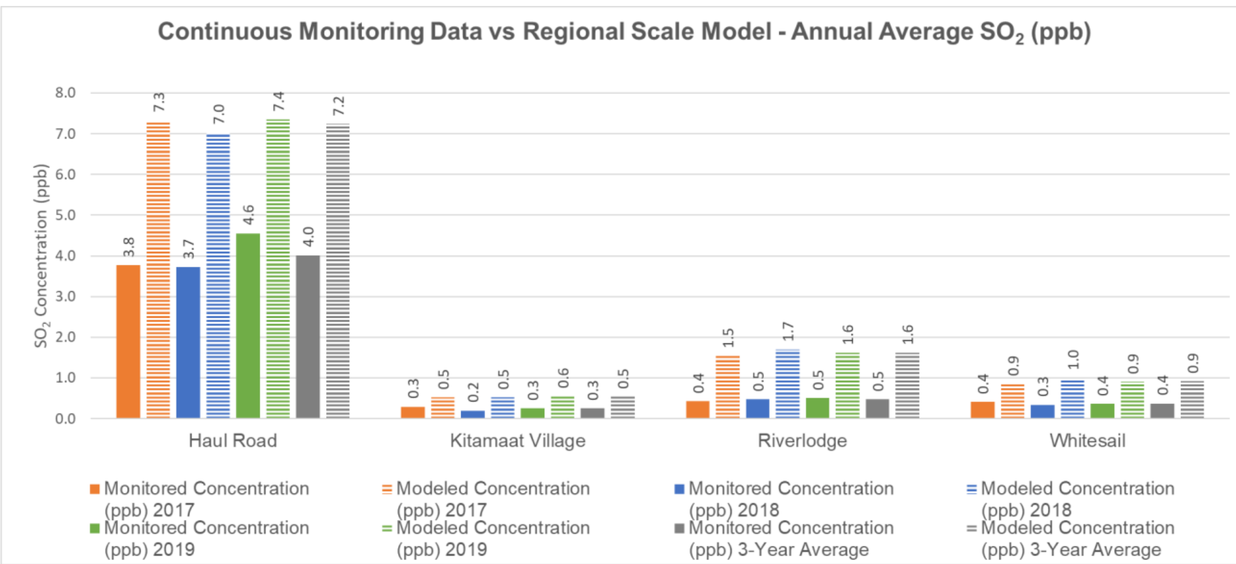


Figure 8. 2019 Monitored annual average data compared to modelled concentrations.

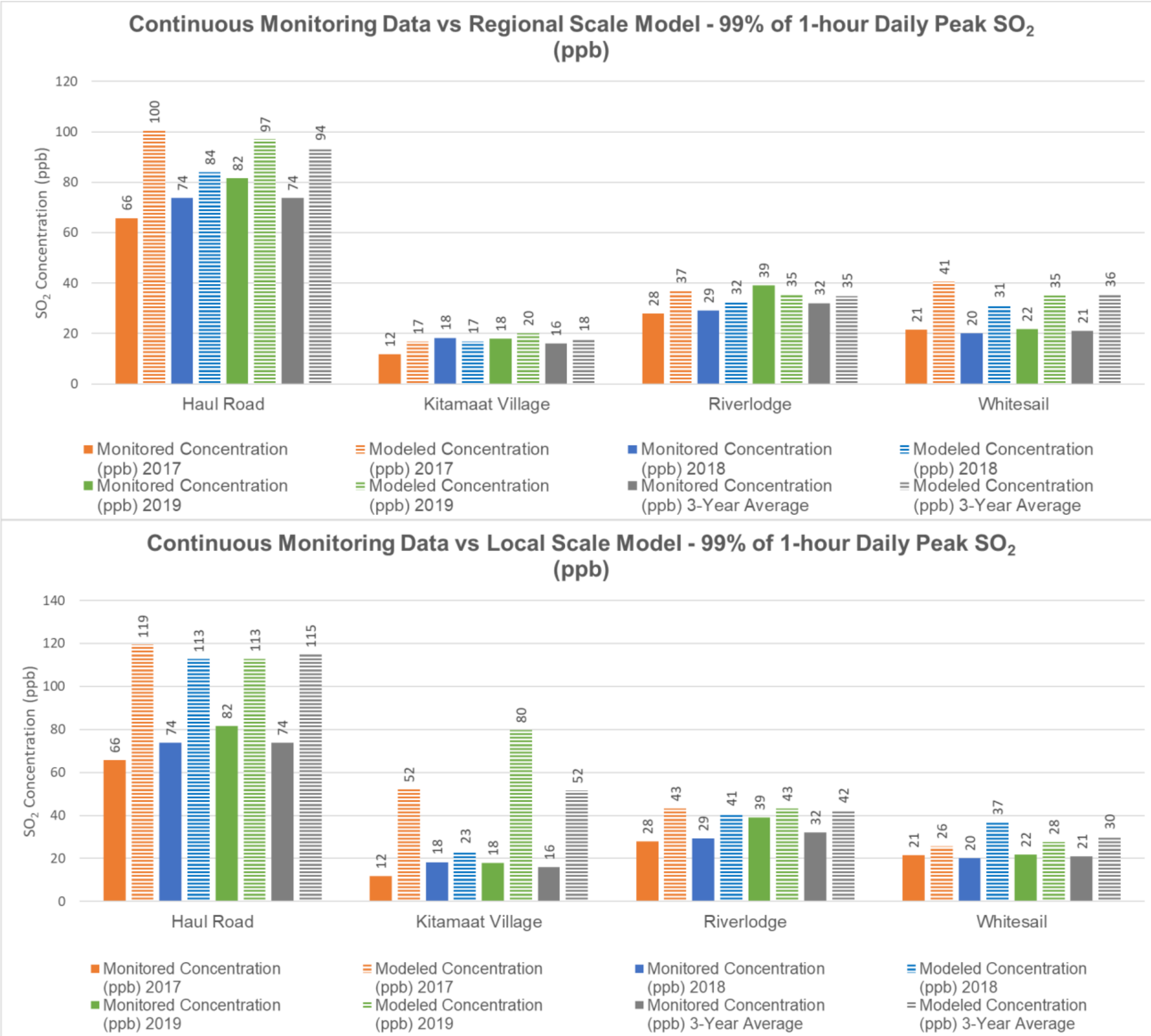


Figure 9. 2019 Monitored 1-hour data compared to modelled concentrations.

Network Optimization

Rio Tinto is in the process of conducting Phase 2 of the network optimization. The draft Terms of Reference (TOR) for the SO_2 network optimization is being updated to include the latest monitoring data and the 2019 Comprehensive Review model results

Passive Sampling

The network of passive samplers was redeployed in the Kitimat Valley during 2019 following the same protocol as in 2016-2018 (ESSA et al. 2020a). Sampler locations were the same as 2018 with the addition of Lake 28 (Figure 10). As recommended from the pilot study (Technical Memo P03), the network employed IVL passive SO_2 samplers (URL:

diffusivesampling.ivl.se) with an exposure period of one month. The network was established during June 11–13, 2019, at 19 sites within the Kitimat Valley (Figure 10), primarily focused along the Wedeene and Bish roads to capture the plume path, and included co-location with the Haul Road ambient (continuous monitoring) stations (Haul Road, Riverlodge, Whitesail, and Lakelse Lake). During June 2018, a continuous SO_2 monitor was established at Lakelse Lake.

A second network of passive samplers deployed in the urban and residential areas of Kitimat was in continuous operation since June 2018, with 18 (monthly) deployments. The urban network was established on June 13, 2018, at 20 sites located in Kitimat (Figure 10). The network included three sites co-located with ambient stations (Haul Road, Riverlodge, and Whitesail) and one within the industrial zone of Kitimat, which were also included in the valley network. This report only covers the summer 2019 (June–October). The 18-month deployment data are provided in Table 2.

There were 137 sample exposures across both networks, which included replicate samplers deployed >25% of the time (36 duplicate exposures) during the four deployments, June–October 2019.

Four deployments, with an approximate exposure time of one-month (22–35 days), were carried out under the valley network during 10 June–10 October 2019, and similarly four monthly (30–40 days) exposures under the urban network (23 May–09 October). The observed data show elevated atmospheric SO_2 along the plume path (a transect of approximately 45 km; Figure 10); notably during 2019 the plume concentrations were lower south of the smelter compared with 2018, and during 2019 slightly higher concentrations were observed north of Rio Tinto at a few sites. In contrast, all monthly exposures under the urban network were consistently <0.5 ppb (Figure 10).

The 2019 results within the Kitimat Valley are spatially and temporally consistent with the 2016–2018 observations (ESSA et al. 2020a), and further demonstrate the use of the passive samplers to map out the plume path along the Kitimat Valley; it is recommended that deployments are continued during 2020 to further define the plume, with the condition that sites meet the BC ENV guidelines.

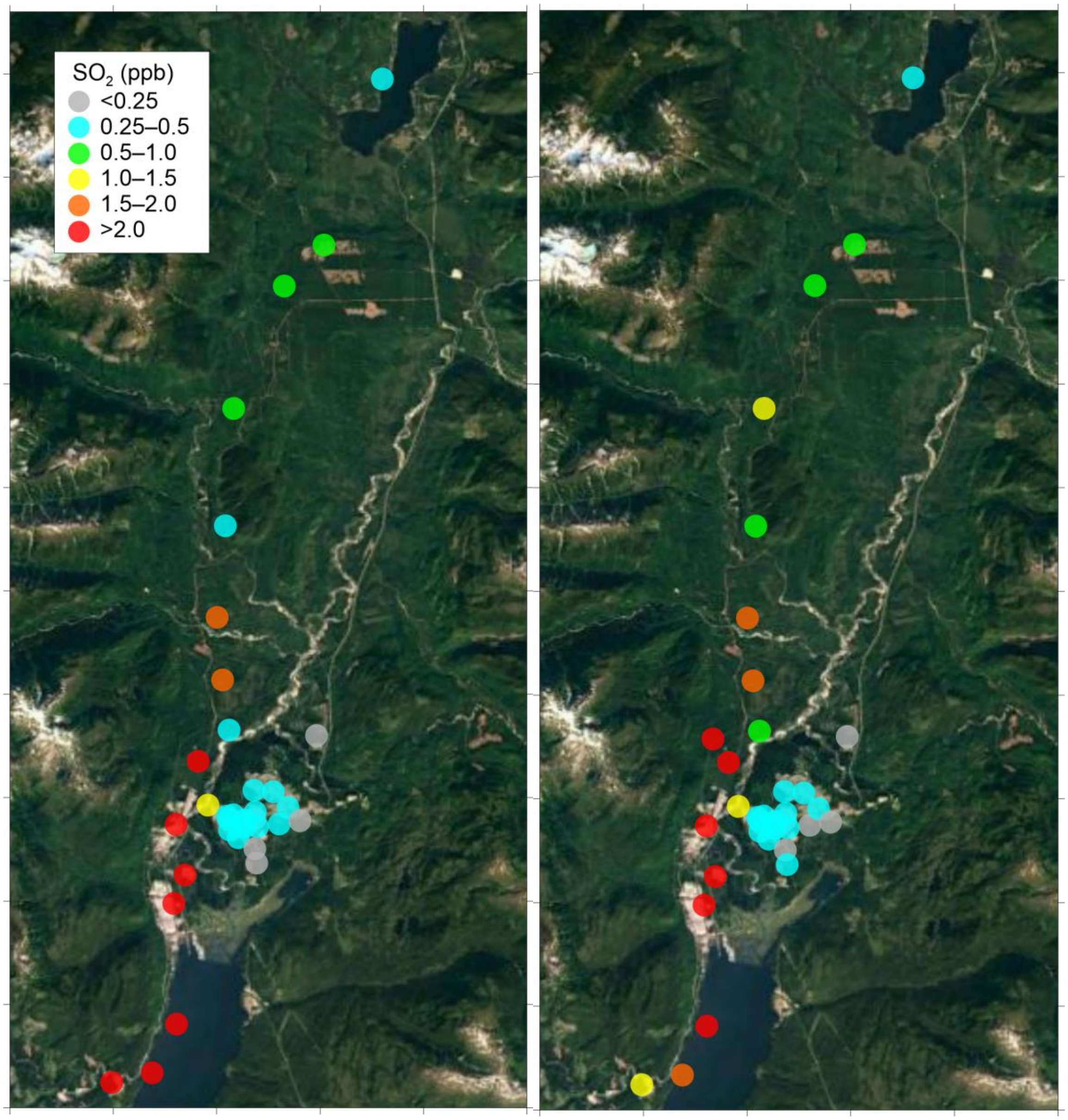


Figure 10. Average atmospheric sulphur dioxide (SO_2) concentration during June–October 2018 (left panel) and June–October 2019 (right panel) in the Kitimat Valley and urban passive diffusive monitoring networks. For further details on passive samplers see: IVL: www.diffusivesampling.ivl.se. (Source: Dr. Julian Aherne, Trent University)

Table 2. Data for the 18 month deployment of the urban passive sampling network from July 2018 to December 2019.

ID	Site Name	Latitude	Longitude	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
A01	Haul Road station	54.029	-128.702	13.3	22.4	12.1	5.7	7.0	8.4	4.5	5.6	2.9	9.2	12.0	13.8	20.6		11.1	8.1	11.3	
A02	Riverlodge station	54.054	-128.671	2.0	1.1	1.3	0.7	0.7	1.1	1.2	0.7	1.7	1.6	2.4	1.3	0.5	2.0	0.9	0.6	1.1	1.0
A03	Whitesail station	54.067	-128.639	1.0	1.0	0.7	0.5	0.2	0.9	0.6	0.4	1.0	1.0	1.4	0.9	0.4	1.0	0.7	0.5	0.4	0.6
U01	Low Channel	54.046	-128.664	1.3	1.1	0.6	0.9	0.7	0.6	0.7	0.5	1.1	1.2	1.5	0.8	0.4	1.1	0.4	0.6	0.8	0.4
U02	Kitimat City Centre MAML	54.055	-128.652			0.5	0.7	0.4	0.5	0.4	0.6	0.8	1.1	1.4		0.8		0.4	0.5	0.5	0.3
U03a	Nechako Elementary	54.053	-128.634	0.8	1.1	0.5	0.7	0.6	1.7	0.5	0.3	0.6	0.9	1.4	0.7	0.4	1.0	0.3	1.0	0.5	0.4
U04	Mount Elizabeth School	54.060	-128.628	0.8	1.0	0.5	0.5	0.7	0.5	0.4	0.3	0.7	0.7	1.2	0.7	0.4	1.0	0.5	0.5	0.4	0.4
U05	Cable Car residential area	54.092	-128.609	0.8	0.8	0.4	0.3	0.3	0.4	0.3	0.3	0.4	0.5	1.0	0.6		0.5	0.2	0.2	0.3	0.3
U06	Kitimat General Hospital	54.051	-128.650	1.1	0.9	1.4	1.4	2.1	1.0	0.5	0.4	0.8	1.3	1.7	0.8	1.7	1.1	0.5	1.5	2.0	1.1
U07	Blueberry Street	54.042	-128.651	0.6	0.8	0.4	0.5	0.3	0.3	0.4	0.3	0.7	0.8	1.5	0.6	0.4	1.0	0.4	0.6	0.4	0.3
U08a	Anderson Street	54.067	-128.653	1.1	1.1	0.6	0.8	0.6	0.6	0.6	0.4	1.0	1.1	1.5	1.1	2.2	1.4	0.4	0.6	0.5	0.4
U11a	Kitimat City High	54.058	-128.652	0.9	1.0	0.3	0.7	0.4	0.4	0.4	0.3	0.8	0.9	1.5	0.8	0.5	1.0	0.4	0.4	0.3	0.3
U12	Industrial area Kitimat Hotel	54.060	-128.687	4.0	4.1	3.4	2.3	2.4	1.7	1.8	1.4	2.3	4.5	4.2	4.5	3.5	4.2	1.7	2.4	2.8	1.6
U13	St. Anthony's Elementary	54.055	-128.618	0.8		0.5	0.5	0.4	0.5	0.5	0.3	0.7	0.8	1.5	0.7	0.3	0.7	0.5	0.5	0.5	0.4
U14	Kildala Elementary	54.051	-128.660	0.9	1.1	0.6	0.8	0.6	0.6	0.6	0.5	1.1	1.2	1.5	0.9	0.5	1.1	0.5	0.6	0.4	0.3
U16	Kootenay Street (north)	54.054	-128.659	1.0	1.1	0.5	0.6	0.4	0.5	0.6	0.4	1.0	1.2	1.7	0.8	0.5	1.2	0.5	0.5	0.6	0.4
U17	Daadok Avenue	54.056	-128.668	1.6	1.2	0.8	1.1	0.5	0.8	1.0	0.5	1.5	1.3	2.3		0.7	1.8	0.7	0.7	0.9	0.4
U18	G Street and H Avenue	54.056	-128.672	1.6	1.3	0.9	1.2	0.6	1.0	1.0	0.6	1.7	1.6	2.2	1.4	0.8	1.6	0.6	0.9	1.2	0.9
U19	Peace Street	54.050	-128.670	1.2	0.9	0.6	0.9	0.4	0.4	0.5	0.5	1.2	1.2	2.0	1.0	0.4	1.4	0.3	0.4	0.4	0.4
U20	Strawberry Meadows	54.036	-128.649	0.5	0.9	0.5	0.6	0.5	0.3	0.4	0.2	0.7	0.7	1.4	0.7	0.5	1.1	0.3	0.4	0.3	0.3

Wet Deposition

Figure 11 compares the amount of annual precipitation (mm) Haul Road and Lakelse Lake precipitation chemistry monitoring stations during 2013 to 2019. Note: because the Lakelse Lake station was only in operation for part of 2013, data from that location are only shown for 2014 to 2019. Average annual precipitation volume was 2245 mm at Haul Road compared with 1375 mm at Lakelse Lake during the six-year period, 2014–2019. During 2019, precipitation volume at Haul Road (1919 mm) and at Lakelse Lake (1205 mm) were low compared with the six-year average

Weekly precipitation volume (mm) at the two stations (operated by the NADP) during the same seven-year period showed a highly synchronous pattern but with generally higher volume at Haul Road (Figure 12); higher volume was recorded at Lakelse Lake for < 15% of the observations. In addition, higher weekly sulphate concentration (mg/L) and lower pH was observed at Haul Road compared with Lakelse Lake (Figure 12). The higher SO_4 and lower pH in rainfall at Haul Road is caused by the higher atmospheric concentration of SO_2 at Haul Rd, as demonstrated by the passive samplers (Figure 10).

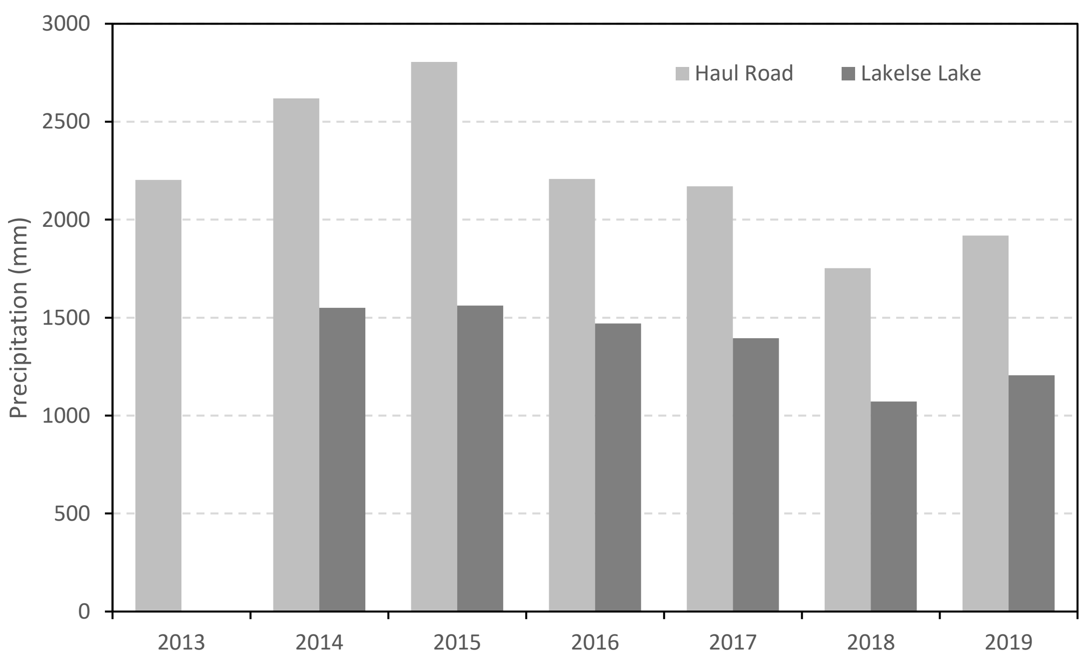


Figure 11. Annual precipitation volume (mm) from 2013 to 2019 at the Haul Road and Lakelse Lake precipitation chemistry monitoring stations. (Source: NADP [URL: nadp.sws.uiuc.edu])

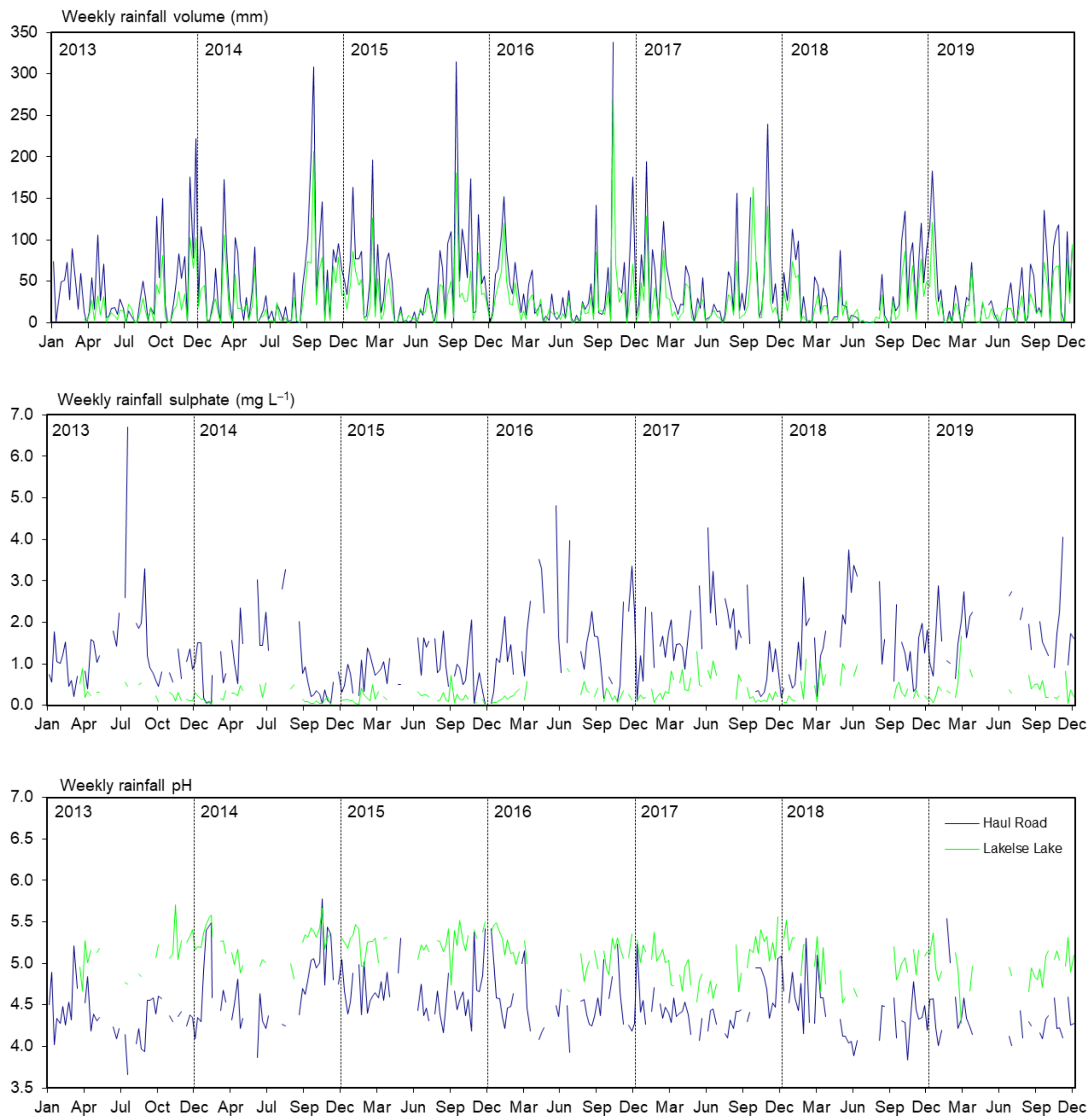


Figure 12. Weekly precipitation volume (mm) and chemistry (mg/L) at Haul Road (January 2013 to December 2019) and Lakelse Lake (April 2013–December 2019) showing inter-annual variation in precipitation volume (upper graph), sulphate concentration (middle graph) and precipitation pH (lower graph).

Dry Deposition

The relative contribution of wet and dry deposition to total sulphur deposition requires the use of an inferential model to estimate dry deposition. The determination of dry deposition for SO_2 under the EEM Program is being estimated the big-leaf model (Zhang et al. 2003, 2014). The big-leaf model (Zhang et al., 2003) which requires several meteorological variables such as surface temperature, wind speed, relative humidity, solar irradiance, precipitation, and surface pressure. The model provides hourly or daily deposition velocity for SO_2; dry deposition is estimated by multiplying air concentration with deposition velocity. The big-leaf model was used to estimate dry deposition under the 2019 Comprehensive Review based on meteorological data from Haul Road, Whitesail and Terrace airport (ESSA et al. 2020a). During 2019, the big-leaf model is being used to estimated dry deposition at Haul Road and Lakelse Lake; a continuous SO_2 monitor was installed at Lakelse Lake during 2018. Total deposition at Lakelse Lake is being compared with estimates of total deposition from Ion Exchange Resin (IER) columns deployed during June–October 2019.

Long-term estimates of dry deposition at the Haul Road NAPD monitoring station from 2005 to the end of 2019 (Figure 13) were determined following the approach used in the STAR (which used the same estimate of monthly deposition velocity from the big-leaf model; ESSA et al. 2013). The equipment at the Haul Road site was updated to the NADP standard during the fall of 2012, which explains the gap in wet deposition data during this period. The NADP equipment provides better estimates of precipitation chemistry, which may be partly responsible for the observed trends in wet deposition since fall 2012. Problems with the SO_2 data logger at Haul Road explain the gap in dry deposition estimates during the latter half of 2012 and first quarter of 2013. A sharp rise was seen in estimated dry deposition during December 2016 consistent with the higher SO_2 emissions (Figure 13). On average, total deposition was composed of 53% wet and 47% dry deposition during the period 2013–2019.

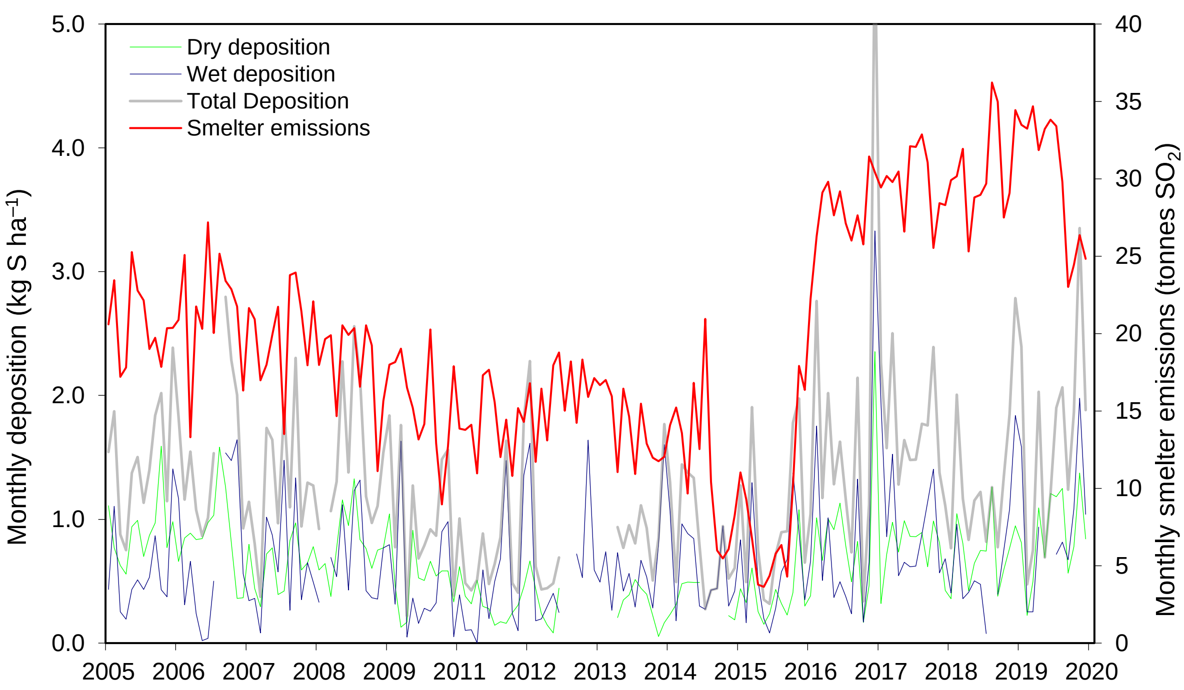


Figure 13. Long-term (2005–2019) monthly dry (green line) and wet (blue line) deposition of sulphur (kg S/ha), and smelter emissions of sulphur dioxide (red line; tonnes SO_2) at Haul Road.

3.2 Human Health

A province-wide interim SO_2 ambient air quality objective (AAQO) was adopted on December 15, 2016, and became the Health KPI of the SO_2 EEM Program starting in 2017. The SO_2 Health KPI is a threshold for residential SO_2 ambient air concentration of 75 ppb and is evaluated through the following protocol:

- At the end of 2017: Three-year average of the 97th percentile of the daily one-hour average maximum (D1HM) for 2015 – 2017.
- At the end of 2018: Three-year average of the 97.5th percentile of the D1HM for 2016 – 2018,
- At the end of 2019: Three-year average of the 98th percentile of the D1HM for 2017 – 2019, and
- At the end of 2020 and the end of each subsequent year: Three-year average of the 99th percentile of the D1HM for that year and the two preceding consecutive years.

There is an allowance of a one-time exceedance of the 75 ppb threshold to a maximum concentration of 85 ppb, over the three-year interim period.

Table 3 provides the KPI results for 2019, using the 3-year average of the 98th percentile of the D1HM for 2017 – 2019. The "Human Health KPI Calculations for 2019" memo is provided in Appendix A.

Table 3. Calculation method and results for the SO_2 Health KPI in 2019.*

Station	98th percentile D1HM** SO_2 (ppb)			SO_2 Health KPI (ppb) (3-year average of 98th percentile D1HM**)	KPI Attainment / Non-Attainment
	2019	2018	2017		
Riverlodge	31.5	24.7	17.0	24.4	Attainment
Whitesail	18.2	16.0	14.9	16.4	Attainment
Kitamaat Village	14.3	10.4	7.1	10.6	Attainment

* Data for this table were extracted from the Envista database of the BC ENV in May 2020, following the verification by ENV in April 2020.
** Daily 1-hour average maximum

3.3 Vegetation

Vegetation Survey and Sampling

Sampling of western hemlock (*Tsuga heterophylla*) foliage was conducted by personnel from Stantec Consulting Ltd., Terrace, BC, from September 3-6, 2019. Western hemlock foliage was collected for analysis of sulphur (S) content at 27 established sampling locations (Figure 14). Based on an analysis of historic S in western hemlock foliage data and consultation with ENV, 13 previously sampled sites were not sampled due to a lack of a relationship with SO_2 emissions or because they were redundant. Under the SO_2 EEM Program, a survey and inspection of vegetation is conducted biennially and was not due in 2019, however Rio Tinto requested an inspection. The inspection and assessment were conducted by John Laurence, Rio Tinto's QP for vegetation.

In 2019, the site and sample-tree assessment checklist was used to document conditions at the time of sampling. Details of site conditions may be found in the 2019 Vegetation Program Annual Report (Stantec and Laurence, 2020).

No signs or symptoms of SO_2 injury were observed at any inspection or sampling site. Vegetation at sites near Terrace, the reference sites in the Williams Creek drainage, and on the east side of Minette Bay had similar symptoms of insect, pathogen, and cultural conditions as the other sites. Old-growth forest along the ridge to the west of the smelter was inspected from the air as the area is not safely accessible from the ground at this time. This area includes the region of predicted soil critical load exceedance from the CALPUFF dispersion model in the 2019 Comprehensive Review of the SO_2 EEM Program under the 42 tonnes/day emissions (permitted rate) scenario (ESSA et al. 2020a). The area of predicted soil critical load exceedance encompasses approximately 216 hectares, 112 hectares of which are outside the Rio Tinto property line. Deposition of SO_4^{2-} post-KMP has been approximately 70% of the permitted level with only about 20 ha off Rio Tinto property projected to have exceedance of soil critical load under actual emissions. There was no difference visible during a helicopter overview flight between the forests and other vegetation within the area of predicted soil critical load exceedance and forest stands located further from the smelter where exceedance was not predicted.

Vegetation in the area of predicted soil critical load exceedance under actual deposition levels was visually inspected on the ground at sites 1 and 20, at Moore Creek Falls, and along Smelter Site Road. No signs or symptoms associated with potential soil acidification, such as those of nutrient deficiencies due to reduced root function, were observed.

Overall, the health of vegetation was similar at all inspected and sampled sites. Pest and pathogen activites are generally at a low level throughout the Kitimat Valley. No new instances of hemlock woolly adelgid infestation were observed at any sample sites in 2019. Three sites (37, 43A, 44) had remnant signs of woolly adelgid presence from previous years. Tar spot of false azalea (*Menziesia ferruginea*) caused by the fungus *Rhytisma arbuti* was observed at every site where false azalea was observed (10 of 27 sites). At some locations it was quite severe, however the disease develops late in the growing season and causes little or no impact on the health of the infected shrubs. The occurrence of tar spot of sycamore, caused by a closely related fungus, was used to map the occurrence of SO_2 in the 1970s in England

and is still used as an indicator of SO_2 and NO_2 concentrations. The development of the disease is associated with low concentrations of both pollutants; the disease does not develop on sycamore where pollutant concentrations are elevated (Gosling et al. 2016, Kosiba 2007, Vick and Bevan 1976). Tar spot of false azalea occurred as close to the Rio Tinto aluminum smelter as the Moore Creek Falls trail and site 44 (500 m from the smelter) and as far away as site 84 (52 km). Severity of infection was not related to proximity to the smelter.

Analysis of western hemlock foliage for S was conducted by the Rio Tinto laboratory in Jonquière, Québec. The S concentration in western hemlock foliage ranged from 0.05% at sites 56 and 490 to 0.15% at site 44A. The precision of the analytical method is ± 0.01%. No sites exceeded their historic mean values in S concentration used in the SO_2 EEM Program, thus the informative indicator was not exceeded. All but one of the S concentrations measured are below the maximum background S concentration (0.144%) reported in the scientific literature, including in western hemlock in BC (Kayahara et al. 1995, Linzon et al. 1979, Reimann et al. 2003). Sites 490 and 492, added in 2016 at the request of ENV as reference sites, had S concentrations of 0.05% and 0.06% respectively.

Additional information, including the results of the chemical analysis for each site, can be found in the 2019 Vegetation Program Annual Report (Stantec and Laurence 2020).

The results of the vegetation inspection show that the KPI of 'more than occasional symptoms of SO_2 injury outside of Rio Tinto Alcan [Rio Tinto B.C. Works] Kitimat properties, causally related to B.C. Works' was not exceeded since SO_2 injury was not observed at any site. The results of the vegetation sampling and analysis of western hemlock needles do not indicate a need for increased action under the SO_2 EEM Program with regard to the health of vegetation. The informative indicator of 'S content in hemlock needles' does not surpass the threshold for increased monitoring (an increase of more than 1 standard deviation from the pre-KMP baseline data in 20% of the sites for 3 consecutive years, causally related to B.C. Works). No sites had an increase in S content of more than 1 standard deviation from the STAR historic baseline concentration (1998-2011).

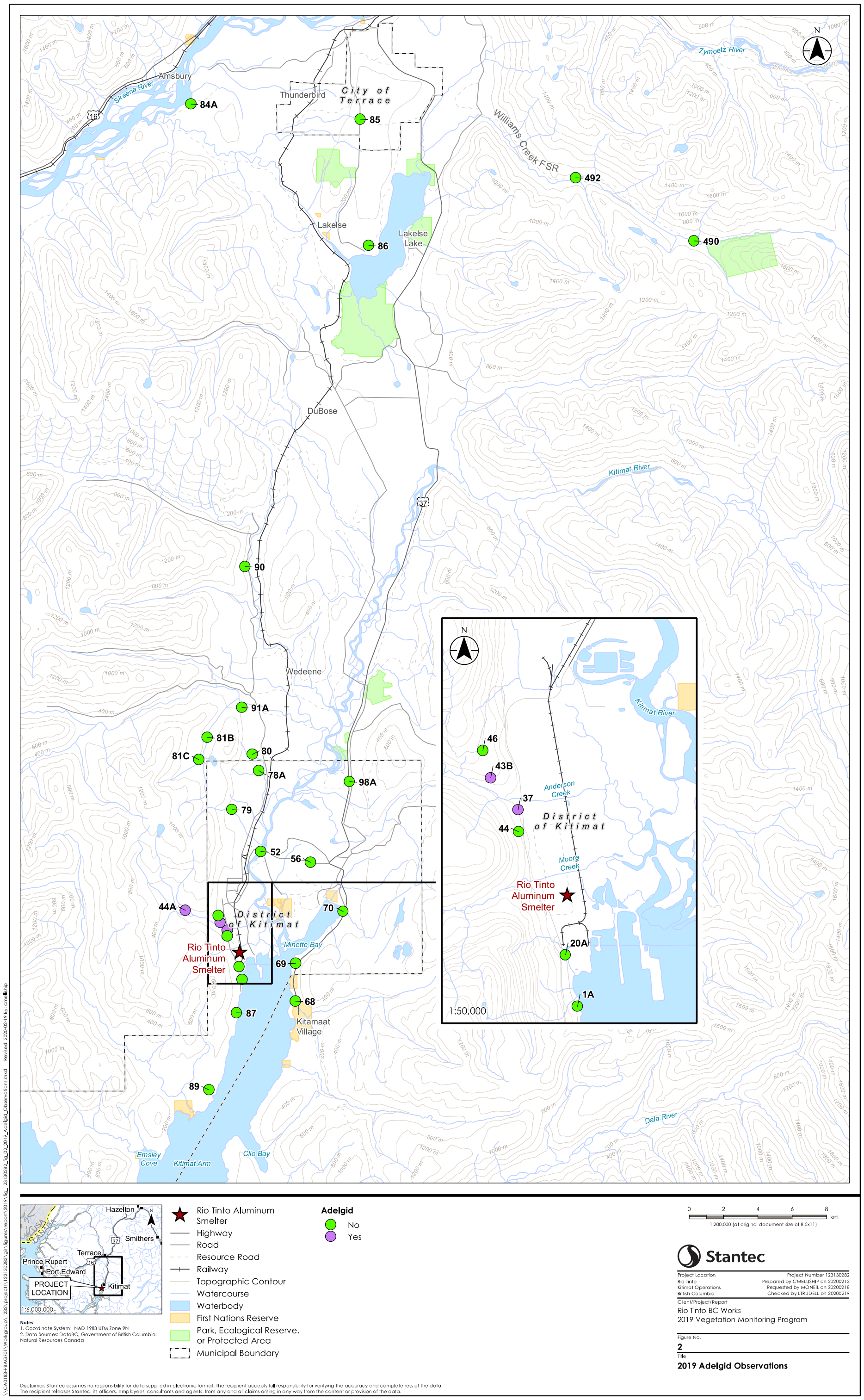


Figure 14. Location of vegetation sampling. (Source: Stantec and Laurence 2020)

3.4 Terrestrial Ecosystems (Soils)

Soils work in 2019 was focused on the 2019 Comprehensive Review. There was no field work done in 2019 for the KPI of critical load exceedance or the KPI of long-term soil acidification attributable to sulphur deposition.

3.5 Aquatic Ecosystems (Lakes, Streams and Aquatic Biota)

This section contains a condensed summary of the major actions and knowledge gained in 2019 with respect to the Aquatic Ecosystems receptor. Further detail is provided in the Aquatic Ecosystems Actions and Analyses Technical Memo (W08).

Major Actions Taken in 2019

In 2019, Limnotek sampled 14 lakes as part of the EEM long-term sampling plan. These lakes included the seven sensitive lakes and three less sensitive lakes identified in the EEM Plan, the high recreational value LAK024 (Lakelse Lake; added to the EEM Program in 2014), and three additional control lakes added to the EEM Program in 2015. The three control lakes (NC184, NC194 and DCAS14A) are all located outside of the B.C. Works-influenced airshed and have baseline data for 2013 from sampling as part of the KAA (ESSA et al. 2014b). The sampling methodology is described in detail in Limnotek's technical report on the water quality monitoring (Limnotek 2020).

We examined the empirical changes in water chemistry between the pre-KMP baseline (2012) and the post-KMP period (2016-2019), especially with respect to the KPI thresholds. We also conducted statistical analyses on the changes between these two periods, repeating the Bayesian "Method 1" analysis applied in the 2019 Comprehensive Review with the addition of the new data from 2019, to assess the % belief that any of the lakes had exceeded their KPI thresholds.

We re-applied the simplified evidentiary framework put forth in the 2019 Comprehensive Review with the new results from the statistical analyses.

Knowledge Gained from Actions taken in 2019

Empirical Changes in Water Chemistry

Empirical changes in pH, Gran ANC, SO_4^{2-}, DOC, sum of base cations, chloride, and calcium are shown in Table 4. Changes are reported in terms of the difference between the post-KMP average (2016-2019) and the pre-KMP baseline (2012 for the sensitive and less sensitive lakes; 2013 for the control lakes).

The mean values of pH and Gran ANC for the post-KMP period indicate that there have been no exceedances of the KPI thresholds.

None of the 7 sensitive EEM lakes show any decrease in pH from the 2012 baseline to the post-KMP period of 2016-2019. The empirical data indicate that none of the lakes have exceeded the threshold of a 0.3 unit decline in pH associated with the KPI.

Similarly, none of the 7 sensitive EEM lakes show any decrease in Gran ANC over this timeframe either and thus the empirical data indicate that none of the lakes have exceeded the lake-specific thresholds of decline put forward in the 2019 Comprehensive Review.

