



Real-Time Water Quality Deployment Report

Teck Duck Pond Operations

2018



Government of Newfoundland & Labrador
Department of Municipal Affairs and Environment
Water Resources Management Division
St. John's, NL, A1B 4J6 Canada

Introduction

Real-time monitoring (RTWQ) of surface and groundwater quality on the Teck: Duck Pond Operations site (Teck DPO) is carried out by the Department of Municipal Affairs and Environment (MAE), Water Resources Management Division (WRMD). This work is undertaken in circumstances where industrial development has the potential to impact water bodies. The RTWQ program consists of more than 30 stations across the province from Voisey's Bay to St. Lawrence and Corner Brook to St. John's.

RTWQ work at Teck DPO has been ongoing since 2006 with the installation of three monitoring stations: East Pond Brook (abbreviated EPB) station, Tributary to Gill's Pond Brook (abbreviated TGPB) station, and Monitoring Well after Tailings Dam A station.

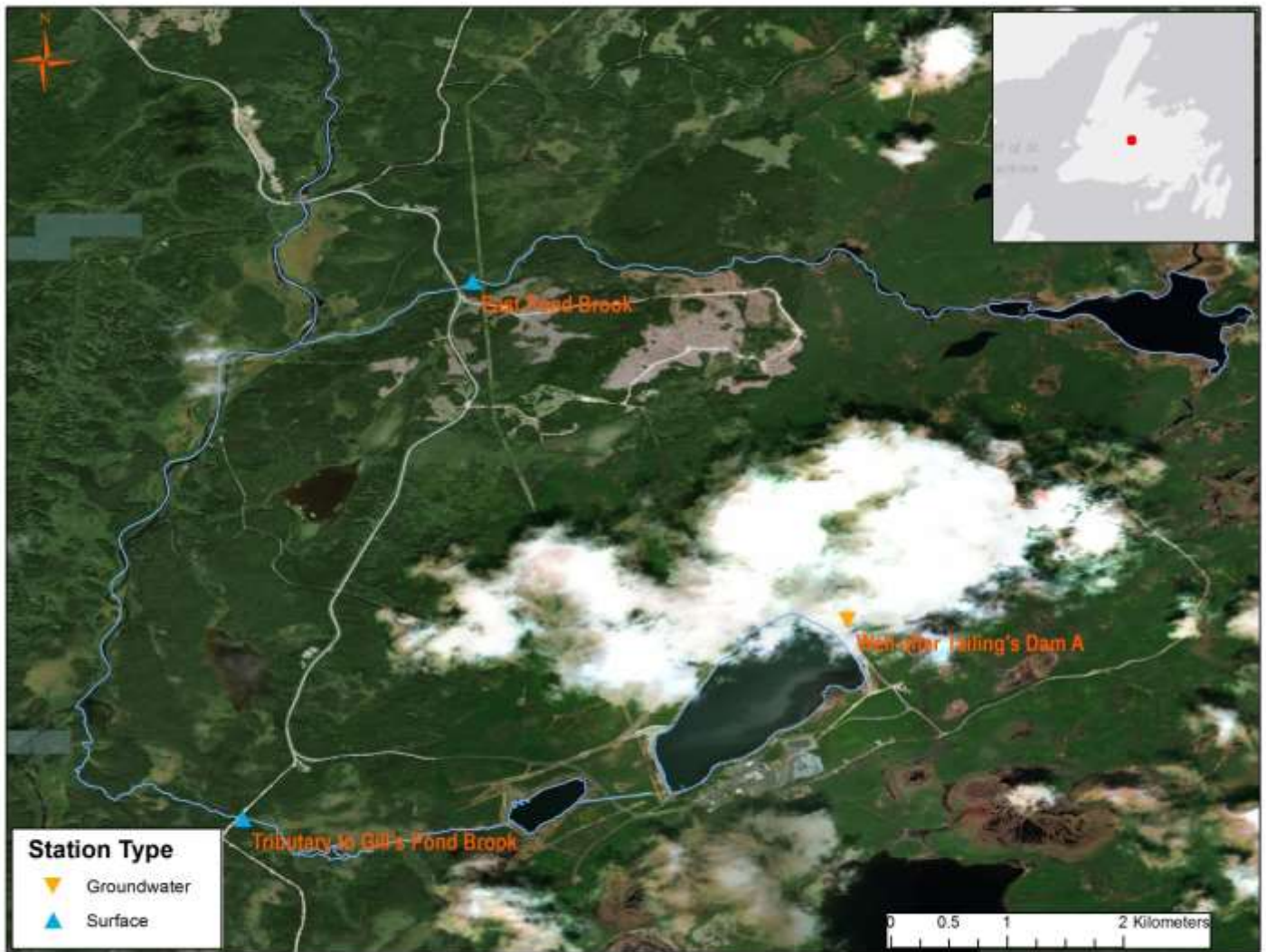


Photo 1: Aerial photo of Teck DPO project site and water quality stations

These stations, identified in Photo 1, were placed to observe water quality at key location over the course of the Teck DPO project. EPB station was placed to intercept potential seepage from underneath flow control structures that maintain the tailings management area. TGPB is placed to observe water quality following the

ultimate discharge of treated effluent from the polishing pond into the environment. Well after Tailings Dam A is also located in the East Pond Brook watershed, but is immediately adjacent to the flow control structure that ensures the tailings management area drains towards the polishing pond and the eventual discharge point above TGPB station.

In this report, notable events and trends from 2018 are identified and discussed in relation to previous years. Thorough statistical analysis is intentionally avoided in favour of brief summary statistics.

Methods and Procedures

Work under the RTWQ program is conducted according to the Protocols Manual for Real-Time Water Quality Monitoring in NL¹. This document outlines the procedures, methods, and QAQC regimen used by all staff involved in the RTWQ program at all stations, province wide. For surface water monitoring, water quality instrumentation – in this case the Hydrolab DS5X multi-parameter sonde – is deployed on six-week intervals with *in situ* data validation at the beginning and end of deployment using an equivalent and freshly calibrated multi-parameter sonde. A grab sample is collected at the start of a deployment as an independent indicator of data quality.

Due to the narrow confines of a 2” monitoring well, insertion of additional instruments into the well for verification purposes results in considerable changes to the well chemistry. As a result, data validation is restricted to capturing a grab sample immediately prior to insertion of newly-calibrated monitoring equipment in the well. Protocol requires a volume equivalent to three well casings to be purged from the well prior to sampling. This process flushes stagnant water from the well and ensures that the water being observed is aquifer water.

In the next section, long-term data from both the surface and groundwater monitoring networks are presented as line and boxplots. Guidelines set by the Canadian Council of Ministers of the Environment (CCME) and site-specific guidelines are indicated by dashed lines. Grab sample data for pH, specific conductivity, and turbidity is presented as black dots in the same figures. Boxplots are presented to illustrate how water quality parameters change from year to year.

Summary statistics are presented for each surface and groundwater parameter in the next section. Each table lists the 2018 median, minimum, and maximum values. *Average median* values for each parameter are calculated from the median values of each previous year and is provided in the same tables and labelled as *average* for simplicity. Median values are preferred throughout this report as a more robust indicator of central tendency than average values, especially given the highly skewed characteristic of environmental data.

Results and Discussion

The following pages provide interpretation of water quality events and trends observed at each real-time water quality monitoring station at Teck DPO.

¹ https://www.mae.gov.nl.ca/waterres/rti/rtwq/NL_RTWQ_Manual.pdf

Surface Water Network

The surface water network at Teck DPO consists of EPB and TGPB stations which are discussed in this section.

Water Temperature

Water temperatures in 2018 were slightly lower than mean temperatures from the previous eight years (see Table 1). This is likely annual variation and of no immediate concern.

Some transmission issues resulted in a loss of some data in May, 2018. As a result, the median temperature value became highly skewed at Gill's Pond Brook station. Mean water temperatures are reported in Table 1.

Table 1: Water Temperature at Teck DPO

Station	Segment	Mean	Min	Max
East Pond Brook	Average	7.32	-0.15	29.05
	2018	6.80	-0.32	28.10
Gills Pond Brook	Average	7.13	-0.45	27.80
	2018	6.79	-0.34	27.01

Figure 1: Water Temperature at Teck DPO

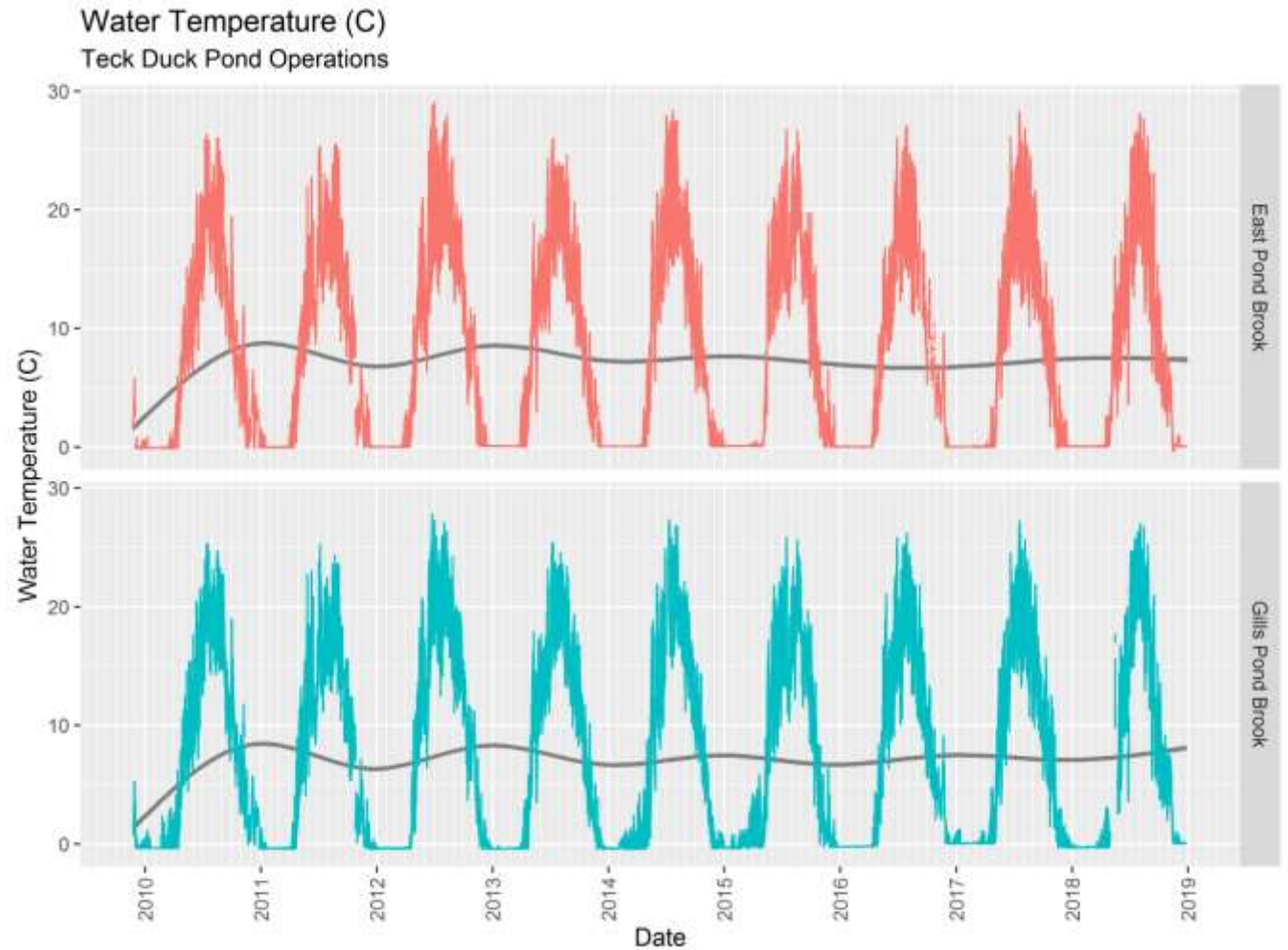
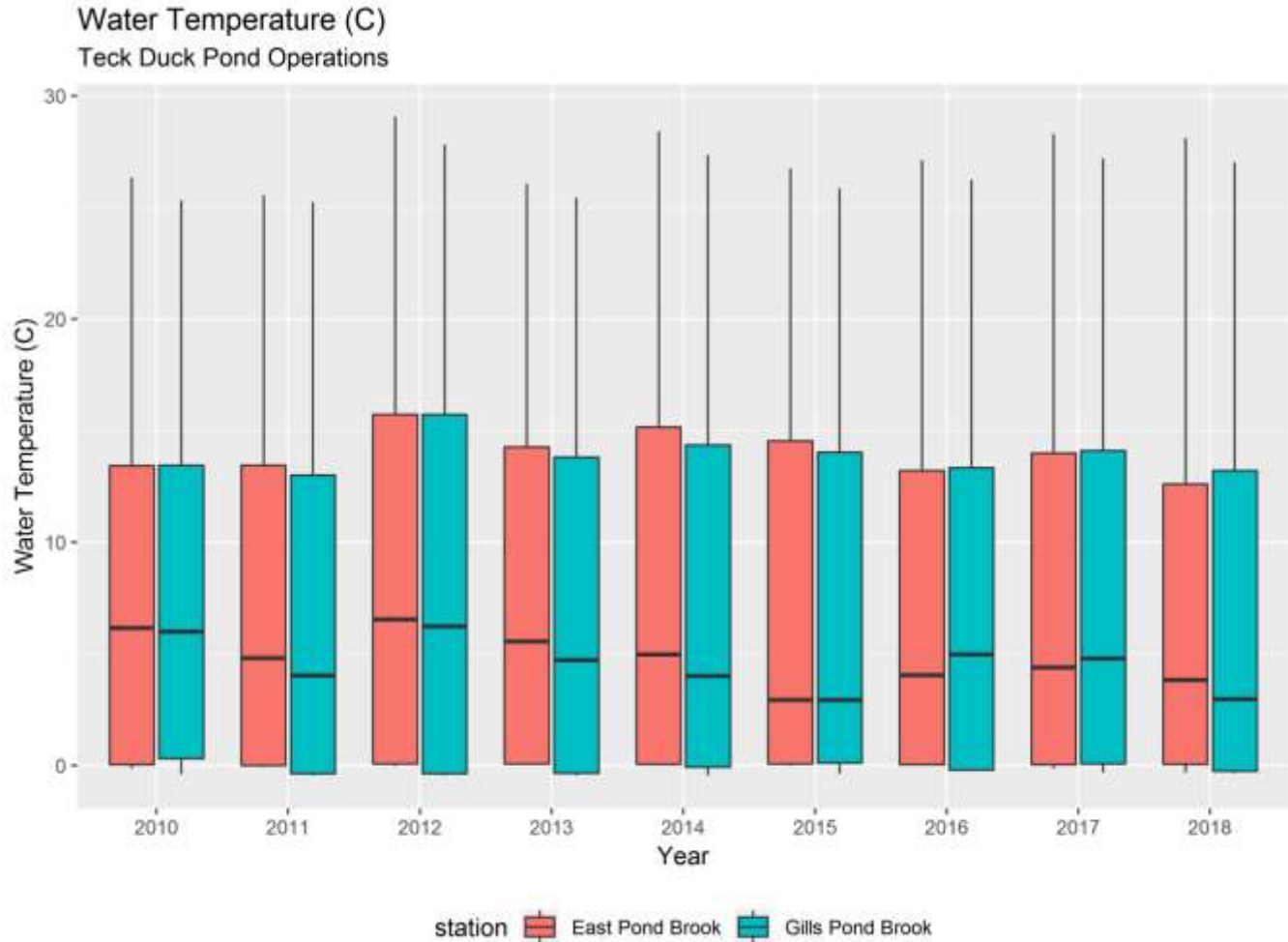