Table 3-2 in Technical Memo W08 shows how the new data from 2019 compare to the values for the post-KMP averaging period used in the 2019 Comprehensive Review (i.e., the mean of 2016-2018). The pH values for 2019 were the same or higher for 5 of 7 sensitive lakes, 3 of 4 less sensitive lakes, and 1 of 3 control lakes. For the other 5 lakes, the 2019 pH values were 0.1 pH units less than the values for 2016-2018.

Table 4. Empirical changes in pH, Gran ANC, SO_4^{2-}, DOC, base cations, chloride, and calcium for EEM lakes, 2012-2019. Both the differences across the full record of sampling and from 2012 to the average of the post-KMP period (2016-2019) are shown. 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 pink.

SITE	pH (TU)	Gran ANC (µeq/L)	SO_4^{2-} (µeq/L)	DOC (mg/L)	∑ BC (µeq/L)	Cl (µeq/L)	Ca (µeq/L)
Lak006	0.3	3.0	3.3	0.3	13.7	0.2	5.1
LAK012	0.5	0.5	6.9	0.3	-9.5	2.3	-12.5
LAK022	0.2	5.9	11.2	0.7	18.9	0.8	10.8
LAK023	0.2	5.2	-6.4	1.5	6.9	0.4	4.1
LAK028	0.1	2.2	76.5	1.4	68.0	3.1	46.7
LAK042	0.6	27.2	-0.2	-2.8	10.2	0.4	6.4
LAK044	0.1	4.0	-1.8	0.3	4.3	0.7	1.5
LAK007	0.1	-54.5	-5.4	-0.2	-11.6	2.0	-21.9
LAK016	0.3	21.4	9.0	0.9	15.5	1.7	6.8
LAK024	0.4	172.2	14.5	0.6	231.7	42.8	176.1
LAK034	-0.3	42.5	-23.8	1.5	-8.8	-1.3	-1.6
DCAS14A	0.2	6.0	4.1	-0.1	22.4	-1.6	15.3
NC184	0.1	10.3	0.8	-1.5	8.3	-5.1	7.9
NC194	-0.2	-3.6	-1.1	0.3	7.5	-0.9	5.8

Statistical Analyses 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 5 and Figure 15. These results applied Bayesian Method 1, described in Appendix F of the 2019 Comprehensive Review Report (ESSA et al. 2020b).

The new results were **very** similar (see Table 4-1 in Technical Memo W08), which shows that the conclusions of the comprehensive review are strongly supported with an additional year of monitoring data. For SO_4^{2-}, only two lakes had changes in % belief of greater than 10% - less sensitive lake LAK016 decreased from a 97% belief in an increase to an 81% belief and control lake NC184 increased from a 58% belief to a 69% belief in an increase (of negligible magnitude). For Gran ANC, none of the lakes had changes in % belief of greater than 1%. For pH, only two lakes had changes in % belief of greater than 10% - sensitive lake LAK028 decreased from an 18% belief to a 6% belief in exceeding the pH threshold (i.e., decreasing in pH by >0.3 pH units) and control lake NC184 decreased from a 28% belief to a 14% belief. The decrease in percent belief for LAK028 is an important result. LAK028 is the only lake which showed evidence of sulphur-induced acidification (both pre- and post-KMP). It previously showed low support for an exceedance of the pH KPI threshold (18%), and it now shows very low support (6%). Out of 14 total lakes, the number that showed differences in % belief of <5% were 10 for SO_4^{2-}, all 14 for Gran ANC, and 10 for pH.

Table 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 (ESSA et al. 2020b). Values of % belief < 20% are coloured green, 20-80% yellow, and >80% red.

LAKE	Changes in SO_4 (% belief in SO_4 increase / decrease from Bayesian analysis - Method 1 violin plot)	Changes in Gran ANC (% belief that ANC threshold exceeded, from Bayesian analysis - Method 1 violin plot)	Changes in pH (% belief that pH threshold exceeded, from Bayesian analysis - Method 1 violin plot)	OVERALL INTERPRETATION
Sensitive Lakes				
LAK006	85% belief in increase	0%	0%	SO_4 increase; no evidence of S-induced acidification
LAK012	95% belief in increase	1%	0%	SO_4 increase; no evidence of S-induced acidification
LAK022	89% belief in increase	0%	0%	SO_4 increase; no evidence of S-induced acidification
LAK023	2% belief in increase	0%	0%	SO_4 decrease; no evidence of S-induced acidification
LAK028	97% belief in increase	2%	6%	SO_4 increase; very limited evidence of S-induced acidification; low belief in exceeding pH and ANC thresholds; conditions were potentially damaging to biota pre-KMP and remained so (see section 7.3.4.2 of 2019 Comprehensive Review report).
LAK042	44% belief in increase	0%	0%	No clear change in SO_4; no evidence of S-induced acidification
LAK044	0% belief in increase	0%	0%	SO_4 decrease; no evidence of S-induced acidification
Less Sensitive Lakes				
LAK007	4% belief in increase	58%	1%	SO_4 decrease; no evidence of S-induced acidification
LAK016	81% belief in increase	0%	0%	SO_4 increase; no evidence of S-induced acidification
LAK024	98% belief in increase	1%	0%	SO_4 increase; no evidence of S-induced acidification
LAK034	0% belief in increase	0%	39% [1]	SO_4 decrease; no evidence of S-induced acidification
Control Lakes				
DCAS14A	75% belief in increase [2]	0%	0%	No clear change in SO_4; no evidence of S-induced acidification
NC184	69% belief in negligible increase [2]	5%	14%	No clear change in SO_4; no evidence of S-induced acidification
NC194	1% belief in increase	TBD [3]	4%	SO_4 decrease; no evidence of S-induced acidification

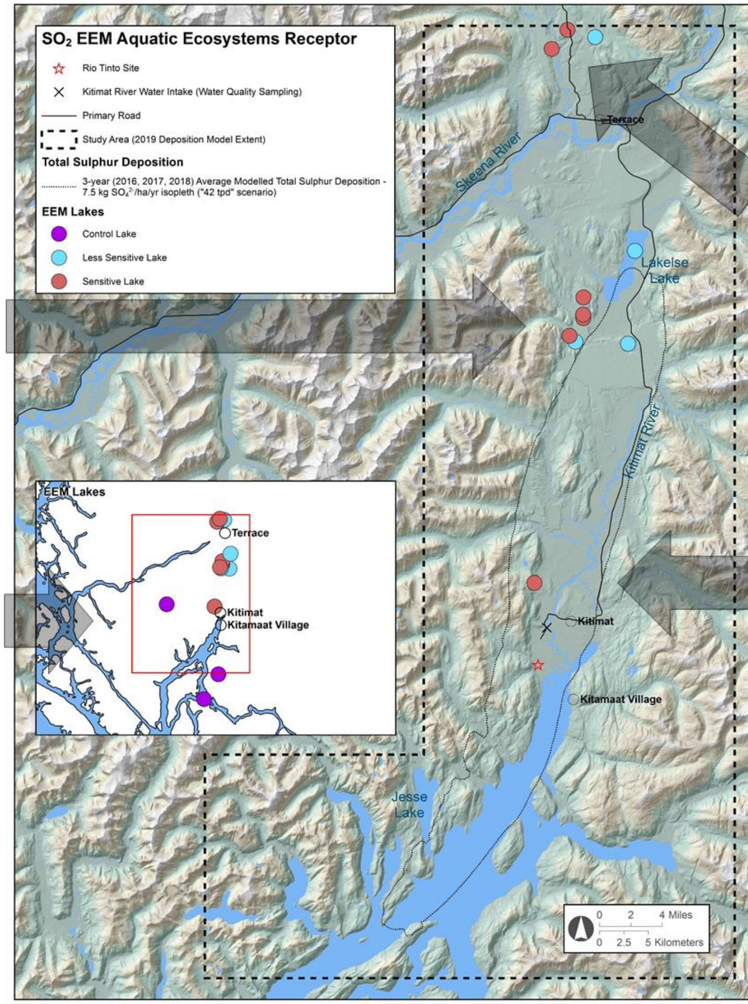
[1] Not related to S deposition as lake SO_4 has declined in LAK034.

[2] Magnitude of increase in [SO_4] between 2013 and 2016-2019 is small in DCAS14A (4.1 µeq/L) and very small in NC184 (0.8 µeq/L).

[3] Lake NC194 did not have a lab titration from which we could determine an ANC threshold. It had a 57% belief in an ANC decline (about 3.6 µeq/L between 2013 and 2016-2019), though very low belief (1%) in a SO_4 increase, so the ANC decline was not related to SO_4.

LAKE	% belief in change ↑ SO_4^{2-}	↓ ANC	↓ pH
LAK006	85%	0%	0%
LAK012	95%	0%	0%
LAK022	89%	0%	0%
LAK023	2%	0%	0%
LAK007	4%	58%	1%
LAK016	81%	0%	0%
LAK024	98%	0%	0%

LAKE	% belief in change ↑ SO_4^{2-}	↓ ANC	↓ pH
DCAS14A	75%**	0%	6%
NC184	69%**	4%	28%
NC194	1%	TBD	12%



LAKE	% belief in change ↑ SO_4^{2-}	↓ ANC	↓ pH
LAK042	44%	0%	0%
LAK044	0%	0%	0%
LAK034	0%	0%	39%

LAKE	% belief in change ↑ SO_4^{2-}	↓ ANC	↓ pH
LAK028	97%	1%	6%

Figure 15. Spatial distribution of percent belief in chemical change. Numbers show % belief in: a) SO_4 increase (no threshold), b) pH decrease below 0.3 threshold, and c) Gran ANC decrease below lake-specific 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 (ESSA et al. 2020b). NC194 does not have an estimated ANC threshold because it did not have appropriate titration data available. **The increase in SO_4^{2-} in control lake DCAS014A was only ~4.1 μeq/L, and only 0.8 μeq/L in NC184.

Application of the Evidentiary Framework

We have applied the simplified evidentiary framework, as described in the 2019 Comprehensive Review Report, using the updated results of the statistical analyses. The results are shown in Figure 16. The underlying results are compiled in Table 4-2 of Technical Memo W08. The updated application of the simplified evidentiary framework show that: a) 2 sensitive lakes, 2 less sensitive lakes, and all 3 control lakes[5] land within the first box, "smelter not causally linked to changes in lake chemistry"; b) 3 sensitive lakes and 2 less sensitive lakes all land within the second box, "lake is healthy, and not acidifying"; and c) 2 sensitive lakes (LAK012 and LAK028) land within "some evidence of acidification". For LAK012, this classification is based on intermediate support for a decline in Gran ANC (47% belief) but zero support for a decline in pH. For LAK028, this classification is based on low-intermediate support for declines in Gran ANC (37% belief) and pH (35% belief). However, both lakes have very low to zero support for declines exceeding their Gran ANC and pH thresholds. The classification of LAK042 is also based on only intermediate support for an increase in SO_4^{2-} (44% belief). These results completely mirror those presented in the 2019 Comprehensive Review. None of the lakes have moved positions within the framework.

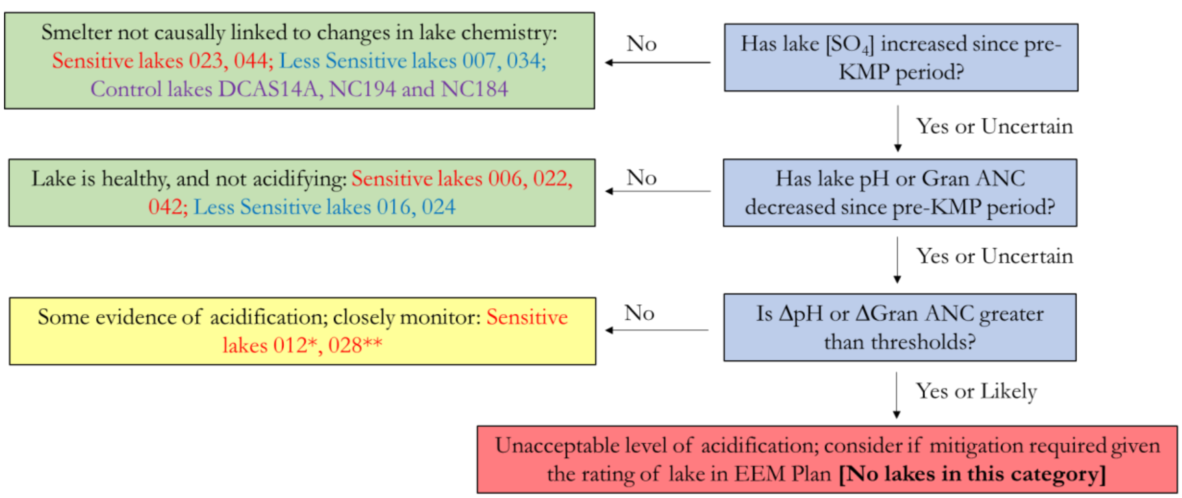


Figure 16. Classification of EEM lakes according to the simplified evidentiary framework. * LAK012 has intermediate support for decline in Gran ANC but no support for exceeding the threshold. ** LAK028 has low-intermediate support for declines in Gran ANC and pH but very low support for exceeding the thresholds.

[5] 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.

4 List of Cited Reports

ESSA et al. 2013. ESSA Technologies, J. Laurence, Limnotek, Risk Sciences International, Rio Tinto Alcan, Trent University, Trinity Consultants, and University of Illinois. 2013. Sulphur Dioxide Technical Assessment Report in Support of the 2013 Application to Amend the P2-00001 Multimedia Permit for the Kitimat Modernization Project. Volume 2: Final Technical Report. Prepared for Rio Tinto Alcan, Kitimat, BC. 450 pp.

ESSA Technologies, J. Laurence, Limnotek, Risk Sciences International, Trent University, and Trinity Consultants. 2014a. Environmental Effects Monitoring Program for the Kitimat Modernization Project. Program Plan for 2013 to 2018. Prepared for Rio Tinto Alcan, Kitimat, BC. 67 pp.

ESSA Technologies, J. Laurence, Risk Sciences International, Trent University, and Trinity Consultants. 2014b. Kitimat Airshed Emissions Effects Assessment. Report prepared for BC Ministry of Environment, Smithers, BC. 205 pp. + appendices.

ESSA Technologies, J. Laurence, Risk Sciences International, Trent University, and Trinity Consultants. 2020a. 2019 Comprehensive Review of Sulphur Dioxide Environmental Effects Monitoring for the Kitimat Modernization Project – Volume 1, V.3 Final. Prepared October 15, 2020 for Rio Tinto, B.C. Works, Kitimat, B.C.

ESSA Technologies, J. Laurence, Risk Sciences International, Trent University, and Trinity Consultants. 2020b. 2019 Comprehensive Review of Sulphur Dioxide Environmental Effects Monitoring for the Kitimat Modernization Project – Volume 2: Technical Appendices (Appendix 7), V.3 Final. Prepared for Rio Tinto, B.C. Works, Kitimat, B.C.

Gosling, L., Ashmore, M., Sparks, T., and Bell, N. (2016). Citizen science identifies the effects of nitrogen dioxide and other environmental drivers on tar spot of sycamore. Environmental Pollution, 214, 549–555. https://doi.org/10.1016/j.envpol.2016.04.066.

Kayahara, J., R.E. Carter and K. Klinka. 1995. Site Index of Western Hemlock (*Tsuga heterophylla*) in Relation to Soil Nutrient and Foliar Chemical Measures. Forest and Ecology Management 74: 161–169.

Kosiba, P. (2007). Impact of air pollution on the occurrence of Rhytisma acerinium "tar-spot" on maple leaves. Acta Societatis Botanicorum Poloniae, 76(4), 333–343. https://doi.org/10.5586/asbp.2007.037.

Limnotek. 2020. Rio Tinto SO_2 Environmental Effects Program: Monitoring of lakes and streams in 2019. Report prepared by Limnotek Research and Development Inc. for Rio Tinto Ltd. 111 pp.

Linzon, S.N., P.J. Temple and R.G. Pearson. 1979. Sulfur Concentrations in Plant Foliage and Related Effects, Journal of the Air Pollution Control Association, 29:5, 520-525, DOI: 10.1080/00022470.1979.10470822.

Reimann, C., F. Koller, B. Frengstad, G. Kashulina, H. Niskavaara, and P. Englmaier. 2003. Total sulphur in leaves of several plant species from nine catchments within a 1 500 000 km^2 area in northern Europe: local vs. regional variability. Geochemistry: Exploration, Environment, Analysis 3: 205-215.

Stantec Consulting, Ltd. and J. Laurence. 2020. Vegetation Monitoring Report. Annual Report for 2019. Submitted to Rio Tinto March 17, 2020. 240 pp.

Vick, C. M. and R. Bevan(1976). Lichens and tar spot fungus (Rhytisma acerinum) as indicators of sulphur dioxide pollution on Merseyside. Environmental Pollution (1970), 11(3), 203–216. https://doi.org/10.1016/0013-9327(76)90085-9.

Zhang L., Brook J. R., and Vet R. 2003. A revised parameterization for gaseous dry deposition in air-quality models. Atmos. Chem. Phys., 3, 2067–2082.

Zhang L. and He Z. 2014. Technical Note: An empirical algorithm estimating dry deposition velocity of fine, coarse and giant particles. Atmos. Chem. Phys., 14, 3729–3737.

5 List of Cited EEM Technical Memos

The numbering of Technical Memos continues from the numbers in the previous Annual Reports. Technical Memo W08 is provided in Appendix B. Technical memos prepared in prior years are cited in previous annual reports, and can be obtained from the Rio Tinto website.

Technical Memo P03. Atmospheric Sulphur Dioxide – Passive Diffusive Sampler Network: Pilot Study Results (September 2016, Trent University)

Technical Memo P04. Atmospheric Sulphur Dioxide – Passive Diffusive Sampler Network: 2016 (March 2017, Trent University)

Technical Memo S06. Long-term Soil Monitoring Plots – Plot Establishment (March 2017, Trent University)

Technical Memo W03. Aquatic Ecosystems Actions and Analyses (March 2016, ESSA Technologies Ltd.)

Technical Memo W06. Aquatic Ecosystems Actions and Analyses (March 2017, ESSA Technologies Ltd.)

Technical Memo W07. Aquatic Ecosystems Actions and Analyses (April 2018, ESSA Technologies Ltd.)

Technical Memo W08. Aquatic Ecosystems Actions and Analyses (July 2019, ESSA Technologies Ltd.)

Appendix A: Human Health KPI Calculations Memo

The following pages contain the memorandum for the Human Health KPI Calculations for 2019.

MEMORANDUM

To: Mr. Shawn Zettler - Rio Tinto

From: Anna Henolson, Hui Cheng - Trinity Consultants

Date: July 7, 2020

RE: Human Health KPI Calculations for 2019

The SO_2 Environmental Effects Monitoring (EEM) Program establishes Key Performance Indicators (KPIs) of various pathways in order to monitor effects of SO_2 from Rio Tinto's Kitimat aluminum smelter. This memorandum describes the SO_2 monitoring data collected in 2017 through 2019 in the Kitimat area and the methodology used in order to compare to the human health KPI for reporting year 2019.

Health KPI

British Columbia Ministry of Environment and Climate Change Strategy (BC ENV) updated the province-wide interim SO_2 ambient air quality objective (IAAQO) in 2016, which became the SO_2 health KPI of EEM Program starting 2017. Starting January 1, 2020, the SO_2 health KPI will implement the SO_2 Canadian Ambient Air Quality Standards (CAAQS). The SO_2 health KPI is used to assess residential SO_2 ambient air quality.

For the year 2019, the SO_2 IAAQO is 75 ppb, assessed by comparing annual 98th percentile of daily 1-hour maximum values averaged over 2017 through 2019. The IAAQO also allows one excursion above 75 ppb to a maximum of 85 ppb over a three-year period. Exceptional events as defined in the 2019 BCEAB Consent Order were not evaluated and included in the attainment determination of the 2019 Health KPI. Exceptional events will be assessed going forward in 2020.

Calculation Methodology

The monitoring data at residential areas in Kitimat is collected at three residential monitoring stations: Riverlodge, Whitesail, and Kitamaat Village[1]. Ambient SO_2 monitors collect the SO_2 measurements continuously and hourly measurements are reported to BC ENV's Envista database[2]. The measurements at these monitor stations are reviewed and validated by BC ENV on annual basis:

- Monitoring data for 2017 was validated by June 1, 2018.
- Monitoring data for 2018 was validated as of January 14, 2019.
- Monitoring data for 2019 was validated as of April 17, 2020.

The hourly measurements for calendar years 2017, 2018 and 2019 were downloaded from the Envista database after the validation was complete, and then processed following the procedures described in

[1] Note that the BC ENV Envista database lists the Kitamaat Village monitoring station as the Haisla Village monitoring station.

[2] BC Air Data Archive Website (Envista database), available at https://envistaweb.env.gov.bc.ca/.

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Guidance on Application of Provincial Air Quality Objectives for SO_2[3] (the Guidance). Following the Guidance the monitoring data was processed in the following steps:

1. Check daily data completeness and determine the daily 1-hour maximum concentration.
   - Daily measurements are the hourly readings from 1 AM to 12 AM marked for the same day.
   - A valid daily value is calculated as the maximum hourly reading from the day:
     - Where at least 18 hourly measurements are available in a day, the daily value is the maximum value from those readings in the same day; or
     - Where less than 18 hourly measurements are available in a day but at least one hourly measurement exceeds 75 ppb, the daily value is the maximum value from available readings in the same day.[4]
   - All values are reported to the nearest 0.1 ppb.
   - A summary of daily completeness is provided in Attachment 1.
2. Check quarterly and annual data completeness. A summary of quarterly and annual data completeness is provided in Table 1.
   - The data is considered complete when there are at least 60% of all daily maximum 1-hour measurements in each quarter and at least 75% of all daily maximum 1-hour measurements in each year.
   - Periods which do not satisfy the data completeness criteria are flagged.

Table 1. Quarterly and Annual Data Completeness

	2017			2018			2019		
Period [a]	**Kitamaat Village**	**Riverlodge**	**Whitesail**	**Kitamaat Village**	**Riverlodge**	**Whitesail**	**Kitamaat Village**	**Riverlodge**	**Whitesail**
Q1	100.0%	100.0%	100.0%	100.0%	98.9%	100.0%	100.0%	98.9%	98.9%
Q2	100.0%	100.0%	100.0%	98.9%	100.0%	100.0%	100.0%	98.9%	98.9%
Q3	96.7%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	98.9%
Q4	88.0%	100.0%	98.9%	98.9%	100.0%	98.9%	100.0%	100.0%	100.0%
Annual	96.2%	100.0%	99.7%	99.5%	99.7%	99.7%	100.0%	99.5%	99.2%

a. Q1 refers to January to March, Q2 refers to April to June, Q3 refers to July to September, and Q4 refers to October to December.

3. Calculate the 98th percentile value of daily 1-hour maximum values for each year at each station.
   - Firstly, all daily 1-hour maximum values for the year are sorted from highest to lowest. For example, there were 351 valid daily 1-hour maximum values at Kitamaat Village for 2017, and these 351 values were ordered from highest to lowest.
   - Secondly, count the number of valid daily values, and determine the corresponding rank for the annual 98th percentile value following Table I-1 of the Guidance. For example, the corresponding rank equivalent to annual 98th percentile is 8 for Kitamaat Village for 2017, as there were 351 valid daily values.
   - Lastly, report the value in the corresponding rank equivalent to annual 98th percentile of the daily 1-hour maximum values. The value is reported to the nearest 1 ppb. For example, the 8th highest daily value is reported for Kitamaat Village for 2017, which is 7 ppb.

[3] *Guidance on Application of Provincial Air Quality Objectives for SO_2,* BC ENV, Feburary 7, 2017, available at https://www2.gov.bc.ca/assets/gov/environment/air-land-water/air/reports-pub/so2_aqo-implementation_guide.pdf.

[4] In this case, there were no SO_2 readings higher than 75 ppb from the three monitoring stations in any day in 2017, 2018 and 2019.

4. Calculate the three-year average of annual 98th percentile of the daily 1-hour maximum values at each station.

The annual 98th percentile value of daily 1-hour maximum values for each year at each station and the three-year average values at each station are summarized in Table 2. The three-year average of annual 98th percentile of daily 1-hour maximum over 2017, 2018 and 2019 at all three monitor stations are also compared to the SO_2 IAAQO of 75 ppb, as shown in Table 2. Since all values are below 75 ppb, and since all hourly measurements in 2017, 2018, or 2019 are below 75 ppb, all three monitor stations are considered in the attained status regarding this human health KPI.

Table 2. Annual 98th Percentile and Three-Year Average

Monitor Station	Annual 98th Percentile of Daily 1-hour Maximum [a] (ppb)			Three-Year Average [a] (ppb)	Health KPI Attainment Status
	2017	2018	2019		
Kitamaat Village	7.1	10.4	14.3	10.6	Attained
Riverlodge	17.0	24.7	31.5	24.4	Attained
Whitesail	14.9	16.0	18.2	16.4	Attained

a. All values are reported with one decimal per comments from ENV (Memorandum P2-00001, dated June 4, 2020).

2019 Monitoring Data Review

The BC ENV began a pilot project in Kitimat to issue alerts when SO_2 levels equal or exceed 36 ppb. According to the ENV information page, "[i]t is expected that 1-hour SO_2 levels of 35 ppb and lower will pose little or no additional health risk to even sensitive individuals."[5] The periods of time in 2019 with elevated SO_2 concentrations at these three residential monitor stations were infrequent. The date and hour with hourly SO_2 measurements equal to or higher than 36 ppb include:

- At Kitamaat Village, between 10-11 AM on August 19, 2019 (72.8 ppb);
- At Riverlodge[6]
  - between 11 AM to 2 PM on March 21, 2019 (36.5 ppb, 36.7 ppb, 66.6 ppb);
  - between 12-1 PM on May 7, 2019 (37.8 ppb);
  - between 10-11 AM on August 6, 2019 (39.5 ppb);
  - between 9-10 AM on August 12, 2019 (39 ppb);
  - between 12-1 PM on September 11, 2019 (53.4 ppb); and
- At Whitesail
  - between 2-3 PM on March 21, 2019 (40.2 ppb);
  - between 2-3 PM on September 11, 2019 (43.6 ppb).

[5] https://www2.gov.bc.ca/gov/content/environment/air-land-water/air/air-quality/measuring/kitimat-so2-alert-pilot-project

[6] An alert was issued in on February 18, 2019 with a reading of 36.2 ppb, but the ENV-validated data lists the reading as 35.8 ppb.

Attachment 1

Daily 1-hour Maximum Concentrations and Completeness

Note: The daily completeness is calculated by the number of valid hourly measurements in the day divided by 24. Where the daily completeness is below 75% (less than 18 measurements), the daily 1-hr maximum value for the given day is not calculated unless the daily 1-hr maximum exceeds 75 ppb (not applicable for 2019).

Haisla Village 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
1/1/2017	0.40	96%
1/2/2017	0.20	96%
1/3/2017	0.20	96%
1/4/2017	0.30	96%
1/5/2017	0.30	96%
1/6/2017	0.10	96%
1/7/2017	0.20	96%
1/8/2017	0.20	96%
1/9/2017	0.30	83%
1/10/2017	1.40	96%
1/11/2017	0.20	96%
1/12/2017	0.20	96%
1/13/2017	0.60	96%
1/14/2017	0.20	100%
1/15/2017	0.20	96%
1/16/2017	1.00	96%
1/17/2017	0.60	96%
1/18/2017	0.30	96%
1/19/2017	0.30	96%
1/20/2017	5.90	96%
1/21/2017	0.20	96%
1/22/2017	0.20	96%
1/23/2017	0.50	96%
1/24/2017	0.90	96%
1/25/2017	0.30	96%
1/26/2017	0.30	96%
1/27/2017	4.20	96%
1/28/2017	0.30	96%
1/29/2017	0.30	96%
1/30/2017	0.30	96%
1/31/2017	0.30	96%
2/1/2017	0.30	96%
2/2/2017	0.30	96%
2/3/2017	0.30	96%
2/4/2017	0.20	96%
2/5/2017	0.40	96%
2/6/2017	0.20	96%
2/7/2017	0.30	96%
2/8/2017	0.20	100%
2/9/2017	0.30	96%
2/10/2017	1.00	83%
2/11/2017	0.20	96%
2/12/2017	0.20	96%
2/13/2017	2.90	96%
2/14/2017	2.50	96%
2/15/2017	0.80	92%

Haisla Village 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
2/16/2017	0.30	96%
2/17/2017	12.40	96%
2/18/2017	0.20	96%
2/19/2017	0.30	96%
2/20/2017	0.30	96%
2/21/2017	1.40	96%
2/22/2017	5.70	96%
2/23/2017	7.90	96%
2/24/2017	0.30	96%
2/25/2017	0.50	96%
2/26/2017	0.70	96%
2/27/2017	3.10	96%
2/28/2017	0.40	96%
3/1/2017	0.30	96%
3/2/2017	0.30	88%
3/3/2017	0.50	96%
3/4/2017	0.30	96%
3/5/2017	0.40	100%
3/6/2017	0.40	96%
3/7/2017	0.30	96%
3/8/2017	0.30	96%
3/9/2017	0.30	96%
3/10/2017	0.40	96%
3/11/2017	0.40	96%
3/12/2017	0.60	96%
3/13/2017	0.70	88%
3/14/2017	0.20	96%
3/15/2017	0.20	96%
3/16/2017	0.50	96%
3/17/2017	0.70	96%
3/18/2017	0.20	96%
3/19/2017	0.20	96%
3/20/2017	0.30	96%
3/21/2017	0.20	96%
3/22/2017	4.30	96%
3/23/2017	7.10	96%
3/24/2017	0.20	75%
3/25/2017	0.20	96%
3/26/2017	0.30	96%
3/27/2017	1.30	96%
3/28/2017	1.20	96%
3/29/2017	4.10	96%
3/30/2017	0.20	100%
3/31/2017	0.20	96%
4/1/2017	0.20	96%
4/2/2017	0.20	96%

Haisla Village 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
4/3/2017	2.90	96%
4/4/2017	1.20	96%
4/5/2017	0.50	96%
4/6/2017	0.60	88%
4/7/2017	0.40	96%
4/8/2017	0.40	96%
4/9/2017	3.30	96%
4/10/2017	11.70	96%
4/11/2017	0.30	79%
4/12/2017	0.70	96%
4/13/2017	0.20	96%
4/14/2017	0.40	96%
4/15/2017	0.20	96%
4/16/2017	4.70	96%
4/17/2017	0.50	96%
4/18/2017	0.70	96%
4/19/2017	2.70	96%
4/20/2017	6.10	96%
4/21/2017	5.80	96%
4/22/2017	0.70	96%
4/23/2017	1.20	96%
4/24/2017	7.40	100%
4/25/2017	3.00	96%
4/26/2017	0.30	96%
4/27/2017	0.30	96%
4/28/2017	0.30	96%
4/29/2017	0.30	96%
4/30/2017	0.50	96%
5/1/2017	0.50	96%
5/2/2017	3.70	96%
5/3/2017	0.30	96%
5/4/2017	0.30	96%
5/5/2017	1.50	96%
5/6/2017	0.20	96%
5/7/2017	0.20	96%
5/8/2017	0.30	96%
5/9/2017	0.30	96%
5/10/2017	1.60	96%
5/11/2017	0.50	83%
5/12/2017	0.10	96%
5/13/2017	0.10	96%
5/14/2017	0.10	96%
5/15/2017	0.20	96%
5/16/2017	0.30	96%
5/17/2017	2.00	96%
5/18/2017	0.10	96%

Haisla Village 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
5/19/2017	3.70	100%
5/20/2017	1.30	96%
5/21/2017	0.10	96%
5/22/2017	0.20	96%
5/23/2017	0.10	96%
5/24/2017	0.50	96%
5/25/2017	4.00	96%
5/26/2017	2.70	96%
5/27/2017	3.50	96%
5/28/2017	5.30	96%
5/29/2017	0.20	96%
5/30/2017	0.20	96%
5/31/2017	3.90	96%
6/1/2017	0.20	96%
6/2/2017	1.20	92%
6/3/2017	0.20	96%
6/4/2017	0.20	96%
6/5/2017	0.20	96%
6/6/2017	3.10	96%
6/7/2017	5.60	83%
6/8/2017	0.30	96%
6/9/2017	0.20	96%
6/10/2017	0.90	96%
6/11/2017	0.30	96%
6/12/2017	0.30	96%
6/13/2017	0.20	100%
6/14/2017	0.20	96%
6/15/2017	0.60	96%
6/16/2017	0.30	96%
6/17/2017	0.30	96%
6/18/2017	3.60	96%
6/19/2017	1.20	96%
6/20/2017	0.30	96%
6/21/2017	0.30	96%
6/22/2017	4.90	96%
6/23/2017	4.00	96%
6/24/2017	5.30	96%
6/25/2017	0.40	96%
6/26/2017	0.30	96%
6/27/2017	0.30	92%
6/28/2017	2.00	96%
6/29/2017	0.30	96%
6/30/2017	0.30	96%
7/1/2017	0.20	96%
7/2/2017	0.20	96%
7/3/2017	0.20	96%

Haisla Village 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
7/4/2017	0.30	96%
7/5/2017	3.40	96%
7/6/2017	0.80	88%
7/7/2017	0.30	96%
7/8/2017	0.10	100%
7/9/2017	0.20	96%
7/10/2017	1.20	96%
7/11/2017	0.20	96%
7/12/2017	0.30	96%
7/13/2017	0.30	96%
7/14/2017	--	71%
7/15/2017	0.70	96%
7/16/2017	0.20	96%
7/17/2017	5.60	96%
7/18/2017	2.00	96%
7/19/2017	0.20	96%
7/20/2017	0.20	96%
7/21/2017	0.20	96%
7/22/2017	1.20	96%
7/23/2017	0.20	96%
7/24/2017	1.30	96%
7/25/2017	0.20	96%
7/26/2017	0.20	96%
7/27/2017	0.20	96%
7/28/2017	0.20	96%
7/29/2017	0.30	96%
7/30/2017	0.20	96%
7/31/2017	2.60	96%
8/1/2017	1.90	96%
8/2/2017	2.70	100%
8/3/2017	5.20	96%
8/4/2017	3.00	96%
8/5/2017	3.40	96%
8/6/2017	0.10	96%
8/7/2017	11.70	96%
8/8/2017	3.90	96%
8/9/2017	4.00	96%
8/10/2017	2.30	96%
8/11/2017	--	54%
8/12/2017	--	63%
8/13/2017	0.10	96%
8/14/2017	0.10	79%
8/15/2017	0.10	96%
8/16/2017	0.10	92%
8/17/2017	0.50	83%
8/18/2017	0.10	96%

Haisla Village 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
8/19/2017	0.10	96%
8/20/2017	2.50	96%
8/21/2017	0.30	96%
8/22/2017	0.20	96%
8/23/2017	0.20	96%
8/24/2017	0.30	83%
8/25/2017	0.30	96%
8/26/2017	0.30	96%
8/27/2017	0.30	100%
8/28/2017	0.30	96%
8/29/2017	1.30	96%
8/30/2017	0.50	96%
8/31/2017	0.30	96%
9/1/2017	0.10	96%
9/2/2017	1.30	88%
9/3/2017	4.60	96%
9/4/2017	0.80	96%
9/5/2017	3.40	96%
9/6/2017	3.90	96%
9/7/2017	0.60	96%
9/8/2017	0.10	96%
9/9/2017	0.10	96%
9/10/2017	3.20	96%
9/11/2017	0.20	88%
9/12/2017	3.60	96%
9/13/2017	4.60	96%
9/14/2017	2.80	96%
9/15/2017	3.10	96%
9/16/2017	6.40	96%
9/17/2017	5.40	96%
9/18/2017	0.20	96%
9/19/2017	0.20	96%
9/20/2017	0.60	96%
9/21/2017	5.20	100%
9/22/2017	0.40	96%
9/23/2017	0.10	96%
9/24/2017	0.10	96%
9/25/2017	6.40	96%
9/26/2017	0.20	96%
9/27/2017	14.10	96%
9/28/2017	0.20	96%
9/29/2017	0.20	96%
9/30/2017	0.20	96%
10/1/2017	5.40	96%
10/2/2017	0.10	96%
10/3/2017	0.40	96%

Haisla Village 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
10/4/2017	0.30	79%
10/5/2017	1.10	92%
10/6/2017	0.20	96%
10/7/2017	0.20	96%
10/8/2017	0.50	96%
10/9/2017	0.20	96%
10/10/2017	0.20	96%
10/11/2017	8.30	96%
10/12/2017	3.60	96%
10/13/2017	4.30	96%
10/14/2017	0.20	96%
10/15/2017	0.20	96%
10/16/2017	0.50	100%
10/17/2017	0.20	96%
10/18/2017	3.30	96%
10/19/2017	1.40	96%
10/20/2017	0.20	96%
10/21/2017	0.30	83%
10/22/2017	0.30	83%
10/23/2017	0.60	96%
10/24/2017	0.20	96%
10/25/2017	1.20	96%
10/26/2017	0.40	96%
10/27/2017	0.20	96%
10/28/2017	0.40	96%
10/29/2017	0.30	96%
10/30/2017	--	54%
10/31/2017	--	21%
11/1/2017	--	29%
11/2/2017	0.20	92%
11/3/2017	0.20	88%
11/4/2017	0.20	96%
11/5/2017	4.20	96%
11/6/2017	0.10	96%
11/7/2017	0.10	96%
11/8/2017	0.10	96%
11/9/2017	--	21%
11/10/2017	--	0%
11/11/2017	--	0%
11/12/2017	--	0%
11/13/2017	--	0%
11/14/2017	--	29%
11/15/2017	0.20	96%
11/16/2017	0.30	96%
11/17/2017	1.30	96%
11/18/2017	0.40	79%

Haisla Village 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
11/19/2017	0.30	88%
11/20/2017	0.30	96%
11/21/2017	0.20	96%
11/22/2017	1.10	96%
11/23/2017	0.30	96%
11/24/2017	0.30	96%
11/25/2017	0.40	96%
11/26/2017	0.40	96%
11/27/2017	--	71%
11/28/2017	--	25%
11/29/2017	0.20	88%
11/30/2017	0.20	96%
12/1/2017	0.30	83%
12/2/2017	1.30	96%
12/3/2017	0.20	96%
12/4/2017	0.20	96%
12/5/2017	1.10	100%
12/6/2017	0.20	96%
12/7/2017	0.20	96%
12/8/2017	0.20	96%
12/9/2017	1.40	96%
12/10/2017	0.50	96%
12/11/2017	0.50	96%
12/12/2017	0.50	96%
12/13/2017	0.40	96%
12/14/2017	0.30	96%
12/15/2017	0.20	96%
12/16/2017	0.20	96%
12/17/2017	0.30	96%
12/18/2017	1.00	92%
12/19/2017	0.50	96%
12/20/2017	1.00	96%
12/21/2017	2.10	96%
12/22/2017	0.20	96%
12/23/2017	0.40	96%
12/24/2017	0.20	96%
12/25/2017	0.20	96%
12/26/2017	0.20	96%
12/27/2017	0.20	96%
12/28/2017	0.20	96%
12/29/2017	0.20	96%
12/30/2017	0.20	100%
12/31/2017	0.30	96%

Riverlodge 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
1/1/2017	0.20	96%
1/2/2017	0.20	96%
1/3/2017	0.20	96%
1/4/2017	0.10	96%
1/5/2017	0.30	96%
1/6/2017	0.30	88%
1/7/2017	0.30	96%
1/8/2017	0.30	96%
1/9/2017	0.20	96%
1/10/2017	0.30	96%
1/11/2017	0.20	96%
1/12/2017	0.20	96%
1/13/2017	1.10	100%
1/14/2017	0.40	96%
1/15/2017	0.40	96%
1/16/2017	2.90	96%
1/17/2017	0.30	96%
1/18/2017	0.30	96%
1/19/2017	0.40	96%
1/20/2017	5.60	96%
1/21/2017	0.30	96%
1/22/2017	0.30	96%
1/23/2017	0.20	96%
1/24/2017	0.80	96%
1/25/2017	0.30	96%
1/26/2017	0.30	96%
1/27/2017	1.20	96%
1/28/2017	0.50	96%
1/29/2017	0.80	96%
1/30/2017	1.10	96%
1/31/2017	0.20	96%
2/1/2017	0.30	96%
2/2/2017	0.30	96%
2/3/2017	0.30	96%
2/4/2017	0.20	96%
2/5/2017	0.50	96%
2/6/2017	0.20	96%
2/7/2017	0.30	100%
2/8/2017	0.20	96%
2/9/2017	0.30	88%
2/10/2017	18.40	96%
2/11/2017	1.70	96%
2/12/2017	9.90	96%
2/13/2017	3.60	96%
2/14/2017	0.60	96%
2/15/2017	0.40	96%

Riverlodge 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
2/16/2017	1.30	96%
2/17/2017	9.90	96%
2/18/2017	0.40	96%
2/19/2017	0.30	96%
2/20/2017	0.30	96%
2/21/2017	1.30	96%
2/22/2017	0.50	96%
2/23/2017	15.50	96%
2/24/2017	0.50	96%
2/25/2017	1.00	96%
2/26/2017	0.40	96%
2/27/2017	0.30	96%
2/28/2017	2.70	96%
3/1/2017	6.30	96%
3/2/2017	2.30	88%
3/3/2017	0.80	96%
3/4/2017	0.30	100%
3/5/2017	0.20	96%
3/6/2017	11.20	96%
3/7/2017	0.20	96%
3/8/2017	0.20	96%
3/9/2017	0.30	96%
3/10/2017	0.30	96%
3/11/2017	0.30	96%
3/12/2017	0.20	96%
3/13/2017	0.70	88%
3/14/2017	0.60	96%
3/15/2017	3.20	96%
3/16/2017	0.70	96%
3/17/2017	0.30	96%
3/18/2017	0.30	96%
3/19/2017	4.80	96%
3/20/2017	0.20	96%
3/21/2017	0.20	96%
3/22/2017	1.00	96%
3/23/2017	5.20	96%
3/24/2017	0.20	96%
3/25/2017	2.20	96%
3/26/2017	0.60	96%
3/27/2017	12.20	96%
3/28/2017	0.80	96%
3/29/2017	2.10	100%
3/30/2017	0.40	96%
3/31/2017	0.30	96%
4/1/2017	1.30	96%
4/2/2017	1.40	96%

Riverlodge 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
4/3/2017	6.20	96%
4/4/2017	0.40	96%
4/5/2017	2.20	88%
4/6/2017	0.60	96%
4/7/2017	0.20	96%
4/8/2017	0.50	96%
4/9/2017	3.90	96%
4/10/2017	5.50	96%
4/11/2017	6.90	88%
4/12/2017	0.20	96%
4/13/2017	0.50	96%
4/14/2017	0.70	96%
4/15/2017	1.00	96%
4/16/2017	13.40	96%
4/17/2017	0.80	96%
4/18/2017	1.60	96%
4/19/2017	1.50	96%
4/20/2017	5.30	96%
4/21/2017	3.50	96%
4/22/2017	0.40	96%
4/23/2017	6.20	100%
4/24/2017	6.60	96%
4/25/2017	3.70	96%
4/26/2017	4.70	96%
4/27/2017	4.40	96%
4/28/2017	0.50	96%
4/29/2017	0.40	96%
4/30/2017	2.70	96%
5/1/2017	0.40	96%
5/2/2017	5.00	96%
5/3/2017	0.30	96%
5/4/2017	0.20	96%
5/5/2017	1.40	96%
5/6/2017	0.70	96%
5/7/2017	1.60	96%
5/8/2017	0.20	96%
5/9/2017	4.40	96%
5/10/2017	5.00	88%
5/11/2017	1.30	96%
5/12/2017	0.20	96%
5/13/2017	0.20	96%
5/14/2017	3.50	96%
5/15/2017	1.20	96%
5/16/2017	0.30	96%
5/17/2017	4.50	96%
5/18/2017	0.30	100%

Riverlodge 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
5/19/2017	6.20	96%
5/20/2017	9.30	96%
5/21/2017	0.40	96%
5/22/2017	1.80	96%
5/23/2017	1.70	96%
5/24/2017	18.30	96%
5/25/2017	4.90	96%
5/26/2017	7.20	96%
5/27/2017	4.20	96%
5/28/2017	6.30	96%
5/29/2017	3.10	96%
5/30/2017	19.90	96%
5/31/2017	28.00	96%
6/1/2017	0.90	96%
6/2/2017	0.90	83%
6/3/2017	2.10	96%
6/4/2017	8.90	96%
6/5/2017	16.80	96%
6/6/2017	6.20	96%
6/7/2017	3.10	96%
6/8/2017	1.30	96%
6/9/2017	0.30	96%
6/10/2017	13.30	96%
6/11/2017	0.50	96%
6/12/2017	0.80	100%
6/13/2017	0.90	96%
6/14/2017	13.20	96%
6/15/2017	0.30	96%
6/16/2017	1.20	96%
6/17/2017	1.00	96%
6/18/2017	9.90	96%
6/19/2017	4.20	96%
6/20/2017	1.60	96%
6/21/2017	8.90	83%
6/22/2017	6.50	96%
6/23/2017	3.80	96%
6/24/2017	5.80	96%
6/25/2017	0.40	96%
6/26/2017	1.10	96%
6/27/2017	1.80	96%
6/28/2017	4.60	96%
6/29/2017	0.50	96%
6/30/2017	30.60	96%
7/1/2017	0.20	96%
7/2/2017	1.60	96%
7/3/2017	3.80	96%

Riverlodge 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
7/4/2017	0.20	96%
7/5/2017	17.00	83%
7/6/2017	0.90	96%
7/7/2017	0.30	100%
7/8/2017	0.20	96%
7/9/2017	1.60	96%
7/10/2017	17.00	96%
7/11/2017	4.10	96%
7/12/2017	7.30	96%
7/13/2017	0.10	96%
7/14/2017	8.00	96%
7/15/2017	0.80	96%
7/16/2017	0.50	96%
7/17/2017	41.00	96%
7/18/2017	4.40	96%
7/19/2017	0.60	96%
7/20/2017	0.20	96%
7/21/2017	3.30	96%
7/22/2017	0.40	96%
7/23/2017	0.10	96%
7/24/2017	1.20	96%
7/25/2017	0.30	96%
7/26/2017	0.20	96%
7/27/2017	0.20	96%
7/28/2017	0.20	96%
7/29/2017	1.30	96%
7/30/2017	0.40	96%
7/31/2017	3.10	96%
8/1/2017	3.80	96%
8/2/2017	2.70	96%
8/3/2017	0.60	83%
8/4/2017	0.10	96%
8/5/2017	0.70	96%
8/6/2017	0.30	96%
8/7/2017	1.30	96%
8/8/2017	0.70	96%
8/9/2017	0.70	96%
8/10/2017	3.00	96%
8/11/2017	0.30	96%
8/12/2017	0.20	96%
8/13/2017	0.30	96%
8/14/2017	0.20	96%
8/15/2017	0.20	96%
8/16/2017	0.20	88%
8/17/2017	0.20	96%
8/18/2017	1.00	96%

Riverlodge 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
8/19/2017	0.20	96%
8/20/2017	0.40	96%
8/21/2017	0.30	96%
8/22/2017	0.20	96%
8/23/2017	0.90	96%
8/24/2017	0.20	96%
8/25/2017	0.20	96%
8/26/2017	0.20	100%
8/27/2017	0.20	96%
8/28/2017	0.30	96%
8/29/2017	6.30	100%
8/30/2017	0.30	92%
8/31/2017	0.30	96%
9/1/2017	0.10	96%
9/2/2017	12.80	96%
9/3/2017	0.10	96%
9/4/2017	0.10	96%
9/5/2017	1.90	96%
9/6/2017	5.70	96%
9/7/2017	1.30	96%
9/8/2017	2.60	88%
9/9/2017	0.20	96%
9/10/2017	0.10	96%
9/11/2017	3.90	96%
9/12/2017	0.20	96%
9/13/2017	0.60	96%
9/14/2017	0.30	96%
9/15/2017	7.30	96%
9/16/2017	2.50	96%
9/17/2017	2.10	96%
9/18/2017	2.00	96%
9/19/2017	11.00	100%
9/20/2017	0.20	100%
9/21/2017	4.30	96%
9/22/2017	1.30	100%
9/23/2017	0.20	96%
9/24/2017	0.20	96%
9/25/2017	5.20	100%
9/26/2017	0.20	96%
9/27/2017	44.70	96%
9/28/2017	0.30	96%
9/29/2017	0.60	96%
9/30/2017	0.10	96%
10/1/2017	0.20	96%
10/2/2017	0.20	88%
10/3/2017	0.10	96%

Riverlodge 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
10/4/2017	0.20	96%
10/5/2017	10.80	96%
10/6/2017	2.80	100%
10/7/2017	1.20	96%
10/8/2017	0.90	96%
10/9/2017	1.70	96%
10/10/2017	0.30	96%
10/11/2017	2.00	96%
10/12/2017	0.30	96%
10/13/2017	14.30	100%
10/14/2017	0.20	96%
10/15/2017	0.30	96%
10/16/2017	0.20	100%
10/17/2017	0.30	100%
10/18/2017	0.20	96%
10/19/2017	0.40	96%
10/20/2017	0.60	100%
10/21/2017	0.40	75%
10/22/2017	0.30	83%
10/23/2017	0.30	96%
10/24/2017	0.20	96%
10/25/2017	4.50	96%
10/26/2017	0.20	96%
10/27/2017	0.20	96%
10/28/2017	0.20	96%
10/29/2017	0.30	96%
10/30/2017	0.30	96%
10/31/2017	3.20	96%
11/1/2017	0.40	88%
11/2/2017	0.30	96%
11/3/2017	0.10	96%
11/4/2017	0.10	96%
11/5/2017	0.10	96%
11/6/2017	0.20	96%
11/7/2017	0.20	100%
11/8/2017	0.20	96%
11/9/2017	0.20	96%
11/10/2017	0.10	96%
11/11/2017	0.20	96%
11/12/2017	0.40	96%
11/13/2017	0.30	96%
11/14/2017	0.10	96%
11/15/2017	0.20	96%
11/16/2017	0.10	96%
11/17/2017	5.00	96%
11/18/2017	0.40	79%

Riverlodge 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
11/19/2017	0.10	96%
11/20/2017	0.20	96%
11/21/2017	0.10	96%
11/22/2017	0.10	96%
11/23/2017	0.10	96%
11/24/2017	0.20	96%
11/25/2017	0.10	96%
11/26/2017	0.10	96%
11/27/2017	0.10	96%
11/28/2017	0.60	96%
11/29/2017	0.10	96%
11/30/2017	0.20	96%
12/1/2017	0.20	83%
12/2/2017	0.00	100%
12/3/2017	0.10	96%
12/4/2017	0.00	96%
12/5/2017	0.00	96%
12/6/2017	0.00	96%
12/7/2017	0.10	96%
12/8/2017	0.30	96%
12/9/2017	0.10	96%
12/10/2017	0.20	96%
12/11/2017	0.20	96%
12/12/2017	0.40	96%
12/13/2017	0.30	96%
12/14/2017	0.30	96%
12/15/2017	0.30	96%
12/16/2017	0.40	96%
12/17/2017	0.40	96%
12/18/2017	0.90	96%
12/19/2017	0.10	96%
12/20/2017	0.20	92%
12/21/2017	1.80	96%
12/22/2017	0.30	96%
12/23/2017	0.10	96%
12/24/2017	0.10	96%
12/25/2017	0.10	96%
12/26/2017	0.10	96%
12/27/2017	0.10	100%
12/28/2017	0.10	96%
12/29/2017	0.10	96%
12/30/2017	0.00	96%
12/31/2017	0.30	96%

Whitesail 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
1/1/2017	0.20	96%
1/2/2017	0.20	96%
1/3/2017	0.20	96%
1/4/2017	0.20	96%
1/5/2017	0.20	96%
1/6/2017	0.30	88%
1/7/2017	0.30	96%
1/8/2017	0.30	96%
1/9/2017	0.30	96%
1/10/2017	0.30	96%
1/11/2017	0.30	96%
1/12/2017	0.30	96%
1/13/2017	0.70	96%
1/14/2017	0.20	96%
1/15/2017	0.30	96%
1/16/2017	2.60	96%
1/17/2017	2.10	96%
1/18/2017	1.70	96%
1/19/2017	0.90	96%
1/20/2017	5.60	96%
1/21/2017	0.30	96%
1/22/2017	0.50	96%
1/23/2017	0.30	96%
1/24/2017	1.90	96%
1/25/2017	0.90	96%
1/26/2017	0.50	96%
1/27/2017	7.80	96%
1/28/2017	0.70	96%
1/29/2017	0.60	96%
1/30/2017	0.40	96%
1/31/2017	0.30	100%
2/1/2017	0.40	96%
2/2/2017	0.40	96%
2/3/2017	0.40	96%
2/4/2017	0.40	96%
2/5/2017	0.60	96%
2/6/2017	0.40	96%
2/7/2017	0.50	96%
2/8/2017	0.40	96%
2/9/2017	0.40	96%
2/10/2017	3.50	88%
2/11/2017	0.20	96%
2/12/2017	0.40	96%
2/13/2017	5.90	96%
2/14/2017	0.60	96%
2/15/2017	0.70	96%

Whitesail 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
2/16/2017	0.30	96%
2/17/2017	7.90	96%
2/18/2017	0.20	96%
2/19/2017	0.20	96%
2/20/2017	0.20	96%
2/21/2017	1.40	96%
2/22/2017	1.40	96%
2/23/2017	8.70	96%
2/24/2017	0.30	96%
2/25/2017	0.50	100%
2/26/2017	0.30	96%
2/27/2017	0.50	96%
2/28/2017	0.70	79%
3/1/2017	0.20	96%
3/2/2017	2.80	88%
3/3/2017	1.40	96%
3/4/2017	0.50	96%
3/5/2017	0.70	96%
3/6/2017	6.20	96%
3/7/2017	0.30	96%
3/8/2017	0.30	96%
3/9/2017	0.40	96%
3/10/2017	0.40	96%
3/11/2017	0.40	96%
3/12/2017	0.50	96%
3/13/2017	2.30	96%
3/14/2017	0.30	96%
3/15/2017	2.40	83%
3/16/2017	1.80	96%
3/17/2017	0.70	96%
3/18/2017	0.30	96%
3/19/2017	2.50	96%
3/20/2017	0.10	96%
3/21/2017	0.20	96%
3/22/2017	4.40	100%
3/23/2017	9.90	75%
3/24/2017	0.30	96%
3/25/2017	0.40	96%
3/26/2017	0.60	96%
3/27/2017	24.90	96%
3/28/2017	2.00	96%
3/29/2017	2.10	96%
3/30/2017	0.20	96%
3/31/2017	0.20	96%
4/1/2017	0.20	96%
4/2/2017	0.20	96%

Whitesail 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
4/3/2017	6.40	96%
4/4/2017	0.50	96%
4/5/2017	0.50	96%
4/6/2017	0.50	88%
4/7/2017	0.40	96%
4/8/2017	0.60	96%
4/9/2017	3.70	96%
4/10/2017	5.90	96%
4/11/2017	5.20	83%
4/12/2017	0.20	96%
4/13/2017	0.30	96%
4/14/2017	0.70	96%
4/15/2017	1.50	96%
4/16/2017	8.70	100%
4/17/2017	0.30	96%
4/18/2017	2.40	96%
4/19/2017	2.00	96%
4/20/2017	7.90	96%
4/21/2017	2.30	96%
4/22/2017	0.30	96%
4/23/2017	2.30	96%
4/24/2017	4.70	96%
4/25/2017	2.90	96%
4/26/2017	0.40	96%
4/27/2017	0.40	96%
4/28/2017	0.40	96%
4/29/2017	0.50	96%
4/30/2017	1.40	96%
5/1/2017	0.20	96%
5/2/2017	4.80	96%
5/3/2017	0.80	96%
5/4/2017	0.30	96%
5/5/2017	8.70	96%
5/6/2017	0.20	96%
5/7/2017	0.40	96%
5/8/2017	0.30	96%
5/9/2017	2.30	96%
5/10/2017	4.10	83%
5/11/2017	0.80	100%
5/12/2017	0.30	96%
5/13/2017	0.30	96%
5/14/2017	0.30	96%
5/15/2017	1.50	96%
5/16/2017	0.80	96%
5/17/2017	2.90	96%
5/18/2017	0.30	96%

Whitesail 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
5/19/2017	2.80	96%
5/20/2017	8.30	96%
5/21/2017	0.40	96%
5/22/2017	0.50	96%
5/23/2017	0.30	96%
5/24/2017	10.90	96%
5/25/2017	1.50	96%
5/26/2017	3.00	96%
5/27/2017	2.40	96%
5/28/2017	6.50	96%
5/29/2017	0.50	96%
5/30/2017	3.50	96%
5/31/2017	16.70	96%
6/1/2017	0.60	96%
6/2/2017	4.20	88%
6/3/2017	0.70	96%
6/4/2017	17.40	96%
6/5/2017	13.80	100%
6/6/2017	3.90	96%
6/7/2017	3.90	96%
6/8/2017	0.50	96%
6/9/2017	0.50	96%
6/10/2017	20.50	96%
6/11/2017	0.50	96%
6/12/2017	0.60	96%
6/13/2017	1.30	96%
6/14/2017	31.50	96%
6/15/2017	0.80	96%
6/16/2017	0.60	96%
6/17/2017	1.00	96%
6/18/2017	1.70	96%
6/19/2017	2.40	96%
6/20/2017	0.50	96%
6/21/2017	0.60	96%
6/22/2017	6.00	96%
6/23/2017	2.20	96%
6/24/2017	7.80	96%
6/25/2017	0.80	96%
6/26/2017	0.60	96%
6/27/2017	1.40	96%
6/28/2017	3.30	96%
6/29/2017	0.70	96%
6/30/2017	11.70	100%
7/1/2017	0.30	96%
7/2/2017	0.20	96%
7/3/2017	0.20	96%

Whitesail 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
7/4/2017	0.30	96%
7/5/2017	12.00	96%
7/6/2017	1.30	88%
7/7/2017	0.60	96%
7/8/2017	0.50	96%
7/9/2017	0.40	96%
7/10/2017	3.50	96%
7/11/2017	10.60	96%
7/12/2017	1.80	96%
7/13/2017	0.40	96%
7/14/2017	2.80	96%
7/15/2017	1.00	96%
7/16/2017	0.30	96%
7/17/2017	14.90	96%
7/18/2017	3.10	96%
7/19/2017	0.60	96%
7/20/2017	0.30	96%
7/21/2017	3.40	96%
7/22/2017	4.80	96%
7/23/2017	0.40	96%
7/24/2017	1.10	96%
7/25/2017	0.50	100%
7/26/2017	0.40	96%
7/27/2017	0.40	96%
7/28/2017	0.40	96%
7/29/2017	0.30	96%
7/30/2017	0.30	96%
7/31/2017	6.50	96%
8/1/2017	5.40	96%
8/2/2017	3.70	96%
8/3/2017	4.40	96%
8/4/2017	4.70	83%
8/5/2017	6.40	96%
8/6/2017	0.70	96%
8/7/2017	12.10	96%
8/8/2017	5.10	96%
8/9/2017	3.80	96%
8/10/2017	21.40	96%
8/11/2017	0.40	96%
8/12/2017	0.60	96%
8/13/2017	0.40	96%
8/14/2017	0.40	96%
8/15/2017	0.30	96%
8/16/2017	0.40	88%
8/17/2017	0.30	96%
8/18/2017	0.40	96%

Whitesail 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
8/19/2017	0.40	100%
8/20/2017	1.50	96%
8/21/2017	0.40	96%
8/22/2017	0.50	96%
8/23/2017	0.70	96%
8/24/2017	0.40	96%
8/25/2017	0.60	96%
8/26/2017	0.60	96%
8/27/2017	0.60	96%
8/28/2017	1.30	96%
8/29/2017	4.80	96%
8/30/2017	0.60	96%
8/31/2017	0.40	96%
9/1/2017	0.20	96%
9/2/2017	5.20	96%
9/3/2017	1.30	96%
9/4/2017	0.20	96%
9/5/2017	5.00	96%
9/6/2017	5.90	96%
9/7/2017	0.70	96%
9/8/2017	0.30	83%
9/9/2017	0.70	96%
9/10/2017	0.60	96%
9/11/2017	0.20	96%
9/12/2017	3.50	96%
9/13/2017	0.20	100%
9/14/2017	2.30	96%
9/15/2017	4.30	96%
9/16/2017	6.10	96%
9/17/2017	6.20	96%
9/18/2017	0.90	96%
9/19/2017	12.70	96%
9/20/2017	0.40	96%
9/21/2017	9.60	96%
9/22/2017	1.10	96%
9/23/2017	0.30	96%
9/24/2017	0.60	96%
9/25/2017	9.60	96%
9/26/2017	0.30	96%
9/27/2017	40.70	96%
9/28/2017	0.70	96%
9/29/2017	0.60	96%
9/30/2017	0.30	96%
10/1/2017	0.10	96%
10/2/2017	0.40	88%
10/3/2017	0.20	96%

Whitesail 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
10/4/2017	0.20	96%
10/5/2017	1.20	96%
10/6/2017	0.40	96%
10/7/2017	0.10	96%
10/8/2017	0.10	100%
10/9/2017	0.10	96%
10/10/2017	0.10	96%
10/11/2017	0.20	96%
10/12/2017	0.20	96%
10/13/2017	1.30	96%
10/14/2017	0.20	96%
10/15/2017	0.30	96%
10/16/2017	0.30	96%
10/17/2017	0.30	96%
10/18/2017	0.20	96%
10/19/2017	0.20	96%
10/20/2017	0.20	96%
10/21/2017	0.20	75%
10/22/2017	0.30	88%
10/23/2017	0.20	96%
10/24/2017	0.30	96%
10/25/2017	0.40	96%
10/26/2017	0.20	96%
10/27/2017	0.20	96%
10/28/2017	0.20	96%
10/29/2017	0.20	96%
10/30/2017	0.20	96%
10/31/2017	0.90	96%
11/1/2017	--	71%
11/2/2017	0.10	88%
11/3/2017	0.10	96%
11/4/2017	0.10	96%
11/5/2017	0.10	96%
11/6/2017	0.20	96%
11/7/2017	0.10	96%
11/8/2017	0.10	96%
11/9/2017	0.10	96%
11/10/2017	0.10	96%
11/11/2017	0.10	96%
11/12/2017	0.20	96%
11/13/2017	0.10	96%
11/14/2017	0.10	96%
11/15/2017	0.10	96%
11/16/2017	0.10	96%
11/17/2017	4.20	96%
11/18/2017	0.50	83%

Whitesail 2017

Date	Daily 1-hr Max Value (ppb)	Daily completeness
11/19/2017	0.20	96%
11/20/2017	0.50	96%
11/21/2017	0.10	96%
11/22/2017	0.90	96%
11/23/2017	1.20	96%
11/24/2017	2.00	96%
11/25/2017	0.60	96%
11/26/2017	0.30	96%
11/27/2017	0.30	100%
11/28/2017	0.80	96%
11/29/2017	0.20	96%
11/30/2017	0.20	96%
12/1/2017	0.20	96%
12/2/2017	0.90	96%
12/3/2017	0.60	96%
12/4/2017	0.60	83%
12/5/2017	1.50	96%
12/6/2017	0.00	96%
12/7/2017	0.00	96%
12/8/2017	0.00	96%
12/9/2017	0.40	96%
12/10/2017	0.60	96%
12/11/2017	0.10	96%
12/12/2017	0.60	96%
12/13/2017	0.30	96%
12/14/2017	0.20	96%
12/15/2017	0.00	96%
12/16/2017	0.10	96%
12/17/2017	0.00	96%
12/18/2017	0.90	96%
12/19/2017	0.30	96%
12/20/2017	0.20	96%
12/21/2017	4.80	96%
12/22/2017	0.10	100%
12/23/2017	0.10	96%
12/24/2017	0.10	96%
12/25/2017	0.10	96%
12/26/2017	0.10	96%
12/27/2017	0.10	96%
12/28/2017	0.10	96%
12/29/2017	0.10	96%
12/30/2017	0.10	96%
12/31/2017	0.40	96%

Haisla Village 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
1/1/2018	0.50	96%
1/2/2018	0.00	96%
1/3/2018	0.00	96%
1/4/2018	0.10	96%
1/5/2018	0.20	79%
1/6/2018	0.00	96%
1/7/2018	0.30	96%
1/8/2018	0.20	96%
1/9/2018	0.00	96%
1/10/2018	0.10	96%
1/11/2018	0.10	96%
1/12/2018	0.10	96%
1/13/2018	0.10	96%
1/14/2018	0.10	96%
1/15/2018	0.20	96%
1/16/2018	0.40	96%
1/17/2018	0.60	96%
1/18/2018	0.10	96%
1/19/2018	0.10	96%
1/20/2018	0.10	96%
1/21/2018	0.10	96%
1/22/2018	0.10	96%
1/23/2018	0.20	96%
1/24/2018	0.10	100%
1/25/2018	0.10	96%
1/26/2018	0.10	96%
1/27/2018	0.10	96%
1/28/2018	0.10	96%
1/29/2018	0.10	96%
1/30/2018	0.40	96%
1/31/2018	0.30	96%
2/1/2018	0.60	96%
2/2/2018	0.10	96%
2/3/2018	0.40	96%
2/4/2018	0.10	96%
2/5/2018	0.20	88%
2/6/2018	0.10	96%
2/7/2018	0.10	96%
2/8/2018	0.10	96%
2/9/2018	0.30	96%
2/10/2018	1.90	96%
2/11/2018	0.10	96%
2/12/2018	2.60	96%
2/13/2018	0.10	96%
2/14/2018	0.10	96%
2/15/2018	0.40	96%

Haisla Village 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
2/16/2018	1.20	96%
2/17/2018	0.10	96%
2/18/2018	0.60	100%
2/19/2018	0.10	96%
2/20/2018	0.10	96%
2/21/2018	0.70	96%
2/22/2018	3.60	96%
2/23/2018	0.00	96%
2/24/2018	0.10	96%
2/25/2018	0.30	96%
2/26/2018	0.10	92%
2/27/2018	0.10	96%
2/28/2018	0.30	96%
3/1/2018	0.10	96%
3/2/2018	0.10	83%
3/3/2018	0.10	96%
3/4/2018	0.40	96%
3/5/2018	6.10	96%
3/6/2018	5.00	96%
3/7/2018	0.40	96%
3/8/2018	0.60	96%
3/9/2018	0.10	96%
3/10/2018	0.10	96%
3/11/2018	0.10	96%
3/12/2018	0.10	96%
3/13/2018	0.30	96%
3/14/2018	1.90	96%
3/15/2018	30.70	100%
3/16/2018	2.30	96%
3/17/2018	0.20	96%
3/18/2018	8.40	96%
3/19/2018	0.10	96%
3/20/2018	0.10	96%
3/21/2018	22.30	96%
3/22/2018	0.30	96%
3/23/2018	23.20	96%
3/24/2018	0.10	96%
3/25/2018	0.10	96%
3/26/2018	0.10	96%
3/27/2018	0.10	96%
3/28/2018	0.10	83%
3/29/2018	0.20	96%
3/30/2018	1.70	96%
3/31/2018	0.10	96%
4/1/2018	0.50	96%
4/2/2018	2.00	96%

Haisla Village 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
4/3/2018	0.70	96%
4/4/2018	0.20	96%
4/5/2018	0.10	96%
4/6/2018	0.20	96%
4/7/2018	0.10	96%
4/8/2018	4.60	96%
4/9/2018	0.10	100%
4/10/2018	0.10	96%
4/11/2018	0.40	96%
4/12/2018	0.10	96%
4/13/2018	3.00	96%
4/14/2018	0.20	96%
4/15/2018	1.10	96%
4/16/2018	0.60	96%
4/17/2018	0.20	96%
4/18/2018	0.10	96%
4/19/2018	0.10	96%
4/20/2018	0.20	96%
4/21/2018	0.20	96%
4/22/2018	0.10	96%
4/23/2018	0.20	96%
4/24/2018	0.50	96%
4/25/2018	3.50	96%
4/26/2018	0.20	83%
4/27/2018	5.40	96%
4/28/2018	3.90	96%
4/29/2018	1.80	96%
4/30/2018	0.30	96%
5/1/2018	8.20	96%
5/2/2018	0.50	96%
5/3/2018	3.40	96%
5/4/2018	0.10	100%
5/5/2018	18.30	96%
5/6/2018	0.50	96%
5/7/2018	1.40	96%
5/8/2018	3.20	96%
5/9/2018	3.10	96%
5/10/2018	--	67%
5/11/2018	0.80	96%
5/12/2018	1.30	96%
5/13/2018	2.40	96%
5/14/2018	4.60	96%
5/15/2018	5.60	96%
5/16/2018	1.00	96%
5/17/2018	3.60	96%
5/18/2018	3.40	96%

Haisla Village 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
5/19/2018	0.10	96%
5/20/2018	0.10	96%
5/21/2018	0.00	96%
5/22/2018	0.10	96%
5/23/2018	10.70	96%
5/24/2018	0.10	96%
5/25/2018	0.10	96%
5/26/2018	0.10	96%
5/27/2018	0.10	96%
5/28/2018	0.10	96%
5/29/2018	0.10	100%
5/30/2018	0.10	79%
5/31/2018	3.60	96%
6/1/2018	2.50	96%
6/2/2018	0.10	96%
6/3/2018	0.20	96%
6/4/2018	0.10	96%
6/5/2018	1.00	96%
6/6/2018	0.10	96%
6/7/2018	0.10	96%
6/8/2018	0.70	96%
6/9/2018	0.10	96%
6/10/2018	0.10	96%
6/11/2018	0.10	96%
6/12/2018	6.60	96%
6/13/2018	0.20	96%
6/14/2018	0.10	96%
6/15/2018	1.50	96%
6/16/2018	2.40	92%
6/17/2018	5.10	96%
6/18/2018	2.80	96%
6/19/2018	2.90	96%
6/20/2018	0.10	96%
6/21/2018	0.70	96%
6/22/2018	0.10	79%
6/23/2018	0.10	100%
6/24/2018	2.80	96%
6/25/2018	0.10	96%
6/26/2018	0.10	96%
6/27/2018	0.10	96%
6/28/2018	0.10	96%
6/29/2018	0.10	96%
6/30/2018	0.10	96%
7/1/2018	0.10	96%
7/2/2018	0.10	96%
7/3/2018	1.90	96%

Haisla Village 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
7/4/2018	3.60	96%
7/5/2018	0.60	96%
7/6/2018	0.10	96%
7/7/2018	0.10	96%
7/8/2018	0.80	96%
7/9/2018	0.30	96%
7/10/2018	0.10	96%
7/11/2018	0.20	96%
7/12/2018	0.10	96%
7/13/2018	2.10	96%
7/14/2018	7.90	96%
7/15/2018	0.10	96%
7/16/2018	0.10	96%
7/17/2018	0.60	96%
7/18/2018	0.10	100%
7/19/2018	0.10	96%
7/20/2018	0.10	96%
7/21/2018	5.10	96%
7/22/2018	0.10	96%
7/23/2018	1.50	96%
7/24/2018	1.60	96%
7/25/2018	3.70	96%
7/26/2018	5.60	96%
7/27/2018	4.90	75%
7/28/2018	1.80	96%
7/29/2018	10.60	96%
7/30/2018	2.60	96%
7/31/2018	5.40	96%
8/1/2018	0.10	96%
8/2/2018	0.10	96%
8/3/2018	0.10	96%
8/4/2018	0.10	96%
8/5/2018	4.00	96%
8/6/2018	0.20	96%
8/7/2018	0.10	96%
8/8/2018	0.10	96%
8/9/2018	0.10	96%
8/10/2018	0.40	96%
8/11/2018	2.50	96%
8/12/2018	0.20	100%
8/13/2018	1.70	96%
8/14/2018	0.10	96%
8/15/2018	3.20	96%
8/16/2018	0.10	96%
8/17/2018	0.10	96%
8/18/2018	4.40	96%

Haisla Village 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
8/19/2018	2.20	96%
8/20/2018	1.30	96%
8/21/2018	2.20	96%
8/22/2018	0.20	96%
8/23/2018	0.10	96%
8/24/2018	0.10	96%
8/25/2018	0.10	96%
8/26/2018	2.10	96%
8/27/2018	1.10	96%
8/28/2018	0.10	96%
8/29/2018	0.10	96%
8/30/2018	0.10	96%
8/31/2018	0.10	79%
9/1/2018	0.10	96%
9/2/2018	0.10	96%
9/3/2018	0.20	96%
9/4/2018	10.40	96%
9/5/2018	1.10	96%
9/6/2018	8.60	100%
9/7/2018	0.70	96%
9/8/2018	2.90	96%
9/9/2018	0.80	96%
9/10/2018	0.30	96%
9/11/2018	5.40	96%
9/12/2018	4.10	88%
9/13/2018	1.30	96%
9/14/2018	0.10	96%
9/15/2018	0.10	96%
9/16/2018	0.10	96%
9/17/2018	0.20	96%
9/18/2018	2.50	96%
9/19/2018	4.00	96%
9/20/2018	0.70	96%
9/21/2018	0.50	75%
9/22/2018	0.20	96%
9/23/2018	0.10	96%
9/24/2018	0.10	96%
9/25/2018	0.20	96%
9/26/2018	0.10	96%
9/27/2018	1.90	96%
9/28/2018	0.10	96%
9/29/2018	0.20	96%
9/30/2018	0.10	96%
10/1/2018	0.10	100%
10/2/2018	0.10	96%
10/3/2018	10.00	96%

Haisla Village 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
10/4/2018	13.40	96%
10/5/2018	2.80	96%
10/6/2018	0.10	96%
10/7/2018	0.30	96%
10/8/2018	1.00	96%
10/9/2018	0.10	96%
10/10/2018	0.10	96%
10/11/2018	0.40	96%
10/12/2018	0.70	96%
10/13/2018	0.10	96%
10/14/2018	0.40	96%
10/15/2018	3.10	96%
10/16/2018	0.40	96%
10/17/2018	0.10	96%
10/18/2018	0.60	96%
10/19/2018	0.60	96%
10/20/2018	0.20	96%
10/21/2018	0.10	96%
10/22/2018	0.10	96%
10/23/2018	1.10	96%
10/24/2018	2.70	96%
10/25/2018	0.10	83%
10/26/2018	0.00	100%
10/27/2018	0.10	96%
10/28/2018	0.50	96%
10/29/2018	0.10	96%
10/30/2018	0.40	96%
10/31/2018	0.30	79%
11/1/2018	0.20	96%
11/2/2018	0.30	96%
11/3/2018	0.10	96%
11/4/2018	0.00	96%
11/5/2018	0.10	96%
11/6/2018	0.30	96%
11/7/2018	0.00	96%
11/8/2018	8.90	96%
11/9/2018	0.10	96%
11/10/2018	10.30	96%
11/11/2018	0.10	96%
11/12/2018	0.00	96%
11/13/2018	2.20	96%
11/14/2018	0.30	96%
11/15/2018	0.70	96%
11/16/2018	0.00	75%
11/17/2018	2.40	96%
11/18/2018	2.60	96%

Haisla Village 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
11/19/2018	1.00	96%
11/20/2018	0.60	100%
11/21/2018	0.40	96%
11/22/2018	0.10	96%
11/23/2018	0.20	96%
11/24/2018	0.10	96%
11/25/2018	0.60	96%
11/26/2018	0.10	96%
11/27/2018	0.40	96%
11/28/2018	0.40	96%
11/29/2018	0.80	96%
11/30/2018	0.20	96%
12/1/2018	0.10	96%
12/2/2018	0.20	96%
12/3/2018	0.10	96%
12/4/2018	0.10	96%
12/5/2018	0.10	96%
12/6/2018	0.30	96%
12/7/2018	0.10	96%
12/8/2018	0.10	96%
12/9/2018	0.10	96%
12/10/2018	0.10	96%
12/11/2018	0.10	96%
12/12/2018	0.20	96%
12/13/2018	0.20	96%
12/14/2018	0.20	96%
12/15/2018	0.20	100%
12/16/2018	0.10	96%
12/17/2018	0.80	96%
12/18/2018	0.90	96%
12/19/2018	--	50%
12/20/2018	0.40	96%
12/21/2018	0.90	96%
12/22/2018	0.00	96%
12/23/2018	0.30	96%
12/24/2018	0.20	96%
12/25/2018	0.50	96%
12/26/2018	0.10	96%
12/27/2018	0.30	96%
12/28/2018	2.40	96%
12/29/2018	8.20	96%
12/30/2018	0.50	96%
12/31/2018	0.60	96%

Riverlodge 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
1/1/2018	0.10	96%
1/2/2018	0.10	96%
1/3/2018	0.10	88%
1/4/2018	0.10	96%
1/5/2018	0.20	96%
1/6/2018	0.90	96%
1/7/2018	0.10	96%
1/8/2018	0.10	96%
1/9/2018	0.10	96%
1/10/2018	0.10	96%
1/11/2018	0.10	96%
1/12/2018	0.00	96%
1/13/2018	0.10	96%
1/14/2018	0.00	96%
1/15/2018	0.10	96%
1/16/2018	0.20	96%
1/17/2018	0.10	96%
1/18/2018	0.30	96%
1/19/2018	0.00	96%
1/20/2018	0.20	96%
1/21/2018	0.10	100%
1/22/2018	0.20	96%
1/23/2018	0.30	96%
1/24/2018	0.30	96%
1/25/2018	0.10	96%
1/26/2018	0.10	96%
1/27/2018	0.10	96%
1/28/2018	0.10	96%
1/29/2018	0.10	96%
1/30/2018	0.20	96%
1/31/2018	0.30	96%
2/1/2018	0.10	96%
2/2/2018	0.30	96%
2/3/2018	0.40	96%
2/4/2018	0.40	96%
2/5/2018	0.10	96%
2/6/2018	0.20	96%
2/7/2018	0.20	88%
2/8/2018	0.20	96%
2/9/2018	0.10	96%
2/10/2018	8.20	96%
2/11/2018	0.20	96%
2/12/2018	3.90	96%
2/13/2018	1.00	96%
2/14/2018	0.40	96%
2/15/2018	1.10	75%

Riverlodge 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
2/16/2018	--	54%
2/17/2018	0.20	96%
2/18/2018	0.10	96%
2/19/2018	0.10	96%
2/20/2018	0.20	92%
2/21/2018	4.30	96%
2/22/2018	6.90	96%
2/23/2018	0.60	96%
2/24/2018	0.90	96%
2/25/2018	8.20	96%
2/26/2018	5.50	96%
2/27/2018	10.80	96%
2/28/2018	0.30	96%
3/1/2018	0.20	96%
3/2/2018	0.20	96%
3/3/2018	0.10	96%
3/4/2018	0.20	96%
3/5/2018	2.50	83%
3/6/2018	9.20	96%
3/7/2018	0.50	96%
3/8/2018	3.40	96%
3/9/2018	1.80	96%
3/10/2018	3.90	96%
3/11/2018	0.50	96%
3/12/2018	0.40	100%
3/13/2018	0.40	96%
3/14/2018	2.50	96%
3/15/2018	28.50	96%
3/16/2018	0.30	96%
3/17/2018	0.50	96%
3/18/2018	12.10	96%
3/19/2018	1.60	96%
3/20/2018	1.40	96%
3/21/2018	0.40	96%
3/22/2018	0.40	96%
3/23/2018	6.80	96%
3/24/2018	9.60	100%
3/25/2018	0.20	96%
3/26/2018	0.10	96%
3/27/2018	7.70	96%
3/28/2018	2.40	88%
3/29/2018	0.20	96%
3/30/2018	4.60	96%
3/31/2018	0.10	96%
4/1/2018	0.20	96%
4/2/2018	10.50	96%

Riverlodge 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
4/3/2018	2.00	96%
4/4/2018	0.20	96%
4/5/2018	0.10	96%
4/6/2018	0.20	100%
4/7/2018	0.20	96%
4/8/2018	11.30	96%
4/9/2018	1.20	96%
4/10/2018	6.50	96%
4/11/2018	4.40	96%
4/12/2018	3.00	96%
4/13/2018	6.30	96%
4/14/2018	1.00	96%
4/15/2018	0.20	96%
4/16/2018	1.50	96%
4/17/2018	0.50	96%
4/18/2018	4.10	96%
4/19/2018	0.50	96%
4/20/2018	0.60	96%
4/21/2018	1.10	96%
4/22/2018	6.20	96%
4/23/2018	1.40	96%
4/24/2018	0.40	96%
4/25/2018	0.10	83%
4/26/2018	28.30	96%
4/27/2018	7.50	96%
4/28/2018	0.80	96%
4/29/2018	4.80	96%
4/30/2018	1.00	92%
5/1/2018	17.60	100%
5/2/2018	0.40	96%
5/3/2018	5.70	96%
5/4/2018	0.20	96%
5/5/2018	19.50	96%
5/6/2018	1.80	96%
5/7/2018	3.20	96%
5/8/2018	8.60	96%
5/9/2018	3.10	96%
5/10/2018	6.90	96%
5/11/2018	11.70	96%
5/12/2018	1.30	96%
5/13/2018	2.60	96%
5/14/2018	19.20	96%
5/15/2018	9.20	96%
5/16/2018	15.80	96%
5/17/2018	3.50	96%
5/18/2018	7.80	96%

Riverlodge 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
5/19/2018	26.80	96%
5/20/2018	0.10	96%
5/21/2018	0.20	96%
5/22/2018	0.20	96%
5/23/2018	8.70	96%
5/24/2018	1.70	96%
5/25/2018	2.60	96%
5/26/2018	3.20	100%
5/27/2018	0.20	96%
5/28/2018	2.20	96%
5/29/2018	0.30	96%
5/30/2018	1.20	75%
5/31/2018	5.20	96%
6/1/2018	0.60	96%
6/2/2018	0.30	96%
6/3/2018	5.00	96%
6/4/2018	1.90	96%
6/5/2018	1.40	96%
6/6/2018	1.70	96%
6/7/2018	24.70	96%
6/8/2018	12.10	96%
6/9/2018	0.50	96%
6/10/2018	0.30	96%
6/11/2018	0.20	96%
6/12/2018	29.40	96%
6/13/2018	13.00	96%
6/14/2018	2.10	96%
6/15/2018	7.50	96%
6/16/2018	9.60	92%
6/17/2018	7.70	96%
6/18/2018	4.20	96%
6/19/2018	4.50	96%
6/20/2018	29.20	100%
6/21/2018	1.00	79%
6/22/2018	0.10	96%
6/23/2018	0.60	96%
6/24/2018	10.60	96%
6/25/2018	11.50	96%
6/26/2018	12.70	96%
6/27/2018	4.30	96%
6/28/2018	1.50	96%
6/29/2018	0.20	96%
6/30/2018	1.70	96%
7/1/2018	1.40	96%
7/2/2018	13.50	96%
7/3/2018	0.40	96%

Riverlodge 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
7/4/2018	0.10	96%
7/5/2018	7.70	96%
7/6/2018	0.40	96%
7/7/2018	0.20	96%
7/8/2018	6.80	96%
7/9/2018	5.30	96%
7/10/2018	0.40	96%
7/11/2018	0.20	96%
7/12/2018	19.70	96%
7/13/2018	9.30	96%
7/14/2018	6.40	96%
7/15/2018	1.00	100%
7/16/2018	1.80	96%
7/17/2018	16.40	96%
7/18/2018	0.10	96%
7/19/2018	0.30	96%
7/20/2018	0.30	96%
7/21/2018	8.90	96%
7/22/2018	4.70	96%
7/23/2018	0.30	96%
7/24/2018	3.20	96%
7/25/2018	4.70	83%
7/26/2018	8.60	96%
7/27/2018	7.30	96%
7/28/2018	3.40	96%
7/29/2018	23.10	96%
7/30/2018	6.30	96%
7/31/2018	8.80	100%
8/1/2018	0.40	96%
8/2/2018	0.50	96%
8/3/2018	0.10	96%
8/4/2018	0.40	96%
8/5/2018	5.10	96%
8/6/2018	7.50	96%
8/7/2018	14.30	96%
8/8/2018	0.20	96%
8/9/2018	0.20	100%
8/10/2018	6.90	96%
8/11/2018	3.20	96%
8/12/2018	0.30	96%
8/13/2018	12.10	96%
8/14/2018	0.40	96%
8/15/2018	4.20	96%
8/16/2018	1.00	96%
8/17/2018	0.20	96%
8/18/2018	10.20	96%

Riverlodge 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
8/19/2018	0.50	96%
8/20/2018	0.10	96%
8/21/2018	2.30	96%
8/22/2018	5.40	96%
8/23/2018	1.50	96%
8/24/2018	1.90	96%
8/25/2018	0.30	96%
8/26/2018	4.00	96%
8/27/2018	7.40	96%
8/28/2018	7.20	96%
8/29/2018	2.10	96%
8/30/2018	1.50	79%
8/31/2018	7.70	96%
9/1/2018	2.80	96%
9/2/2018	10.70	96%
9/3/2018	2.80	100%
9/4/2018	11.50	96%
9/5/2018	0.90	96%
9/6/2018	7.70	96%
9/7/2018	0.40	96%
9/8/2018	0.80	96%
9/9/2018	0.50	96%
9/10/2018	0.30	96%
9/11/2018	5.60	88%
9/12/2018	4.40	96%
9/13/2018	0.10	96%
9/14/2018	0.10	96%
9/15/2018	0.10	96%
9/16/2018	0.00	96%
9/17/2018	1.90	96%
9/18/2018	4.60	96%
9/19/2018	7.00	96%
9/20/2018	0.80	96%
9/21/2018	0.10	96%
9/22/2018	0.10	96%
9/23/2018	0.20	96%
9/24/2018	0.20	96%
9/25/2018	30.10	96%
9/26/2018	0.20	96%
9/27/2018	1.20	83%
9/28/2018	0.30	100%
9/29/2018	0.10	96%
9/30/2018	0.20	96%
10/1/2018	0.20	96%
10/2/2018	0.20	96%
10/3/2018	35.10	96%