Figure 2 shows the range in water temperatures at EPB and TGPB stations since 2010. In that time span, 2018 saw the second lowest temperatures where 2015 was the coolest.

Figure 2: Boxplots of water temperature at Teck DPO from 2010 to 2018



pH

Median pH values observed at EPB and TGPB stations in 2018 are not meaningfully different from values observed in the previous eight years (Table 2).

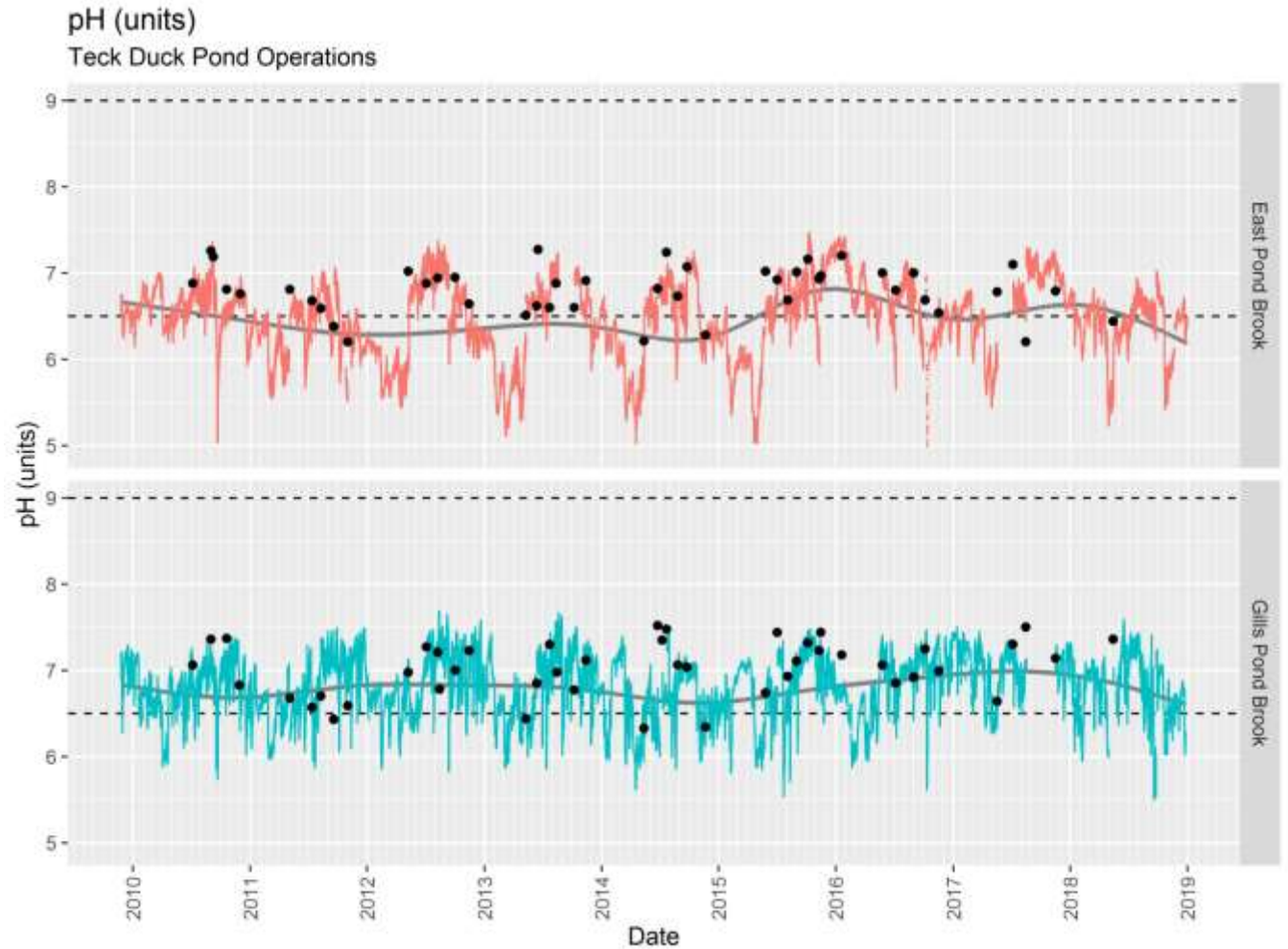
Figure 3 shows that pH levels at East Pond Brook typically fall at, or somewhat below, the CCME guidelines for the protection aquatic organisms (dashed lines). pH levels at Gill's Pond Brook typically fall at, or somewhat above, CCME guidelines.

Ambient waters on the island of Newfoundland tend to be acidic due to geochemical processes. As such, the ambient waters of East Pond Brook are slightly acidic. Gills Pond Brook waters, however, are highly influenced by treated effluent discharged from an upstream polishing pond. These waters are treated to maintain a near-basic pH of 7.0

Table 2: pH at Teck DPO

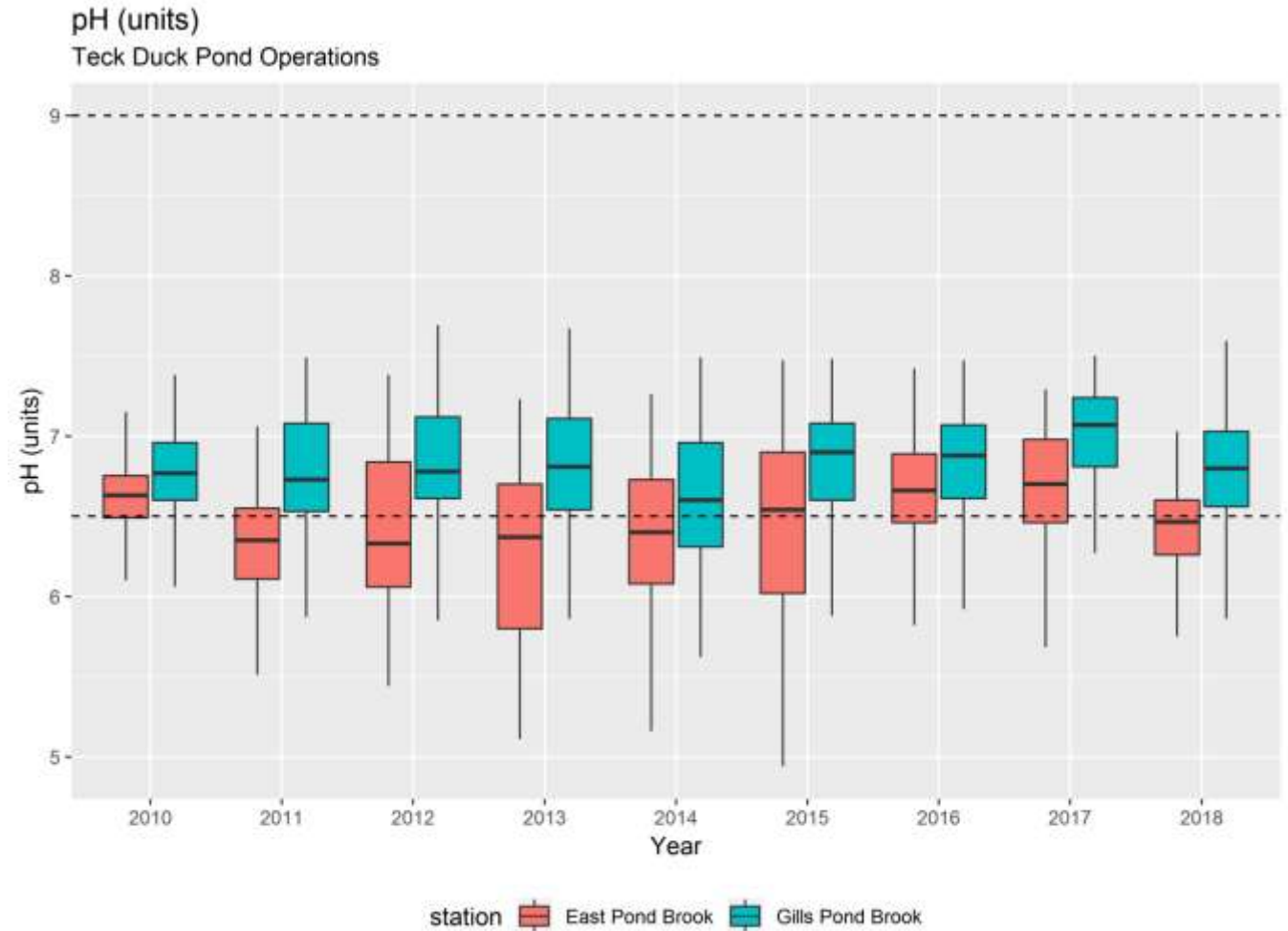
Station	Segment	Median	Min	Max
East Pond Brook	Average	6.54	4.94	7.47
	2018	6.47	5.23	7.03
Gills Pond Brook	Average	6.82	5.54	7.69
	2018	6.80	5.50	7.59

Figure 3: pH at Teck DPO



pH values in 2018 were somewhat lower than those observed in 2017 at both stations, as seen in Figure 4. Declines in pH are still within historical levels.

Figure 4: Boxplots of pH at Teck DPO from 2010 to 2018



Specific Conductivity

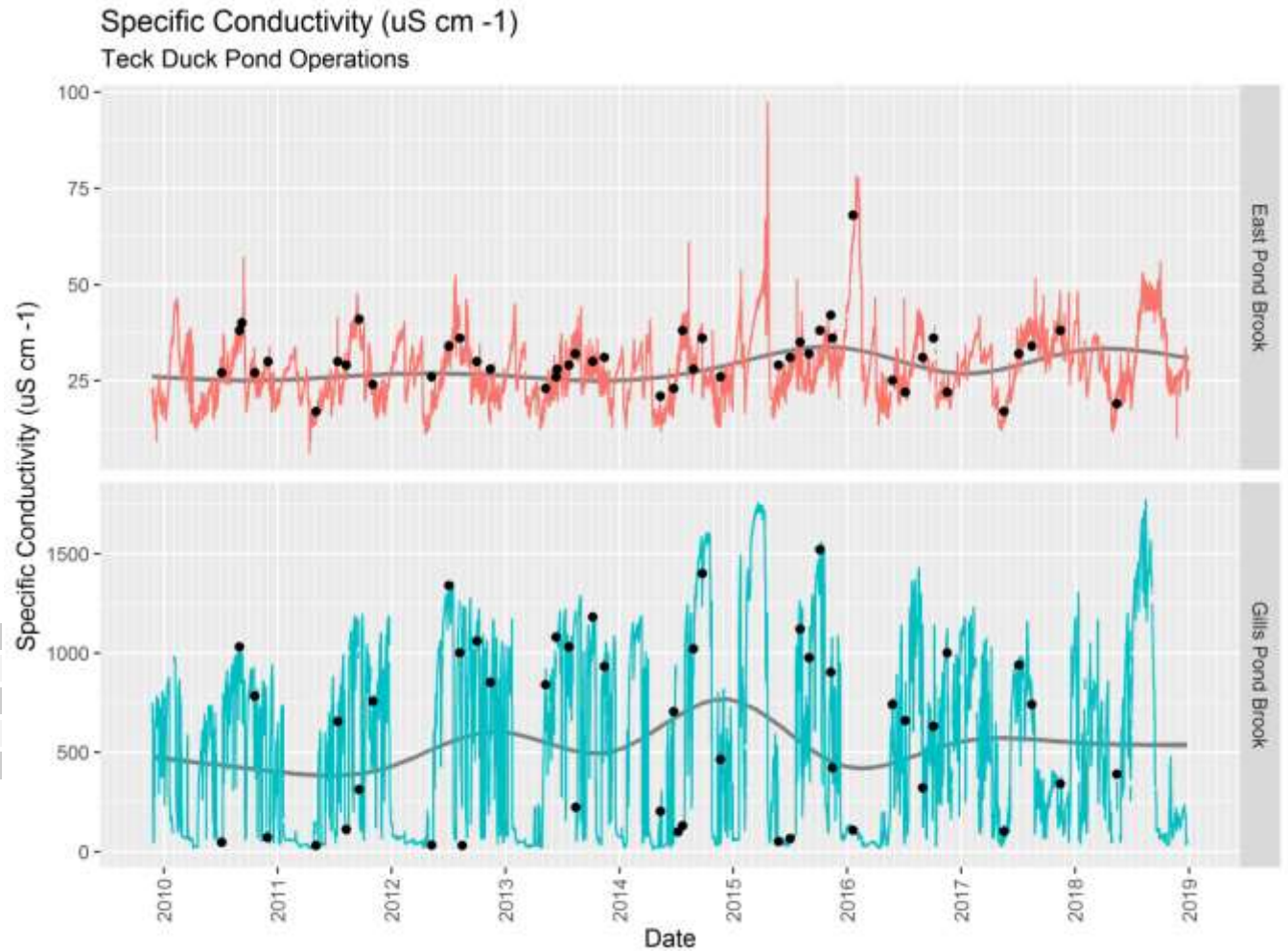
In Table 3, median specific conductivity values at both stations were somewhat greater in 2018 than levels seen over the previous eight years.

A slow and long term rising trend in conductivity appears to be occurring at East Pond Brook, as shown by the trend line in Figure 5. The driving force behind this increase may be related to a number of factors such as atmospheric deposition of dust from industrial activity in the area, soil disturbance from nearby logging activities, or movement of dissolved solid-laden groundwater from the tailings management area higher in the watershed.

Table 3: Specific conductivity at Teck DPO

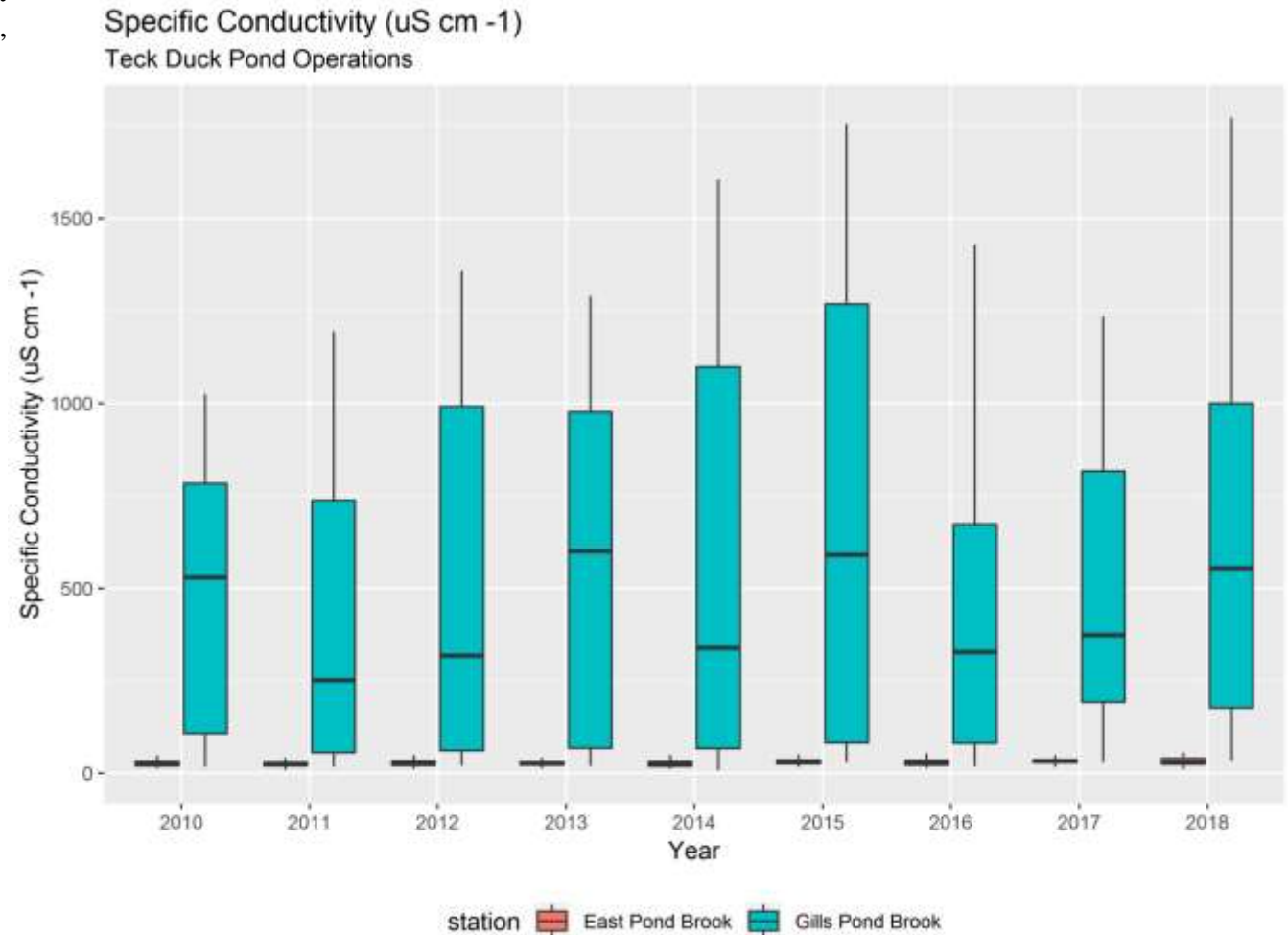
Station	Segment	Median	Min	Max
East Pond Brook	Average	26.8	6.3	97.3
	2018	28.6	10.2	55.9
Gills Pond Brook	Average	432.0	7.4	1755.0
	2018	554.0	32.1	1771.0

Figure 5: Specific Conductivity at Teck DPO



The influence of polishing pond effluent on water quality in Gill's Pond Brook is evident in Figure 6. Without polishing pond effluent, specific conductivity levels at EPB and TGPB stations would report values similar to one another. Specific conductivity at TGPB station, however, is substantially higher than EPB station which barely registers on the plot to the right.

Figure 6: Boxplots of specific conductivity at Teck DPO from 2010 to 2018



Dissolved Oxygen

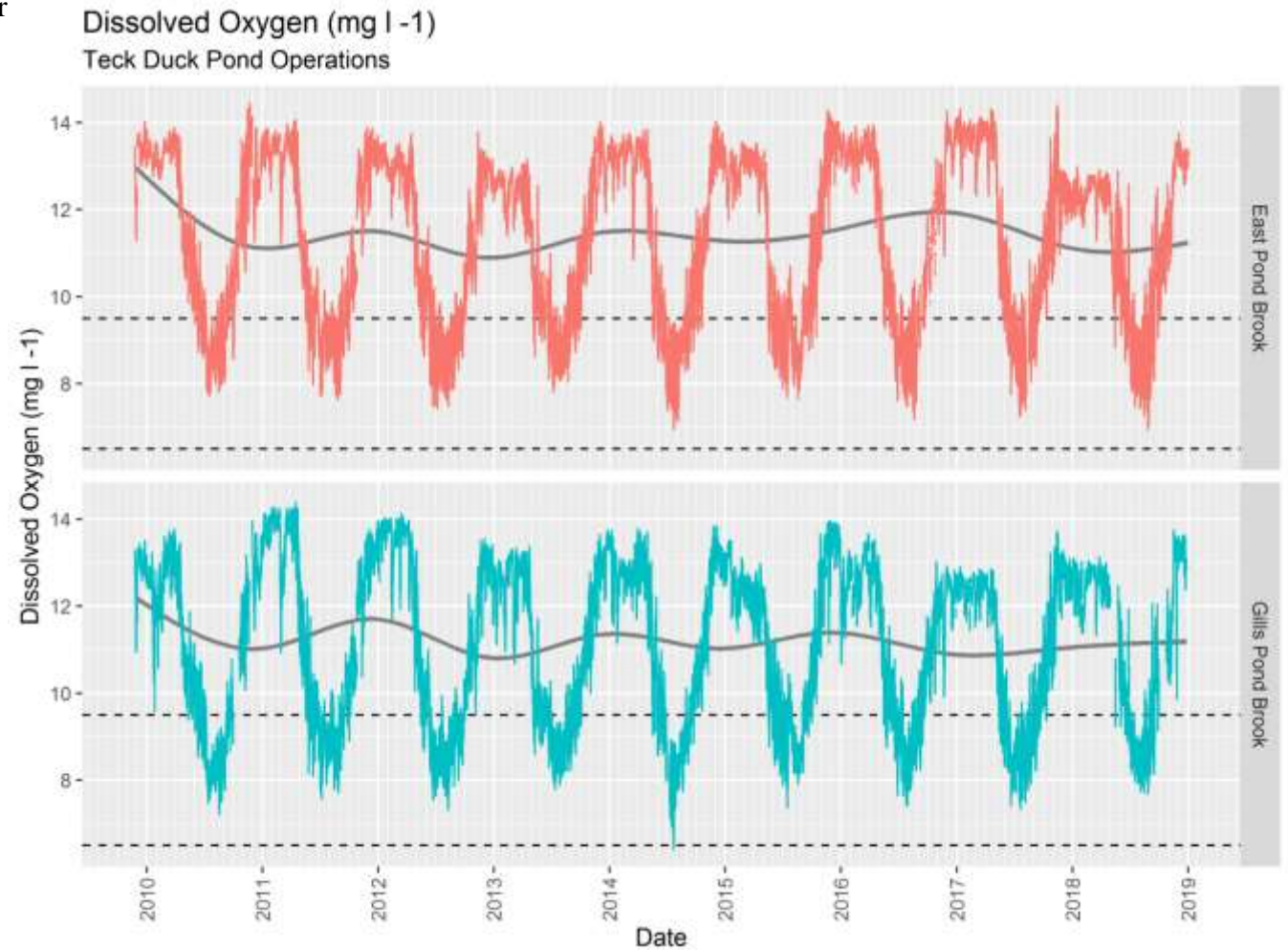
Dissolved oxygen concentrations were lower at East Pond Brook in 2018 compared to the previous eight years, whereas it was higher at Gill's Pond Brook in 2018 compared to previous years (Table 4).

In 2018, all dissolved oxygen values were found to be within CCME guidelines (dashed lines in Figure 7), even during warm-water periods when oxygen concentrations are typically low.