Riverlodge 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
10/4/2018	10.10	96%
10/5/2018	7.20	96%
10/6/2018	0.40	96%
10/7/2018	0.30	96%
10/8/2018	0.40	96%
10/9/2018	0.30	96%
10/10/2018	0.20	96%
10/11/2018	3.40	96%
10/12/2018	1.60	96%
10/13/2018	0.30	96%
10/14/2018	1.40	96%
10/15/2018	5.70	96%
10/16/2018	0.30	96%
10/17/2018	1.50	96%
10/18/2018	0.50	96%
10/19/2018	0.70	96%
10/20/2018	0.30	96%
10/21/2018	0.30	96%
10/22/2018	0.10	96%
10/23/2018	0.40	100%
10/24/2018	2.70	96%
10/25/2018	0.20	79%
10/26/2018	0.50	96%
10/27/2018	0.10	96%
10/28/2018	0.10	96%
10/29/2018	0.20	96%
10/30/2018	0.10	96%
10/31/2018	1.30	96%
11/1/2018	0.10	96%
11/2/2018	0.30	96%
11/3/2018	0.20	96%
11/4/2018	3.30	96%
11/5/2018	0.40	96%
11/6/2018	0.30	96%
11/7/2018	0.20	96%
11/8/2018	0.30	96%
11/9/2018	0.40	96%
11/10/2018	8.20	96%
11/11/2018	0.20	96%
11/12/2018	0.10	96%
11/13/2018	0.20	96%
11/14/2018	2.00	96%
11/15/2018	0.10	75%
11/16/2018	0.10	96%
11/17/2018	0.80	100%
11/18/2018	5.30	96%

Riverlodge 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
11/19/2018	1.20	96%
11/20/2018	0.10	96%
11/21/2018	1.90	96%
11/22/2018	0.30	96%
11/23/2018	0.20	96%
11/24/2018	0.10	96%
11/25/2018	0.10	96%
11/26/2018	0.20	96%
11/27/2018	0.20	96%
11/28/2018	0.10	96%
11/29/2018	0.20	96%
11/30/2018	0.10	96%
12/1/2018	0.10	96%
12/2/2018	0.20	96%
12/3/2018	0.30	96%
12/4/2018	0.30	96%
12/5/2018	0.20	96%
12/6/2018	0.40	75%
12/7/2018	0.20	96%
12/8/2018	0.10	96%
12/9/2018	0.10	96%
12/10/2018	0.20	96%
12/11/2018	2.00	96%
12/12/2018	20.50	100%
12/13/2018	3.50	96%
12/14/2018	0.60	96%
12/15/2018	0.30	96%
12/16/2018	0.20	96%
12/17/2018	0.20	96%
12/18/2018	0.10	96%
12/19/2018	0.10	96%
12/20/2018	5.60	96%
12/21/2018	3.30	96%
12/22/2018	0.30	96%
12/23/2018	0.30	96%
12/24/2018	0.20	96%
12/25/2018	0.30	96%
12/26/2018	0.20	96%
12/27/2018	0.20	96%
12/28/2018	0.30	96%
12/29/2018	11.10	96%
12/30/2018	0.30	96%
12/31/2018	0.70	96%

Whitesail 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
1/1/2018	0.10	96%
1/2/2018	0.10	96%
1/3/2018	0.10	96%
1/4/2018	0.00	88%
1/5/2018	0.30	96%
1/6/2018	0.00	96%
1/7/2018	0.60	96%
1/8/2018	0.20	96%
1/9/2018	0.20	96%
1/10/2018	0.10	96%
1/11/2018	0.00	96%
1/12/2018	0.10	96%
1/13/2018	0.10	96%
1/14/2018	0.00	96%
1/15/2018	0.00	96%
1/16/2018	0.40	100%
1/17/2018	0.70	96%
1/18/2018	0.10	96%
1/19/2018	0.10	96%
1/20/2018	0.10	96%
1/21/2018	1.20	96%
1/22/2018	0.20	96%
1/23/2018	0.30	96%
1/24/2018	0.10	96%
1/25/2018	0.10	96%
1/26/2018	0.20	96%
1/27/2018	0.10	96%
1/28/2018	0.20	96%
1/29/2018	0.10	96%
1/30/2018	0.40	96%
1/31/2018	1.40	96%
2/1/2018	0.30	96%
2/2/2018	0.80	96%
2/3/2018	0.20	96%
2/4/2018	0.20	96%
2/5/2018	0.10	96%
2/6/2018	0.10	96%
2/7/2018	0.10	96%
2/8/2018	0.20	83%
2/9/2018	0.10	96%
2/10/2018	2.40	100%
2/11/2018	0.30	96%
2/12/2018	3.50	96%
2/13/2018	0.20	96%
2/14/2018	0.70	96%
2/15/2018	1.10	96%

Whitesail 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
2/16/2018	0.50	96%
2/17/2018	0.20	96%
2/18/2018	0.20	96%
2/19/2018	0.10	96%
2/20/2018	0.10	96%
2/21/2018	2.90	96%
2/22/2018	6.10	96%
2/23/2018	0.10	96%
2/24/2018	0.10	96%
2/25/2018	0.10	96%
2/26/2018	0.10	96%
2/27/2018	0.80	96%
2/28/2018	0.40	96%
3/1/2018	0.20	96%
3/2/2018	0.20	88%
3/3/2018	0.20	96%
3/4/2018	0.20	96%
3/5/2018	8.30	96%
3/6/2018	6.00	96%
3/7/2018	0.40	100%
3/8/2018	2.30	96%
3/9/2018	2.40	96%
3/10/2018	2.40	96%
3/11/2018	0.20	96%
3/12/2018	0.20	96%
3/13/2018	0.50	96%
3/14/2018	1.80	96%
3/15/2018	19.80	96%
3/16/2018	1.20	96%
3/17/2018	0.10	96%
3/18/2018	6.80	96%
3/19/2018	0.20	96%
3/20/2018	0.10	96%
3/21/2018	0.20	96%
3/22/2018	0.20	96%
3/23/2018	5.10	96%
3/24/2018	0.50	96%
3/25/2018	0.10	96%
3/26/2018	0.10	96%
3/27/2018	0.10	96%
3/28/2018	0.10	88%
3/29/2018	0.20	96%
3/30/2018	6.80	96%
3/31/2018	0.10	96%
4/1/2018	0.10	100%
4/2/2018	9.30	96%

Whitesail 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
4/3/2018	1.30	96%
4/4/2018	0.10	96%
4/5/2018	0.10	96%
4/6/2018	0.10	96%
4/7/2018	0.10	96%
4/8/2018	11.80	96%
4/9/2018	0.50	96%
4/10/2018	3.30	96%
4/11/2018	3.50	96%
4/12/2018	1.50	96%
4/13/2018	2.70	96%
4/14/2018	0.30	96%
4/15/2018	0.10	96%
4/16/2018	1.50	96%
4/17/2018	0.10	96%
4/18/2018	0.10	96%
4/19/2018	0.10	96%
4/20/2018	0.30	96%
4/21/2018	0.40	96%
4/22/2018	0.80	96%
4/23/2018	0.70	96%
4/24/2018	0.40	96%
4/25/2018	0.10	75%
4/26/2018	11.50	100%
4/27/2018	4.60	96%
4/28/2018	0.90	96%
4/29/2018	3.10	96%
4/30/2018	1.10	96%
5/1/2018	7.10	96%
5/2/2018	1.10	96%
5/3/2018	3.90	96%
5/4/2018	1.30	96%
5/5/2018	9.90	96%
5/6/2018	2.20	96%
5/7/2018	3.40	96%
5/8/2018	7.10	96%
5/9/2018	3.00	96%
5/10/2018	9.30	96%
5/11/2018	4.60	96%
5/12/2018	2.00	96%
5/13/2018	1.80	96%
5/14/2018	22.20	96%
5/15/2018	8.80	96%
5/16/2018	14.20	96%
5/17/2018	7.60	96%
5/18/2018	6.90	92%

Whitesail 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
5/19/2018	13.70	96%
5/20/2018	0.10	96%
5/21/2018	0.10	100%
5/22/2018	0.70	96%
5/23/2018	8.40	96%
5/24/2018	0.10	96%
5/25/2018	3.60	96%
5/26/2018	0.60	96%
5/27/2018	0.10	96%
5/28/2018	0.30	79%
5/29/2018	1.50	96%
5/30/2018	3.60	96%
5/31/2018	7.90	96%
6/1/2018	1.90	96%
6/2/2018	0.70	96%
6/3/2018	6.70	96%
6/4/2018	2.90	96%
6/5/2018	1.10	100%
6/6/2018	1.90	96%
6/7/2018	15.50	96%
6/8/2018	19.40	96%
6/9/2018	0.70	96%
6/10/2018	0.90	96%
6/11/2018	0.10	96%
6/12/2018	18.60	96%
6/13/2018	5.10	96%
6/14/2018	0.10	96%
6/15/2018	5.10	100%
6/16/2018	3.70	96%
6/17/2018	4.60	96%
6/18/2018	3.70	96%
6/19/2018	4.90	96%
6/20/2018	15.60	96%
6/21/2018	0.20	75%
6/22/2018	0.10	96%
6/23/2018	0.40	96%
6/24/2018	10.70	96%
6/25/2018	0.10	96%
6/26/2018	0.20	96%
6/27/2018	0.10	96%
6/28/2018	4.30	96%
6/29/2018	0.10	96%
6/30/2018	0.10	96%
7/1/2018	0.10	96%
7/2/2018	7.10	96%
7/3/2018	0.20	96%

Whitesail 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
7/4/2018	0.00	96%
7/5/2018	1.30	96%
7/6/2018	0.00	96%
7/7/2018	0.00	96%
7/8/2018	8.70	96%
7/9/2018	10.60	96%
7/10/2018	0.10	100%
7/11/2018	0.10	96%
7/12/2018	23.70	96%
7/13/2018	9.20	96%
7/14/2018	3.20	96%
7/15/2018	0.20	96%
7/16/2018	0.10	96%
7/17/2018	5.40	96%
7/18/2018	0.10	75%
7/19/2018	0.00	96%
7/20/2018	0.00	96%
7/21/2018	5.60	96%
7/22/2018	3.20	96%
7/23/2018	0.10	96%
7/24/2018	3.50	96%
7/25/2018	2.80	96%
7/26/2018	4.40	96%
7/27/2018	7.20	96%
7/28/2018	4.60	96%
7/29/2018	16.00	96%
7/30/2018	4.90	96%
7/31/2018	6.80	96%
8/1/2018	0.10	96%
8/2/2018	0.00	96%
8/3/2018	0.10	96%
8/4/2018	0.70	100%
8/5/2018	4.90	96%
8/6/2018	0.60	96%
8/7/2018	2.30	96%
8/8/2018	0.10	96%
8/9/2018	0.10	96%
8/10/2018	6.60	96%
8/11/2018	2.70	96%
8/12/2018	0.10	96%
8/13/2018	9.60	96%
8/14/2018	0.20	96%
8/15/2018	4.20	96%
8/16/2018	0.90	96%
8/17/2018	0.20	96%
8/18/2018	7.90	96%

Whitesail 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
8/19/2018	0.40	96%
8/20/2018	2.20	96%
8/21/2018	9.50	96%
8/22/2018	0.30	96%
8/23/2018	0.20	96%
8/24/2018	0.20	96%
8/25/2018	0.50	96%
8/26/2018	3.20	96%
8/27/2018	11.50	96%
8/28/2018	0.20	96%
8/29/2018	9.50	100%
8/30/2018	0.20	79%
8/31/2018	0.70	96%
9/1/2018	0.10	96%
9/2/2018	0.10	96%
9/3/2018	20.00	96%
9/4/2018	7.40	96%
9/5/2018	0.50	96%
9/6/2018	6.60	96%
9/7/2018	1.90	96%
9/8/2018	3.20	96%
9/9/2018	0.60	96%
9/10/2018	0.10	96%
9/11/2018	6.40	96%
9/12/2018	4.70	88%
9/13/2018	0.50	96%
9/14/2018	0.00	96%
9/15/2018	0.10	96%
9/16/2018	0.00	96%
9/17/2018	0.40	96%
9/18/2018	3.20	96%
9/19/2018	7.70	96%
9/20/2018	0.50	96%
9/21/2018	0.00	96%
9/22/2018	0.50	96%
9/23/2018	0.20	100%
9/24/2018	0.10	96%
9/25/2018	23.20	96%
9/26/2018	0.10	79%
9/27/2018	1.30	96%
9/28/2018	0.10	96%
9/29/2018	0.10	96%
9/30/2018	0.00	96%
10/1/2018	0.10	96%
10/2/2018	0.10	96%
10/3/2018	10.20	96%

Whitesail 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
10/4/2018	3.50	96%
10/5/2018	2.90	96%
10/6/2018	0.40	96%
10/7/2018	0.70	96%
10/8/2018	0.90	96%
10/9/2018	0.00	96%
10/10/2018	0.10	96%
10/11/2018	0.90	83%
10/12/2018	0.90	96%
10/13/2018	0.10	96%
10/14/2018	0.70	96%
10/15/2018	4.20	96%
10/16/2018	0.50	96%
10/17/2018	3.30	96%
10/18/2018	0.60	100%
10/19/2018	0.70	96%
10/20/2018	0.10	96%
10/21/2018	0.00	96%
10/22/2018	0.00	96%
10/23/2018	1.80	96%
10/24/2018	5.10	96%
10/25/2018	0.10	96%
10/26/2018	0.10	96%
10/27/2018	0.10	96%
10/28/2018	1.20	96%
10/29/2018	1.30	96%
10/30/2018	0.40	96%
10/31/2018	1.50	96%
11/1/2018	0.10	96%
11/2/2018	0.40	96%
11/3/2018	0.10	96%
11/4/2018	0.00	96%
11/5/2018	0.20	96%
11/6/2018	0.10	96%
11/7/2018	0.10	96%
11/8/2018	4.60	96%
11/9/2018	0.60	79%
11/10/2018	12.40	96%
11/11/2018	0.10	96%
11/12/2018	0.10	100%
11/13/2018	1.00	96%
11/14/2018	0.70	96%
11/15/2018	2.40	96%
11/16/2018	0.10	96%
11/17/2018	1.00	96%
11/18/2018	4.90	96%

Whitesail 2018

Date	Daily 1-hr Max Value (ppb)	Daily completeness
11/19/2018	0.50	96%
11/20/2018	0.30	96%
11/21/2018	0.40	96%
11/22/2018	0.20	96%
11/23/2018	0.80	96%
11/24/2018	0.70	96%
11/25/2018	0.80	96%
11/26/2018	0.10	96%
11/27/2018	0.50	96%
11/28/2018	0.30	96%
11/29/2018	3.10	96%
11/30/2018	0.40	96%
12/1/2018	0.20	96%
12/2/2018	0.10	96%
12/3/2018	0.10	96%
12/4/2018	0.10	96%
12/5/2018	0.10	96%
12/6/2018	0.20	96%
12/7/2018	0.10	100%
12/8/2018	0.10	96%
12/9/2018	1.00	96%
12/10/2018	3.80	96%
12/11/2018	3.00	96%
12/12/2018	6.40	96%
12/13/2018	--	63%
12/14/2018	0.60	75%
12/15/2018	0.40	96%
12/16/2018	0.20	96%
12/17/2018	1.10	96%
12/18/2018	1.40	96%
12/19/2018	0.20	96%
12/20/2018	0.30	96%
12/21/2018	0.20	96%
12/22/2018	0.10	96%
12/23/2018	0.20	96%
12/24/2018	0.30	96%
12/25/2018	0.60	96%
12/26/2018	0.10	96%
12/27/2018	0.80	96%
12/28/2018	8.00	96%
12/29/2018	12.20	96%
12/30/2018	0.20	96%
12/31/2018	0.60	96%

Haisla Village 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
1/1/2019	0.20	96%
1/2/2019	0.20	96%
1/3/2019	0.20	96%
1/4/2019	0.20	96%
1/5/2019	0.10	96%
1/6/2019	0.20	96%
1/7/2019	0.50	96%
1/8/2019	0.20	96%
1/9/2019	0.10	100%
1/10/2019	0.30	96%
1/11/2019	1.10	96%
1/12/2019	0.30	96%
1/13/2019	0.20	96%
1/14/2019	0.20	96%
1/15/2019	0.10	96%
1/16/2019	0.10	96%
1/17/2019	0.10	96%
1/18/2019	0.10	96%
1/19/2019	0.60	96%
1/20/2019	0.10	96%
1/21/2019	0.10	96%
1/22/2019	0.10	96%
1/23/2019	0.10	79%
1/24/2019	0.30	88%
1/25/2019	0.20	96%
1/26/2019	0.10	96%
1/27/2019	0.10	96%
1/28/2019	0.10	96%
1/29/2019	0.10	96%
1/30/2019	1.30	96%
1/31/2019	0.70	96%
2/1/2019	0.40	96%
2/2/2019	0.40	96%
2/3/2019	0.20	100%
2/4/2019	0.10	96%
2/5/2019	0.10	79%
2/6/2019	0.10	96%
2/7/2019	0.10	96%
2/8/2019	0.10	96%
2/9/2019	0.10	96%
2/10/2019	1.30	96%
2/11/2019	0.10	92%
2/12/2019	0.10	96%
2/13/2019	0.10	88%
2/14/2019	0.10	96%
2/15/2019	0.20	96%

Haisla Village 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
2/16/2019	0.30	96%
2/17/2019	0.20	96%
2/18/2019	1.60	96%
2/19/2019	0.20	96%
2/20/2019	0.40	96%
2/21/2019	0.40	96%
2/22/2019	0.30	96%
2/23/2019	0.30	96%
2/24/2019	0.40	96%
2/25/2019	0.40	96%
2/26/2019	17.30	96%
2/27/2019	0.30	96%
2/28/2019	0.30	75%
3/1/2019	0.40	96%
3/2/2019	0.10	96%
3/3/2019	0.10	96%
3/4/2019	0.20	96%
3/5/2019	0.20	96%
3/6/2019	0.20	96%
3/7/2019	0.70	96%
3/8/2019	4.90	96%
3/9/2019	2.30	96%
3/10/2019	0.10	96%
3/11/2019	3.00	96%
3/12/2019	0.10	96%
3/13/2019	0.20	96%
3/14/2019	3.40	96%
3/15/2019	0.40	79%
3/16/2019	3.30	96%
3/17/2019	0.40	96%
3/18/2019	1.20	96%
3/19/2019	2.40	96%
3/20/2019	0.30	96%
3/21/2019	3.40	96%
3/22/2019	4.70	96%
3/23/2019	0.40	96%
3/24/2019	0.20	96%
3/25/2019	0.40	100%
3/26/2019	2.80	96%
3/27/2019	0.20	96%
3/28/2019	3.00	96%
3/29/2019	4.50	96%
3/30/2019	18.40	96%
3/31/2019	4.10	96%
4/1/2019	0.70	96%
4/2/2019	3.90	96%

Haisla Village 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
4/3/2019	3.40	96%
4/4/2019	0.20	96%
4/5/2019	0.10	96%
4/6/2019	0.40	96%
4/7/2019	0.10	96%
4/8/2019	0.10	96%
4/9/2019	0.10	96%
4/10/2019	0.10	96%
4/11/2019	2.10	96%
4/12/2019	0.10	96%
4/13/2019	8.00	96%
4/14/2019	0.10	96%
4/15/2019	4.10	92%
4/16/2019	0.10	96%
4/17/2019	0.10	96%
4/18/2019	0.10	96%
4/19/2019	0.10	100%
4/20/2019	3.10	96%
4/21/2019	0.10	96%
4/22/2019	0.10	96%
4/23/2019	0.10	96%
4/24/2019	0.10	79%
4/25/2019	17.90	96%
4/26/2019	0.20	96%
4/27/2019	0.90	96%
4/28/2019	3.30	96%
4/29/2019	2.30	96%
4/30/2019	11.50	96%
5/1/2019	0.90	96%
5/2/2019	0.10	96%
5/3/2019	0.10	96%
5/4/2019	0.10	96%
5/5/2019	0.10	96%
5/6/2019	0.10	96%
5/7/2019	0.10	96%
5/8/2019	1.60	96%
5/9/2019	4.50	96%
5/10/2019	5.20	96%
5/11/2019	0.10	96%
5/12/2019	2.00	96%
5/13/2019	14.30	96%
5/14/2019	2.90	100%
5/15/2019	7.50	96%
5/16/2019	0.40	79%
5/17/2019	0.70	88%
5/18/2019	2.30	96%

Haisla Village 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
5/19/2019	4.50	96%
5/20/2019	0.70	96%
5/21/2019	17.20	96%
5/22/2019	4.20	96%
5/23/2019	0.20	96%
5/24/2019	1.90	96%
5/25/2019	0.60	96%
5/26/2019	6.60	96%
5/27/2019	2.10	96%
5/28/2019	0.20	96%
5/29/2019	0.20	96%
5/30/2019	3.30	96%
5/31/2019	0.20	96%
6/1/2019	0.10	96%
6/2/2019	0.60	96%
6/3/2019	2.30	96%
6/4/2019	0.20	96%
6/5/2019	4.10	96%
6/6/2019	0.10	96%
6/7/2019	4.50	96%
6/8/2019	0.20	100%
6/9/2019	0.20	96%
6/10/2019	0.20	96%
6/11/2019	0.20	96%
6/12/2019	1.70	96%
6/13/2019	0.10	96%
6/14/2019	0.70	96%
6/15/2019	0.10	96%
6/16/2019	0.10	96%
6/17/2019	0.10	96%
6/18/2019	0.10	96%
6/19/2019	0.10	96%
6/20/2019	20.30	96%
6/21/2019	0.80	96%
6/22/2019	0.10	96%
6/23/2019	0.10	96%
6/24/2019	0.10	83%
6/25/2019	4.30	96%
6/26/2019	4.80	96%
6/27/2019	0.60	96%
6/28/2019	0.10	96%
6/29/2019	0.10	96%
6/30/2019	0.10	96%
7/1/2019	0.10	96%
7/2/2019	0.10	96%
7/3/2019	0.10	100%

Haisla Village 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
7/4/2019	5.10	96%
7/5/2019	0.50	96%
7/6/2019	2.80	96%
7/7/2019	0.90	79%
7/8/2019	0.10	96%
7/9/2019	0.20	96%
7/10/2019	1.20	96%
7/11/2019	0.20	96%
7/12/2019	0.20	96%
7/13/2019	0.50	96%
7/14/2019	0.20	96%
7/15/2019	0.10	96%
7/16/2019	0.10	96%
7/17/2019	1.30	96%
7/18/2019	0.20	96%
7/19/2019	0.10	83%
7/20/2019	0.10	96%
7/21/2019	2.90	96%
7/22/2019	3.70	96%
7/23/2019	0.10	96%
7/24/2019	0.10	96%
7/25/2019	2.50	96%
7/26/2019	1.70	96%
7/27/2019	0.10	96%
7/28/2019	0.20	100%
7/29/2019	0.10	96%
7/30/2019	0.10	96%
7/31/2019	0.10	96%
8/1/2019	4.80	96%
8/2/2019	2.50	96%
8/3/2019	0.20	96%
8/4/2019	3.40	96%
8/5/2019	0.20	96%
8/6/2019	0.40	96%
8/7/2019	0.70	88%
8/8/2019	0.10	96%
8/9/2019	0.20	96%
8/10/2019	0.20	96%
8/11/2019	0.20	96%
8/12/2019	1.70	96%
8/13/2019	1.70	96%
8/14/2019	0.20	96%
8/15/2019	0.20	96%
8/16/2019	9.80	96%
8/17/2019	0.20	96%
8/18/2019	0.10	96%

Haisla Village 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
8/19/2019	72.80	96%
8/20/2019	8.70	96%
8/21/2019	0.20	96%
8/22/2019	0.10	79%
8/23/2019	0.20	96%
8/24/2019	0.10	96%
8/25/2019	0.10	96%
8/26/2019	0.20	96%
8/27/2019	0.10	96%
8/28/2019	3.30	96%
8/29/2019	3.10	96%
8/30/2019	4.90	96%
8/31/2019	1.70	96%
9/1/2019	6.70	96%
9/2/2019	0.10	96%
9/3/2019	0.10	96%
9/4/2019	0.10	96%
9/5/2019	3.20	96%
9/6/2019	1.80	96%
9/7/2019	4.10	96%
9/8/2019	0.20	96%
9/9/2019	0.20	96%
9/10/2019	0.40	96%
9/11/2019	3.90	83%
9/12/2019	0.50	92%
9/13/2019	0.20	96%
9/14/2019	0.20	96%
9/15/2019	1.50	96%
9/16/2019	0.20	100%
9/17/2019	0.30	96%
9/18/2019	1.40	96%
9/19/2019	0.20	96%
9/20/2019	0.10	96%
9/21/2019	0.10	96%
9/22/2019	1.30	79%
9/23/2019	0.10	96%
9/24/2019	0.10	96%
9/25/2019	0.10	96%
9/26/2019	0.10	96%
9/27/2019	0.20	83%
9/28/2019	0.10	96%
9/29/2019	0.20	96%
9/30/2019	2.50	96%
10/1/2019	0.10	96%
10/2/2019	0.10	96%
10/3/2019	0.50	96%

Haisla Village 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
10/4/2019	0.10	96%
10/5/2019	0.20	96%
10/6/2019	0.20	96%
10/7/2019	0.10	96%
10/8/2019	0.20	96%
10/9/2019	10.80	96%
10/10/2019	12.10	96%
10/11/2019	0.40	100%
10/12/2019	5.00	96%
10/13/2019	2.00	96%
10/14/2019	0.20	96%
10/15/2019	1.20	96%
10/16/2019	0.40	96%
10/17/2019	0.50	96%
10/18/2019	0.10	96%
10/19/2019	0.00	96%
10/20/2019	0.80	96%
10/21/2019	0.30	96%
10/22/2019	0.10	96%
10/23/2019	0.10	96%
10/24/2019	0.30	96%
10/25/2019	0.20	96%
10/26/2019	0.20	96%
10/27/2019	0.20	96%
10/28/2019	0.10	83%
10/29/2019	10.70	96%
10/30/2019	0.10	96%
10/31/2019	0.90	96%
11/1/2019	0.20	96%
11/2/2019	0.00	96%
11/3/2019	0.10	96%
11/4/2019	0.10	96%
11/5/2019	8.40	100%
11/6/2019	0.10	96%
11/7/2019	0.20	96%
11/8/2019	0.10	96%
11/9/2019	0.20	96%
11/10/2019	0.10	96%
11/11/2019	0.10	96%
11/12/2019	0.10	96%
11/13/2019	1.30	96%
11/14/2019	0.50	96%
11/15/2019	0.30	96%
11/16/2019	1.20	96%
11/17/2019	0.20	96%
11/18/2019	2.60	96%

Haisla Village 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
11/19/2019	0.10	96%
11/20/2019	1.50	96%
11/21/2019	16.50	83%
11/22/2019	0.50	96%
11/23/2019	4.70	96%
11/24/2019	0.10	96%
11/25/2019	0.30	96%
11/26/2019	0.20	96%
11/27/2019	0.20	96%
11/28/2019	0.10	96%
11/29/2019	0.10	96%
11/30/2019	0.20	100%
12/1/2019	0.40	96%
12/2/2019	0.20	96%
12/3/2019	0.10	96%
12/4/2019	0.20	96%
12/5/2019	1.00	96%
12/6/2019	0.20	96%
12/7/2019	0.20	96%
12/8/2019	0.10	96%
12/9/2019	0.10	96%
12/10/2019	0.10	96%
12/11/2019	0.10	96%
12/12/2019	0.50	79%
12/13/2019	0.20	96%
12/14/2019	0.20	96%
12/15/2019	1.30	96%
12/16/2019	0.20	96%
12/17/2019	0.10	96%
12/18/2019	1.00	96%
12/19/2019	0.30	96%
12/20/2019	0.20	96%
12/21/2019	0.20	96%
12/22/2019	0.10	96%
12/23/2019	0.20	96%
12/24/2019	0.10	96%
12/25/2019	1.00	100%
12/26/2019	0.40	96%
12/27/2019	0.10	96%
12/28/2019	0.20	96%
12/29/2019	0.80	96%
12/30/2019	0.10	96%
12/31/2019	0.40	96%

Riverlodge 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
1/1/2019	0.30	96%
1/2/2019	0.90	96%
1/3/2019	0.30	96%
1/4/2019	0.30	96%
1/5/2019	0.10	96%
1/6/2019	16.00	100%
1/7/2019	5.30	96%
1/8/2019	0.10	96%
1/9/2019	0.10	96%
1/10/2019	0.10	96%
1/11/2019	0.20	96%
1/12/2019	0.20	96%
1/13/2019	0.10	96%
1/14/2019	0.40	96%
1/15/2019	0.40	96%
1/16/2019	0.20	96%
1/17/2019	0.20	79%
1/18/2019	0.30	96%
1/19/2019	3.20	96%
1/20/2019	0.70	96%
1/21/2019	0.40	96%
1/22/2019	0.20	96%
1/23/2019	0.20	96%
1/24/2019	0.30	96%
1/25/2019	0.10	96%
1/26/2019	1.10	96%
1/27/2019	0.40	96%
1/28/2019	0.20	96%
1/29/2019	0.20	96%
1/30/2019	3.60	96%
1/31/2019	0.30	100%
2/1/2019	5.40	96%
2/2/2019	0.20	96%
2/3/2019	0.10	96%
2/4/2019	0.10	96%
2/5/2019	0.20	96%
2/6/2019	0.10	79%
2/7/2019	0.20	96%
2/8/2019	0.20	96%
2/9/2019	0.10	96%
2/10/2019	0.10	96%
2/11/2019	0.20	96%
2/12/2019	0.10	96%
2/13/2019	0.10	83%
2/14/2019	0.10	96%
2/15/2019	0.20	96%

Riverlodge 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
2/16/2019	0.30	96%
2/17/2019	0.20	96%
2/18/2019	35.80	96%
2/19/2019	1.10	96%
2/20/2019	0.20	96%
2/21/2019	1.20	96%
2/22/2019	0.20	96%
2/23/2019	0.20	96%
2/24/2019	0.20	96%
2/25/2019	0.40	100%
2/26/2019	0.10	96%
2/27/2019	--	63%
2/28/2019	0.40	96%
3/1/2019	0.10	96%
3/2/2019	0.10	96%
3/3/2019	0.10	96%
3/4/2019	0.10	96%
3/5/2019	0.60	96%
3/6/2019	0.60	96%
3/7/2019	6.20	96%
3/8/2019	6.60	96%
3/9/2019	13.20	96%
3/10/2019	8.70	96%
3/11/2019	0.50	96%
3/12/2019	1.40	96%
3/13/2019	0.30	83%
3/14/2019	1.30	96%
3/15/2019	2.70	96%
3/16/2019	1.20	96%
3/17/2019	0.40	96%
3/18/2019	0.20	96%
3/19/2019	0.20	96%
3/20/2019	0.20	96%
3/21/2019	66.60	96%
3/22/2019	7.30	100%
3/23/2019	16.10	96%
3/24/2019	0.10	96%
3/25/2019	0.30	96%
3/26/2019	4.60	96%
3/27/2019	0.30	96%
3/28/2019	7.40	92%
3/29/2019	7.80	96%
3/30/2019	9.60	96%
3/31/2019	0.30	96%
4/1/2019	0.30	96%
4/2/2019	4.30	96%

Riverlodge 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
4/3/2019	13.70	100%
4/4/2019	3.30	96%
4/5/2019	1.80	96%
4/6/2019	4.50	96%
4/7/2019	0.60	96%
4/8/2019	6.90	96%
4/9/2019	1.50	96%
4/10/2019	3.10	96%
4/11/2019	2.50	96%
4/12/2019	2.20	96%
4/13/2019	7.00	96%
4/14/2019	10.10	96%
4/15/2019	--	71%
4/16/2019	0.40	92%
4/17/2019	5.00	96%
4/18/2019	4.10	96%
4/19/2019	5.20	96%
4/20/2019	7.00	96%
4/21/2019	10.60	96%
4/22/2019	0.20	83%
4/23/2019	5.60	96%
4/24/2019	12.60	96%
4/25/2019	31.50	96%
4/26/2019	16.90	96%
4/27/2019	1.20	96%
4/28/2019	0.10	96%
4/29/2019	0.10	96%
4/30/2019	2.20	96%
5/1/2019	10.60	96%
5/2/2019	18.60	96%
5/3/2019	0.90	96%
5/4/2019	0.30	96%
5/5/2019	1.30	96%
5/6/2019	0.50	96%
5/7/2019	37.80	96%
5/8/2019	1.80	96%
5/9/2019	10.20	96%
5/10/2019	10.10	96%
5/11/2019	0.60	100%
5/12/2019	3.80	96%
5/13/2019	23.20	96%
5/14/2019	2.00	96%
5/15/2019	8.20	79%
5/16/2019	0.20	96%
5/17/2019	4.30	96%
5/18/2019	2.50	96%

Riverlodge 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
5/19/2019	8.40	96%
5/20/2019	1.90	96%
5/21/2019	9.90	96%
5/22/2019	4.70	96%
5/23/2019	0.70	100%
5/24/2019	18.50	96%
5/25/2019	0.50	96%
5/26/2019	1.50	96%
5/27/2019	10.20	96%
5/28/2019	1.40	96%
5/29/2019	7.80	96%
5/30/2019	8.00	96%
5/31/2019	0.90	96%
6/1/2019	2.90	96%
6/2/2019	2.10	96%
6/3/2019	3.50	96%
6/4/2019	2.40	96%
6/5/2019	1.20	100%
6/6/2019	5.70	96%
6/7/2019	14.10	96%
6/8/2019	3.60	96%
6/9/2019	1.50	96%
6/10/2019	0.20	96%
6/11/2019	0.30	96%
6/12/2019	25.20	96%
6/13/2019	0.30	96%
6/14/2019	3.30	96%
6/15/2019	0.10	96%
6/16/2019	0.40	96%
6/17/2019	2.00	96%
6/18/2019	8.10	96%
6/19/2019	0.40	96%
6/20/2019	21.10	75%
6/21/2019	1.90	96%
6/22/2019	0.80	96%
6/23/2019	0.40	96%
6/24/2019	0.30	96%
6/25/2019	0.90	96%
6/26/2019	5.10	96%
6/27/2019	3.40	96%
6/28/2019	0.10	96%
6/29/2019	0.20	96%
6/30/2019	6.20	100%
7/1/2019	0.10	96%
7/2/2019	34.10	96%
7/3/2019	0.10	96%

Riverlodge 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
7/4/2019	5.30	96%
7/5/2019	0.10	96%
7/6/2019	4.10	96%
7/7/2019	1.60	79%
7/8/2019	0.60	88%
7/9/2019	7.80	96%
7/10/2019	2.60	96%
7/11/2019	0.10	96%
7/12/2019	0.40	96%
7/13/2019	4.60	96%
7/14/2019	0.40	96%
7/15/2019	0.90	96%
7/16/2019	0.20	96%
7/17/2019	10.00	96%
7/18/2019	4.40	96%
7/19/2019	1.30	75%
7/20/2019	0.30	96%
7/21/2019	3.80	96%
7/22/2019	8.40	96%
7/23/2019	0.90	96%
7/24/2019	1.50	96%
7/25/2019	3.50	100%
7/26/2019	0.50	96%
7/27/2019	0.70	96%
7/28/2019	0.70	96%
7/29/2019	0.40	96%
7/30/2019	0.20	96%
7/31/2019	0.90	96%
8/1/2019	3.80	96%
8/2/2019	2.70	96%
8/3/2019	0.10	96%
8/4/2019	13.90	96%
8/5/2019	6.90	96%
8/6/2019	39.50	96%
8/7/2019	6.80	88%
8/8/2019	0.10	96%
8/9/2019	4.00	96%
8/10/2019	0.10	96%
8/11/2019	0.20	96%
8/12/2019	39.00	96%
8/13/2019	3.40	96%
8/14/2019	0.40	96%
8/15/2019	0.20	75%
8/16/2019	7.50	96%
8/17/2019	6.90	96%
8/18/2019	25.60	96%

Riverlodge 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
8/19/2019	10.10	100%
8/20/2019	16.10	96%
8/21/2019	13.10	96%
8/22/2019	0.90	96%
8/23/2019	0.30	96%
8/24/2019	2.60	96%
8/25/2019	0.30	96%
8/26/2019	1.10	96%
8/27/2019	5.00	96%
8/28/2019	0.20	96%
8/29/2019	0.20	96%
8/30/2019	5.60	96%
8/31/2019	8.00	96%
9/1/2019	29.70	96%
9/2/2019	10.40	96%
9/3/2019	4.10	96%
9/4/2019	0.30	96%
9/5/2019	3.20	96%
9/6/2019	5.30	96%
9/7/2019	2.20	96%
9/8/2019	0.10	96%
9/9/2019	0.30	96%
9/10/2019	0.50	96%
9/11/2019	53.40	79%
9/12/2019	0.60	96%
9/13/2019	0.10	100%
9/14/2019	1.40	96%
9/15/2019	1.40	96%
9/16/2019	0.20	96%
9/17/2019	0.10	96%
9/18/2019	9.40	83%
9/19/2019	0.10	96%
9/20/2019	0.40	96%
9/21/2019	0.20	96%
9/22/2019	1.10	79%
9/23/2019	0.20	96%
9/24/2019	0.20	96%
9/25/2019	0.20	96%
9/26/2019	1.30	96%
9/27/2019	0.20	96%
9/28/2019	0.20	96%
9/29/2019	0.10	96%
9/30/2019	2.00	96%
10/1/2019	0.60	96%
10/2/2019	0.30	96%
10/3/2019	0.20	96%

Riverlodge 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
10/4/2019	0.10	96%
10/5/2019	0.10	96%
10/6/2019	0.10	96%
10/7/2019	1.30	96%
10/8/2019	0.10	100%
10/9/2019	0.50	75%
10/10/2019	7.40	96%
10/11/2019	0.40	96%
10/12/2019	13.30	96%
10/13/2019	1.40	96%
10/14/2019	0.20	96%
10/15/2019	0.20	96%
10/16/2019	0.30	96%
10/17/2019	0.30	96%
10/18/2019	3.90	96%
10/19/2019	0.20	96%
10/20/2019	0.20	96%
10/21/2019	0.20	96%
10/22/2019	5.60	96%
10/23/2019	0.10	96%
10/24/2019	0.20	96%
10/25/2019	2.30	96%
10/26/2019	0.10	96%
10/27/2019	0.30	96%
10/28/2019	0.30	96%
10/29/2019	12.10	96%
10/30/2019	0.30	96%
10/31/2019	1.50	96%
11/1/2019	0.20	96%
11/2/2019	0.20	100%
11/3/2019	0.70	96%
11/4/2019	0.60	96%
11/5/2019	17.30	96%
11/6/2019	0.40	96%
11/7/2019	0.20	96%
11/8/2019	0.30	96%
11/9/2019	0.30	96%
11/10/2019	0.30	96%
11/11/2019	0.20	96%
11/12/2019	0.20	96%
11/13/2019	0.20	96%
11/14/2019	0.30	96%
11/15/2019	0.50	79%
11/16/2019	0.40	96%
11/17/2019	0.50	96%
11/18/2019	0.20	96%

Riverlodge 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
11/19/2019	0.10	96%
11/20/2019	0.40	96%
11/21/2019	14.60	96%
11/22/2019	4.50	96%
11/23/2019	5.00	96%
11/24/2019	10.90	96%
11/25/2019	3.30	96%
11/26/2019	0.20	96%
11/27/2019	0.20	100%
11/28/2019	0.10	96%
11/29/2019	0.10	96%
11/30/2019	0.20	96%
12/1/2019	0.10	96%
12/2/2019	0.40	96%
12/3/2019	0.30	96%
12/4/2019	0.50	96%
12/5/2019	0.30	96%
12/6/2019	0.20	96%
12/7/2019	0.20	96%
12/8/2019	0.20	96%
12/9/2019	0.30	96%
12/10/2019	0.20	96%
12/11/2019	0.30	96%
12/12/2019	0.30	83%
12/13/2019	0.30	96%
12/14/2019	0.30	96%
12/15/2019	0.20	96%
12/16/2019	0.30	96%
12/17/2019	2.10	96%
12/18/2019	0.20	96%
12/19/2019	0.20	96%
12/20/2019	0.10	96%
12/21/2019	0.20	96%
12/22/2019	0.10	100%
12/23/2019	0.20	96%
12/24/2019	0.30	96%
12/25/2019	0.20	96%
12/26/2019	0.30	96%
12/27/2019	3.30	96%
12/28/2019	0.30	96%
12/29/2019	0.30	96%
12/30/2019	0.30	96%
12/31/2019	0.30	96%

Whitesail 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
1/1/2019	0.10	100%
1/2/2019	0.30	96%
1/3/2019	0.20	96%
1/4/2019	0.20	96%
1/5/2019	0.30	96%
1/6/2019	0.20	96%
1/7/2019	5.50	96%
1/8/2019	0.20	96%
1/9/2019	0.10	96%
1/10/2019	0.20	96%
1/11/2019	--	71%
1/12/2019	1.60	96%
1/13/2019	0.20	96%
1/14/2019	0.20	96%
1/15/2019	0.20	96%
1/16/2019	0.10	96%
1/17/2019	0.20	96%
1/18/2019	0.20	96%
1/19/2019	2.00	96%
1/20/2019	0.20	96%
1/21/2019	2.10	96%
1/22/2019	0.50	96%
1/23/2019	0.20	96%
1/24/2019	0.20	96%
1/25/2019	0.20	96%
1/26/2019	0.20	100%
1/27/2019	0.30	96%
1/28/2019	0.20	96%
1/29/2019	0.20	96%
1/30/2019	1.90	96%
1/31/2019	2.60	96%
2/1/2019	0.90	96%
2/2/2019	0.20	96%
2/3/2019	0.40	96%
2/4/2019	0.30	96%
2/5/2019	0.10	96%
2/6/2019	0.10	83%
2/7/2019	0.10	96%
2/8/2019	0.10	96%
2/9/2019	0.10	96%
2/10/2019	0.10	96%
2/11/2019	0.10	96%
2/12/2019	0.10	96%
2/13/2019	0.10	88%
2/14/2019	0.10	96%
2/15/2019	0.10	96%