Table 4: Dissolved Oxygen at Teck DPO

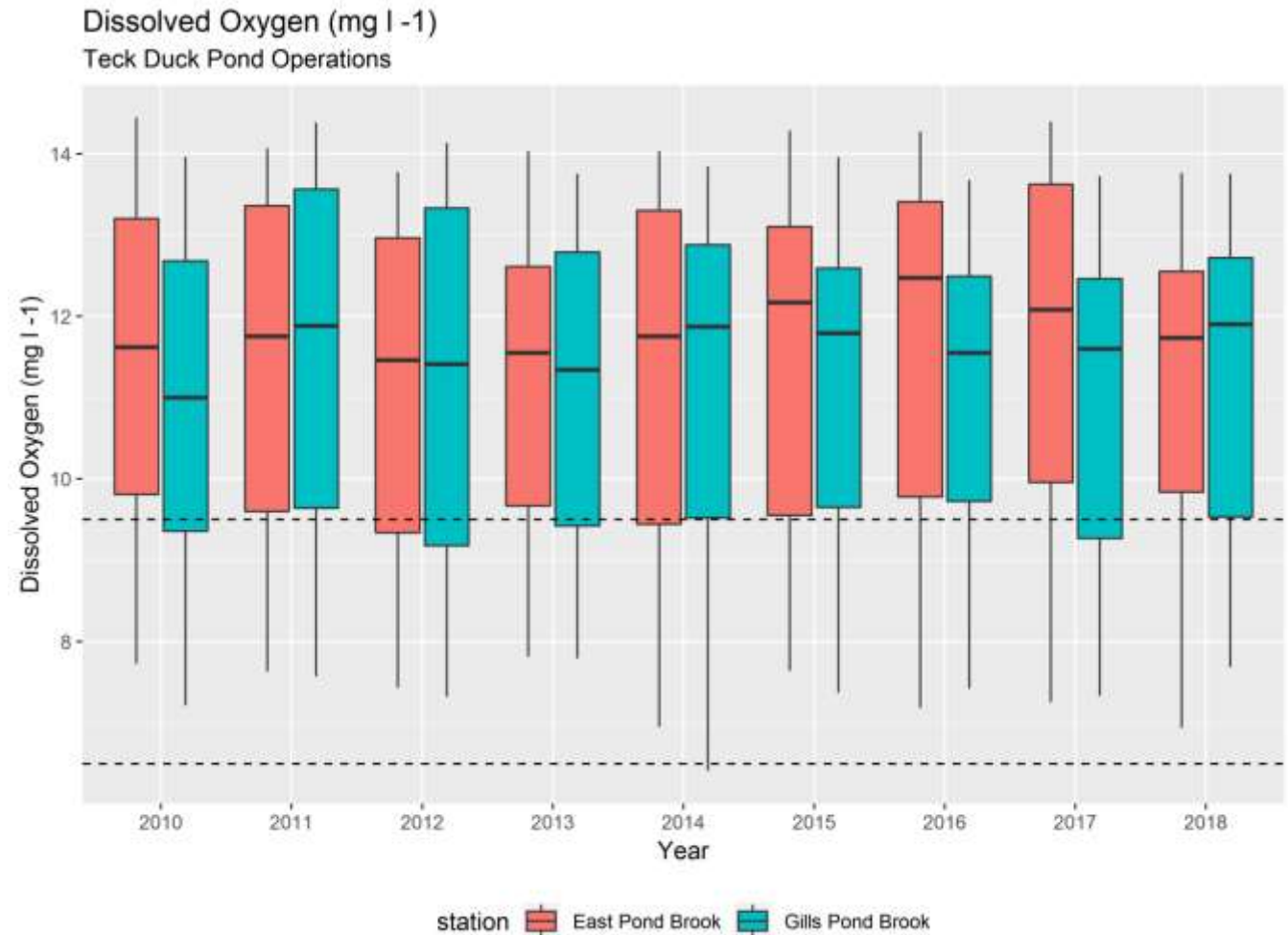
Station	Segment	Median	Min	Max
East Pond Brook	Average	11.93	6.95	14.44
	2018	11.73	6.94	13.76
Gills Pond Brook	Average	11.63	6.41	14.38
	2018	11.90	7.68	13.75

Figure 7: Dissolved oxygen at Teck DPO



As seen in Figure 8, dissolved oxygen concentrations have not changed in any considerable up- or downward trend since monitoring began. Each box, which represents the central 75% of values, is generally greater than the least-conservative CCME guideline of 9.5 mg/l for the protection of aquatic biota (black, dashed lines).

Figure 8: Boxplots of dissolved oxygen at Teck DPO from 2010 to 2018



Turbidity

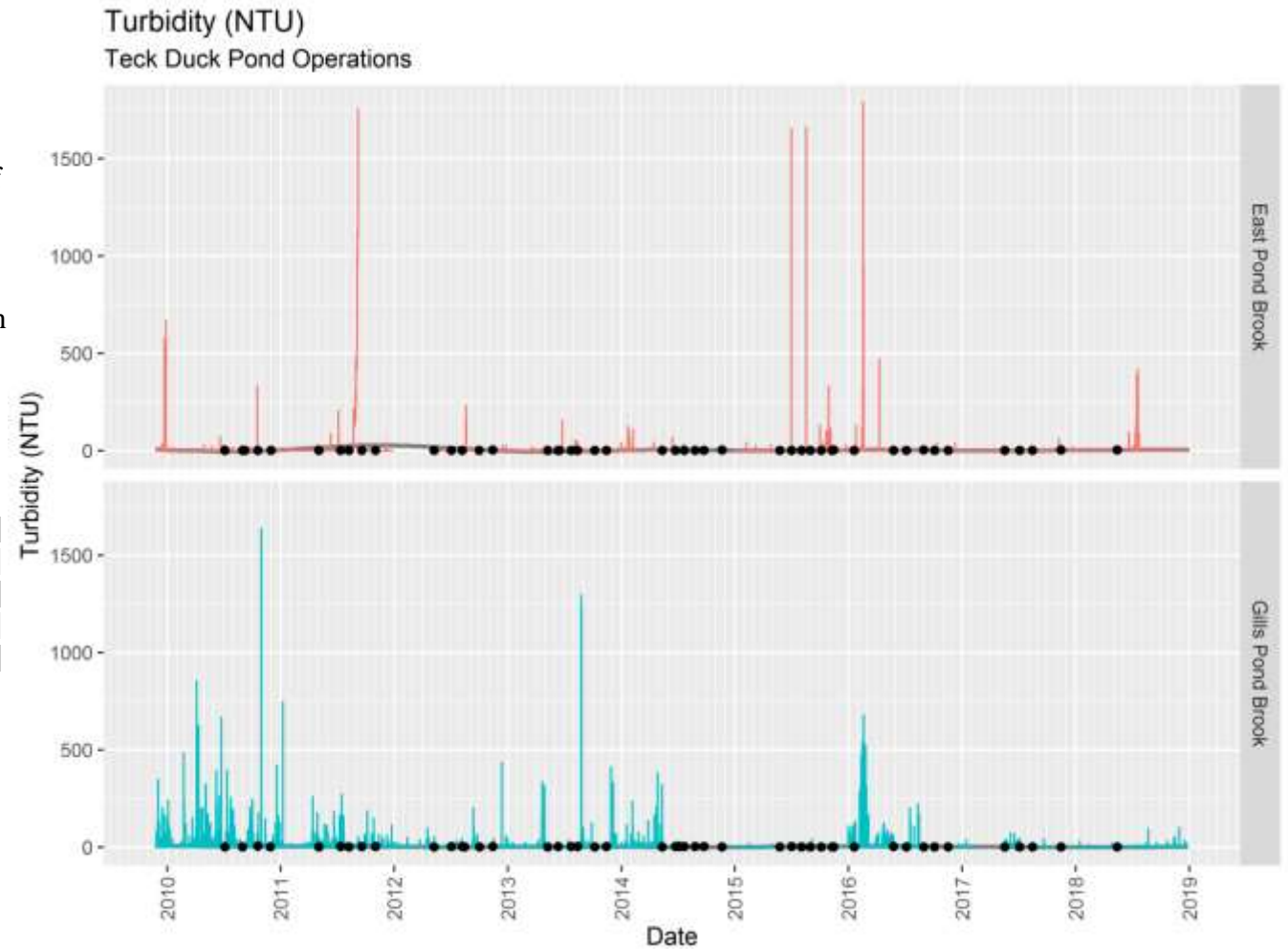
Turbidity levels at both Gill's Pond Brook and East Pond Brook stations are generally very low (Table 5).

Despite median values of 0 NTU, Figure 9 shows that there are some notable periods of higher turbidity. At TGPB station, these periods are especially obvious from 2010 to mid-2014. Following this period, turbidity events became fewer in number and lower in magnitude. In 2018, only a small number of turbidity events were encountered at either station.

Table 6: Turbidity at Teck DPO

Station	segment	Median	Min	Max
East Pond Brook	Average	0.0	0.0	1789.0
	2018	0.0	0.0	417.0
Gills Pond Brook	Average	0.0	0.0	1635.0
	2018	0.0	0.0	103.7

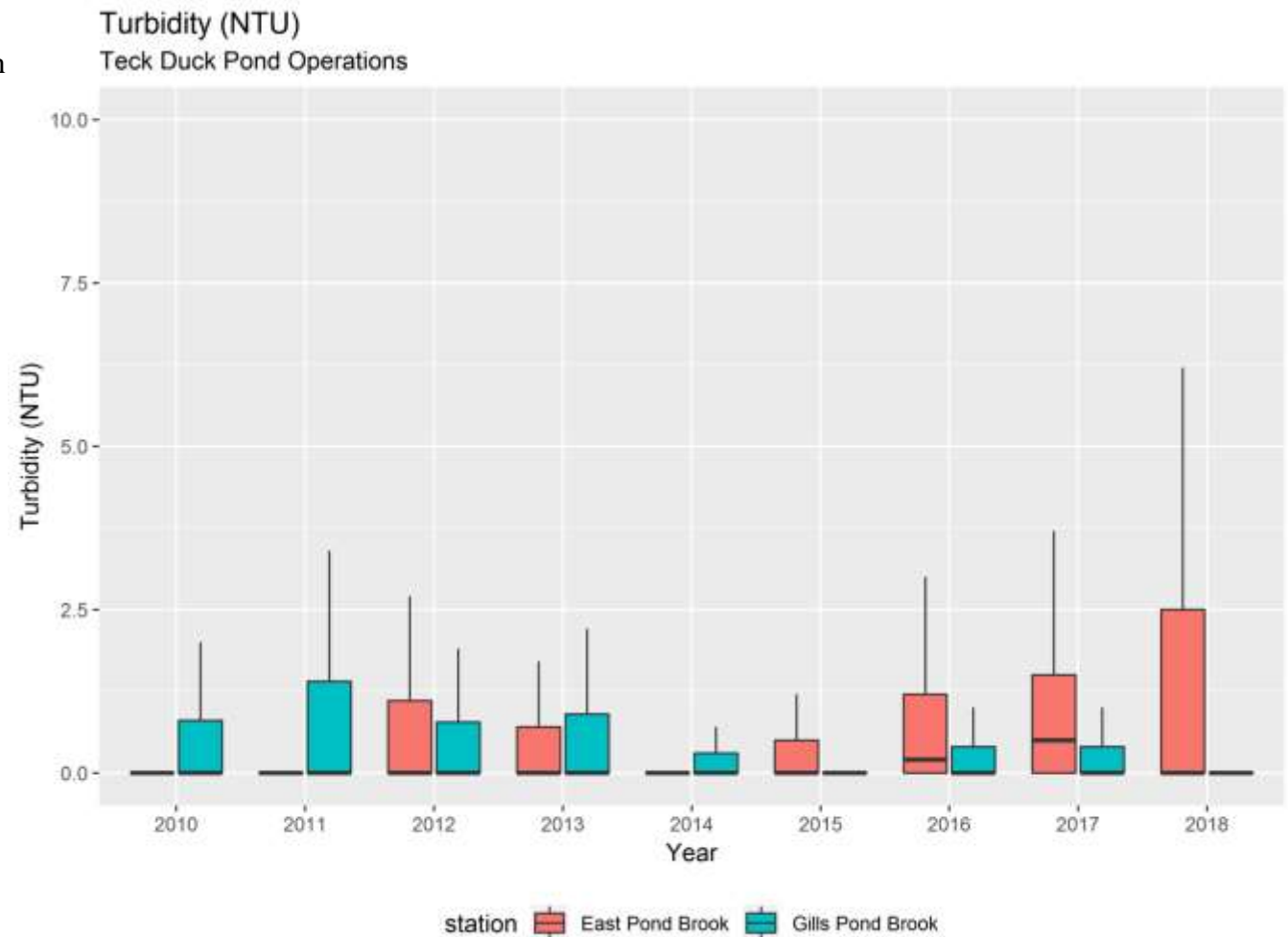
Figure 9: Turbidity at Teck DPO from 2010 to 2018



The long-term characteristics of turbidity at the Teck DPO sites are seen in Figure 10. Within each boxplot, a central, horizontal black bar indicates median turbidity. Median values are generally located at 0 NTU, except for East Pond Brook in 2016 and 2017. Those two years seemed to indicate a rising trend in turbidity but median turbidity once again fell to 0.0 NTU in 2018. Nevertheless, the upper range of turbidity values at East Pond Brook continued to increase from 2015 to 2018.

The mechanisms responsible for this increase is not known but possible explanations could be closure work at Teck DPO or logging in the area.

Figure 10: Boxplots of turbidity at Teck DPO from 2010 to 2018



Well after Tailings Dam A

This section presents groundwater quality parameters from a location immediately adjacent to the northeastern downgradient edge of the tailings management area.

Water Temperature

In 2018 water temperatures fell within a range of 1.13°C, according to Table 7. These temperatures fall within historical ranges.

Figure 11 shows that annual low temperatures tend to occur in mid-July and annual high temperatures tend to occur in mid-December.

Table 7: Water Temperature at Well after Tailings Dam, Teck DPO

Segment	Median	Min	Max
Average	5.30	4.51	6.13
2018	5.28	4.72	5.85

Figure 11: Water temperature at Well after Tailings Dam, Teck DPO

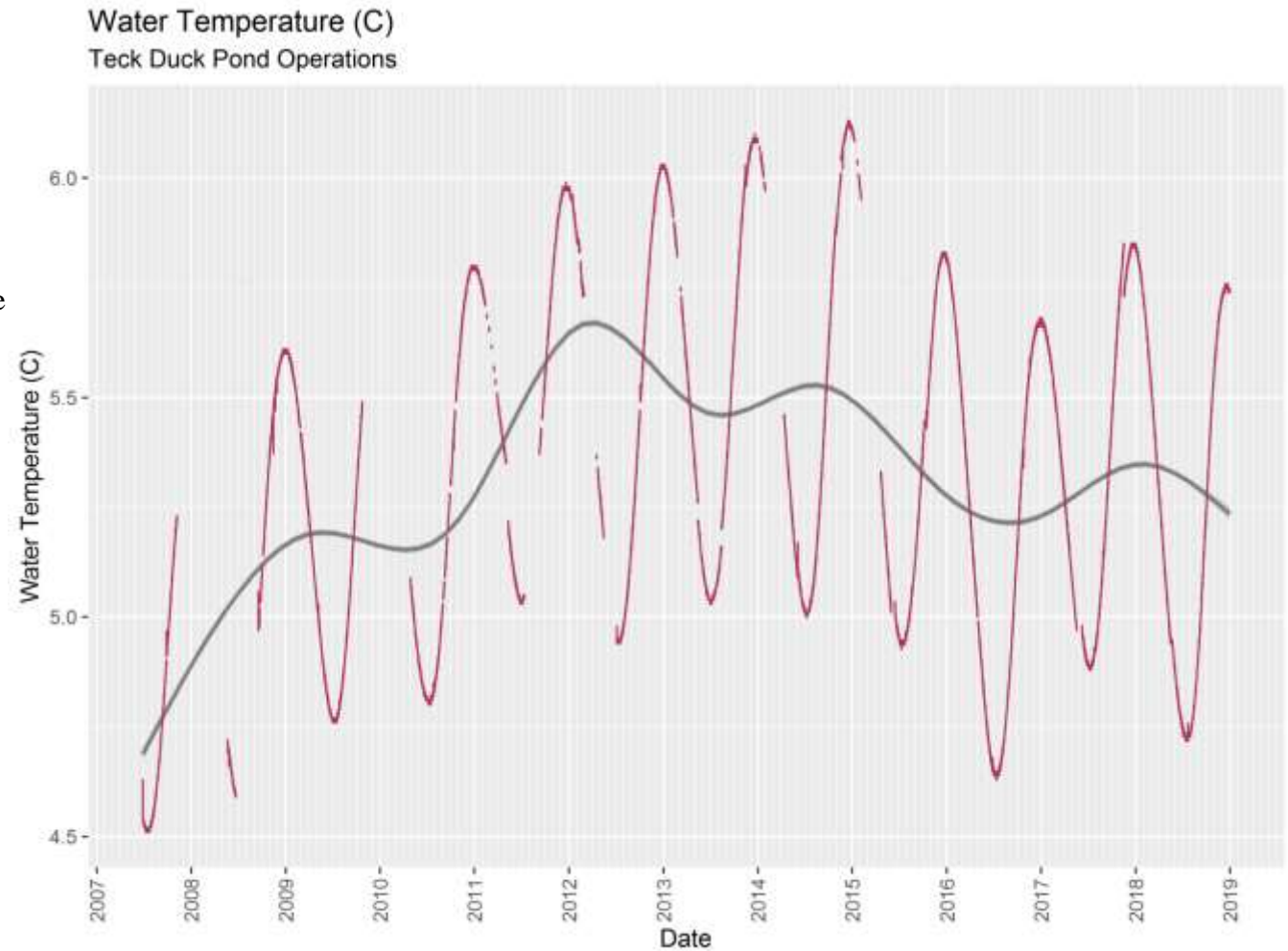
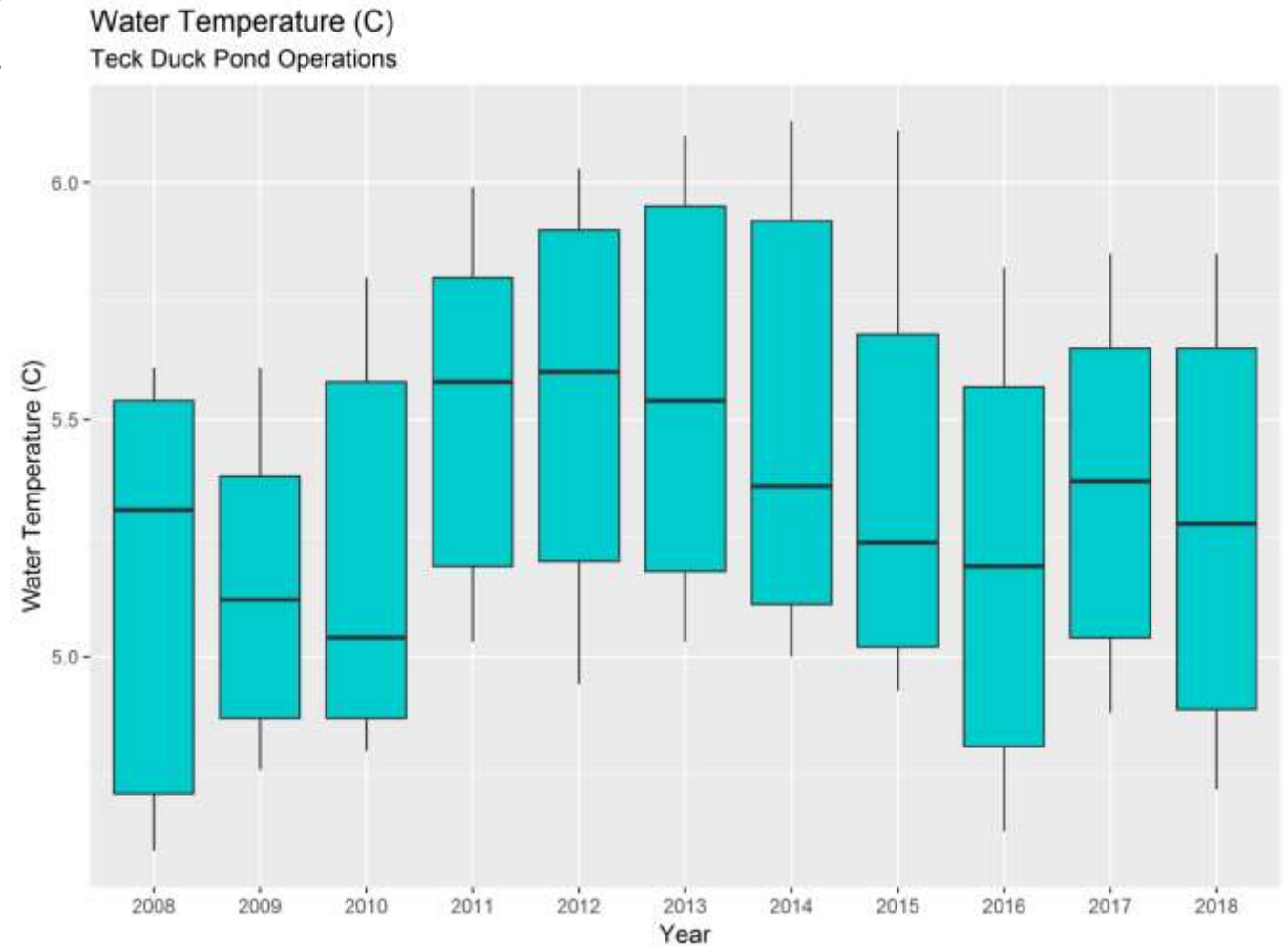


Figure 12 shows the consistency of water temperatures from 2008 to 2018 where there is considerable overlap in ranges from one year to the next. No notable trend is obvious at this time.

Figure 12: Boxplots of water temperature at Well after Tailings Dam, Teck DPO



pH

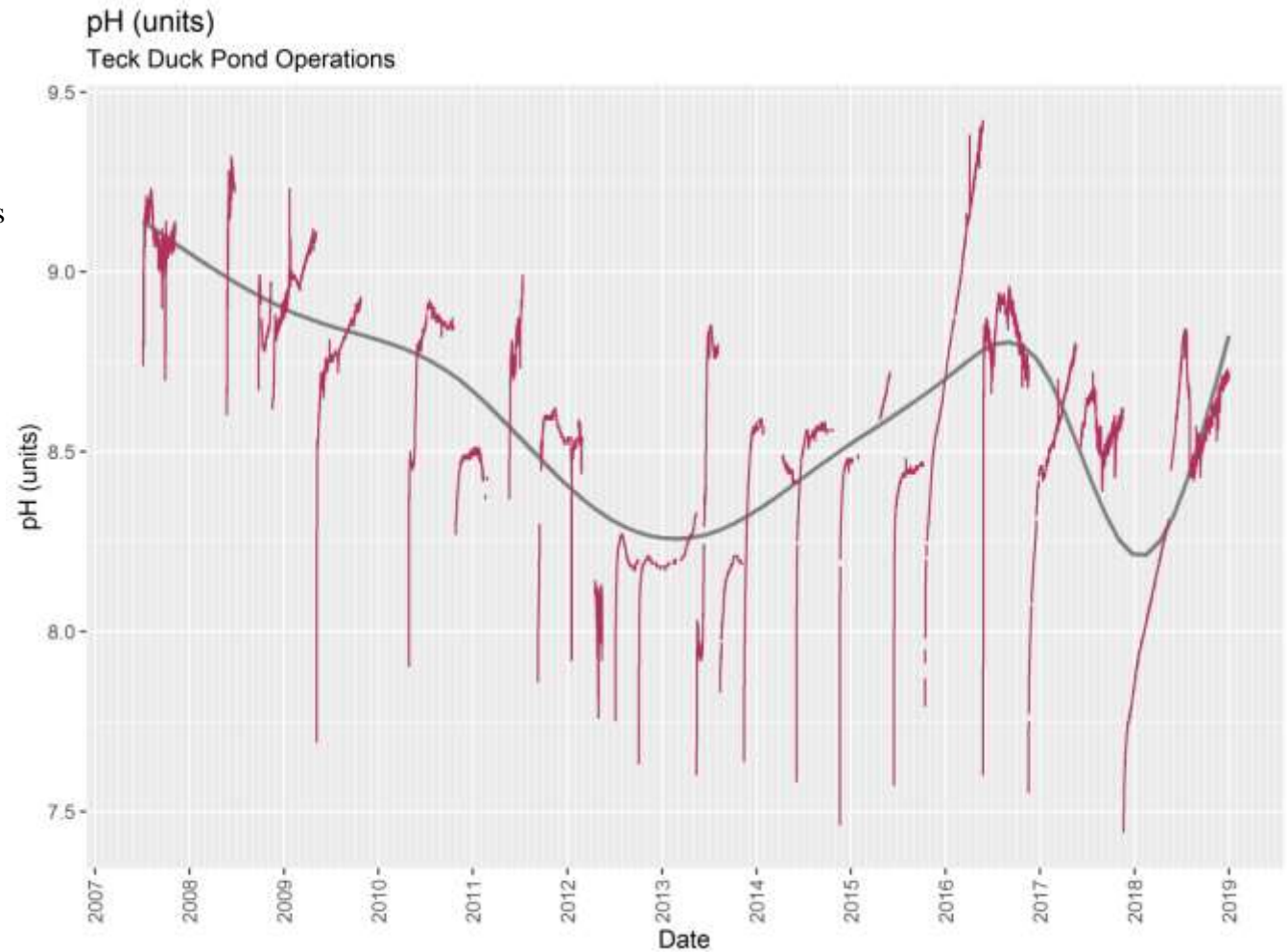
In 2018, median pH was similar to the median pH calculated from previous years (Table 8).

Readily apparent in Figure 13 is the long period of time it takes for pH to stabilize in the well following routine maintenance. This effect can be attributed to factors such as sensor stabilisation or chemical change resulting from aquifer water being pulled into the borehole. The rising trend can take upwards of a month to stabilize.

Table 8: pH at Well after Tailings Dam, Teck DPO

Segment	Median	Min	Max
Average	8.57	7.44	9.42
2018	8.51	7.85	8.84

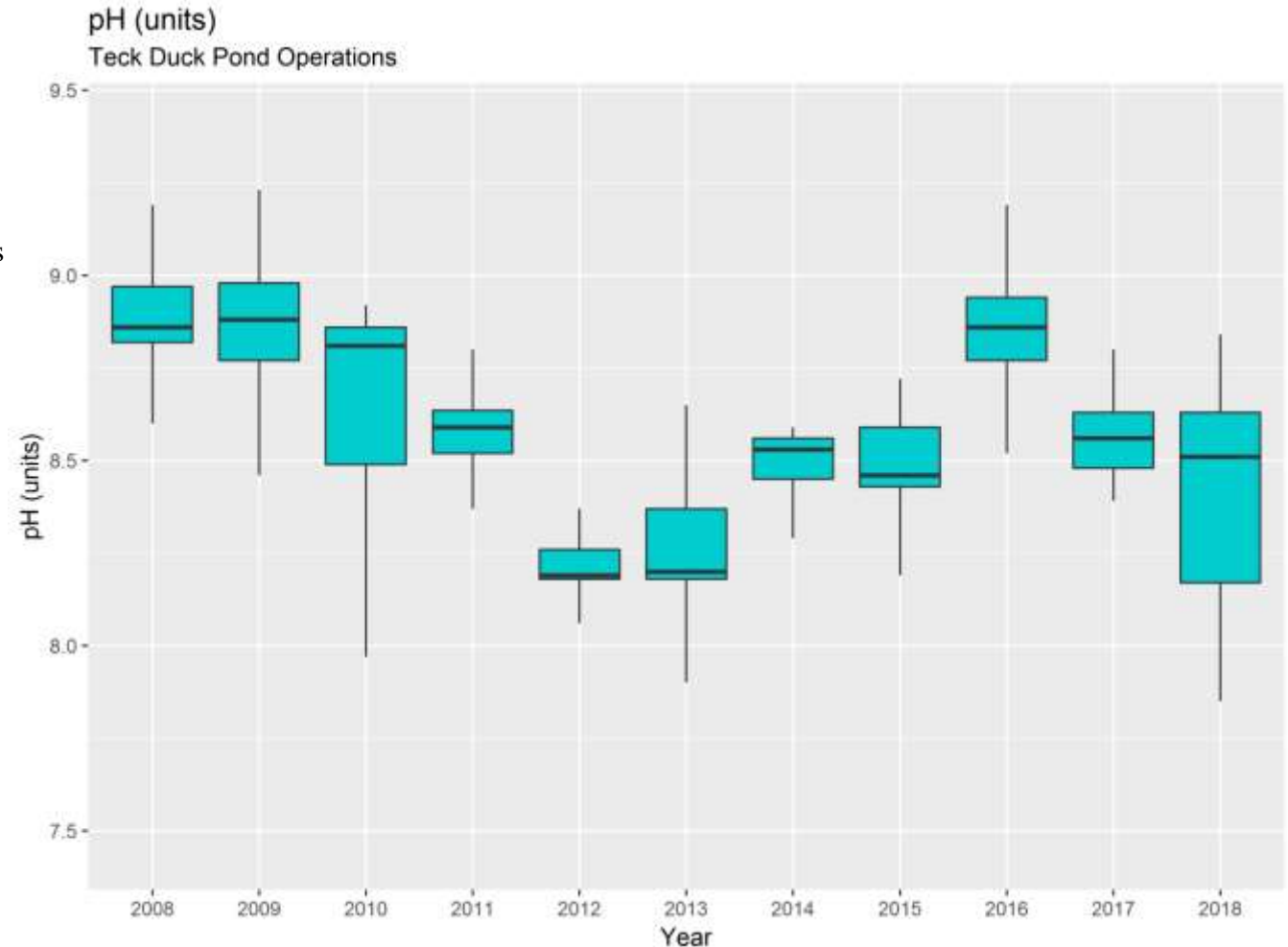
Figure 13: pH at Well after Tailings Dam, Teck DPO