Whitesail 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
2/16/2019	0.20	96%
2/17/2019	0.10	96%
2/18/2019	4.30	96%
2/19/2019	0.40	96%
2/20/2019	0.30	83%
2/21/2019	0.80	96%
2/22/2019	0.30	96%
2/23/2019	0.20	96%
2/24/2019	0.20	96%
2/25/2019	0.20	96%
2/26/2019	0.20	96%
2/27/2019	0.20	96%
2/28/2019	0.20	96%
3/1/2019	0.20	96%
3/2/2019	0.20	96%
3/3/2019	0.10	96%
3/4/2019	0.10	96%
3/5/2019	0.20	96%
3/6/2019	0.10	96%
3/7/2019	5.20	96%
3/8/2019	4.30	96%
3/9/2019	8.00	96%
3/10/2019	0.70	96%
3/11/2019	5.90	96%
3/12/2019	0.60	96%
3/13/2019	1.30	96%
3/14/2019	2.10	79%
3/15/2019	5.70	96%
3/16/2019	3.10	96%
3/17/2019	0.40	100%
3/18/2019	0.00	96%
3/19/2019	0.00	96%
3/20/2019	0.00	96%
3/21/2019	40.20	96%
3/22/2019	6.60	96%
3/23/2019	9.60	96%
3/24/2019	0.10	96%
3/25/2019	0.10	96%
3/26/2019	4.40	96%
3/27/2019	0.30	96%
3/28/2019	5.30	96%
3/29/2019	6.20	96%
3/30/2019	6.10	96%
3/31/2019	0.20	96%
4/1/2019	0.10	96%
4/2/2019	6.70	96%

Whitesail 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
4/3/2019	3.80	96%
4/4/2019	6.90	96%
4/5/2019	0.30	96%
4/6/2019	0.60	96%
4/7/2019	0.30	96%
4/8/2019	4.90	96%
4/9/2019	0.10	96%
4/10/2019	0.10	96%
4/11/2019	3.20	100%
4/12/2019	0.90	96%
4/13/2019	6.30	96%
4/14/2019	4.70	96%
4/15/2019	--	33%
4/16/2019	0.40	96%
4/17/2019	0.20	96%
4/18/2019	0.20	96%
4/19/2019	3.60	96%
4/20/2019	2.40	96%
4/21/2019	5.00	96%
4/22/2019	0.60	96%
4/23/2019	0.80	96%
4/24/2019	1.70	96%
4/25/2019	15.00	96%
4/26/2019	0.60	96%
4/27/2019	0.80	96%
4/28/2019	0.20	96%
4/29/2019	0.10	96%
4/30/2019	3.10	96%
5/1/2019	15.00	96%
5/2/2019	0.30	96%
5/3/2019	0.10	96%
5/4/2019	0.20	96%
5/5/2019	0.30	96%
5/6/2019	0.40	83%
5/7/2019	14.50	96%
5/8/2019	1.10	96%
5/9/2019	4.70	96%
5/10/2019	6.60	96%
5/11/2019	0.20	96%
5/12/2019	3.10	96%
5/13/2019	14.90	96%
5/14/2019	6.30	96%
5/15/2019	2.90	96%
5/16/2019	0.50	96%
5/17/2019	0.60	96%
5/18/2019	2.30	96%

Whitesail 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
5/19/2019	3.80	96%
5/20/2019	1.20	96%
5/21/2019	10.10	96%
5/22/2019	3.30	96%
5/23/2019	0.30	96%
5/24/2019	4.50	96%
5/25/2019	0.10	96%
5/26/2019	1.90	96%
5/27/2019	3.70	96%
5/28/2019	0.40	96%
5/29/2019	5.10	96%
5/30/2019	4.80	96%
5/31/2019	0.20	100%
6/1/2019	0.70	96%
6/2/2019	1.30	96%
6/3/2019	5.70	96%
6/4/2019	0.40	96%
6/5/2019	0.70	96%
6/6/2019	0.90	96%
6/7/2019	8.80	96%
6/8/2019	3.10	96%
6/9/2019	6.20	96%
6/10/2019	0.40	96%
6/11/2019	0.70	88%
6/12/2019	21.70	96%
6/13/2019	0.20	96%
6/14/2019	8.50	79%
6/15/2019	0.20	96%
6/16/2019	0.10	96%
6/17/2019	0.10	96%
6/18/2019	0.10	96%
6/19/2019	0.10	96%
6/20/2019	10.30	96%
6/21/2019	5.30	96%
6/22/2019	0.70	96%
6/23/2019	0.10	96%
6/24/2019	0.30	96%
6/25/2019	0.90	100%
6/26/2019	2.20	96%
6/27/2019	5.20	96%
6/28/2019	0.20	96%
6/29/2019	0.10	96%
6/30/2019	5.50	96%
7/1/2019	0.20	96%
7/2/2019	4.90	96%
7/3/2019	0.10	96%

Whitesail 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
7/4/2019	2.20	96%
7/5/2019	0.20	96%
7/6/2019	4.60	96%
7/7/2019	0.90	79%
7/8/2019	0.50	88%
7/9/2019	13.60	96%
7/10/2019	1.70	96%
7/11/2019	3.60	96%
7/12/2019	2.60	96%
7/13/2019	0.20	96%
7/14/2019	0.50	96%
7/15/2019	1.10	96%
7/16/2019	0.90	96%
7/17/2019	4.60	96%
7/18/2019	2.70	75%
7/19/2019	1.20	96%
7/20/2019	2.80	100%
7/21/2019	3.30	96%
7/22/2019	1.40	96%
7/23/2019	1.10	96%
7/24/2019	0.60	96%
7/25/2019	4.50	96%
7/26/2019	1.10	96%
7/27/2019	0.10	96%
7/28/2019	0.10	96%
7/29/2019	1.00	96%
7/30/2019	0.20	96%
7/31/2019	0.40	96%
8/1/2019	2.80	96%
8/2/2019	3.00	96%
8/3/2019	1.90	96%
8/4/2019	7.00	96%
8/5/2019	2.30	96%
8/6/2019	28.80	96%
8/7/2019	2.90	88%
8/8/2019	0.20	96%
8/9/2019	9.60	96%
8/10/2019	0.20	96%
8/11/2019	0.20	96%
8/12/2019	19.30	96%
8/13/2019	3.50	96%
8/14/2019	0.20	100%
8/15/2019	0.20	96%
8/16/2019	5.90	96%
8/17/2019	0.20	96%
8/18/2019	0.20	96%

Whitesail 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
8/19/2019	--	71%
8/20/2019	18.20	96%
8/21/2019	1.10	96%
8/22/2019	0.20	96%
8/23/2019	0.30	88%
8/24/2019	0.50	96%
8/25/2019	0.20	96%
8/26/2019	3.40	96%
8/27/2019	0.20	96%
8/28/2019	1.70	96%
8/29/2019	6.80	96%
8/30/2019	3.60	96%
8/31/2019	4.20	96%
9/1/2019	12.80	96%
9/2/2019	19.40	96%
9/3/2019	1.50	96%
9/4/2019	0.20	96%
9/5/2019	3.80	96%
9/6/2019	3.30	96%
9/7/2019	2.00	96%
9/8/2019	0.30	100%
9/9/2019	0.20	96%
9/10/2019	0.40	96%
9/11/2019	43.60	88%
9/12/2019	1.80	83%
9/13/2019	0.30	96%
9/14/2019	1.70	96%
9/15/2019	2.40	96%
9/16/2019	0.70	96%
9/17/2019	0.30	96%
9/18/2019	4.60	96%
9/19/2019	0.30	96%
9/20/2019	0.10	96%
9/21/2019	0.10	96%
9/22/2019	1.40	79%
9/23/2019	0.20	96%
9/24/2019	0.10	96%
9/25/2019	0.10	96%
9/26/2019	0.90	96%
9/27/2019	0.20	96%
9/28/2019	0.20	96%
9/29/2019	0.20	96%
9/30/2019	1.20	79%
10/1/2019	0.40	96%
10/2/2019	0.40	96%
10/3/2019	1.30	100%

Whitesail 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
10/4/2019	0.10	96%
10/5/2019	0.10	96%
10/6/2019	0.10	96%
10/7/2019	1.60	96%
10/8/2019	0.10	96%
10/9/2019	5.60	96%
10/10/2019	4.30	96%
10/11/2019	0.80	96%
10/12/2019	18.60	96%
10/13/2019	2.30	96%
10/14/2019	0.10	96%
10/15/2019	0.40	96%
10/16/2019	0.60	96%
10/17/2019	1.00	96%
10/18/2019	0.30	96%
10/19/2019	0.50	96%
10/20/2019	0.30	96%
10/21/2019	0.20	96%
10/22/2019	0.20	96%
10/23/2019	0.70	96%
10/24/2019	0.70	96%
10/25/2019	0.20	96%
10/26/2019	0.20	96%
10/27/2019	0.10	96%
10/28/2019	0.10	100%
10/29/2019	8.60	96%
10/30/2019	0.40	96%
10/31/2019	0.90	79%
11/1/2019	0.20	96%
11/2/2019	0.10	96%
11/3/2019	0.10	96%
11/4/2019	0.20	96%
11/5/2019	8.20	96%
11/6/2019	0.20	96%
11/7/2019	0.20	96%
11/8/2019	0.20	96%
11/9/2019	0.20	96%
11/10/2019	0.20	96%
11/11/2019	0.10	96%
11/12/2019	0.20	96%
11/13/2019	1.00	96%
11/14/2019	5.30	96%
11/15/2019	0.30	96%
11/16/2019	1.90	96%
11/17/2019	0.10	96%
11/18/2019	1.00	96%

Whitesail 2019

Date	Daily 1-hr Max Value (ppb)	Daily completeness
11/19/2019	0.10	96%
11/20/2019	0.10	96%
11/21/2019	13.70	79%
11/22/2019	0.40	100%
11/23/2019	2.70	96%
11/24/2019	0.40	96%
11/25/2019	0.20	96%
11/26/2019	0.10	96%
11/27/2019	0.20	96%
11/28/2019	0.10	96%
11/29/2019	0.00	96%
11/30/2019	0.10	96%
12/1/2019	0.70	96%
12/2/2019	0.50	96%
12/3/2019	0.10	96%
12/4/2019	0.10	96%
12/5/2019	0.30	96%
12/6/2019	0.30	96%
12/7/2019	0.10	96%
12/8/2019	0.10	96%
12/9/2019	0.10	96%
12/10/2019	0.10	96%
12/11/2019	0.10	79%
12/12/2019	0.70	96%
12/13/2019	0.60	96%
12/14/2019	0.10	96%
12/15/2019	0.10	96%
12/16/2019	0.10	96%
12/17/2019	0.30	100%
12/18/2019	3.20	96%
12/19/2019	1.70	96%
12/20/2019	1.50	96%
12/21/2019	0.40	96%
12/22/2019	0.20	96%
12/23/2019	1.00	96%
12/24/2019	0.30	96%
12/25/2019	1.60	96%
12/26/2019	1.30	96%
12/27/2019	0.10	96%
12/28/2019	0.70	96%
12/29/2019	1.40	96%
12/30/2019	0.40	96%
12/31/2019	0.70	96%

Appendix B: Technical Memo W08

The following pages contain new **B.C. Works SO_2 EEM Technical Memo W08**.

Rio Tinto

B.C. Works SO_2 EEM Program – Technical Memo W08

Aquatic Ecosystems Actions and Analyses

July 31, 2020

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1 Introduction

This Technical Memo provides additional information on the data and analyses in support of the 2019 requirements for the Aquatic Ecosystems component of the B.C. Works SO_2 Environmental Effects Monitoring (EEM) program (ESSA et al. 2014b). These data and analyses thus provide the foundation for Section 3.5 in the 2019 Annual Report (ESSA et al. 2020).

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; Bennett and Perrin 2018, Limnotek 2019, Limnotek 2020). 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 extensively throughout this technical memo, often without their full citation:

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

2 Methods

2.1 Water Chemistry Sampling

EEM Lakes

In 2019, Limnotek sampled 14 lakes as part of the EEM long-term sampling plan. These lakes included the seven sensitive lakes and three less sensitive lakes identified in the EEM Plan, the high recreational value LAK024 (Lakelse Lake; added to the EEM in 2014), and three additional control lakes added to the EEM in 2015. The three control lakes (NC184, NC194 and DCAS14A) are all located outside of the B.C. Works-influenced airshed and have baseline data for 2013 from sampling as part of the KAA (ESSA et al., 2014a). The sampling methodology is described in detail in Limnotek's technical report on the water quality monitoring (Limnotek 2020). Table 2-1 summarizes all of the EEM sites sampled during 2012-2019. Figure 2-1 shows a map of the lakes sampled in 2019.

Table 2-1. Summary of sites sampled within the EEM Program.

Sample Site	Year of Sampling								Rationale for sampling
	2012	2013	2014	2015	2016	2017	2018	2019	
	STAR	EEM	EEM	EEM	EEM	EEM	EEM	EEM	
Lake 006	✓	✓	✓	✓	✓	✓	✓	✓	EEM sensitive lake
Lake 012	✓	✓	✓	✓	✓	✓	✓	✓	EEM sensitive lake
Lake 022	✓	✓	✓	✓	✓	✓	✓	✓	EEM sensitive lake
Lake 023	✓	✓	✓	✓	✓	✓	✓	✓	EEM sensitive lake
Lake 028	✓	✓	✓	✓	✓	✓	✓	✓	EEM sensitive lake
Lake 042	✓	✓	✓	✓	✓	✓	✓	✓	EEM sensitive lake
Lake 044	✓	✓	✓	✓	✓	✓	✓	✓	EEM sensitive lake
Lake 007	✓	✓	✓	✓	✓	✓	✓	✓	EEM less sensitive lake
Lake 016	✓	✓	✓	✓	✓	✓	✓	✓	EEM less sensitive lake
Lake 034	✓	✓	✓	✓	✓	✓	✓	✓	EEM less sensitive lake
Lake 024	✓		✓	✓	✓	✓	✓	✓	Added to the EEM long-term monitoring lake set due to public importance
NC184		✓[1]		✓	✓	✓	✓	✓	Control lakes added to EEM in 2015
NC194		✓[1]		✓	✓	✓	✓	✓	
DCAS14A		✓[1]		✓	✓	✓	✓	✓	
MOE3		✓							Potentially sensitive lakes / streams not previously sampled
Cecil Creek 1		✓							
Cecil Creek 2		✓							
Cecil Creek 3		✓							
MOE6			✓						
Goose Creek tributaries									
GC1			✓						
GC2			✓						
GC2us							✓	✓	
GC3							✓		
GC4			✓						
GC5			✓				✓		
GC6			✓				✓	✓	
GC7			✓						
GC8							✓		
GCNT1				✓			✓		
GCNT2				✓			✓	✓	

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

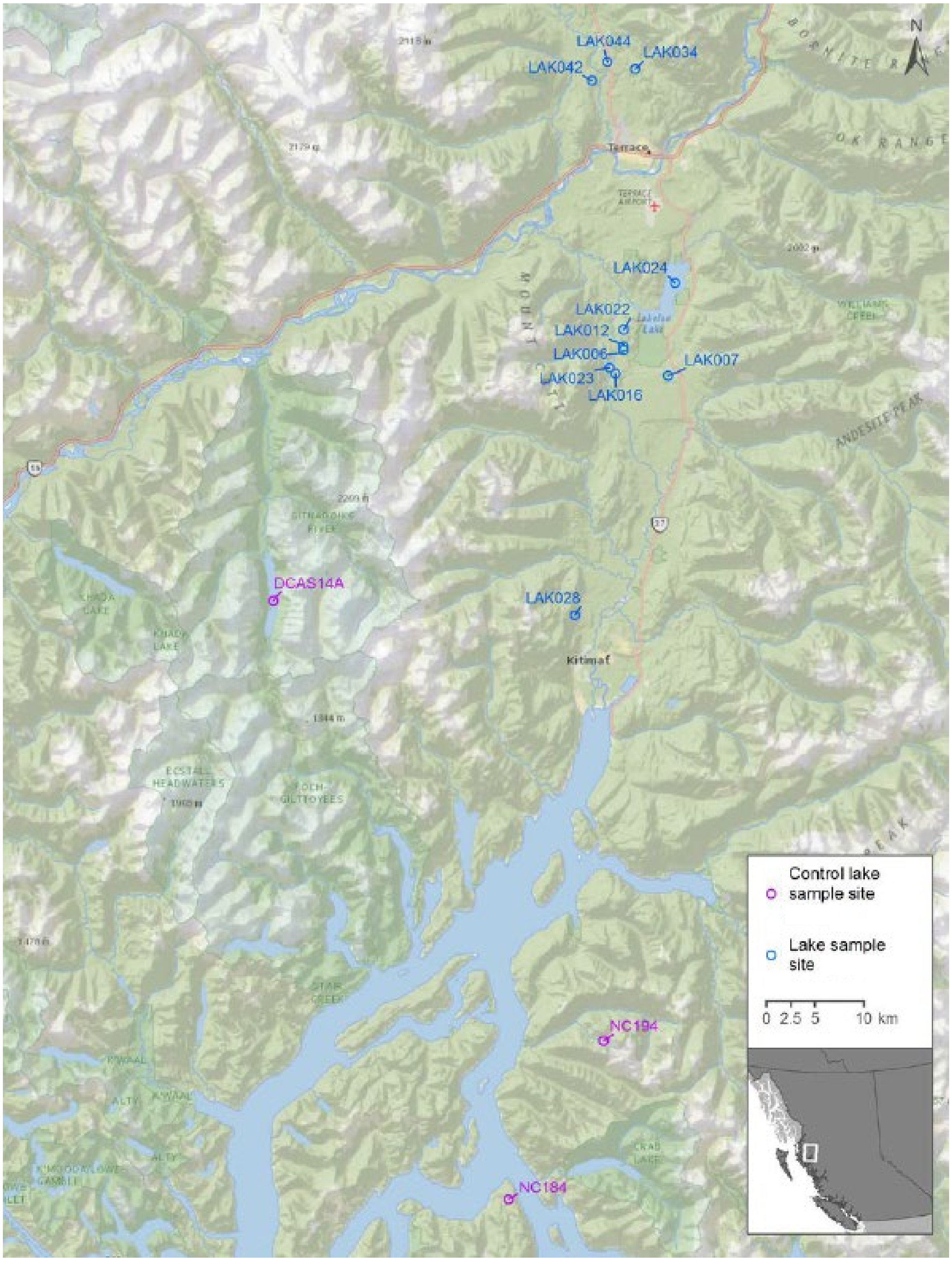


Figure 2-1. Location of the lakes that were sampled in 2019. The three control lakes are labelled with purple text (Source: Bennett and Perrin 2018).

Sampling frequency

The only differences in sampling frequency from the last several years were:

- The three EEM control lakes were each sampled three times in October rather than just once, to assess variability in lake chemistry within the October sampling period
- LAK028 had four additional samples with full chemistry analysis taken over June through early September, to assess seasonal variability in lake chemistry
- LAK028 had deep water samples with full chemistry analysis taken concurrent to each of the surface water samples, to assess hypolimnetic processes such as bacterial sulphate reduction

Continuous monitoring

Four lakes (LAK006, LAK012, LAK023, 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 2019 are reported in Limnotek (2020).

Water chemistry data

The only difference in the water chemistry data from the 2019 sample compared to previous years is that all the samples taken during the fall index period had duplicate samples sent to an additional laboratory (BASL, University of Alberta) for analysis of pH, Gran ANC and conductivity. More details, including a cross-lab comparison, are reported in Limnotek (2020).

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 EEM Program, proposing instead that BCS be used as an indicator of Al toxicity concerns.

This Annual Report thus repeats the analyses conducted in the Comprehensive Review with the 2019 data and compares those results to the 2013 data, with the primary focus of determining whether the same conclusions hold true when examined with data from a different year. Additionally, the 2019 data include a total of 51 observation from surface waters, compared to only 12 for 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 first iteration of re-running those analyses with an additional year of monitoring data. These methods are described in detail in the Appendix F of the 2019 Comprehensive Review Report (see Bayesian Method 1 especially).

3 Results

3.1 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 2019 (with the data from 2012-2018 included for reference), for major water chemistry metrics (pH, DOC, Gran ANC, base cations, and major anions).

3.2 Empirical Changes in Water Chemistry

Empirical changes in pH, Gran ANC, 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 (2016-2019) 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 previous annual reports, 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 2016-2019.

For additional reference, Table 3-2 shows the pH values over period of record for EEM lakes and average pH values for both the full post-KMP period (i.e., 2016-2019) and the post-KMP period applied in the 2019 comprehensive review (i.e., 2016-2018). These data facilitate comparison to the results of the 2019 comprehensive review and explicitly illustrate how the 2019 data relates to those previously reported results.

Appendix 2 provides a detailed set of figures showing the inter-annual changes in major water chemistry metrics (Gran ANC, base cations, calcium, SO_4^{2-}, chloride, pH and DOC) for each of the EEM lakes across the eight years of annual monitoring (2012-2019). Similar figures are also included for the three control lakes based on their six years of annual monitoring (2013 and 2015-2019).

Table 3-1. Empirical changes in pH, Gran ANC, SO_4^{2-}, DOC, base cations, chloride, and calcium for EEM lakes, 2012-2019. Both the differences across the full record of sampling and from 2012 to the average of the post-KMP period (2016-2019) are shown. 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 pink.

SITE	pH (TU)	Gran ANC (μeq/L)	SO_4^{2-} (μeq/L)	DOC (mg/L)	∑ BC (μeq/L)	Cl (μeq/L)	Ca (μeq/L)
Lak006	0.3	3.0	3.3	0.3	13.7	0.2	5.1
LAK012	0.5	0.5	6.9	0.3	-9.5	2.3	-12.5
LAK022	0.2	5.9	11.2	0.7	18.9	0.8	10.8
LAK023	0.2	5.2	-6.4	1.5	6.9	0.4	4.1
LAK028	0.1	2.2	76.5	1.4	68.0	3.1	46.7
LAK042	0.6	27.2	-0.2	-2.8	10.2	0.4	6.4
LAK044	0.1	4.0	-1.8	0.3	4.3	0.7	1.5
Total ↑	**7**	**7**	**4**	**6**	**6**	**7**	**6**
Total ↓	**0**	**0**	**3**	**1**	**1**	**0**	**1**
LAK007	0.1	-54.5	-5.4	-0.2	-11.6	2.0	-21.9
LAK016	0.3	21.4	9.0	0.9	15.5	1.7	6.8
LAK024	0.4	172.2	14.5	0.6	231.7	42.8	176.1
LAK034	-0.3	42.5	-23.8	1.5	-8.8	-1.3	-1.6
Total ↑	**3**	**3**	**2**	**3**	**2**	**3**	**2**
Total ↓	**1**	**1**	**2**	**1**	**2**	**1**	**2**
DCAS14A	0.2	6.0	4.1	-0.1	22.4	-1.6	15.3
NC184	0.1	10.3	0.8	-1.5	8.3	-5.1	7.9
NC194	-0.2	-3.6	-1.1	0.3	7.5	-0.9	5.8
Total ↑	**2**	**2**	**2**	**1**	**3**	**0**	**3**
Total ↓	**1**	**1**	**1**	**2**	**0**	**3**	**0**

Table 3-2. pH values over period of record for EEM lakes and average pH values for the post-KMP period. For easier reference to the results described in the 2019 comprehensive review, the post-KMP averaging period applied in the CR (2016-2018) is shown as well as the difference between those values and the new empirical data from 2019.

	2012	2013	2014	2015	2016	2017	2018	2019	Post-KMP averaging period 2016-18	Post-KMP averaging period 2016-19	Difference between 2019 and 2016-18 CR averaging period
LAK006	5.8	6.2	6.1	6.0	6.0	6.0	6.1	6.1	6.0	6.1	0.1
LAK012	5.6	6.3	6.0	6.0	6.2	6.1	6.2	6.1	6.2	6.1	-0.1
LAK022	5.9	6.2	6.3	6.1	6.1	6.1	6.1	6.1	6.1	6.1	0.0
LAK023	5.7	6.0	5.9	5.9	5.9	5.9	6.0	5.8	5.9	5.9	-0.1
LAK028	5.0	5.2	5.3	5.1	5.0	4.8	5.3	5.2	5.0	5.0	0.2
LAK042	4.7	5.5	5.1	5.4	5.4	5.2	5.1	5.4	5.2	5.3	0.2
LAK044	5.4	5.7	5.8	5.8	5.5	5.6	5.5	5.5	5.6	5.5	0.0
LAK007	8.0	7.9	8.1	8.0	8.0	8.0	8.1	8.1	8.0	8.0	0.1
LAK016	6.3	6.7	6.7	6.8	6.6	6.7	6.7	6.6	6.7	6.6	-0.1
LAK024	7.1		7.6	7.4	7.5	7.4	7.6	7.7	7.5	7.5	0.2
LAK034	6.7	6.9	6.7	6.6	6.5	6.4	6.5	6.4	6.4	6.4	0.0
DCAS14A		6.5		6.6	6.6	6.6	6.8	6.6	6.6	6.6	-0.1
NC184		5.7		5.5	5.8	5.4	6.2	5.7	5.8	5.8	-0.1
NC194		6.6		6.5	6.4	6.4	6.5	6.4	6.4	6.4	0.0

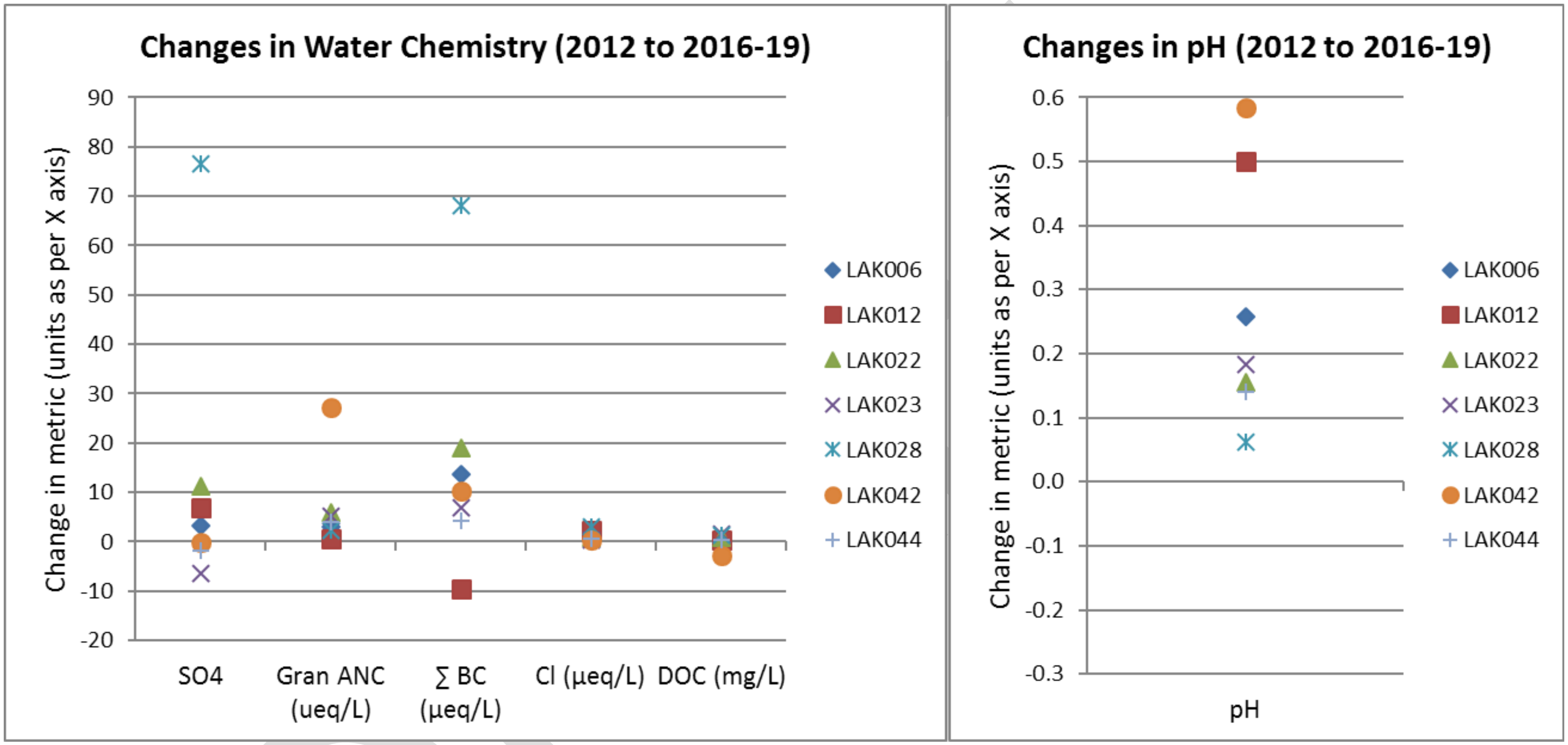


Figure 3-1. Changes in water chemistry metrics (left panel) and pH (right panel) across all of the sensitive EEM lakes, from 2012 to 2016-2019. Values shown are the mean 2016-2019 value minus the mean 2012 value. The large increase in lake SO_4^{2-} in LAK028 has been buffered by a large increase in base cations, due to cation exchange in watershed soils.

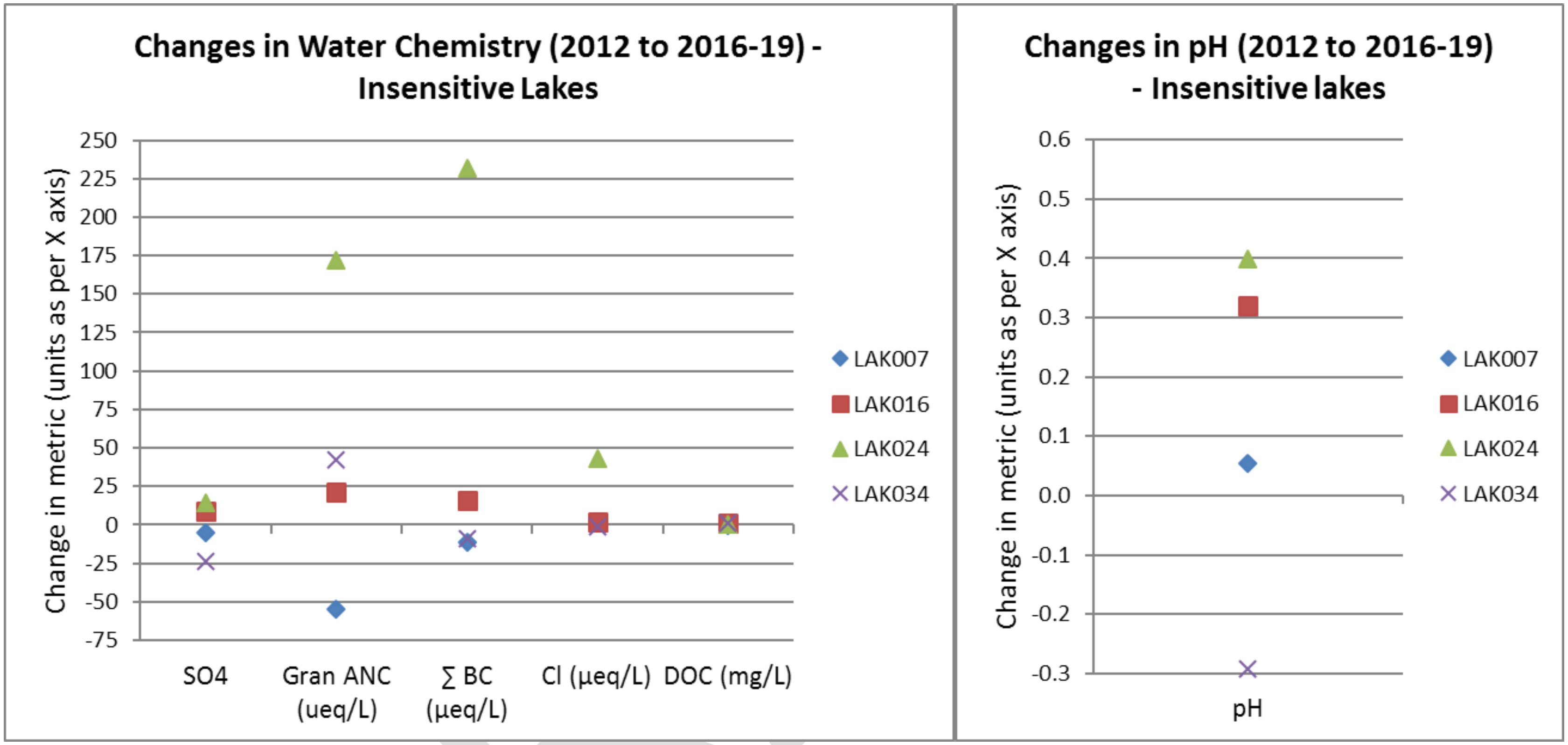
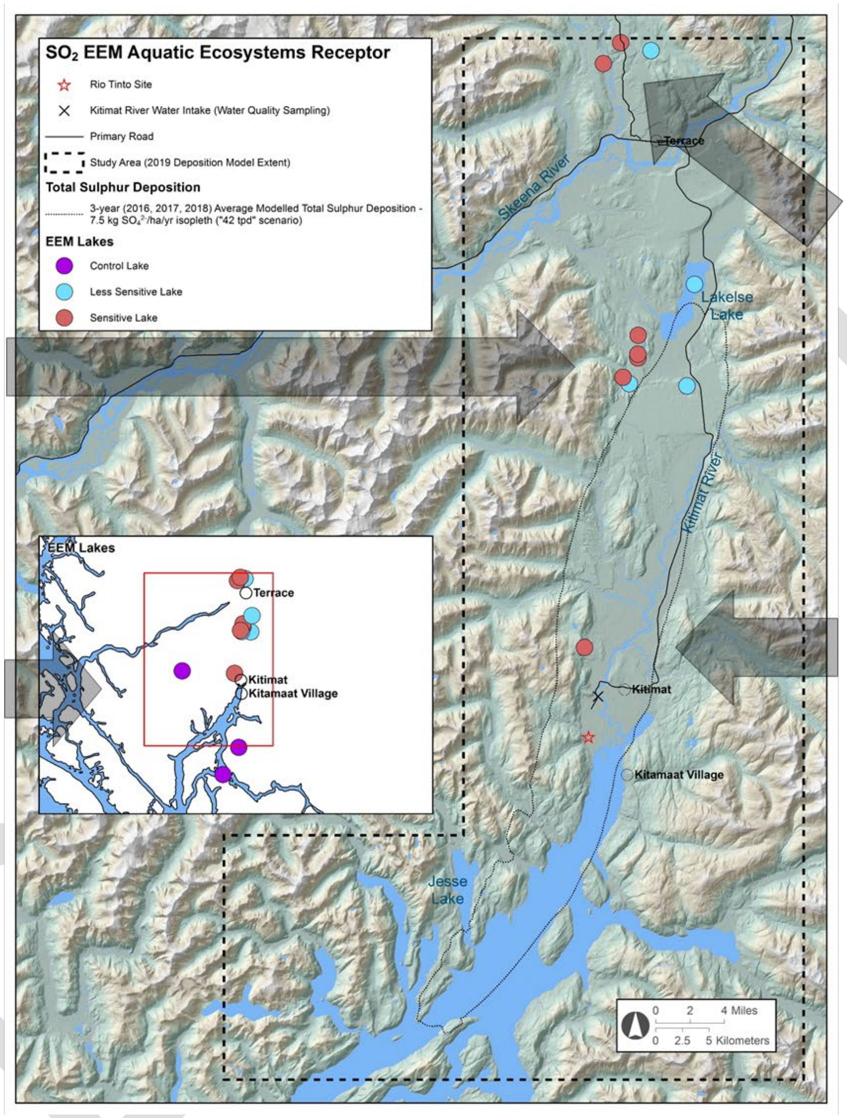


Figure 3-2. Changes in water chemistry metrics (left panel) and pH (right panel) across all of the less sensitive EEM lakes, from 2012 to 2016-2019. Values shown are the mean 2016-2019 value minus the mean 2012 value. The decline in Gran ANC in LAK007, and the decline in pH in LAK034 are both not related to the smelter as SO_4^{2-} declined.

	2012 to 2016-19		
LAKE	ΔSO_4^{2-}	ΔANC	ΔpH
Lak006	3.3	3.0	0.3
LAK012	6.9	0.5	0.5
LAK022	11.2	5.9	0.2
LAK023	-6.4	5.2	0.2
LAK007	-5.4	-54.5	0.1
LAK016	9.0	21.4	0.3
LAK024	14.5	172.2	0.4

	2013 to 2016-19		
LAKE	ΔSO_4^{2-}	Δ ANC	Δ pH
DCAS14A	4.1	6.0	0.2
NC184	0.8	10.3	0.1
NC194	-1.1	-3.6	-0.2



	2012 to 2016-19		
LAKE	ΔSO_4^{2-}	Δ ANC	Δ pH
LAK042	-0.2	27.2	0.6
LAK044	-1.8	4.0	0.1
LAK034	-23.8	42.5	-0.3

	2012 to 2016-19		
LAKE	ΔSO_4^{2-}	Δ ANC	Δ pH
LAK028	76.5	2.2	0.1

Figure 3-3. Observed changes in SO_4^{2-}, Gran ANC and pH from the baseline period (2012) to the post-KMP period (2016-2019). Green cells indicate increases and red cells indicate decreases.

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).

Figure 3-4 shows that the 2019 data show similar patterns as those identified in the Comprehensive Review - a positive, potentially non-linear relationship between Al_{im} and total Al. Only those sites with total Al values greater than 0.1 mg/L have appreciable levels of Al_{im}. LAK028 continues to have the highest levels of aluminum, then LAK042 and NC184, albeit at much lower concentrations. Figure 3-4 suggests that both LAK028 and LAK042 have increased in Al_{im} since 2013. For LAK042, the total Al values in 2019 are similar or higher than the single sample in 2013. For LAK028, the total Al values in 2019 span a range that includes values both higher and lower than the single sample in 2013. Based on the 2019 data, the range in total Al is notably larger than the range in Al_{im} for both LAK028 and LAK042.

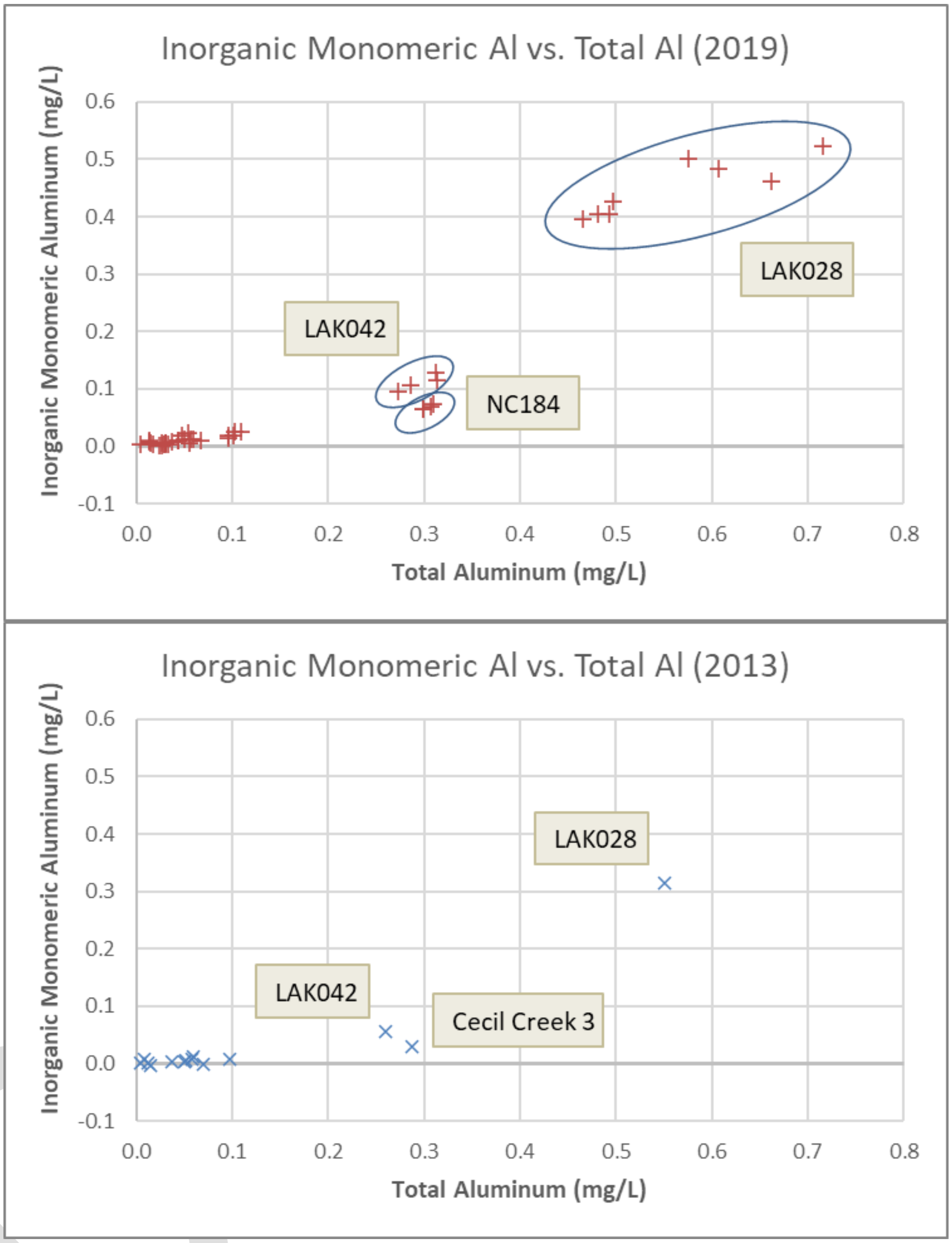


Figure 3-4. Inorganic monomeric aluminum versus total aluminum for 2019 samples (top) and 2013 samples (bottom). Lakes with higher aluminum values are indicated.

Figure 3-5 shows that the expected pattern of Al_{im} increasing with decreasing pH is reflected in the 2019 data. Again, this pattern is most apparent in samples with pH<5.5, illustrated in particular by the same two lakes as in the 2013 data (LAK028 and LAK042). Although it was clear with the 2013 data that the lakes with low pH and higher Al_{im} are also among the sites with the highest DOC levels, this pattern is no longer clear in the 2019 data due to changes in DOC for LAK028. The DOC values for the 2019 samples taken from LAK028 are lower than the value measured in 2013 and predominantly within the "intermediate" range, yet the Al_{im}

values are still the highest and have in fact increased significantly from the 2013 value. Although the DOC values for LAK028 span all three DOC classes, the samples classified as low and high are only 0.2 and 0.03 mg/L outside the "intermediate" range, respectively.