The discord observed in Figure 13 makes it challenging to pick out trends or overall changes in pH. Figure 14 offers a clearer view of pH over time.

pH levels within the well tend to be alkaline in nature. Interestingly, Figure 14 appears to mirror an opposite and inverse relationship with water temperature (Figure 11). In years where water temperature is cooler, pH levels tend to be more alkaline and when water is warmer, conditions appears to be more acidic. It is unclear if this is coincidental or if there is an actual relationship between the two parameters.

Figure 14: Boxplots of specific conductivity at Well after Tailings Dam, Teck DPO



Specific Conductivity

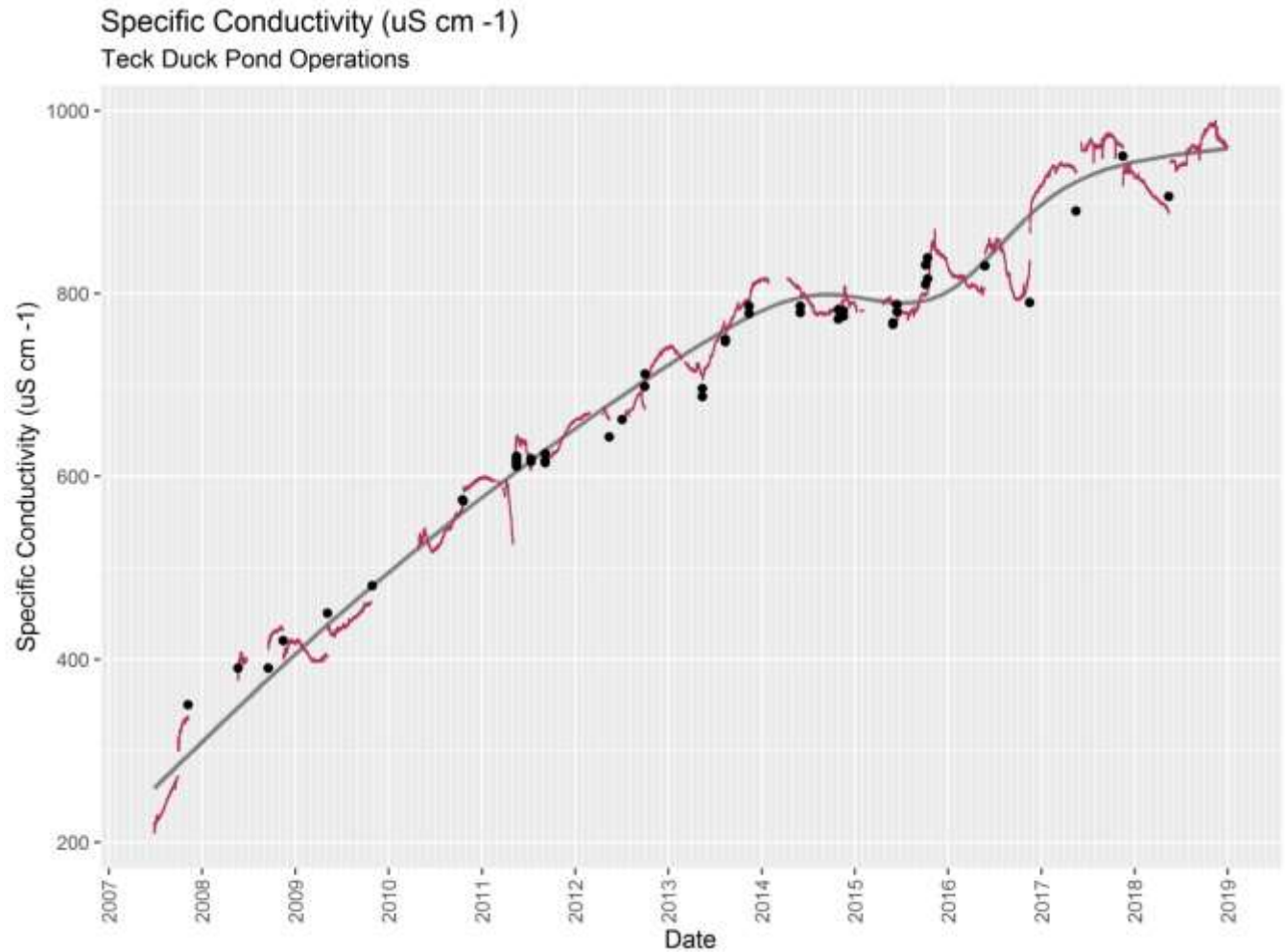
In 2018, specific conductivity values continued to rise above historical values, as seen in Table 9 and in Figure 15.

A plateau phase from 2014 to late 2015 was observed prior to a rising trend from 2016 onwards. At this time, water level in the tailings management area was lowered to perform long-term stabilization work. A lower water level and deposition of materials may have resulted in the sudden increase in conductivity.

Table 9: Specific conductivity at Well after Tailings Dam, Teck DPO

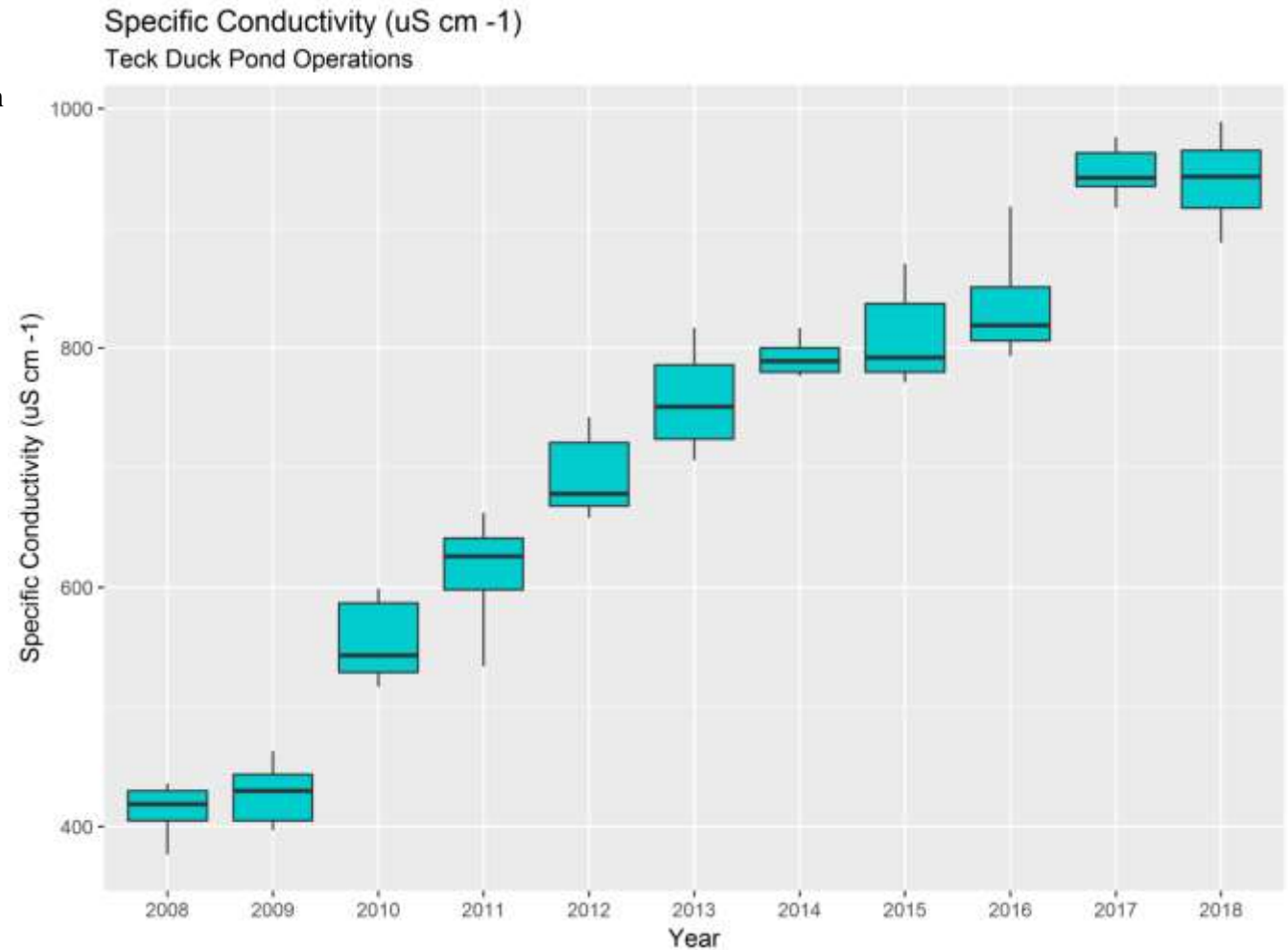
Segment	Median	Min	Max
Average	0.741	0.210	0.976
2018	0.943	0.888	0.989

Figure 15: Specific Conductivity at Well after Tailings Dam, Teck DPO



In Figure 16, 2017 and 2018 show a distinct and separate tendency from the plateau period seen from 2014 to 2016. This tendency likely resulted from work within the tailings management area as discussed in the previous Figure 15.

Figure 16: Boxplots of specific conductivity at Well after Tailings Dam, Teck DPO



Oxidation-Reduction Potential (ORP)

Conditions within the well are predominantly reductive with highly negative values (Table 10).

Much like pH, ORP tends to take a number of days to settle following routine maintenance as depicted in Figure 17. From 2007 to 2016, post-maintenance ORP values were found to be oxidative (> 0 mV) for a brief period before quickly falling to reductive levels (< 0 mV).

There is an indication that ORP values are becoming more reductive over time. From 2015 to 2018, stable ORP values began to fall lower and even post-maintenance ORP values were no longer oxidative.

Table 10: ORP at Well after Tailings Dam, Teck DPO

Segment	Median	Min	Max
Average	-254	-477	99.0
2018	-444	-478	-380

Figure 17: ORP at Well after Tailings Dam, Teck DPO

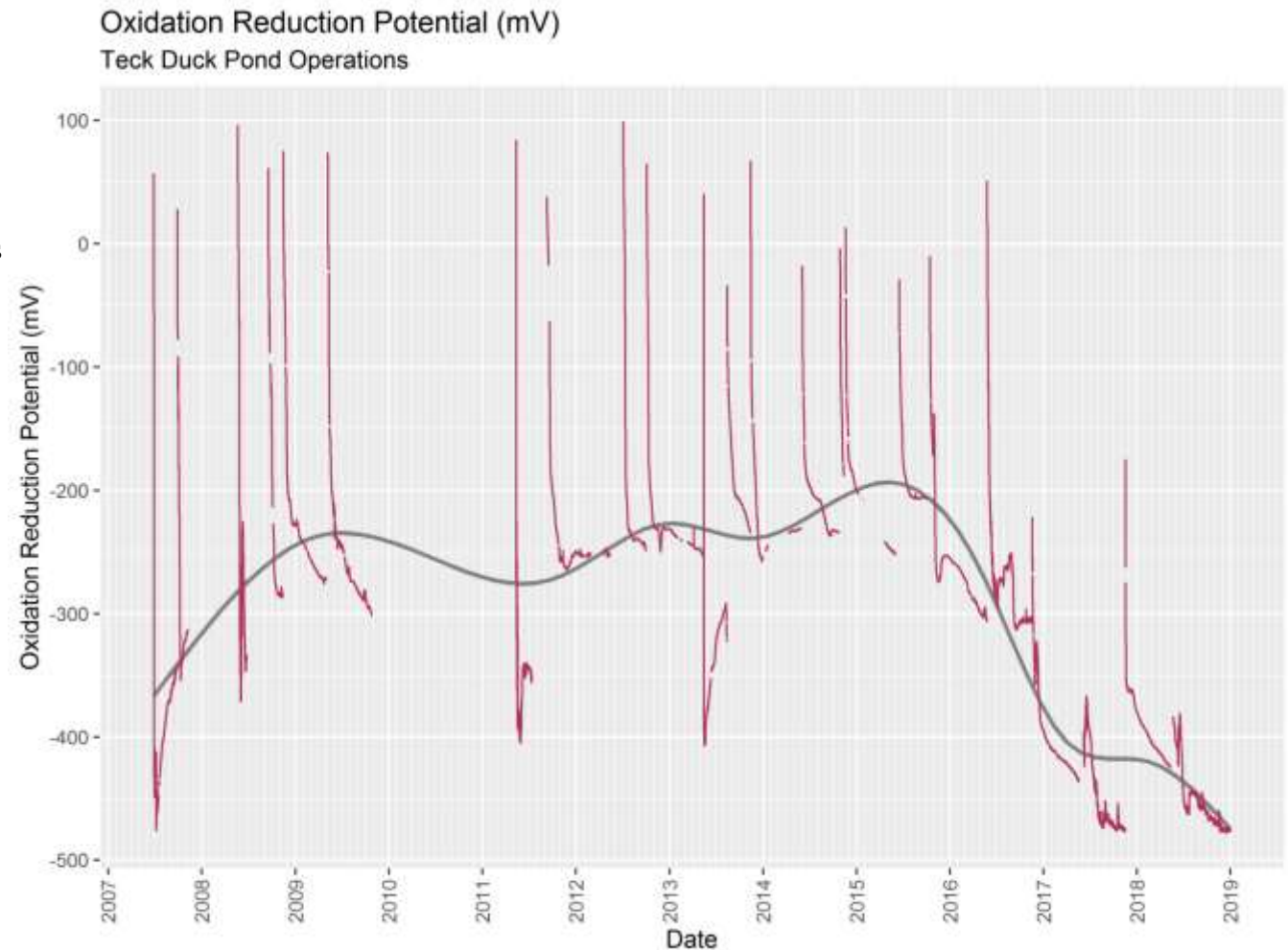
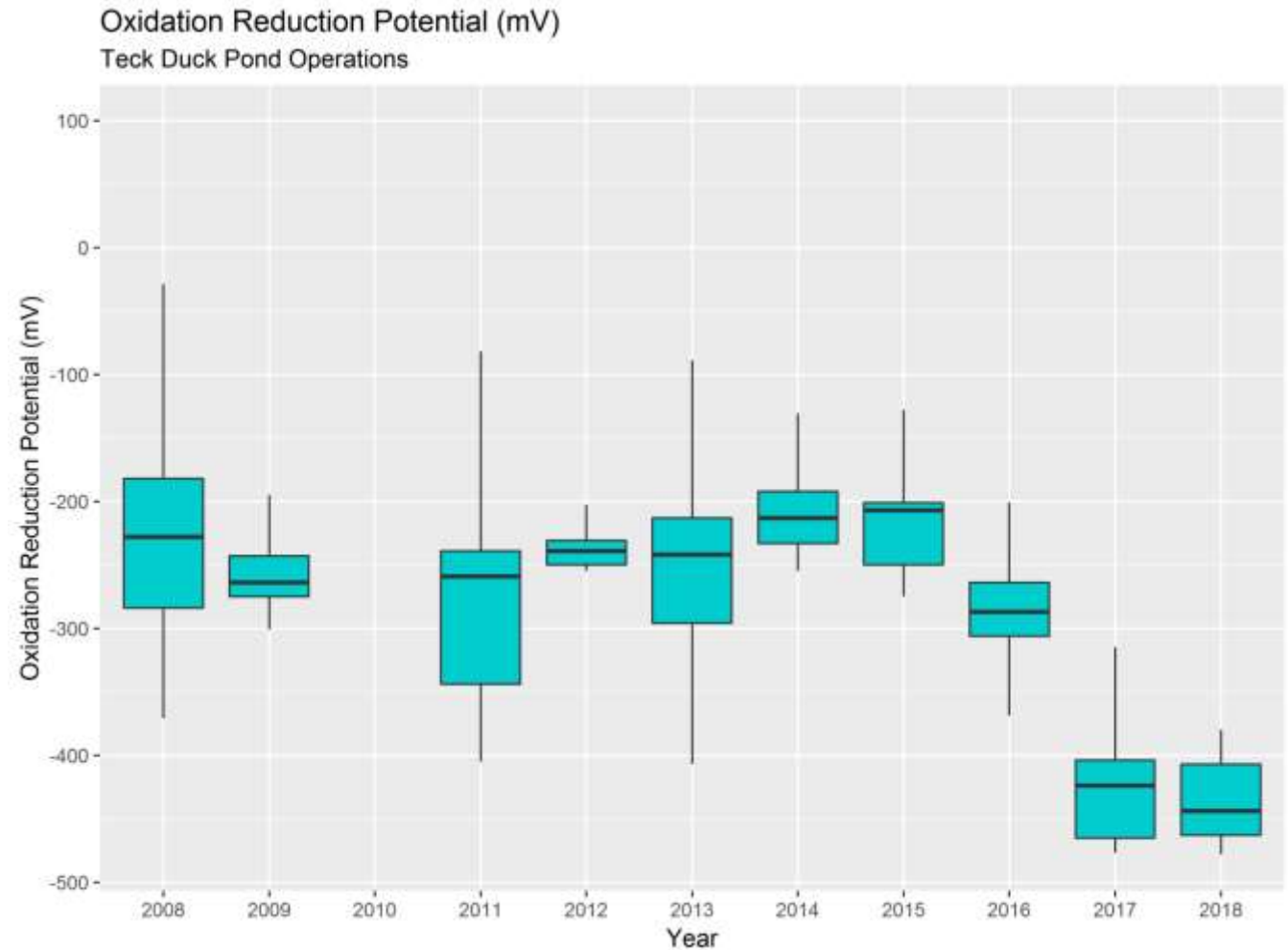


Figure 18 readily shows a decline in ORP from 2016 and into 2018. This decline follows a period of plateau in specific conductivity and could be indicative of a particular chemical change in the aquifer.

Notably, the change from 2017 to 2018 was more subtle.

Figure 18: Boxplots of ORP at Well after Tailings Dam, Teck DPO



Water Elevation

Water elevation indicates the surface of the aquifer above sea level. Water level peaked in 2009 and declined until 2017 when a small uptick was observed in the latter part of 2017 into mid-2018 (Figure 19) before continuing to decline once again.

Table 11: Water elevation at Well after Tailings Pond, Teck DPO

Segment	Median	Min	Max
Average	270.822	270.442	271.208
2018	270.687	270.311	270.900

Figure 19: Water elevation at Well after Tailings Pond, Teck DPO

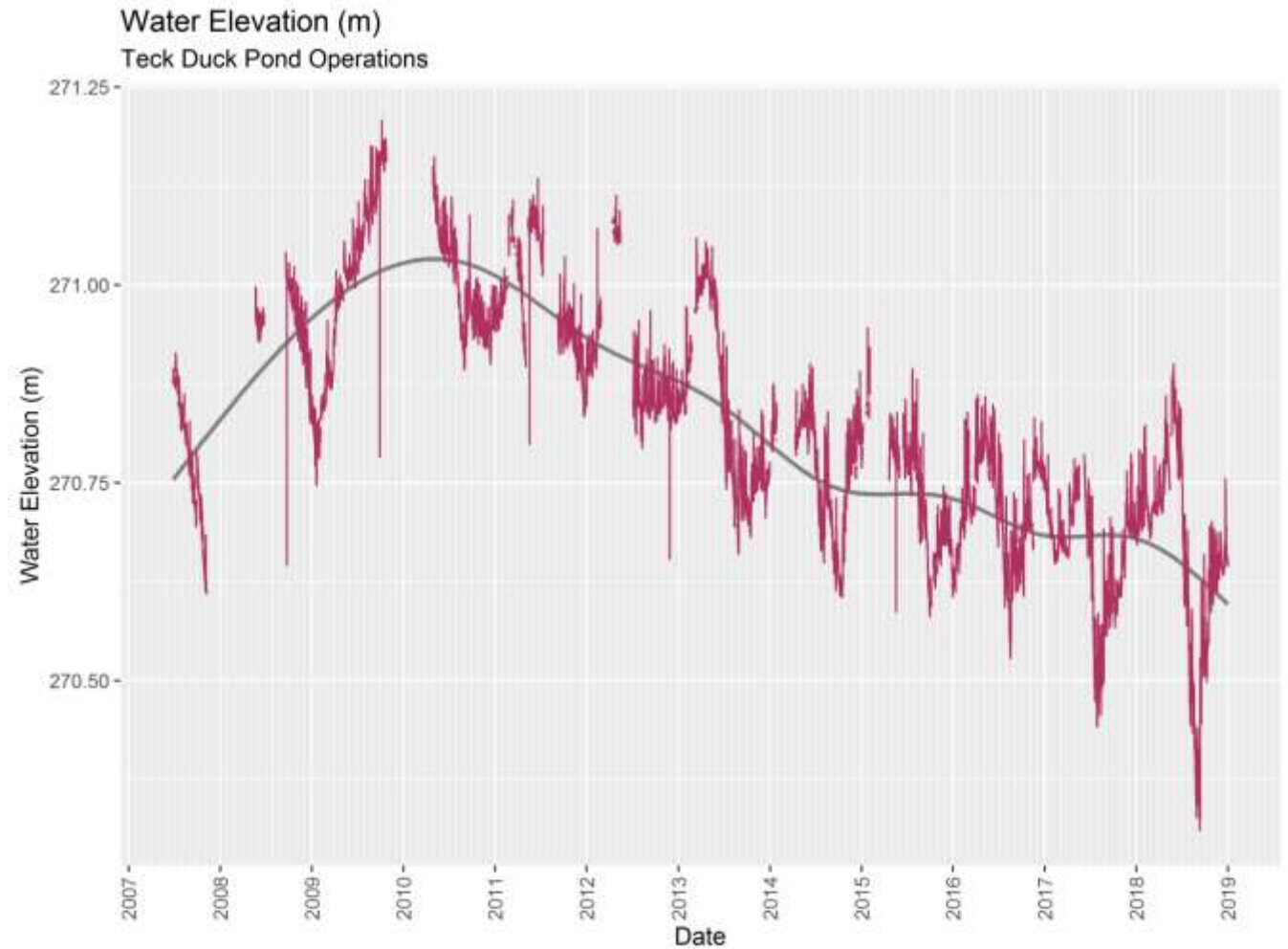
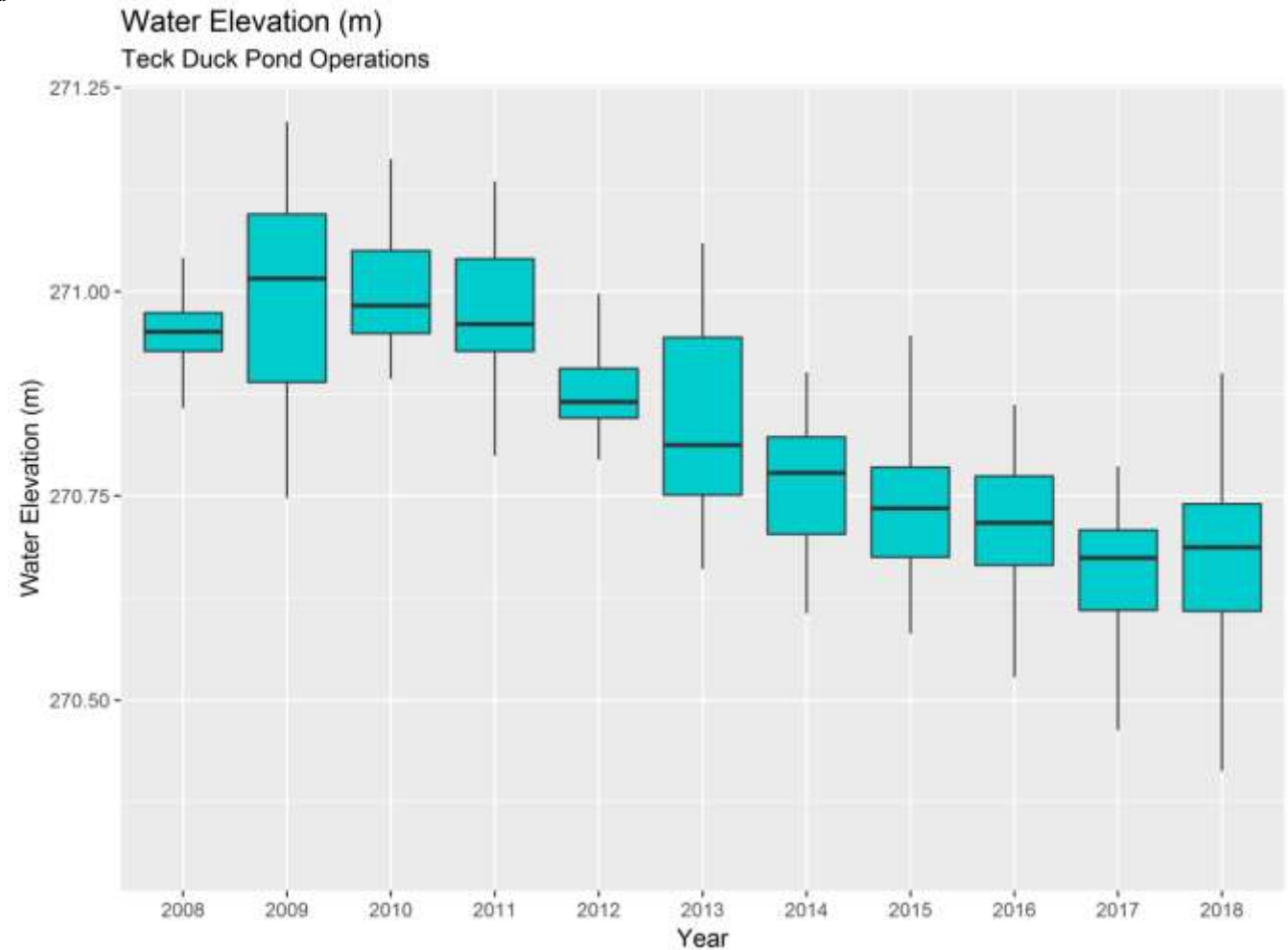


Figure 20 succinctly illustrates the long-term decline in water level from 2009 to 2017 and the uptick observed in 2018.