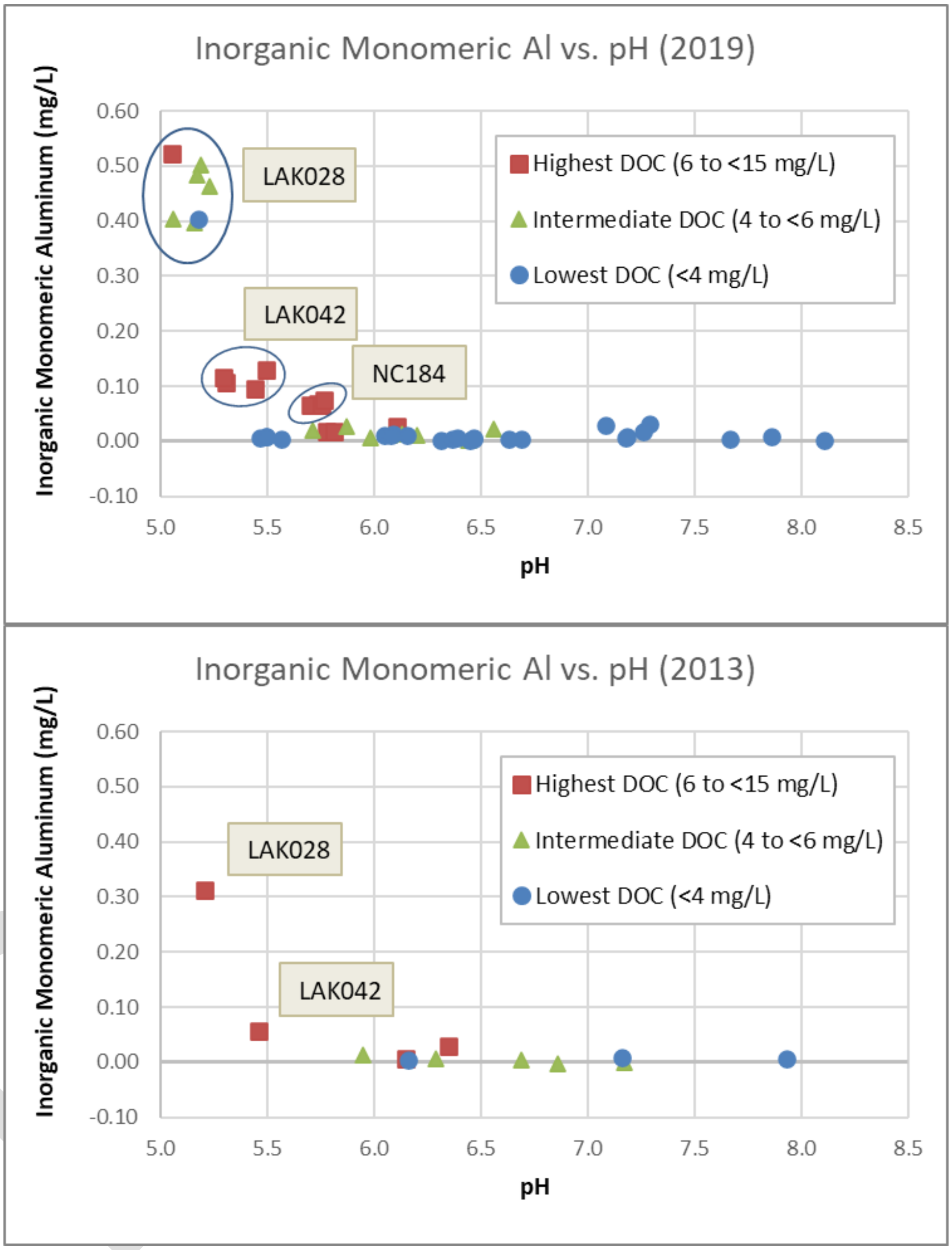


Figure 3-5. Inorganic monomeric aluminum versus pH for 2019 samples (top) and 2013 samples (bottom). The sites are stratified into three classes of DOC, which were applied in the Comprehensive Review based on natural breaks in the 2013 data.

The 2019 data show that concentrations of Al_{im} are inversely related to a lake's BCS and pH, and positively related to a lake's DOC. Within a lake, the DOC present in organic acids will complex aluminum and transform it into the less toxic organic form. However, high concentrations of organic acids can also scavenge sources of aluminum from watershed soils, and bring Al into the lake, thereby increasing the total input of aluminum into lake water (Driscoll 1985).

Similar to 2013, the 2019 data shows 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 and Figure 3-7). 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. As with the 2013 data, LAK028 (pH 5.2, DOC 4.1 to 5.2 mg/L) was again the only lake with BCS < 0 μeq/L and correspondingly has the highest values of Al_{im}. LAK042 (mean pH 5.4, a naturally acidified lake with DOC values in the range of 8.3 to 10.6 mg/L), has the second highest Al_{im} values (mean of 0.11 mg/L), and BCS values in the range of 6-12 μeq/L. About 37% of the total Al (mean 0.30 mg/L) appears as Al_{im} (mean 0.11 mg/L) in LAK042. The only other samples with BCS < 25 μeq/L in 2019 are for LAK044 (2-8 μeq/L), but its Al_{im} values are about 1/20th of those of LAK042. The most likely explanation for the differences between LAK042 and LAK044 is that despite similar pH values (5.4 and 5.5, respectively), LAK044 has much lower DOC values than LAK042 (1.9 to 3.0 mg/L versus 8.3 to 10.6 mg/L), resulting in less transport of watershed sources of Al into LAK044.

Lake NC184 (mean pH 5.7, mean DOC 9.3 mg/L) has a mean Al_{im} of 0.07 mg/L, about 2/3 the value of LAK042), but has a much higher BCS than LAK042, in the range of 39-48 μeq/L. It's plausible that this lake's high DOC helps to complex and transport watershed sources of aluminum into the lake in a complexed form, with about 23% of the total Al (0.07 / 0.3) ultimately remaining in the form of Al_{im}.

Repeating these simple exploratory analyses of Al_{im} with the 2019 data leads to the same conclusion as expressed in the Comprehensive Review based on the 2013 data – LAK028 is still the only lake with concerns regarding potential aluminum toxicity. The higher values of Al_{im} in LAK042 and NC184 are most likely due to higher concentrations of DOC, and transport of organically-complexed Al from the watershed. LAK042 and NC184 have consistently had the two highest DOC levels of all the EEM lakes and in 2019 their mean DOC values were more than 50% higher than the next highest. The findings of these repeated analyses corroborate the findings from that the preliminary analyses that suggest that BCS provides sufficient information on the potential for toxic conditions without the additional measurement of Al_{im}. This conclusion can be further corroborated with samples of Al_{im} taken in 2020.

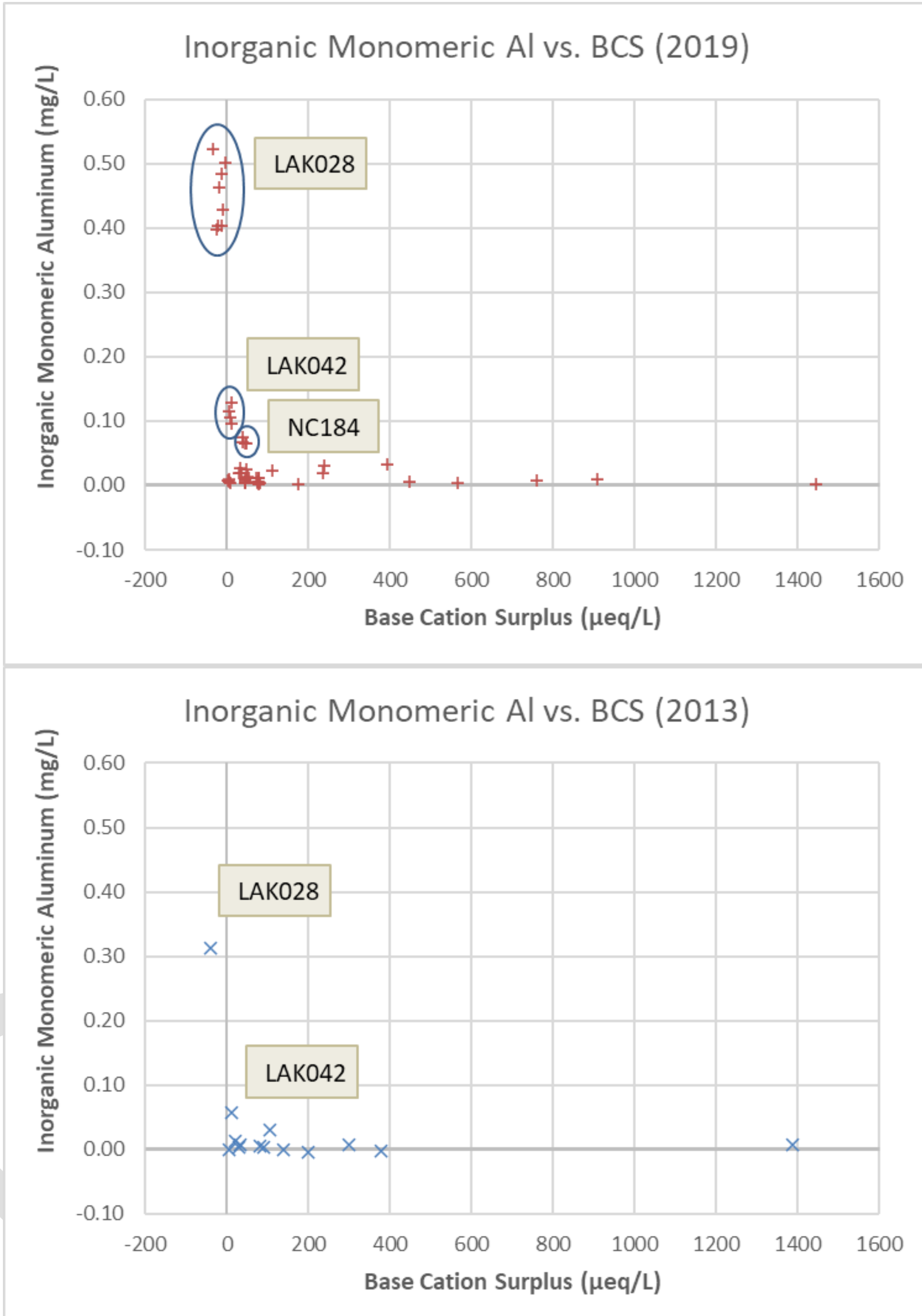


Figure 3-6. Inorganic monomeric aluminum versus Base Cation Surplus (BCS) for 2019 samples (top) and 2013 samples (bottom).

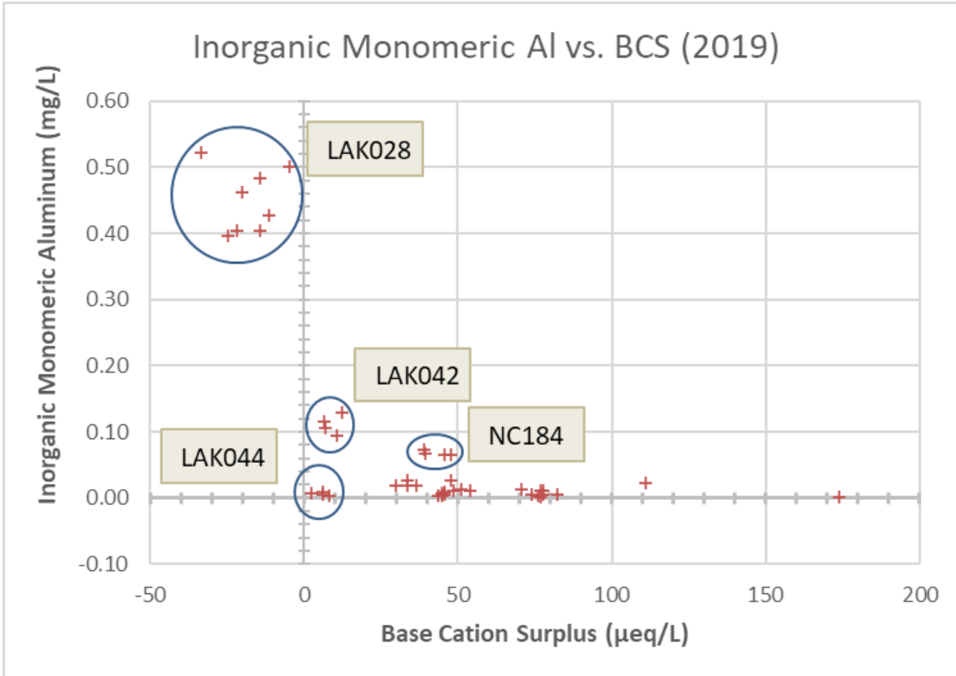


Figure 3-7. Inorganic monomeric aluminum versus Base Cation Surplus (BCS) for 2019 samples with BCS <200 µeq/L (equivalent to Figure 3-6 but with zoomed in x-axis).

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 3-3 and Figure 3-4. These results applied Bayesian Method 1, described in Appendix F of the 2019 Comprehensive Review Report.

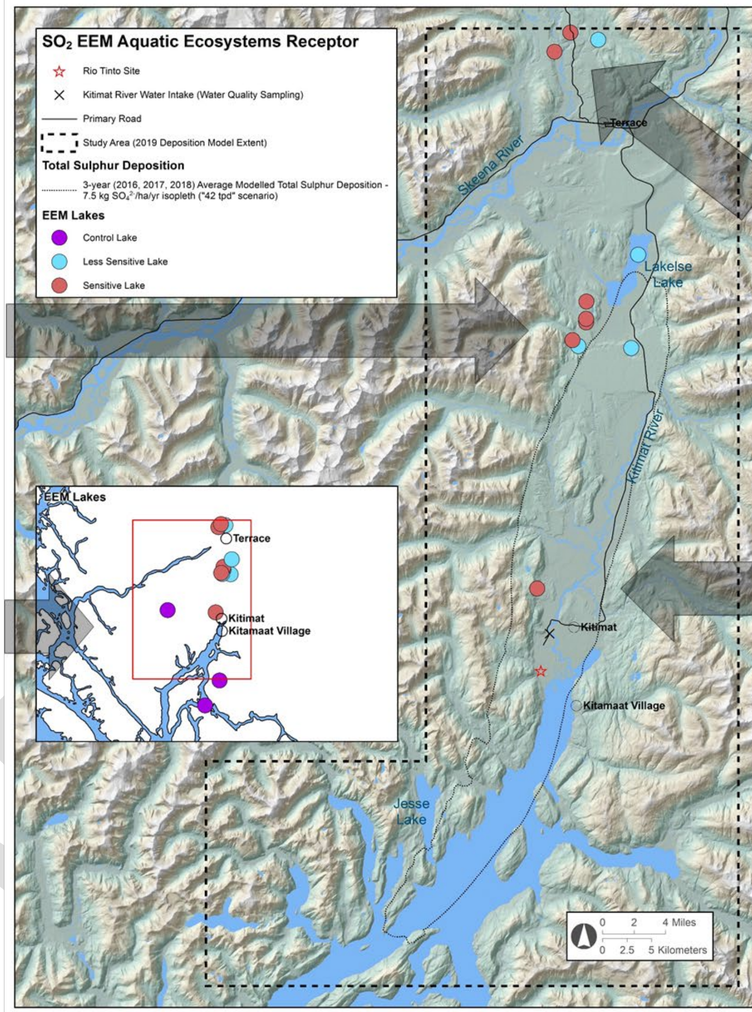
Table 3-3. Summary of findings across all lakes monitored in the EEM program. The % belief values are derived from the Bayesian version of Method 1, as described in Aquatic Appendix F of the 2019 Comprehensive Review Report. Values of % belief < 20% are coloured green, 20-80% yellow, and >80% red.

LAKE	Changes in SO_4 (% belief in SO_4 increase / decrease from Bayesian analysis - Method 1 violin plot)	Changes in Gran ANC (% belief that ANC threshold exceeded, from Bayesian analysis - Method 1 violin plot)	Changes in pH (% belief that pH threshold exceeded, from Bayesian analysis - Method 1 violin plot)	OVERALL INTERPRETATION
Sensitive Lakes				
LAK006	85% belief in increase	0%	0%	SO_4 increase; no evidence of S-induced acidification
LAK012	95% belief in increase	1%	0%	SO_4 increase; no evidence of S-induced acidification
LAK022	89% belief in increase	0%	0%	SO_4 increase; no evidence of S-induced acidification
LAK023	2% belief in increase	0%	0%	SO_4 decrease; no evidence of S-induced acidification
LAK028	97% belief in increase	2%	6%	SO_4 increase; very limited evidence of S-induced acidification; low belief in exceeding pH and ANC thresholds; conditions were potentially damaging to biota pre-KMP and remained so (see section 7.3.4.2 of 2019 Comprehensive Review report).
LAK042	44% belief in increase	0%	0%	No clear change in SO_4; no evidence of S-induced acidification
LAK044	0% belief in increase	0%	0%	SO_4 decrease; no evidence of S-induced acidification
Less Sensitive Lakes				
LAK007	4% belief in increase	58%	1%	SO_4 decrease; no evidence of S-induced acidification
LAK016	81% belief in increase	0%	0%	SO_4 increase; no evidence of S-induced acidification
LAK024	98% belief in increase	1%	0%	SO_4 increase; no evidence of S-induced acidification
LAK034	0% belief in increase	0%	39% [1]	SO_4 decrease; no evidence of S-induced acidification
Control Lakes				
DCAS14A	75% belief in increase [2]	0%	0%	No clear change in SO_4; no evidence of S-induced acidification
NC184	69% belief in negligible increase [2]	5%	14%	No clear change in SO_4; no evidence of S-induced acidification
NC194	1% belief in increase	TBD [3]	4%	SO_4 decrease; no evidence of S-induced acidification

[1] Not related to S deposition as lake SO_4 has declined in LAK034.
[2] Magnitude of increase in [SO_4] between 2013 and 2016-2019 is small in DCAS14A (4.1 μeq/L) and very small in NC184 (0.8 μeq/L).
[3] Lake NC194 did not have a lab titration from which we could determine an ANC threshold. It had a 57% belief in an ANC decline (about 3.6 μeq/L between 2013 and 2016-2019), though very low belief (1%) in a SO_4 increase, so the ANC decline was not related to SO_4.

	% belief in change		
LAKE	↑ SO_4^{2-}	↓ ANC	↓ pH
LAK006	85%	0%	0%
LAK012	95%	0%	0%
LAK022	89%	0%	0%
LAK023	2%	0%	0%
LAK007	4%	58%	1%
LAK016	81%	0%	0%
LAK024	98%	0%	0%

	% belief in change		
LAKE	↑ SO_4^{2-}	↓ ANC	↓ pH
DCAS14A	75%**	0%	6%
NC184	69%**	4%	28%
NC194	1%	TBD	12%



	% belief in change		
LAKE	↑ SO_4^{2-}	↓ ANC	↓ pH
LAK042	44%	0%	0%
LAK044	0%	0%	0%
LAK034	0%	0%	39%

	% belief in change		
LAKE	↑ SO_4^{2-}	↓ ANC	↓ pH
LAK028	97%	1%	6%

Figure 3-8. Spatial distribution of percent belief in chemical change. Numbers show % belief in: a) SO4 increase (no threshold), b) pH decrease below 0.3 threshold, and c) Gran ANC decrease below lake-specific 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. **The increase in SO_4^{2-} in control lake DCAS014A was only ~4.1 μeq/L, and only 0.8 μeq/L in NC184.

4 Discussion

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

The mean values of pH and Gran ANC indicate that there have been no exceedances of the KPI thresholds.

None of the 7 sensitive EEM lakes show any decrease in pH from the 2012 baseline to the post-KMP period of 2016-2019. The empirical data indicate that none of the lakes have exceeded the threshold of a 0.3 unit decline in pH associated with the KPI.

Similarly, none of the 7 sensitive EEM lakes show any decrease in Gran ANC over this timeframe either and thus the empirical data indicate that none of the lakes have exceeded the lake-specific thresholds of decline put forward in the comprehensive review.

The following section applies statistical analyses to the same data to assess the percent belief that KPI thresholds could have been exceeded.

4.2 Statistical Analysis of Changes in Lake Chemistry

Table 4-1 shows the results from 2019 compared to the results reported in the 2019 comprehensive review. The results were **very** similar, which shows that the conclusions of the comprehensive review are strongly supported with an additional year of monitoring data. For SO_4^{2-}, only two lakes had changes in % belief of greater than 10% - less sensitive lake LAK016 decreased from a 97% belief in an increase to an 81% belief and control lake NC184 increased from a 58% belief to a 69% belief in an increase (of negligible magnitude). For Gran ANC, none of the lakes had changes in % belief of greater than 1%. For pH, only two lakes had changes in % belief of greater than 10% - sensitive lake LAK028 decreased from an 18% belief to a 6% belief in exceeding the pH threshold (i.e., decreasing in pH by >0.3 pH units) and control lake NC184 decreased from a 28% belief to a 14% belief. The decrease in percent belief for LAK028 is an important result. LAK028 is the only lake which showed evidence of sulphur-induced acidification (both pre- and post-KMP). It previously showed low support for an exceedance of the pH KPI threshold (18%), and it now shows very low support (6%). Out of 14 total lakes, the number that showed differences in % belief of <5% were 10 for SO_4^{2-}, all 14 for Gran ANC, and 10 for pH.

Table 4-1. Comparison of the results of the updated statistical analyses including the 2019 data to the results presented in the 2019 comprehensive review (CR). The 2019 results are the same as Table 3-3. 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 from Bayesian analysis - Method 1 violin plot)		Changes in Gran ANC (% belief that ANC threshold exceeded, from Bayesian analysis - Method 1 violin plot)		Changes in pH (% belief that pH threshold exceeded, from Bayesian analysis - Method 1 violin plot)	
	CR Results	2019 Results	CR Results	2019 Results	CR Results	2019 Results
Sensitive Lakes						
LAK006	83% belief in increase	85% belief in increase	0%	0%	1%	0%
LAK012	91% belief in increase	95% belief in increase	1%	0%	1%	0%
LAK022	88% belief in increase	89% belief in increase	0%	0%	0%	0%
LAK023	5% belief in increase	2% belief in increase	0%	0%	1%	0%
LAK028	96% belief in increase	97% belief in increase	2%	1%	18%	6%
LAK042	36% belief in increase	44% belief in increase	0%	0%	2%	0%
LAK044	1% belief in increase	0% belief in increase	0%	0%	0%	0%
Less Sensitive Lakes						
LAK007	0% belief in increase	4% belief in increase	58%	58%	2%	1%
LAK016	97% belief in increase	81% belief in increase	0%	0%	1%	0%
LAK024	96% belief in increase	98% belief in increase	1%	0%	1%	0%
LAK034	0% belief in increase	0% belief in increase	0%	0%	43%	39%
Control Lakes						
DCAS14A	68% belief in increase	75% belief in increase	0%	0%	6%	0%
NC184	58% belief in negligible increase	69% belief in negligible increase	5%	4%	28%	14%
NC194	1% belief in increase	1% belief in increase	TBD	TBD	12%	4%

4.3 Application of the Evidentiary Framework

We have applied the simplified evidentiary framework, as described in the 2019 Comprehensive Review Report, using the updated results of the statistical analyses. The results are shown in Figure 4-1. The underlying results are compiled in Table 4-2. The updated application of the simplified evidentiary framework show that: a) 2 sensitive lakes, 2 less sensitive lakes, and all 3 control lakes[2] land within the first box, "smelter not causally linked to changes in lake chemistry"; b) 3 sensitive lakes and 2 less sensitive lakes all land within the second box, "lake is healthy, and not acidifying"; and c) 2 sensitive lakes (LAK012 and LAK028) land within "some evidence of acidification". For LAK012, this classification is based on intermediate support for a decline in Gran ANC (47% belief) but zero support for a decline in pH. For LAK028, this classification is based on low-intermediate support for declines in Gran ANC (37% belief) and pH (35% belief). However, both lakes have very low to zero support for declines exceeding their Gran ANC and pH thresholds. The classification of LAK042 is also based on only intermediate support for an increase in SO_4^{2-} (44% belief). These results completely mirror those presented in the 2019 comprehensive review. None of the lakes have moved positions within the framework.

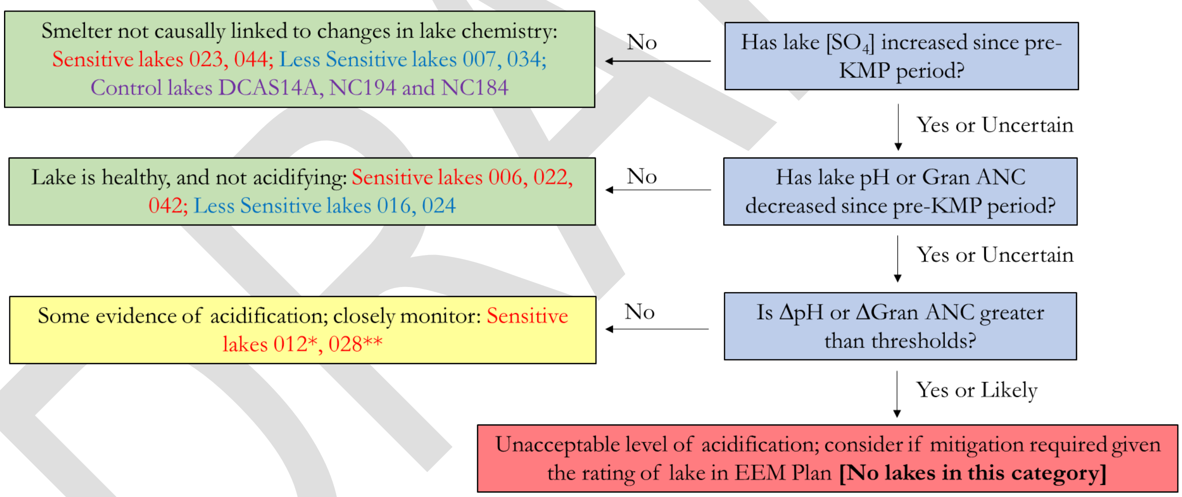


Figure 4-1. Classification of EEM lakes according to the simplified evidentiary framework. * LAK012 has intermediate support for decline in Gran ANC but no support for exceeding the threshold. ** LAK028 has low-intermediate support for declines in Gran ANC and pH but very low support for exceeding the thresholds.

[2] 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.

Table 4-2. Results used in the application of the simplified evidentiary framework. The first four columns are identical to Table 3-3 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)	**Changes in Gran ANC** (% belief that ANC threshold exceeded)	**Changes in pH** (% belief that pH threshold exceeded)	**Change in Gran ANC (no threshold)** (% belief that ANC decreased)	**Change in pH (no threshold)** (% belief that pH decreased)
	(% belief values from Bayesian analysis – Method 1 violin plots)				
Sensitive Lakes					
LAK006	85% belief in increase	0%	0%	7%	0%
LAK012	95% belief in increase	1%	0%	45%	0%
LAK022	89% belief in increase	0%	0%	6%	1%
LAK023	2% belief in increase	0%	0%	9%	1%
LAK028	97% belief in increase	2%	6%	37%	35%
LAK042	44% belief in increase	0%	0%	0%	0%
LAK044	0% belief in increase	0%	0%	1%	0%
Less Sensitive Lakes					
LAK007	4% belief in increase	58%	1%	96%	28%
LAK016	81% belief in increase	0%	0%	1%	2%
LAK024	98% belief in increase	1%	0%	2%	4%
LAK034	0% belief in increase	0%	39%	1%	100%
Control Lakes					
DCAS14A	75% belief in increase	0%	0%	4%	12%
NC184	69% belief in negligible increase	5%	14%	20%	47%
NC194	1% belief in increase	TBD [3]	4%	57%	99%

5 Recommendations

The 2019 EEM Comprehensive Review Report provides extensive recommendations with respect to the aquatic ecosystems component of the EEM Program. These recommendations will be reviewed in depth during the forthcoming discussions on the design of the EEM Phase II update.

The recommendation directly associated with this Annual Report is that BCS should be sufficient for evaluating risks to biota without additional monitoring of inorganic monomeric Al. This recommendation will be re-evaluated with water samples collected in the fall of 2020, which included analyses for inorganic, monomeric aluminum.

6 References Cited

Bennett, S. and C.J. Perrin. 2017. Rio Tinto Alcan Kitimat Modernization Project: Environmental effects monitoring of lakes in 2016. Report prepared by Limnotek Research and Development Inc. for Rio Tinto Alcan Ltd. 40pp. plus appendices.

Bennett, S. and C.J. Perrin. 2018. Rio Tinto Alcan Kitimat Modernization Project: Environmental effects monitoring of lakes in 2017. Report prepared by Limnotek Research and Development Inc. for Rio Tinto Alcan Ltd. 49pp. plus appendices.

Driscoll, C. T., 1985. Aluminum in acidic surface waters: chemistry, transport, and effects. Environmental Health Perspectives (63): 93-104.

ESSA Technologies, J. Laurence, Limnotek, Risk Sciences International, Rio Tinto Alcan, Trent University, Trinity Consultants and University of Illinois. 2013. Sulphur Dioxide Technical Assessment Report in Support of the 2013 Application to Amend the P2-00001 Multimedia Permit for the Kitimat Modernization Project. Vol.2: Final Technical Report. Prepared for RTA, Kitimat, BC. 450 pp.

ESSA Technologies, J. Laurence, Risk Sciences International, Trent University, and Trinity Consultants. 2014a. Kitimat Airshed Emissions Effects Assessment. Report prepared for BC Ministry of Environment, Smithers, BC. 205 pp. + appendices.

ESSA Technologies, J. Laurence, Limnotek, Risk Sciences International, Trent University, and Trinity Consultants. 2014b. Sulphur Dioxide Environmental Effects Monitoring Program for the Kitimat Modernization Project. Program Plan for 2013 to 2018. Prepared for Rio Tinto Alcan, Kitimat, B.C. 99 pp.

ESSA Technologies, J. Laurence, Risk Sciences International, Trent University, and Trinity Consultants. 2020. 2019 Comprehensive Review of Sulphur Dioxide Environmental Effects Monitoring for the Kitimat Modernization Project – Volume 2, V.2. Prepared June 30, 2020 for Rio Tinto, B.C. Works, Kitimat, B.C.

ESSA Technologies. 2015. Sulphur Dioxide Environmental Effects Monitoring for the Kitimat Modernization Project – 2013 and 2014 Annual Reports. Prepared for Rio Tinto Alcan, Kitimat, B.C. 27 pp.

ESSA Technologies Ltd. 2016. Sulphur Dioxide Environmental Effects Monitoring for the Kitimat Modernization Project – 2015 Annual Report. Prepared for Rio Tinto Alcan, Kitimat, B.C.

ESSA Technologies Ltd. 2017. Sulphur Dioxide Environmental Effects Monitoring for the Kitimat Modernization Project – 2016 Annual Report. Prepared for Rio Tinto Alcan, Kitimat, B.C.

ESSA Technologies Ltd. 2018. Sulphur Dioxide Environmental Effects Monitoring for the Kitimat Modernization Project – 2017 Annual Report. Prepared for Rio Tinto Alcan, Kitimat, B.C.

Limnotek. 2016. Rio Tinto Alcan Kitimat Modernization Project: Environmental effects monitoring of water and aquatic Biota in 2015. Report prepared by Limnotek Research and Development Inc. for Rio Tinto Alcan Ltd. 66p.

Limnotek. 2019. Rio Tinto Kitimat Modernization Project: Environmental effects monitoring of lakes and streams in 2018. Report prepared by Limnotek Research and Development Inc. for Rio Tinto Ltd. 84pp. plus appendices.

Limnotek. 2020. Rio Tinto SO2 Environmental Effects Program: Monitoring of lakes and streams in 2019. Report prepared by Limnotek Research and Development Inc. for Rio Tinto Ltd. 111pp.

Marmorek, D.R., M.L. Jones, C.K. Minns, and F.C. Elder. 1990. Assessing the potential extent of damage to inland lakes in eastern Canada due to acidic deposition. I. Development and evaluation of a simple "site" model. Can. J. Fish. Aquat. Sci. 47: 55-66.

Oliver, B.G., E.M. Thurman, and R.L., Malcolm. 1983. The contribution of humic substances to the acidity of colored natural waters. Geochim. Cosmochim. Acta 47, 2031.

Perrin, C.J and S. Bennett 2015. Rio Tinto Alcan Kitimat Modernization Project: Environmental effects monitoring of lake water quality in 2014. Data report prepared by Limnotek Research and Development Inc. for Rio Tinto Alcan Ltd. 20p.

Perrin, C.J., E. Parkinson and S. Bennett 2013. Rio Tinto Alcan Kitimat Modernization Project: Environmental effects monitoring of water and aquatic Biota in 2013. Report prepared by Limnotek Research and Development Inc. for Rio Tinto Alcan Ltd. 41p.

Appendix 1: Water Chemistry Data from Annual Sampling, 2012-2019

The two tables below shows the sample results for each of the EEM lakes and control lakes from annual monitoring conducted from 2012 to 2019, including pH, dissolved organic carbon (DOC), Gran ANC, and the concentration of major anions and cations, as well as the sum of all base cations (BC). In 2013-2019, the pH of the water samples was measured by two different laboratories (Trent University and ALS).

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	pH TU	SE[1]	pH ALS	SE	DOC mg/L	SE	Gran ANC µeq/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
LAK006	2012	5.8				3.6		25.7		11.4		5.8		4.5		30.3		12.5		2.9		14.9		60.6
LAK007	2012	8.0				0.6		1437.6		51.4		24.6		2.8		1272.2		157.0		19.3		55.4		1503.9
LAK012	2012	5.6				4.6		57.0		6.1		4.2		5.0		74.5		20.8		5.2		20.0		120.6
LAK016	2012	6.3				3.7		68.7		39.0		6.3		7.8		117.7		20.5		7.3		20.8		166.3
LAK022	2012	5.9				5.3		27.8		30.2		6.9		6.1		58.1		16.0		3.2		20.8		98.1
LAK023	2012	5.7				4.2		19.8		19.0		4.5		5.6		39.4		12.0		3.7		10.8		65.9
LAK024	2012	7.1				1.4		299.5		24.8		27.3		1.6		273.2		33.0		4.2		29.6		340.0
LAK028	2012	5.0				4.9		-4.0		56.9		6.1		20.7		47.5		9.5		3.1		12.8		72.9
LAK034	2012	6.7				4.5		99.4		24.1		5.8		5.8		119.3		31.6		5.8		44.9		201.7
LAK042	2012	4.7				13.2		-20.4		6.2		6.1		3.2		7.4		22.7		3.1		20.3		53.4
LAK044	2012	5.4				1.7		1.3		6.2		5.6		2.9		6.8		3.2		4.1		0.0		14.2
LAK006	2013	6.2		6.1		3.2		29.0		14.4		8.7		5.6		27.1		13.0		5.3		12.2		57.6
LAK007	2013	7.9		8.1		0.1		1462.1		66.5		36.3		3.7		1226.0		156.5		21.9		47.6		1452.0
LAK012	2013	6.3		6.1		4.2		63.5		11.3		14.7		8.2		64.8		20.3		9.2		14.6		108.9
LAK016	2013	6.7		7.2		4.2		96.9		56.9		12.3		11.5		114.4		23.9		11.2		17.6		167.1
LAK022	2013	6.2		6.1		6.2		36.4		47.1		12.4		8.7		65.1		19.2		6.0		18.8		109.1
LAK023	2013	6.0		6.0		4.0		23.8		24.1		7.5		7.4		37.1		13.3		5.1		8.3		63.9
LAK024	2013																							
LAK028	2013	5.2		5.5		7.1		4.8		128.1		17.7		32.0		85.1		18.3		5.0		13.0		121.3
LAK034	2013	6.9		7.4		4.7		210.4		38.1		8.2		10.0		152.7		41.7		9.2		54.1		257.7
LAK042	2013	5.5		5.4		9.7		21.0		5.7		7.7		3.2		16.0		22.3		3.4		19.3		61.0
LAK044	2013	5.7		6.0		1.5		8.6		6.2		8.9		3.8		7.8		3.6		5.9		-2.0		15.3

Lake	Year	pH TU	SE[1]	pH ALS	SE	DOC mg/L	SE	Gran ANC µeq/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
LAK006	2014	6.1	*0.1*	6.6	*0.6*	3.8	*1.0*	38.8	*2.5*	12.1	*2.2*	8.1	*0.6*	4.8	*0.5*	31.7	*8.7*	14.6	*0.8*	4.7	*0.2*	14.5	*0.6*	65.5
LAK007	2014	8.1		8.0		0.7		1445.7		30.7		19.2		1.9		1276.8		156.7		20.2		61.8		1515.5
LAK012	2014	6.0	*0.2*	6.7	*0.4*	6.3	*2.2*	68.8	*15.2*	15.8	*11.6*	10.3	*4.9*	5.2	*0.5*	69.3	*3.5*	21.3	*1.3*	7.3	*1.1*	18.3	*3.6*	116.1
LAK016	2014	6.7		6.7		4.0		105.7		48.2		9.3		9.5		122.4		25.0		10.1		23.3		180.8
LAK022	2014	6.3		6.4		5.7		46.9		37.8		9.0		6.9		68.5		18.9		5.2		21.4		114.0
LAK023	2014	5.9	*0.1*	6.7	*0.6*	5.7	*1.0*	32.1	*2.5*	18.9	*2.2*	6.1	*0.6*	6.2	*0.5*	49.3	*8.7*	14.9	*0.8*	4.0	*0.2*	10.8	*0.6*	79.0
LAK024	2014	7.6		7.5		1.7		472.1		37.2		65.7		2.3		402.3		50.1		7.8		50.2		510.4
LAK028	2014	5.3		5.7		5.9		22.6		94.4		11.0		23.3		85.9		17.7		4.4		17.6		125.7
LAK034	2014	6.7		7.0		7.0		205.0		17.0		6.5		7.7		161.4		43.6		9.4		51.9		266.3
LAK042	2014	5.1		5.4		10.6		12.5		4.0		11.8		2.6		10.5		23.6		3.7		17.9		55.7
LAK044	2014	5.8		5.6		1.8		5.9		4.6		5.9		2.8		7.8		3.9		5.3		0.4		17.3
LAK006	2015	6.0	*0.1*	6.4	*0.6*	3.9	*0.3*	32.4	*0.7*	11.5	*0.7*	6.6	*0.6*	4.4	*0.2*	32.3	*0.6*	14.8	*0.3*	3.9	*0.1*	15.7	*0.6*	66.7
LAK007	2015	8.0		7.9		0.3		1565.6		45.6		24.0		2.6		1266.6		161.5		21.0		58.6		1507.7
LAK012	2015	6.0	*0.2*	6.3	*0.3*	7.5	*2.1*	65.9	*4.2*	17.6	*6.1*	11.1	*3.3*	4.7	*0.3*	74.8	*7.8*	23.2	*1.8*	8.1	*1.6*	18.0	*1.6*	124.2
LAK016	2015	6.8		6.9		4.3		113.1		40.9		8.7		8.6		130.9		25.0		9.8		22.9		188.6
LAK022	2015	6.1		6.2		6.3		35.6		32.5		7.9		5.9		64.1		18.1		4.4		21.2		107.8
LAK023	2015	5.9	*0.1*	6.2	*0.1*	5.4	*0.7*	30.0	*2.0*	15.1	*1.5*	6.2	*0.6*	5.2	*0.3*	46.1	*3.0*	13.9	*0.6*	3.8	*0.1*	9.7	*0.2*	73.5
LAK024	2015	7.4		7.5		2.2		443.0		34.7		59.0		2.1		400.5		49.3		8.7		49.0		507.6
LAK028	2015	5.1		5.3		8.1		10.8		71.1		9.0		20.5		76.5		15.7		3.2		14.4		109.8
LAK034	2015	6.6		6.7		7.6		177.8		0.9		6.2		4.7		146.5		37.1		5.3		45.1		234.0
LAK042	2015	5.4		5.5		8.3		13.8		3.8		6.5		2.3		10.7		23.1		2.5		23.0		59.3
LAK044	2015	5.8		5.8		1.6		6.2		3.7		5.9		2.7		9.8		4.4		5.5		0.5		20.3
LAK006	2016	6.0	*0.1*	6.3	*0.2*	4.2	*0.2*	26.9	*2.0*	11.8	*0.3*	5.6	*0.4*	4.2	*0.2*	32.6	*1.0*	14.8	*1.3*	4.2	*1.2*	17.2	*1.8*	68.8
LAK007	2016	8.0		8.1		0.8		1368.6		46.7		25.4		2.6		1301.5		162.8		20.2		58.3		1542.8
LAK012	2016	6.2	*0.0*	6.5	*0.2*	5.1	*0.5*	65.8	*2.3*	9.5	*1.1*	5.6	*0.3*	4.6	*0.2*	64.7	*1.7*	20.8	*1.2*	6.0	*1.2*	21.6	*1.6*	113.0
LAK016	2016	6.6		6.9		5.2		93.9		44.9		8.5		8.2		127.4		26.4		8.9		23.7		186.5
LAK022	2016	6.1		6.4		6.7		34.4		34.2		7.9		5.8		68.1		19.2		4.2		23.1		114.6
LAK023	2016	5.9	*0.0*	6.2	*0.1*	5.8	*0.2*	27.9	*3.8*	12.7	*0.4*	4.9	*0.4*	5.1	*0.2*	42.5	*1.8*	14.1	*0.9*	4.7	*1.1*	11.0	*1.5*	72.3
LAK024	2016	7.5		7.6		2.7		463.1		39.2		70.0		2.3		446.5		55.3		9.5		53.9		565.3
LAK028	2016	5.0	*0.2*	5.1	*0.2*	8.1	*0.6*	-4.9	*12.5*	127.8	*16.3*	10.0	*1.1*	26.8	*1.7*	94.7	*16.7*	23.8	*3.5*	3.7	*0.4*	19.5	*3.2*	141.6
LAK034	2016	6.5		7.1		7.6		151.6		0.0		5.4		4.4		130.0		34.3		3.8		44.1		212.3
LAK042	2016	5.4	*0.0*	5.7	*0.1*	9.8	*0.4*	14.0	*3.1*	3.3	*0.5*	7.2	*0.5*	2.2	*0.2*	16.7	*3.4*	24.7	*0.7*	2.7	*0.4*	23.3	*0.4*	67.4
LAK044	2016	5.5	*0.0*	6.0	*0.3*	2.0	*0.2*	4.1	*2.6*	4.1	*0.2*	6.1	*0.3*	2.3	*0.1*	8.2	*0.8*	4.1	*0.1*	5.5	*0.2*	0.3	*0.4*	18.2
LAK006	2017	6.0	*0.1*	6.4	*0.2*	3.8	*0.2*	27.9	*5.3*	14.4	*0.6*	5.4	*0.5*	4.2	*0.1*	34.8	*0.9*	15.6	*0.5*	4.1	*0.2*	18.0	*0.8*	72.5
LAK007	2017	8.0		8.0		0.3		1381.6		47.1		25.9		2.4		1201.7		165.2		19.9		62.6		1449.4
LAK012	2017	6.1	*0.2*	6.5	*0.1*	5.2	*1.0*	58.2	*6.5*	14.6	*5.2*	7.0	*2.4*	4.4	*0.1*	65.4	*9.0*	21.7	*2.3*	7.7	*1.9*	21.5	*1.9*	116.3
LAK016	2017	6.7		6.8		4.1		82.7		43.2		7.3		7.7		114.0		24.7		6.9		22.9		168.6
LAK022	2017	6.1		6.3		5.9		34.2		39.0		7.1		5.4		64.1		19.5		3.8		22.2		109.6
LAK023	2017	5.9	*0.0*	6.2	*0.1*	5.4	*0.1*	28.5	*4.7*	10.1	*3.4*	4.2	*0.5*	4.6	*0.1*	43.2	*4.2*	13.8	*0.7*	2.3	*0.5*	11.2	*0.6*	70.5
LAK024	2017	7.4		7.6		2.0		416.6		34.9		57.5		2.0		399.6		52.2		8.5		54.2		514.4
LAK028	2017	4.8	*0.1*	5.1	*0.1*	7.3	*1.1*	-9.9	*9.0*	150.0	*25.9*	8.7	*1.9*	27.2	*3.4*	102.5	*21.9*	26.5	*5.0*	3.5	*0.7*	19.9	*3.1*	152.4
LAK034	2017	6.4		6.8		6.0		136.5		0.1		4.5		3.4		105.6		30.3		2.7		39.1		177.8
LAK042	2017	5.2	*0.1*	5.4	*0.3*	11.6	*2.3*	2.3	*4.2*	6.8	*1.9*	6.7	*0.9*	2.4	*0.1*	17.1	*5.5*	26.9	*2.3*	2.8	*0.5*	23.2	*0.9*	70.0
LAK044	2017	5.6	*0.1*	6.0	*0.2*	1.6	*0.1*	7.0	*4.4*	4.5	*0.4*	5.9	*0.2*	2.2	*0.0*	7.9	*0.3*	4.2	*0.2*	5.6	*0.2*	0.7	*0.4*	18.4

Lake	Year	pH TU	SE[1]	pH ALS	SE	DOC mg/L	SE	Gran ANC µeq/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
LAK006	2018	6.1	0.0	6.4	0.0	3.8	0.1	28.3	1.2	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
LAK007	2018	8.1		8.1		0.3		1407.6		47.1		27.9		2.6		1251.5		157.4		20.6		61.3		1490.8
LAK012	2018	6.2	0.1	6.6	0.1	4.6	0.1	50.9	4.3	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
LAK016	2018	6.7		6.9		4.6		92.8		45.3		7.3		8.1		128.5		23.3		7.3		24.3		183.5
LAK022	2018	6.1		6.3		5.6		30.3		43.2		7.3		5.8		72.1		19.3		4.2		24.4		119.9
LAK023	2018	6.0	0.1	6.4	0.1	5.6	0.2	23.0	0.7	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
LAK024	2018	7.6		7.6		1.6		509.9		42.6		77.3		2.4		472.7		56.4		9.4		57.2		595.7
LAK028	2018	5.3	0.0	5.5	0.0	4.4	0.1	4.2	1.6	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
LAK034	2018	6.5		6.6		5.1		130.6		0.1		3.7		3.7		113.1		27.7		2.1		40.8		183.7
LAK042	2018	5.1	0.0	5.3	0.0	10.6	0.4	0.6	1.9	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
LAK044	2018	5.5	0.0	5.9	0.0	1.9	0.1	3.9	0.9	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
LAK006	2019	6.1	0.0	6.5	0.1	3.5	0.2	31.6	2.7	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
LAK007	2019	8.1		8.1		0.3		1374.5		43.0		27.1		2.4		1246.6		158.4		20.4		61.2		1486.5
LAK012	2019	6.1	0.0	6.6	0.1	5.0	0.3	55.3	0.9	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
LAK016	2019	6.6		7.1		4.4		90.8		58.6		9.0		7.9		127.9		26.5		9.7		24.4		188.6
LAK022	2019	6.1		6.4		6.0		35.9		49.3		8.7		5.6		71.5		22.4		5.0		25.3		124.2
LAK023	2019	5.8	0.0	6.3	0.1	5.9	0.2	20.7	2.4	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
LAK024	2019	7.7		7.7		1.6		496.9		40.8		75.3		2.1		478.3		58.1		8.7		66.3		611.4
LAK028	2019	5.2	0.0	5.4	0.0	5.2	0.3	3.3	0.7	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
LAK034	2019	6.4		7.0		5.3		148.9		0.9		4.5		4.1		122.1		30.4		1.8		43.5		197.8
LAK042	2019	5.4	0.0	5.6	0.1	9.2	0.5	10.1	0.6	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
LAK044	2019	5.5	0.0	5.9	0.1	2.5	0.3	6.1	0.4	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
NC184	2013	5.7				11.6		16.2		5.7		24.0		0.3		50.5		17.5		4.4		13.8		86.2
NC194	2013	6.6				0.7		28.0		3.6		7.6		0.3		23.2		3.4		5.2		7.4		39.2
DCAS14A	2013	6.5				1.4		50.6		33.4		9.2		0.6		63.9		10.3		10.3		6.1		90.6
NC184	2015	5.5		5.6		9.8		18.4		5.7		21.7		0.5		48.8		16.1		2.9		10.8		78.7
NC194	2015	6.5		6.5		0.8		33.0		2.3		7.3		0.5		26.9		4.4		4.3		7.9		43.4
DCAS14A	2015	6.6		6.7		0.9				35.7		7.3		0.5		77.6		12.4		11.2		9.9		111.0
NC184	2016	5.8		6.2		10.6		27.3		5.5		21.2		0.5		62.6		19.3		2.7		15.5		100.1
NC194	2016	6.4		6.6		1.6		28.7		2.3		7.9		0.5		26.4		4.3		3.8		7.9		42.4
DCAS14A	2016	6.6		6.8		1.5		57.5		36.8		8.5		0.5		77.5		11.8		10.5		9.7		109.6
NC184	2017	5.4		6.0		13.3		9.8		4.7		14.7		0.5		45.2		17.4		2.5		15.9		81.0
NC194	2017	6.4		6.4		1.0		12.4		2.5		4.8		0.5		29.9		5.7		3.6		9.9		49.1
DCAS14A	2017	6.6		6.7		1.5		51.0		31.1		5.6		0.5		68.2		11.8		9.1		9.9		99.0
NC184	2018	6.2		6.4		7.0		44.0		8.3		16.6		0.5		67.8		17.3		3.1		15.3		103.4
NC194	2018	6.5		6.7		0.3		26.1		2.6		5.1		0.5		28.3		4.3		4.1		9.1		45.8
DCAS14A	2018	6.8		6.8		1.0		59.3		41.3		7.3		0.5		85.6		12.6		11.5		10.7		120.4
NC184	2019	5.7	0.0	6.1	0.1	9.3	0.3	24.9	1.5	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
NC194	2019	6.4	0.0	6.6	0.1	1.0	0.2	30.4	5.3	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
DCAS14A	2019	6.6	0.1	6.8	0.0	1.2	0.0	58.6	5.9	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

[1] SE = standard deviation

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	pH (TU)	pH (ALS)	DOC (mg/L)	Gran Alkalinity (mg/L)	Conduct-ivity (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	5.8		3.6	1.3	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	8.0		0.6	71.9	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	5.6		4.6	2.9	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	6.3		3.7	3.4	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	5.9		5.3	1.4	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	5.7		4.2	1.0	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	7.1		1.4	15.0	40.0	1.3	1.0	0.0	0.4	2.4	5.5	0.5	0.2	1.2	0.0	0.0	
LAK028	2012	5.0		4.9	-0.2	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	6.7		4.5	5.0	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	4.7		13.2	-1.0	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	5.4		1.7	0.1	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	6.2	6.1	3.2	1.5	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	7.9	8.1	0.1	73.2	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	6.3	6.1	4.2	3.2	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	6.7	7.2	4.2	4.9	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	6.2	6.1	6.2	1.8	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	6.0	6.0	4.0	1.2	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	5.2	5.5	7.1	0.2	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	6.9	7.4	4.7	10.5	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	5.5	5.4	9.7	1.1	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	5.7	6.0	1.5	0.4	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	6.1	6.6	3.8	1.9	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	8.1	8.0	0.7	72.4	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	6.0	6.7	6.3	3.4	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	6.7	6.7	4.0	5.3	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	6.3	6.4	5.7	2.3	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	5.9	6.7	5.7	1.6	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	7.6	7.5	1.7	23.6	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	5.3	5.7	5.9	1.1	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	6.7	7.0	7.0	10.3	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	5.1	5.4	10.6	0.6	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	5.8	5.6	1.8	0.3	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	6.0	6.4	3.9	1.6	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	8.0	7.9	0.3	78.4	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	6.0	6.3	7.5	3.3	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	6.8	6.9	4.3	5.7	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	6.1	6.2	6.3	1.8	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

Lake	Year	pH (TU)	pH (ALS)	DOC (mg/L)	Gran Alkalinity (mg/L)	Conduct-ivity (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)
LAK023	2015	5.9	6.2	5.4	1.5	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
LAK024	2015	7.4	7.5	2.2	22.2	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	5.1	5.3	8.1	0.5	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	6.6	6.7	7.6	8.9	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	5.4	5.5	8.3	0.7	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	5.8	5.8	1.6	0.3	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	6.0	6.3	4.2	1.3	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	8.0	8.1	0.8	68.5	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	6.2	6.5	5.1	3.3	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	6.6	6.9	5.2	4.7	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	6.1	6.4	6.7	1.7	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	5.9	6.2	5.8	1.4	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	7.5	7.6	2.7	23.2	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	5.0	5.1	8.1	-0.2	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	6.5	7.1	7.6	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	5.4	5.7	9.8	0.7	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	5.5	6.0	2.0	0.2	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	6.0	6.4	3.8	1.4	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	8.0	8.0	0.3	69.1	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	6.1	6.5	5.2	2.9	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	6.7	6.8	4.1	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	6.1	6.3	5.9	1.7	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	5.9	6.2	5.4	1.4	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	7.4	7.6	2.0	20.9	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	4.8	5.1	7.3	-0.5	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	6.4	6.8	6.0	6.8	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	5.2	5.4	11.6	0.1	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	5.6	6.0	1.6	0.4	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	6.1	6.4	3.8	1.4	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	8.1	8.1	0.3	70.4	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	6.2	6.6	4.6	2.5	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	6.7	6.9	4.6	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	6.1	6.3	5.6	1.5	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	6.0	6.4	5.6	1.1	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	7.6	7.6	1.6	25.5	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	5.3	5.5	4.4	0.2	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	6.6	5.1	6.5	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	5.1	5.3	10.6	0.0	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	5.5	5.9	1.9	0.2	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	6.1	6.5	1.1	1.6		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	8.1	8.1	0.3	68.8		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	6.1	6.6	1.8	2.8		0.7	0.3	0.1	3.2	2.5	1.2	0.3	0.3	0.7	0.2	0.0	0.0
LAK016	2019	6.6	7.1	2.5	4.5		2.9	0.3	0.2	2.5	6.2	2.6	0.3	0.4	0.7	0.0	0.1	0.0

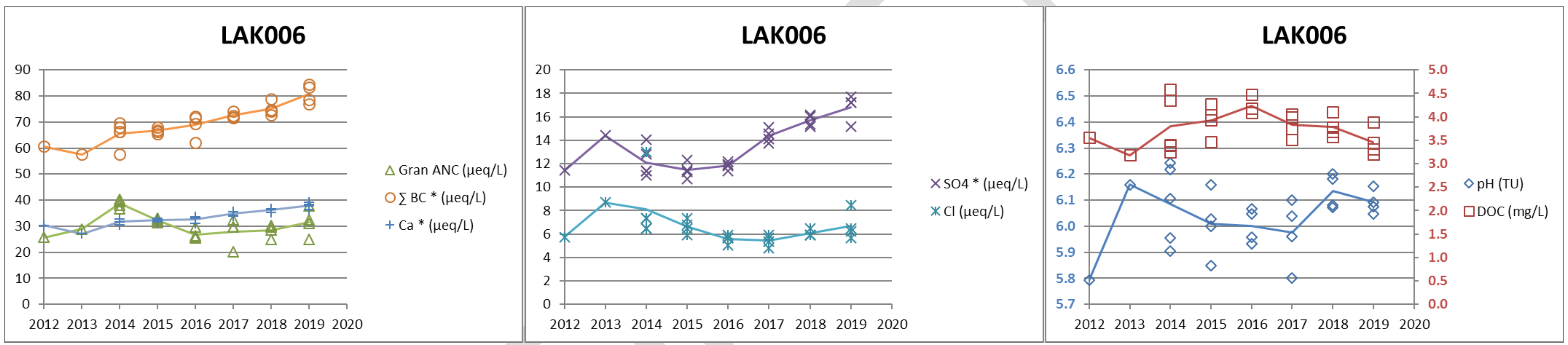
Lake	Year	pH (TU)	pH (ALS)	DOC (mg/L)	Gran Alkalinity (mg/L)	Conduct-ivity (µS/s)	SO4 (mg/L)	Cl (mg/L)	F (mg/L)	NO3 (µg/L)	NH4 (µg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)
LAK022	2019	6.1	6.4	1.3	1.8		2.4	0.3	0.1	2.5	2.5	1.4	0.3	0.2	0.8	0.1	0.1	0.0
LAK023	2019	5.8	6.3	1.0	1.0		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	7.7	7.7	6.9	24.9		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	5.2	5.4	5.4	0.2		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	6.4	7.0	3.0	7.5		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	5.4	5.6	1.5	0.5		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	5.5	5.9	1.5	0.3		0.3	0.2	0.0	2.5	2.5	0.2	0.1	0.2	0.1	0.0	0.0	0.0
NC184	2013	5.7		11.6	0.8	10.0	0.4	0.9	0.0	0.0	0.0	1.0	0.3	0.2	0.8			
NC194	2013	6.6		0.7	1.4	3.9	0.2	0.3	0.0	0.0	0.0	0.5	0.1	0.2	0.3			
DCAS14A	2013	6.5		1.4	2.5	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	2015	5.5	5.6	9.8	0.9	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	6.5	6.5	0.8	1.7	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	5.8	6.2	10.6	1.4	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	6.4	6.6	1.6	1.4	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	6.6	6.8	1.5	2.9	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	5.4	6.0	13.3	0.5	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	6.4	6.4	1.0	0.6	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	6.6	6.7	1.5	2.6	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	6.2	6.4	7.0	2.2	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	6.5	6.7	0.3	1.3	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	6.8	6.8	1.0	3.0	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	5.7	6.1	1.1	1.2		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	6.4	6.6	0.9	1.5		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	6.6	6.8	1.4	2.9		2.0	0.3	0.0	10.3	2.5	1.7	0.2	0.5	0.4	0.0	0.0	0.0

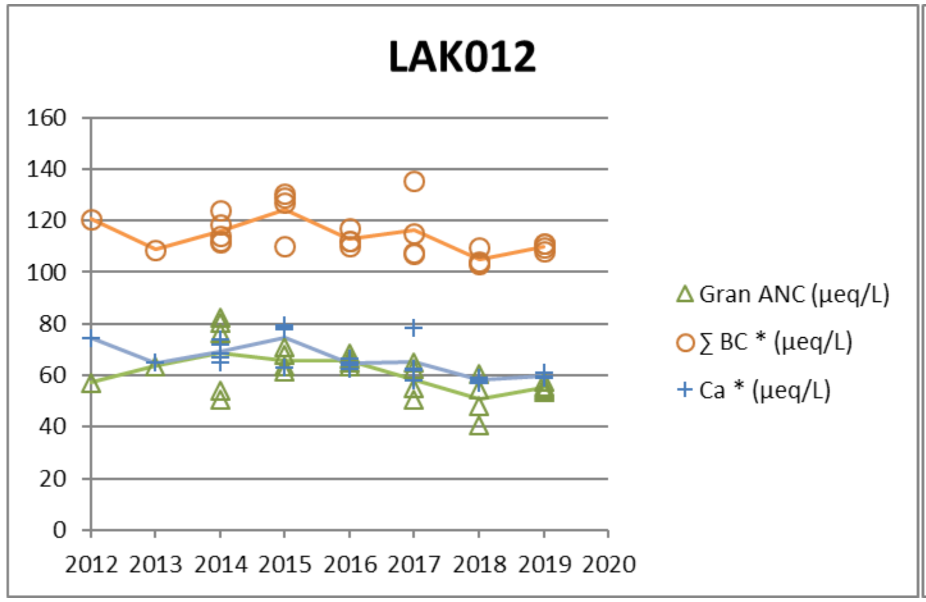
Appendix 2: Changes in Ion Concentrations from 2012 to 2017

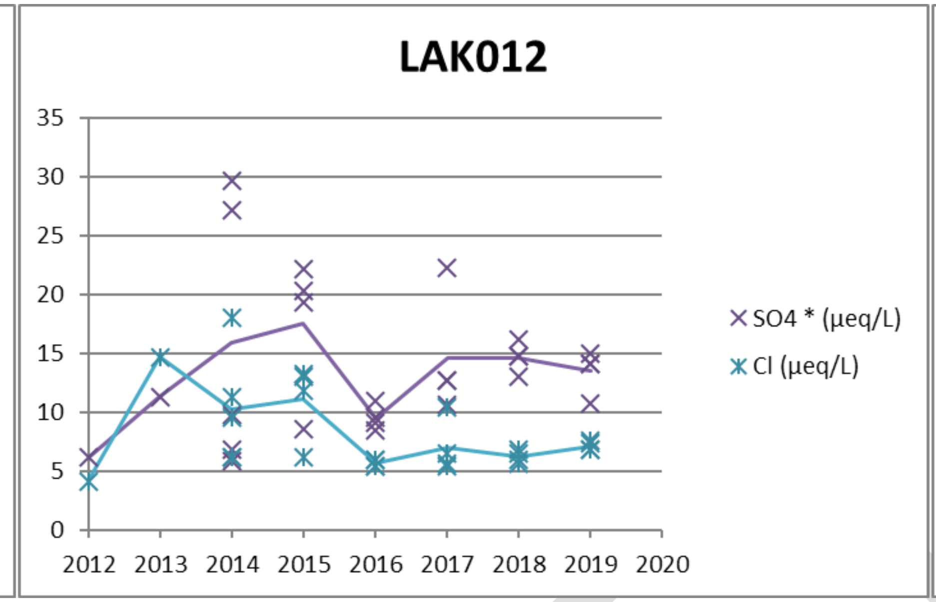
For each of the EEM lakes, the figures in this appendix show the inter-annual changes in six major water chemistry metrics from 2012 to 2019: Gran ANC, base cations and calcium (left panel), sulfate and chloride (centre panel), and pH and dissolved organic carbon (right panel). The selection of each 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.

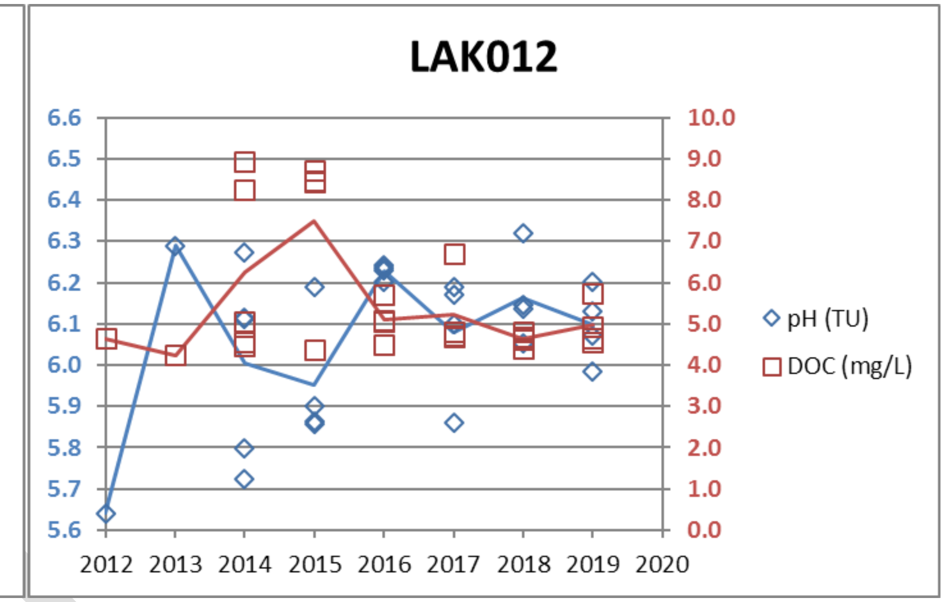
These figures show the results for all of the sampling events for each lake in each year, whether that included multiple within-season samples or only a single annual sample. The points represent the values for individual sampling events. The solid lines represent the annual trend, based on either the 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.

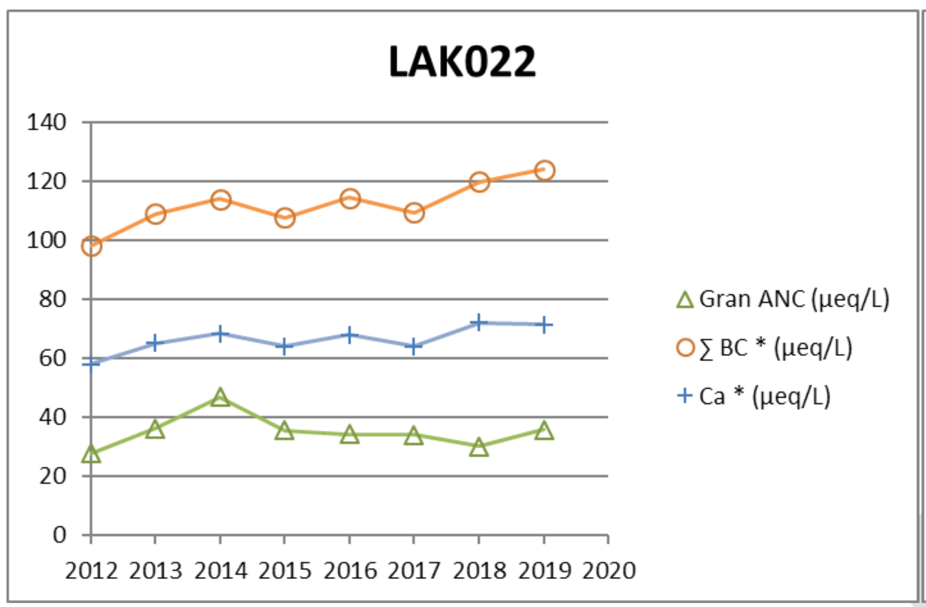
Sensitive Lakes

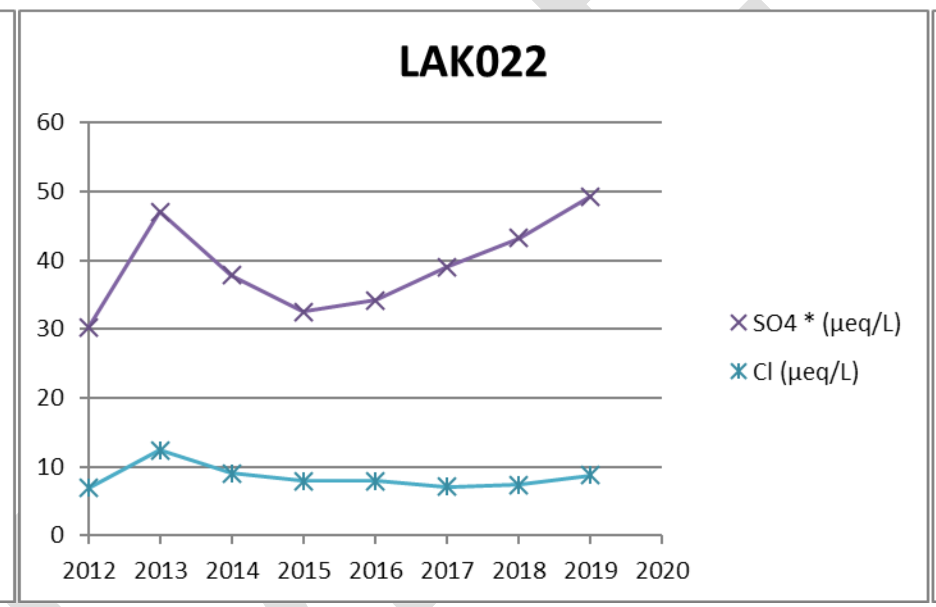


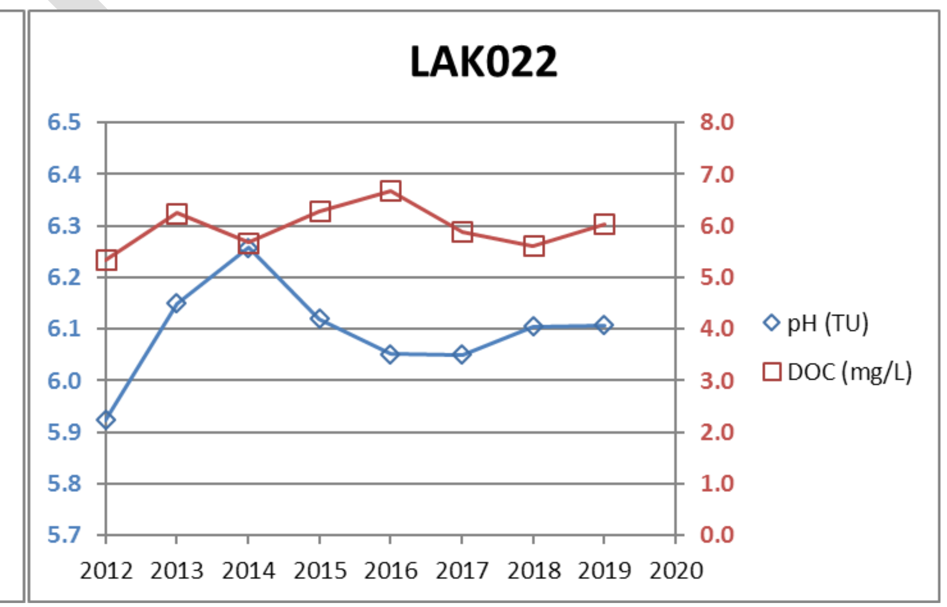

LAK012
160
140
120
100
80
60
40
20
0
2012 2013 2014 2015 2016 2017 2018 2019 2020
Gran ANC (µeq/L)
∑ BC * (µeq/L)
Ca * (µeq/L)

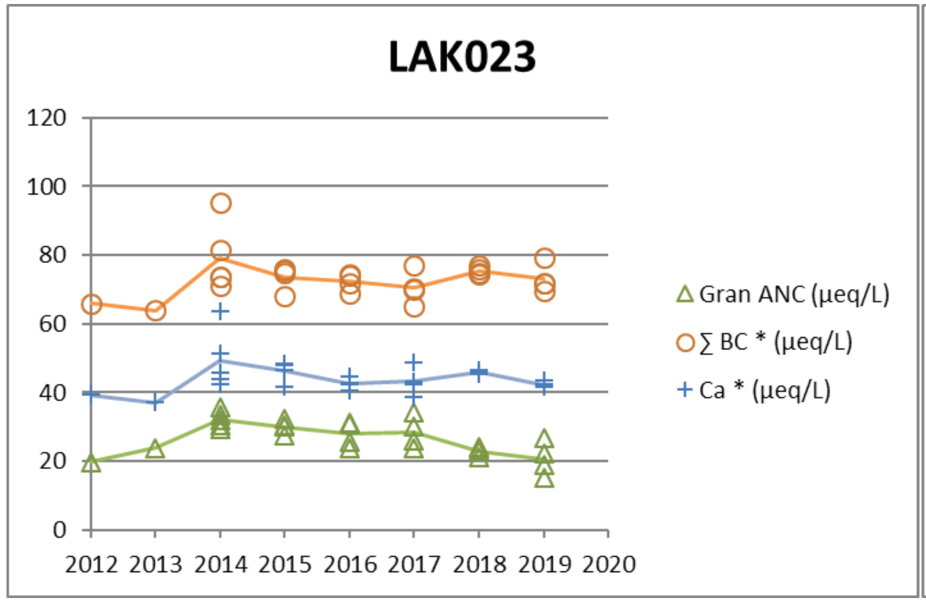

LAK012
35
30
25
20
15
10
5
0
2012 2013 2014 2015 2016 2017 2018 2019 2020
SO4 * (µeq/L)
Cl (µeq/L)

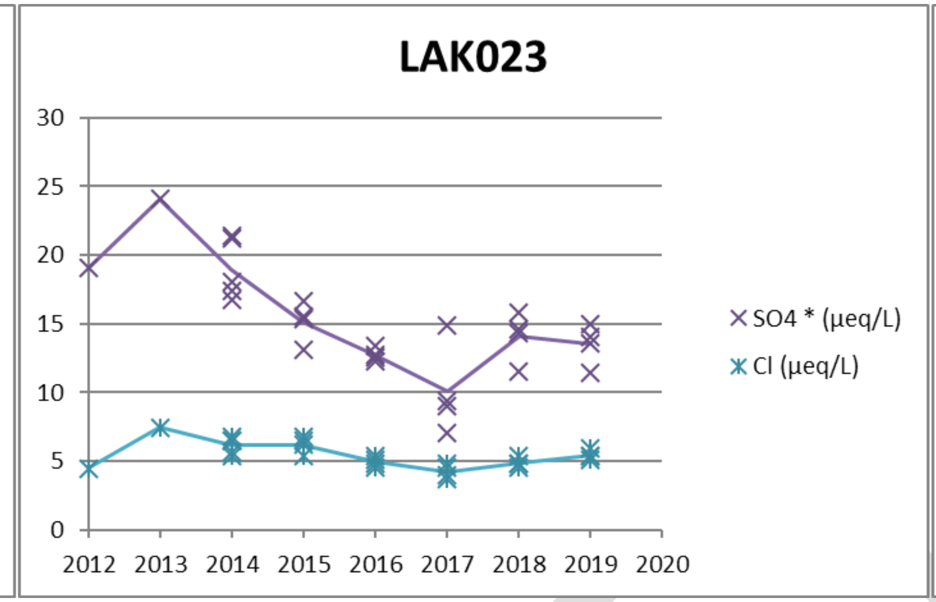

LAK012
6.6
6.5
6.4
6.3
6.2
6.1
6.0
5.9
5.8
5.7
5.6
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
2012 2013 2014 2015 2016 2017 2018 2019 2020
pH (TU)
DOC (mg/L)

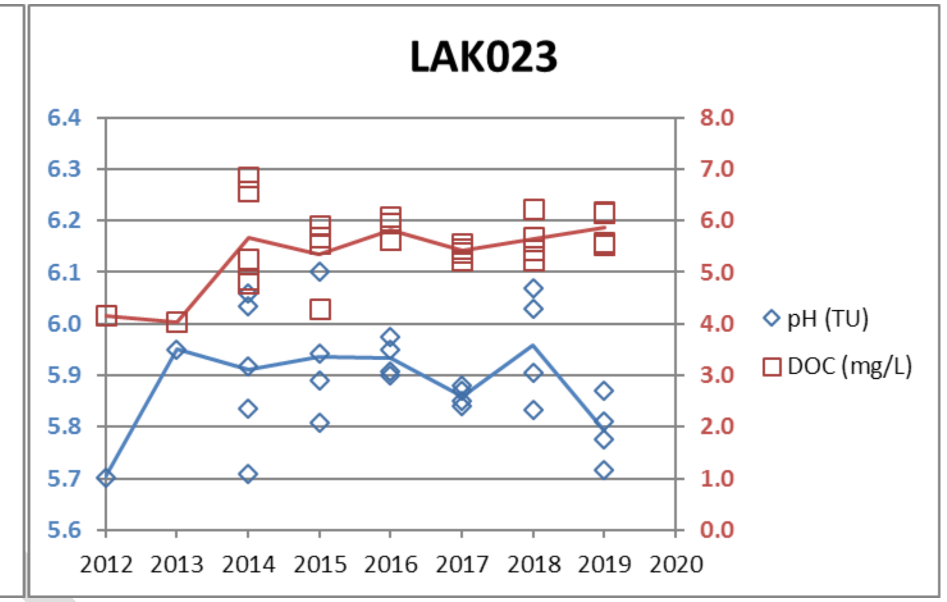

LAK022
140
120
100
80
60
40
20
0
2012 2013 2014 2015 2016 2017 2018 2019 2020
Gran ANC (µeq/L)
∑ BC * (µeq/L)
Ca * (µeq/L)

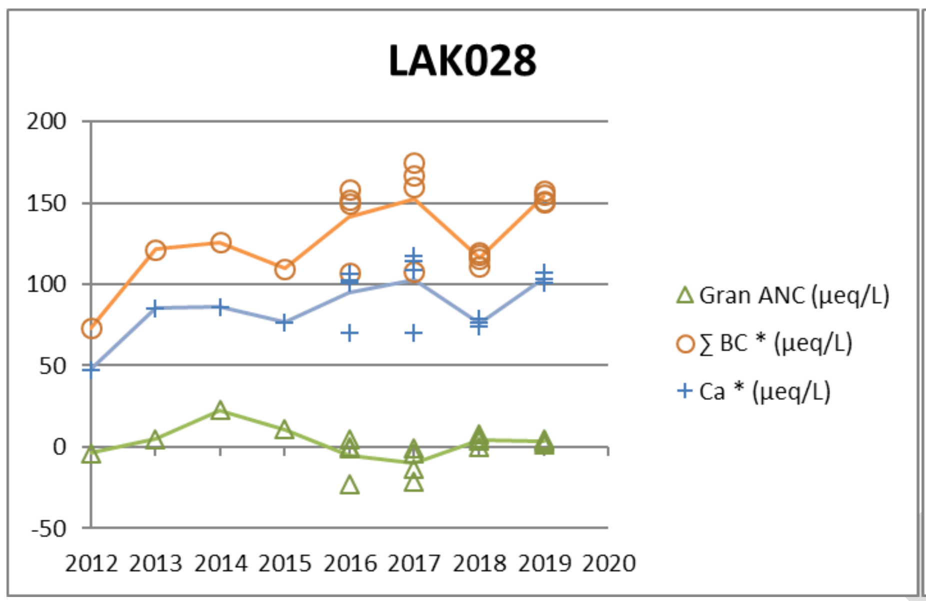

LAK022
60
50
40
30
20
10
0
2012 2013 2014 2015 2016 2017 2018 2019 2020
SO4 * (µeq/L)
Cl (µeq/L)

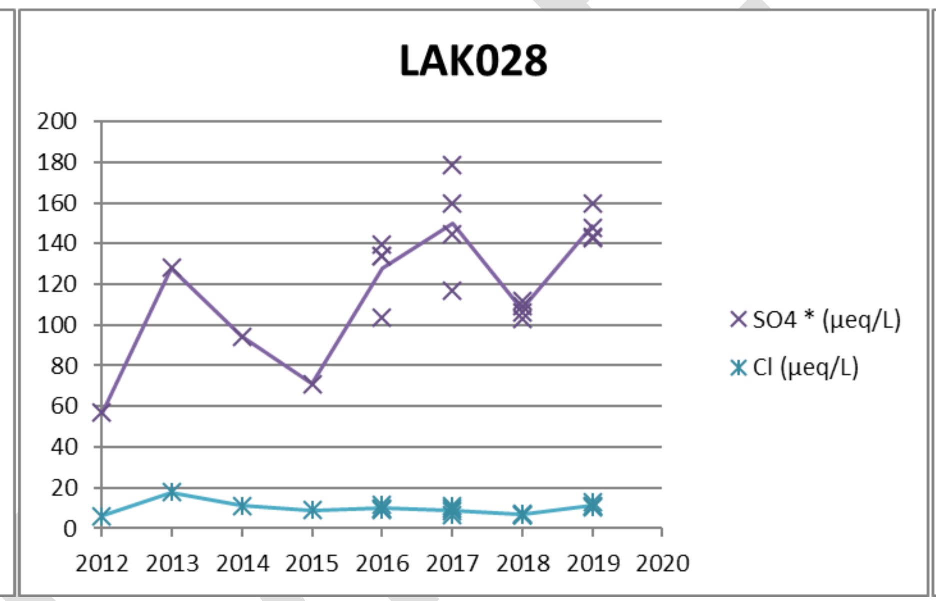

LAK022
6.5
6.4
6.3
6.2
6.1
6.0
5.9
5.8
5.7
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
2012 2013 2014 2015 2016 2017 2018 2019 2020
pH (TU)
DOC (mg/L)

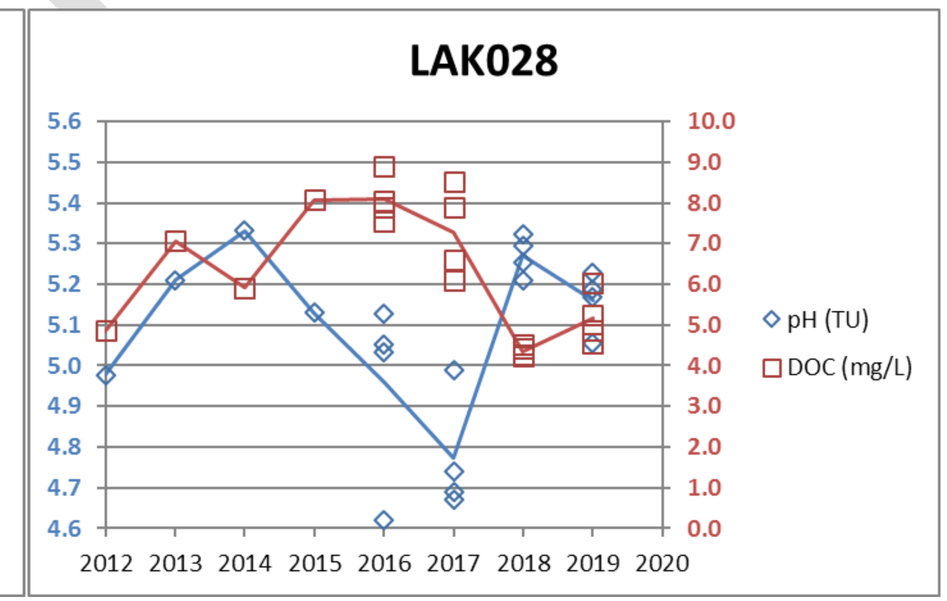

LAK023
120
100
80
60
40
20
0
2012 2013 2014 2015 2016 2017 2018 2019 2020
Gran ANC (µeq/L)
∑ BC * (µeq/L)
Ca * (µeq/L)

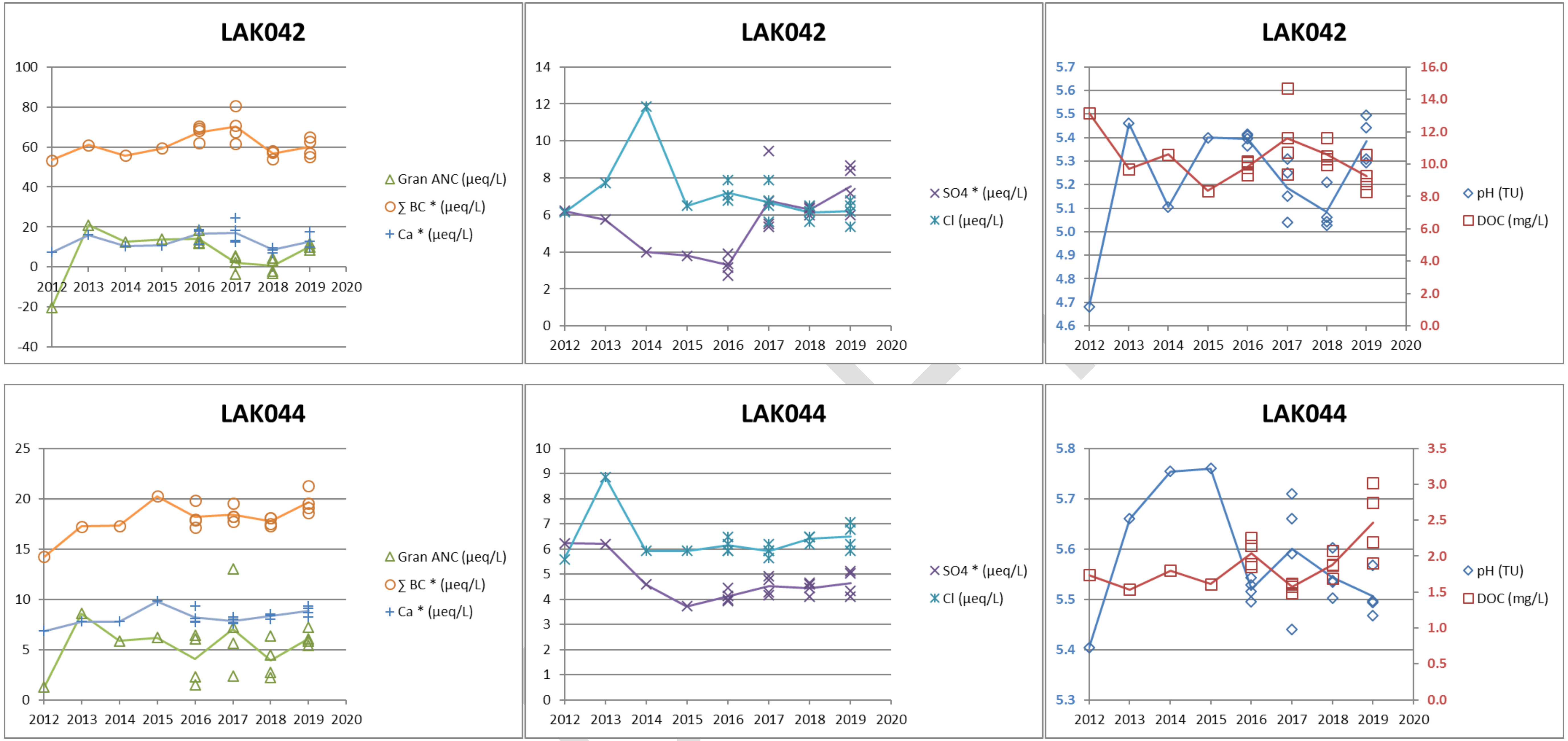

LAK023
30
25
20
15
10
5
0
2012 2013 2014 2015 2016 2017 2018 2019 2020
SO4 * (µeq/L)
Cl (µeq/L)


LAK023
6.4
6.3
6.2
6.1
6.0
5.9
5.8
5.7
5.6
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
2012 2013 2014 2015 2016 2017 2018 2019 2020
pH (TU)
DOC (mg/L)

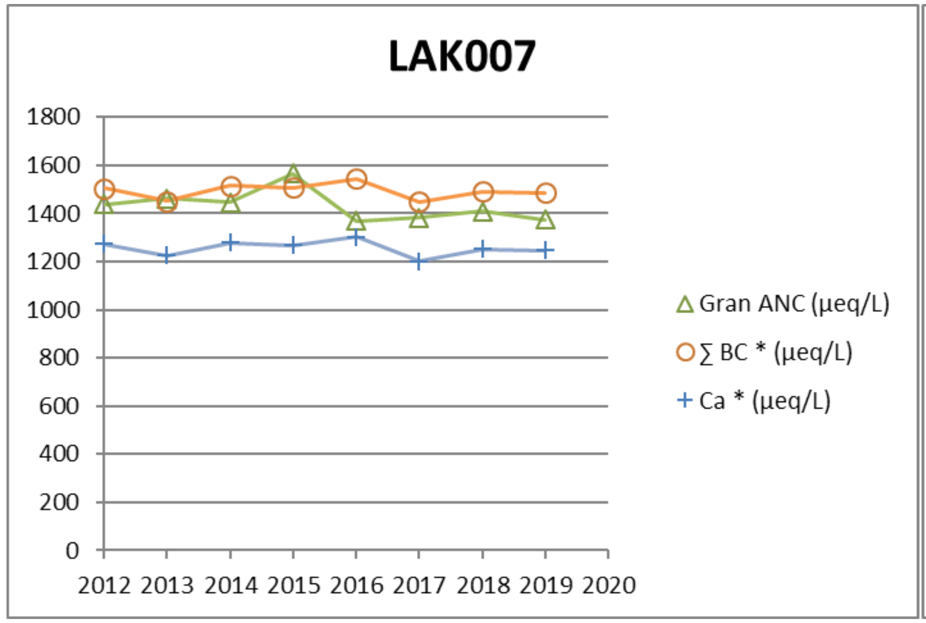

LAK028
200
150
100
50
0
-50
2012 2013 2014 2015 2016 2017 2018 2019 2020
Gran ANC (µeq/L)
∑ BC * (µeq/L)
Ca * (µeq/L)

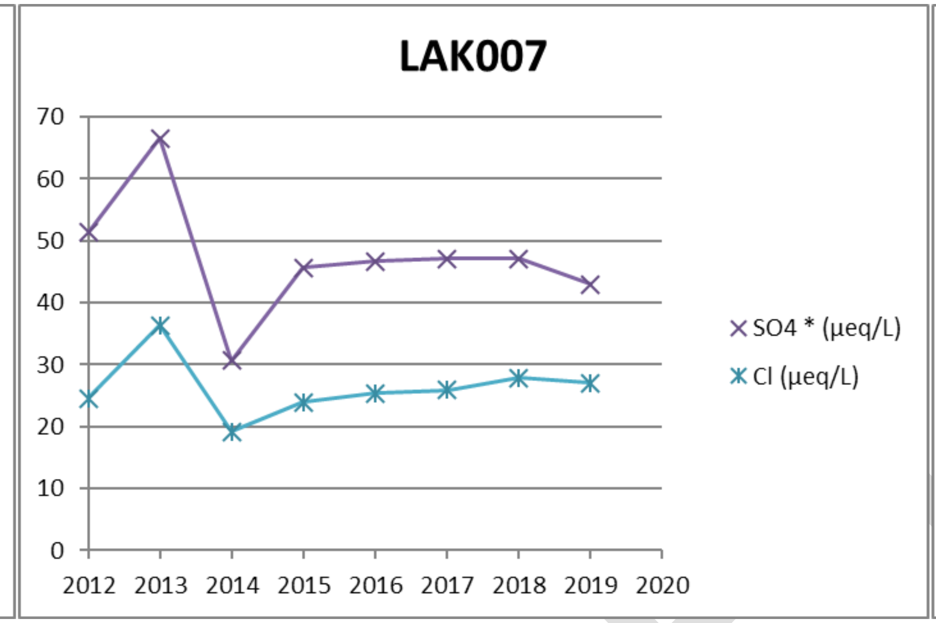

LAK028
200
180
160
140
120
100
80
60
40
20
0
2012 2013 2014 2015 2016 2017 2018 2019 2020
SO4 * (µeq/L)
Cl (µeq/L)

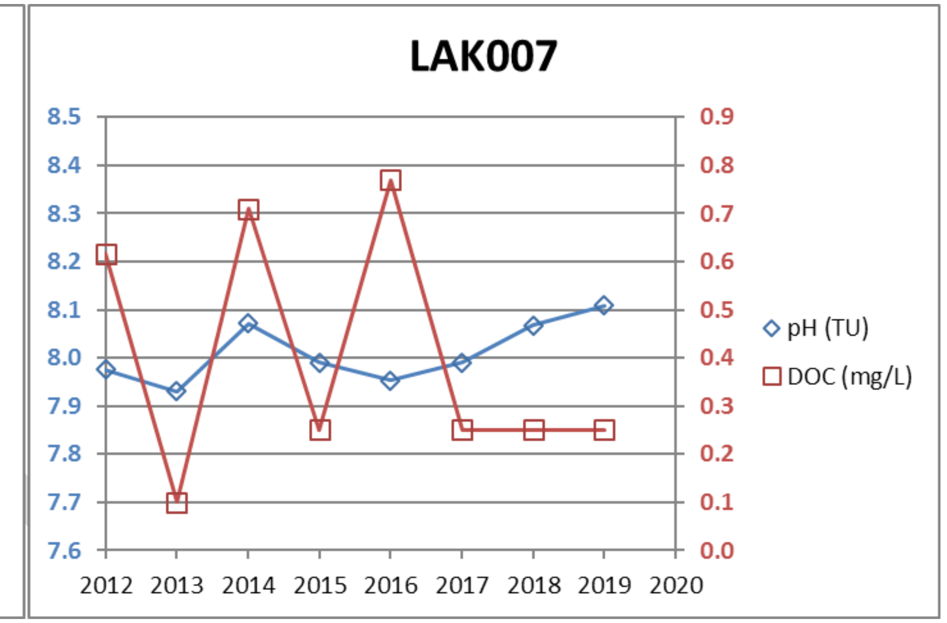

LAK028
5.6
5.5
5.4
5.3
5.2
5.1
5.0
4.9
4.8
4.7
4.6
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
2012 2013 2014 2015 2016 2017 2018 2019 2020
pH (TU)
DOC (mg/L)

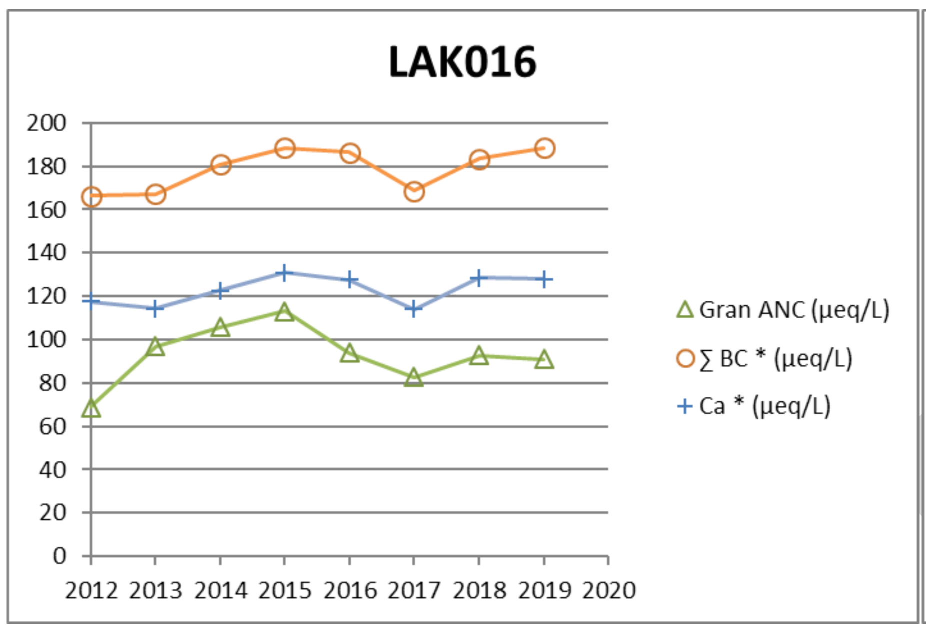

LAK042
Gran ANC (µeq/L)
∑ BC * (µeq/L)
Ca * (µeq/L)
LAK042
SO4 * (µeq/L)
Cl (µeq/L)
LAK042
pH (TU)
DOC (mg/L)
LAK044
Gran ANC (µeq/L)
∑ BC * (µeq/L)
Ca * (µeq/L)
LAK044
SO4 * (µeq/L)
Cl (µeq/L)
LAK044
pH (TU)
DOC (mg/L)

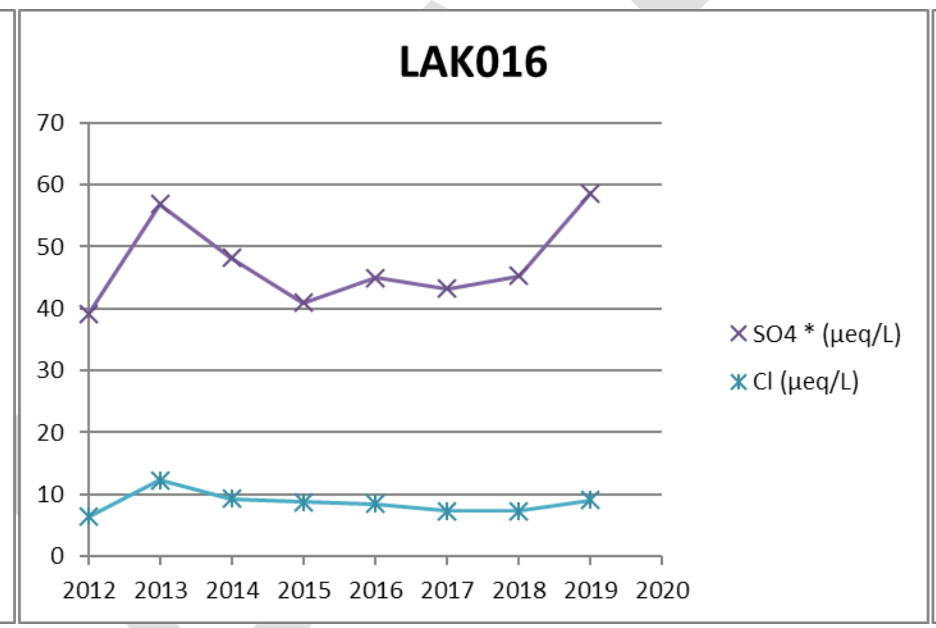
Less Sensitive Lakes

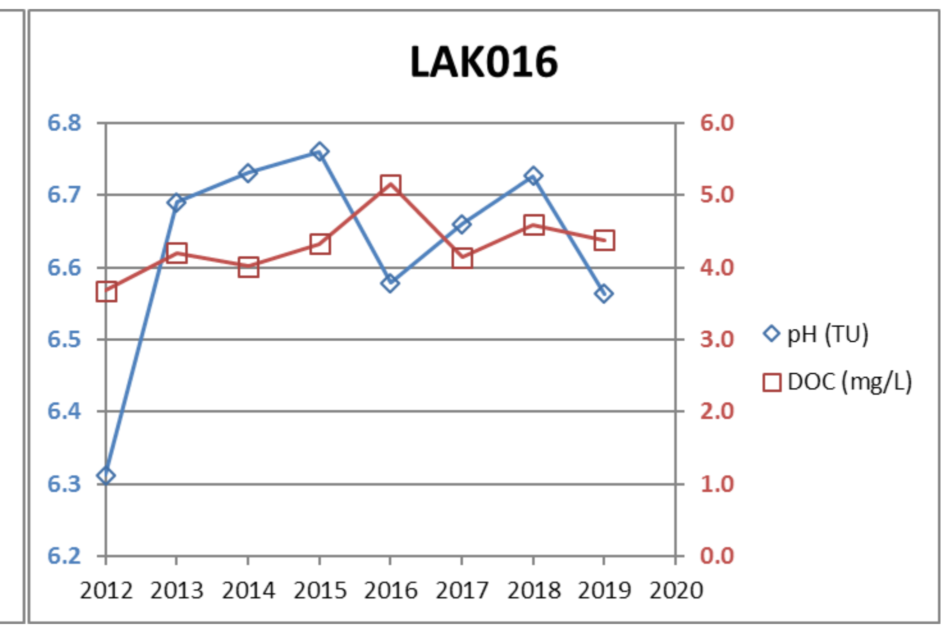


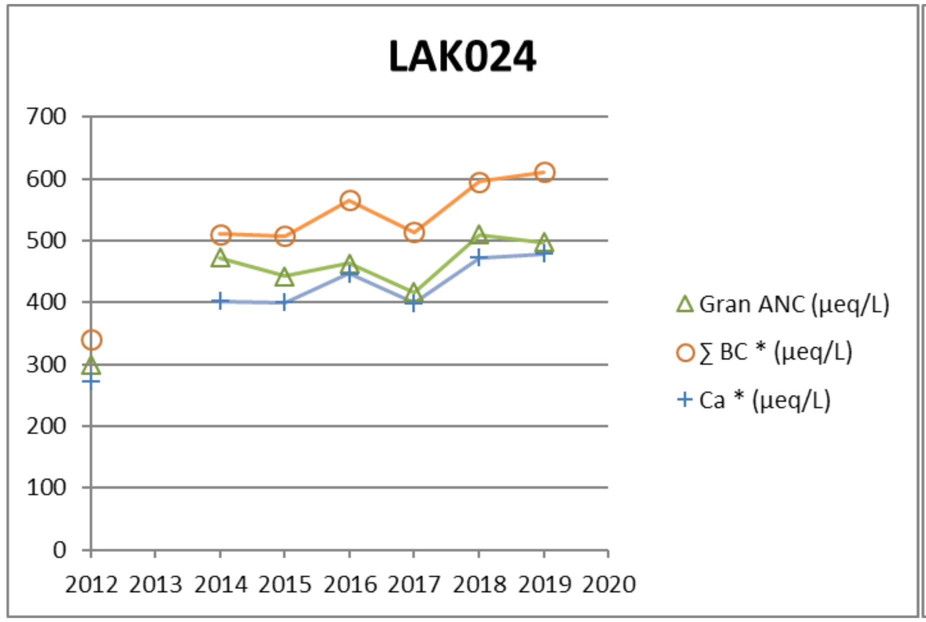


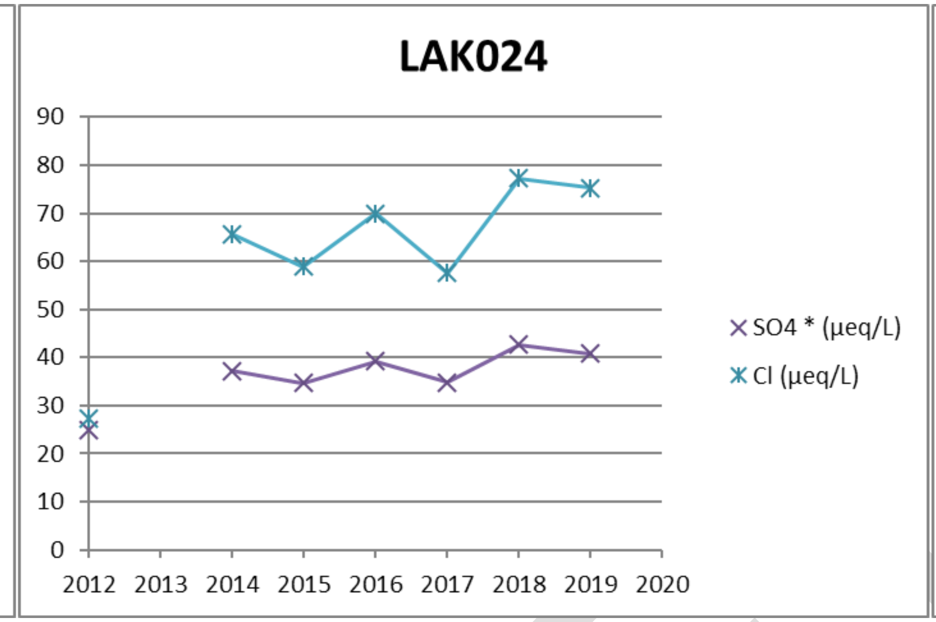


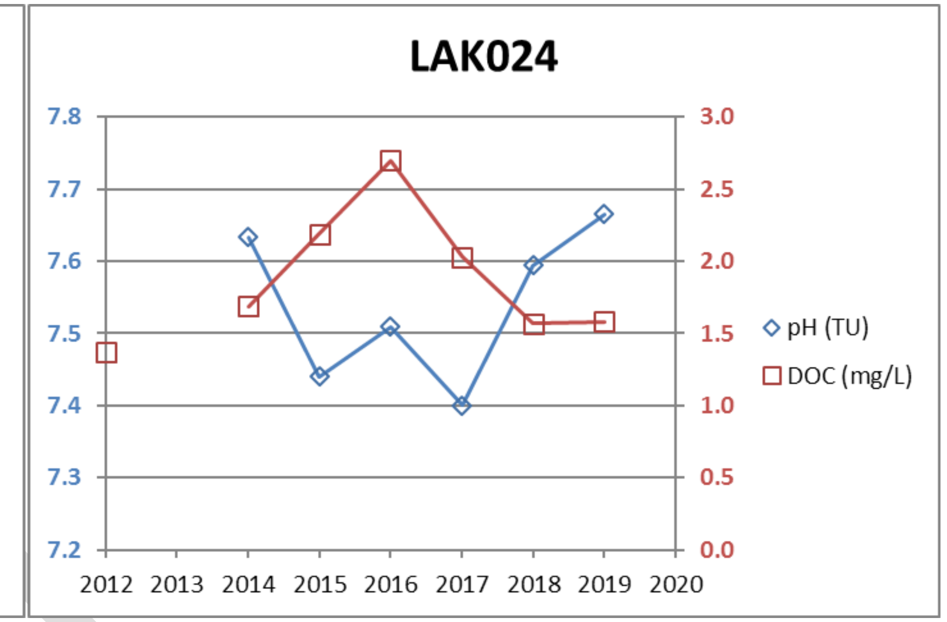


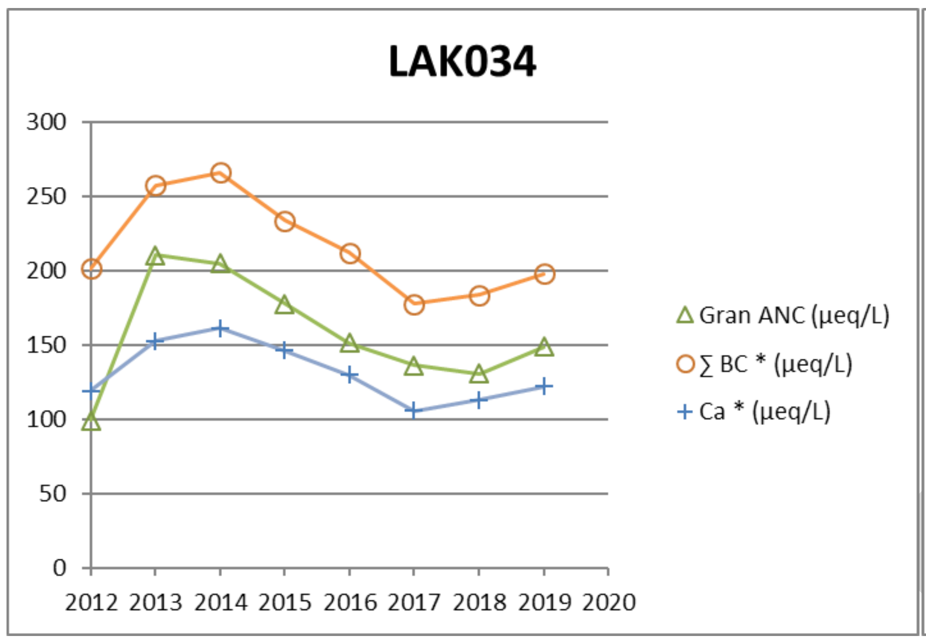


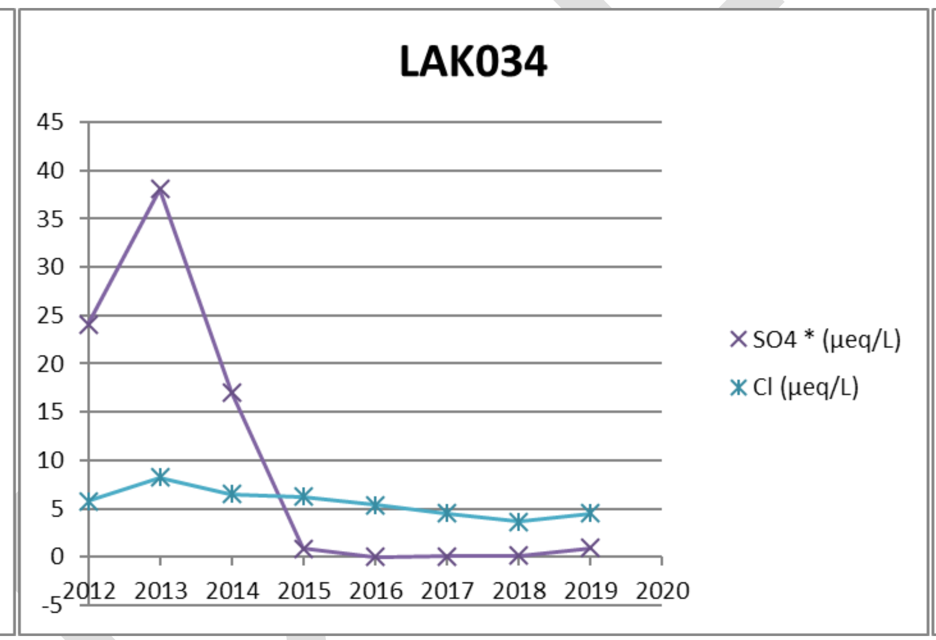


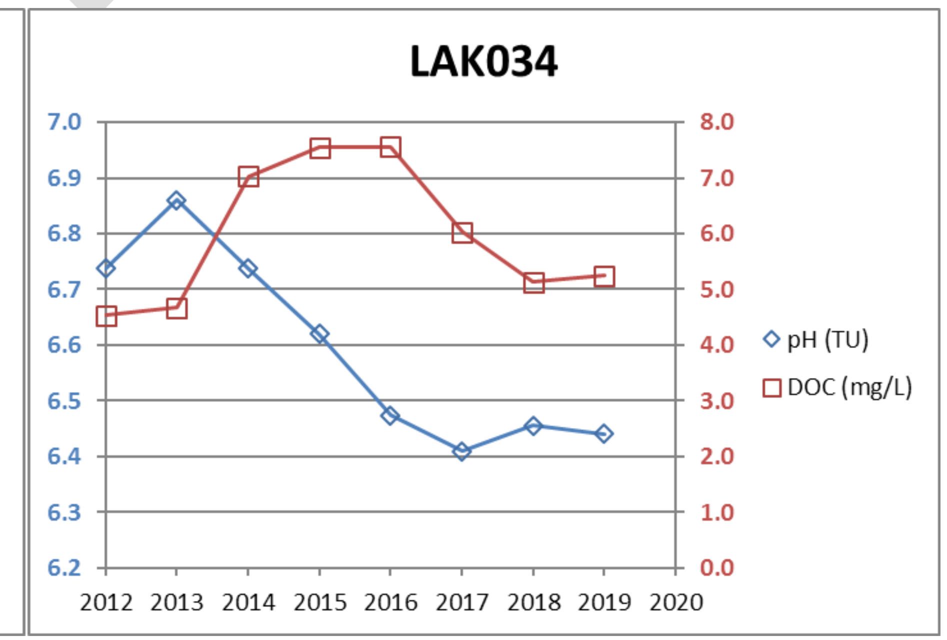

LAK024
700
600
500
400
300
200
100
0
2012 2013 2014 2015 2016 2017 2018 2019 2020
Gran ANC (µeq/L)
∑ BC * (µeq/L)
Ca * (µeq/L)


LAK024
90
80
70
60
50
40
30
20
10
0
2012 2013 2014 2015 2016 2017 2018 2019 2020
SO4 * (µeq/L)
Cl (µeq/L)

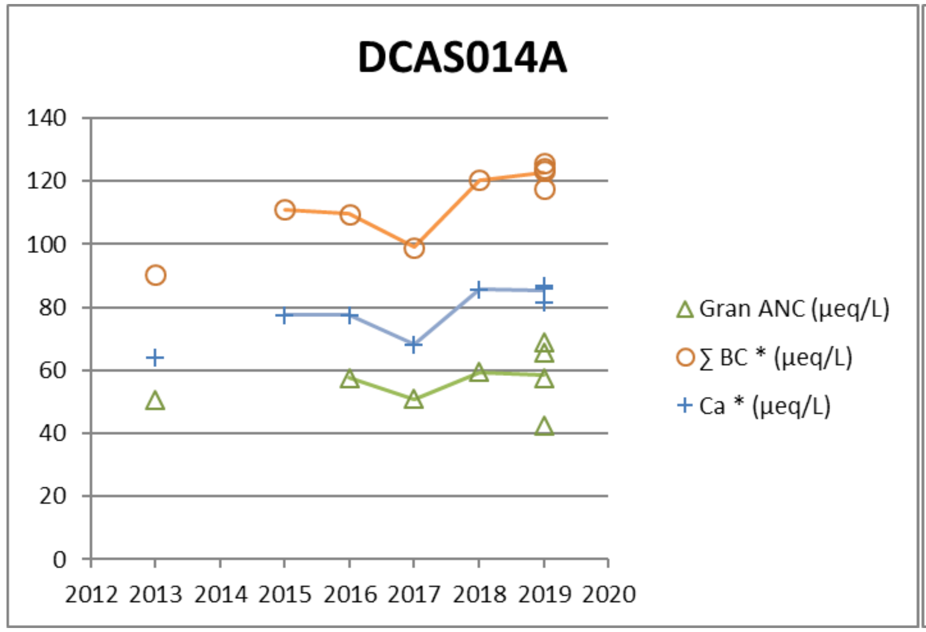

LAK024
7.8
7.7
7.6
7.5
7.4
7.3
7.2
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2012 2013 2014 2015 2016 2017 2018 2019 2020
pH (TU)
DOC (mg/L)

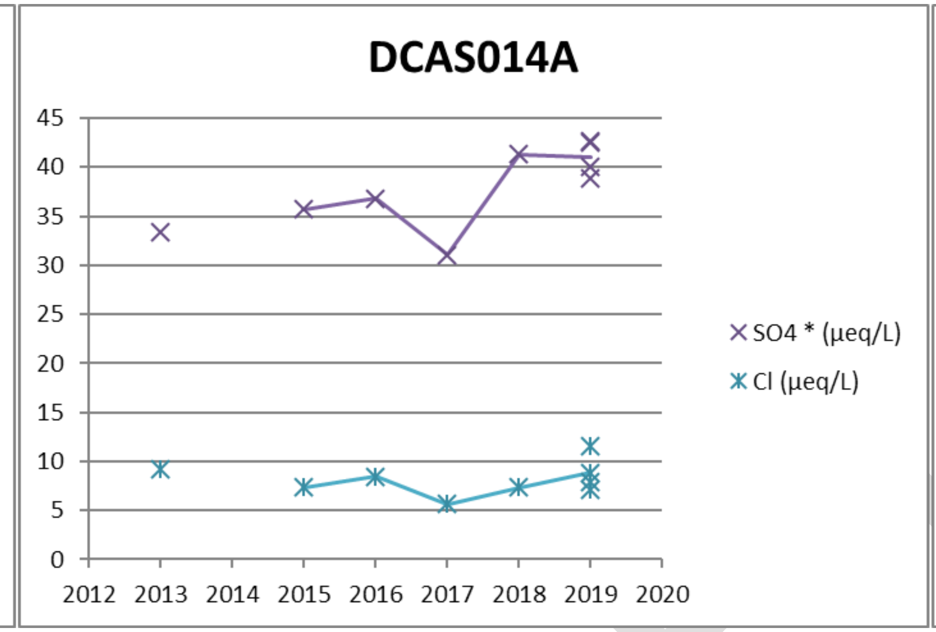

LAK034
300
250
200
150
100
50
0
2012 2013 2014 2015 2016 2017 2018 2019 2020
Gran ANC (µeq/L)
∑ BC * (µeq/L)
Ca * (µeq/L)

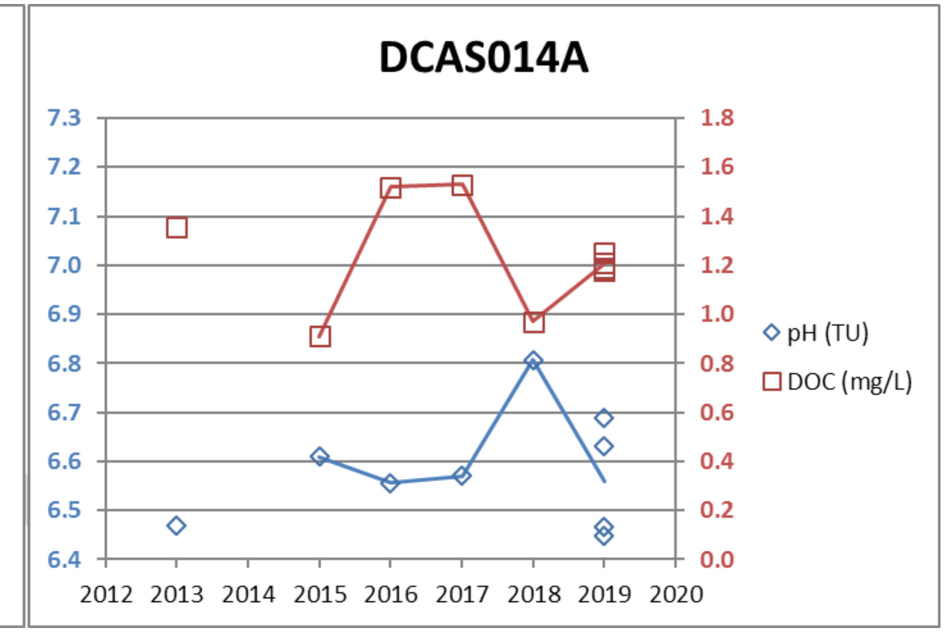

LAK034
45
40
35
30
25
20
15
10
5
0
-5
2012 2013 2014 2015 2016 2017 2018 2019 2020
SO4 * (µeq/L)
Cl (µeq/L)

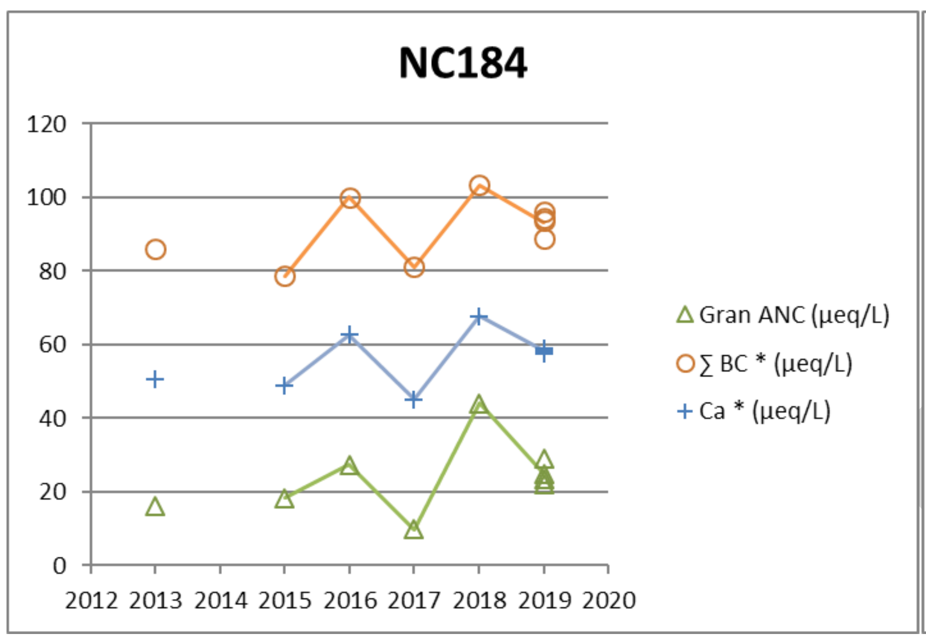

LAK034
7.0
6.9
6.8
6.7
6.6
6.5
6.4
6.3
6.2
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
2012 2013 2014 2015 2016 2017 2018 2019 2020
pH (TU)
DOC (mg/L)

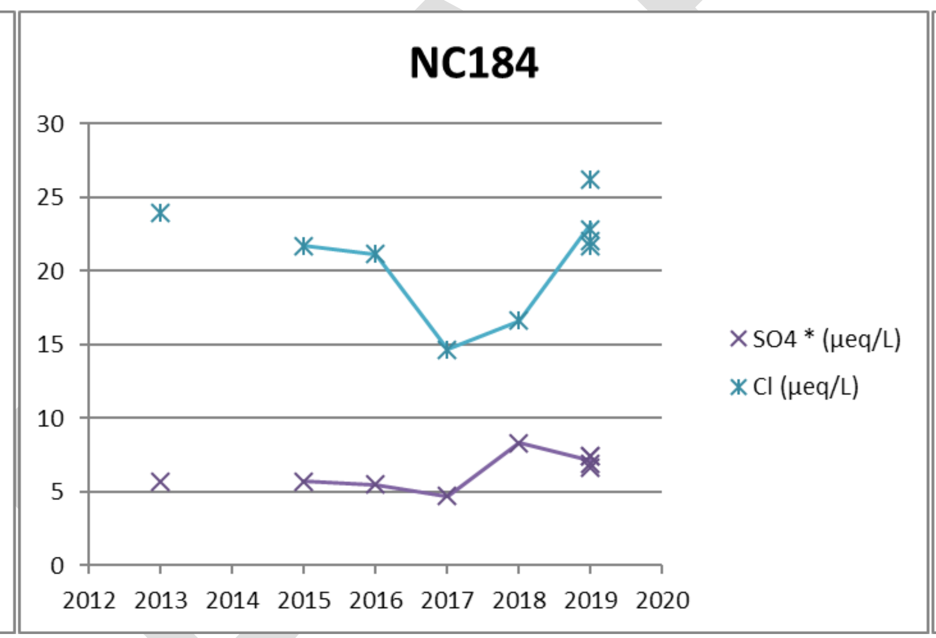
Control Lakes

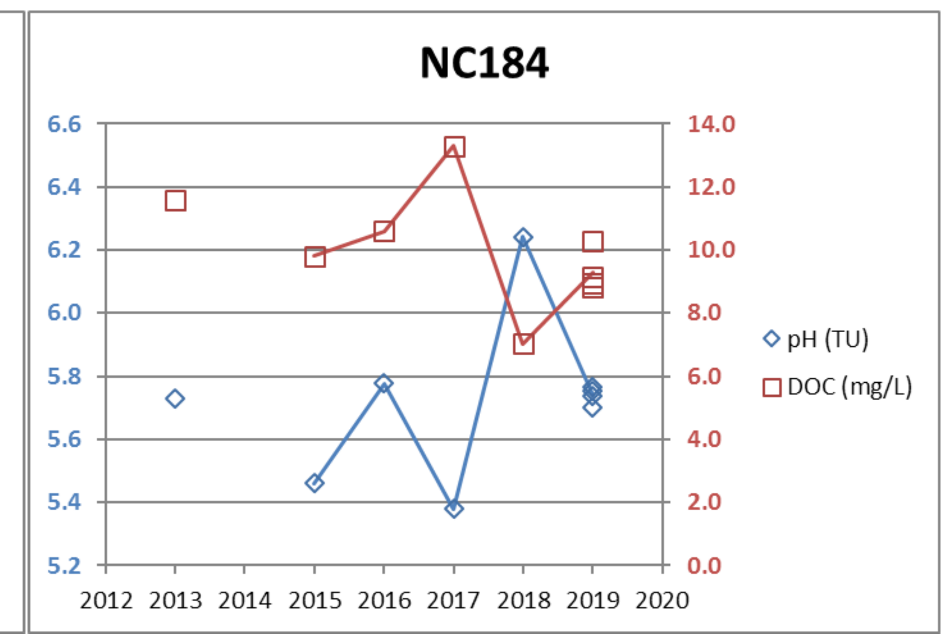


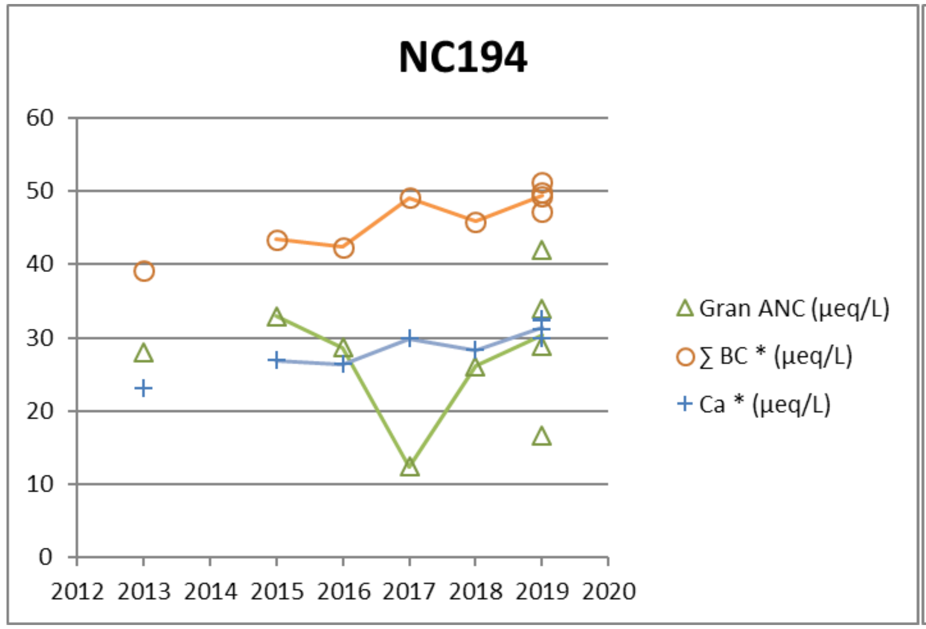


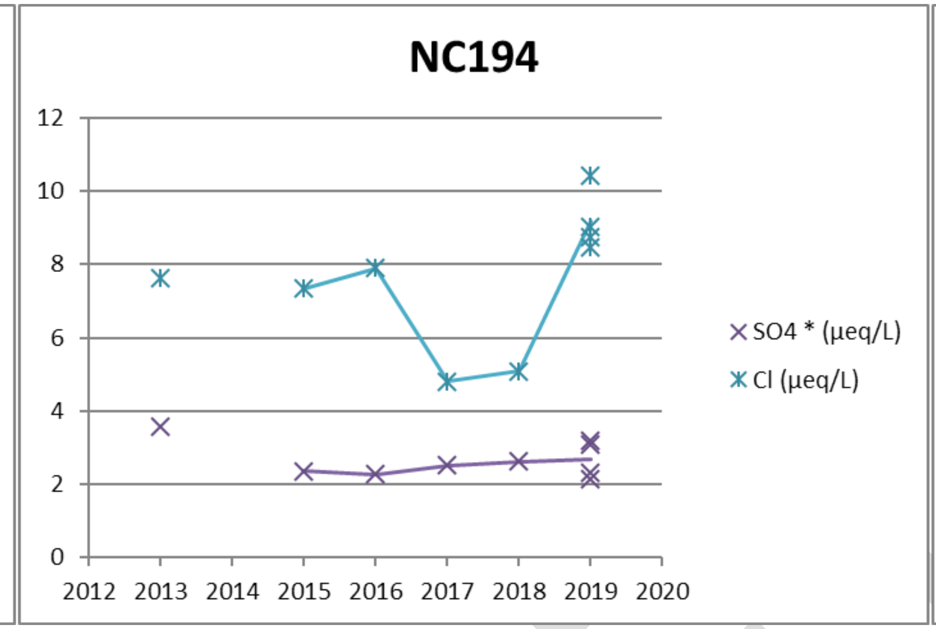


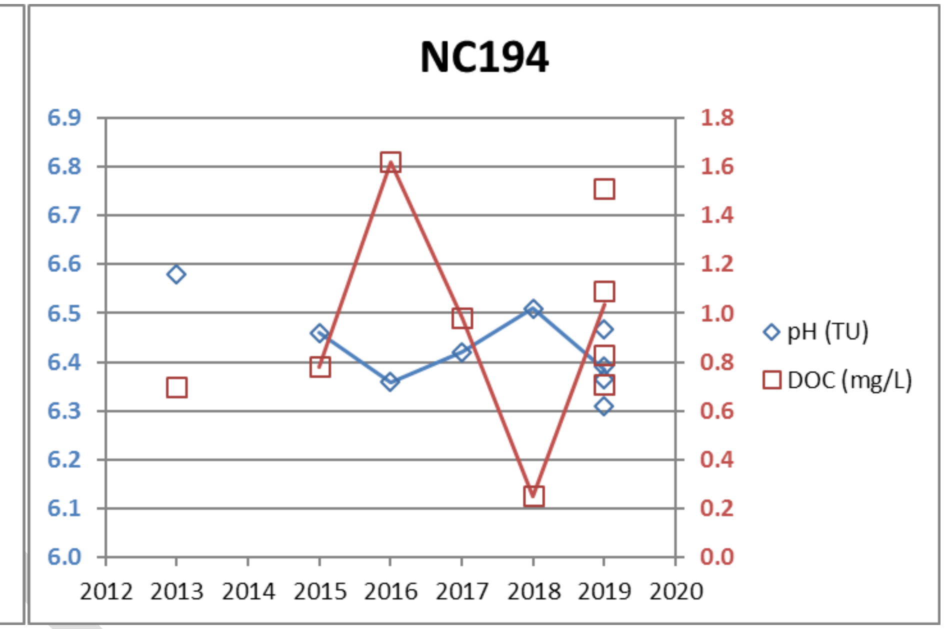







NC194
Gran ANC (µeq/L)
∑ BC * (µeq/L)
Ca * (µeq/L)


NC194
SO4 * (µeq/L)
Cl (µeq/L)


NC194
pH (TU)
DOC (mg/L)