Figure 20: Boxplots of water elevation at Well after Tailings Pond, Teck DPO



Conclusion and Path Forward

Site closure and remediation work continued into 2018. Efforts that are being made to ensure long-term stability of the tailings management area could be implicated in some changes at each monitoring station, especially Well after Tailings Dam A. At this station, variations in pH, specific conductivity, and ORP were observed in 2017 and 2018. These changes in particular could be related to water level reductions in the adjacent waterbody where work is ongoing. As water level is lowered, additional acid-generating mill waste material is exposed. Once water levels are allowed to rise, these parameters should stabilize.

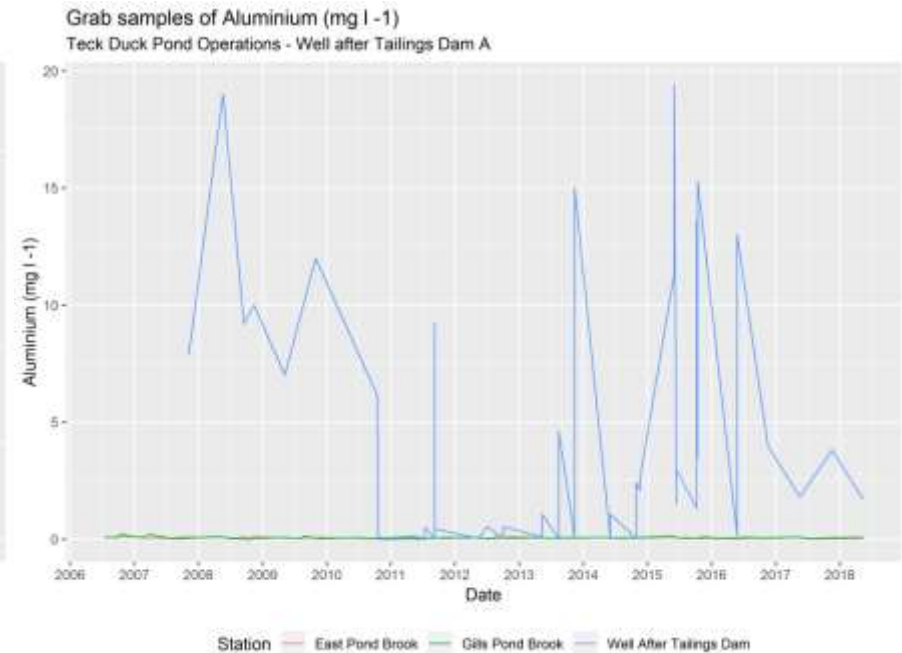
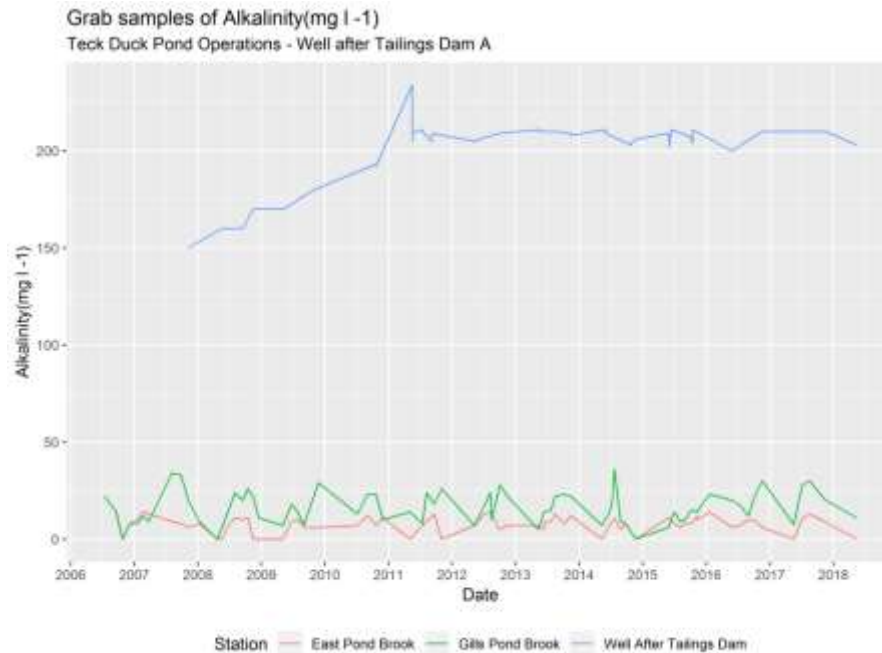
Tailings Dam A was constructed to direct flow from the tailings management area westward towards the Gills Pond watershed. Some changes in water quality may be eventually be seen at EPB station as seepage, identified by the Well after Tailings Dam A station, makes its way northeast towards the East Pond watershed on its original course.

Water quality at East Pond Brook and Tributary to Gills Pond Brook were mostly within range of previous years.

Monitoring efforts will continue for the duration of closure work and potentially longer if determined to be beneficial.

Appendix

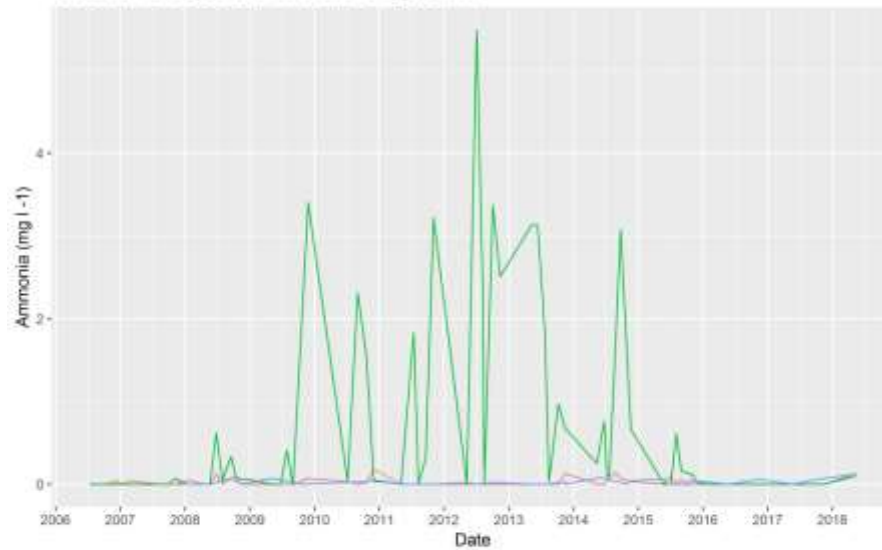
The following figures present grab sample results taken at East Pond Brook, Tributary to Gill's Pond Brook, and Well after Tailings Dam A stations. No discussion is provided for this section; graphs are provided for information purposes only.



Appendix

Grab samples of Ammonia (mg l⁻¹)

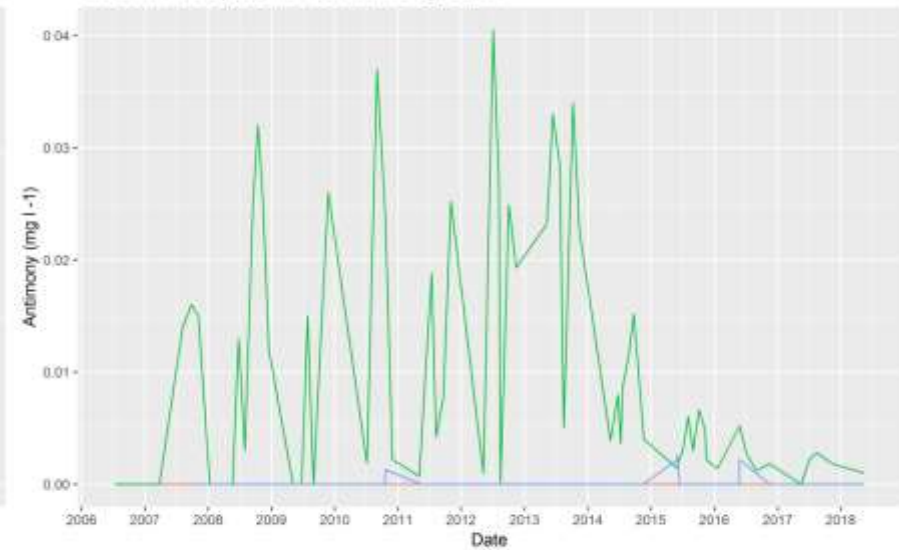
Teck Duck Pond Operations - Well after Tailings Dam A



Station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Antimony (mg l⁻¹)

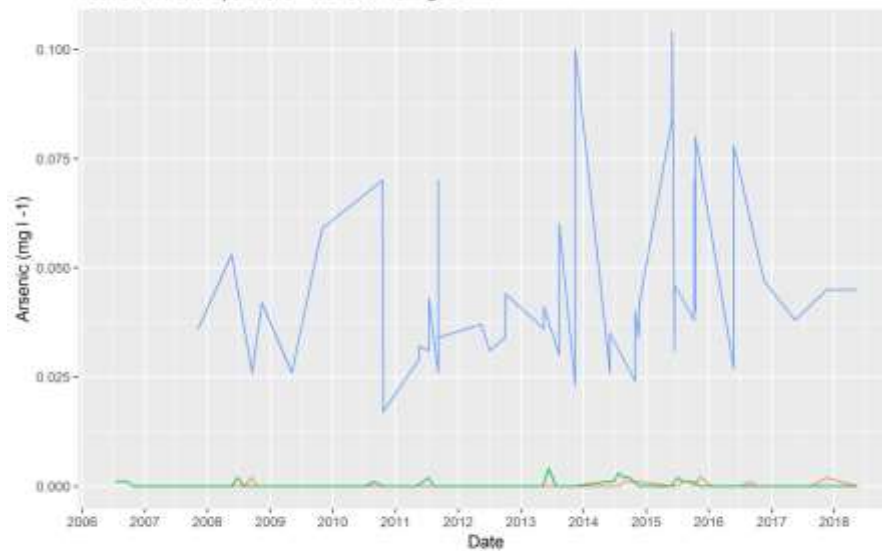
Teck Duck Pond Operations - Well after Tailings Dam A



Station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Arsenic (mg l⁻¹)

Teck Duck Pond Operations - Well after Tailings Dam A



Station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

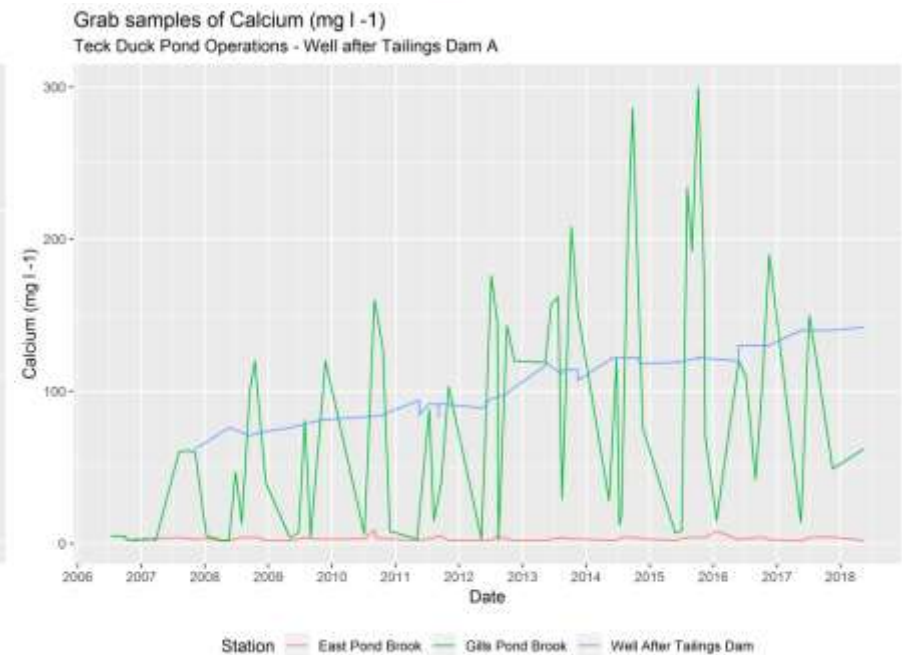
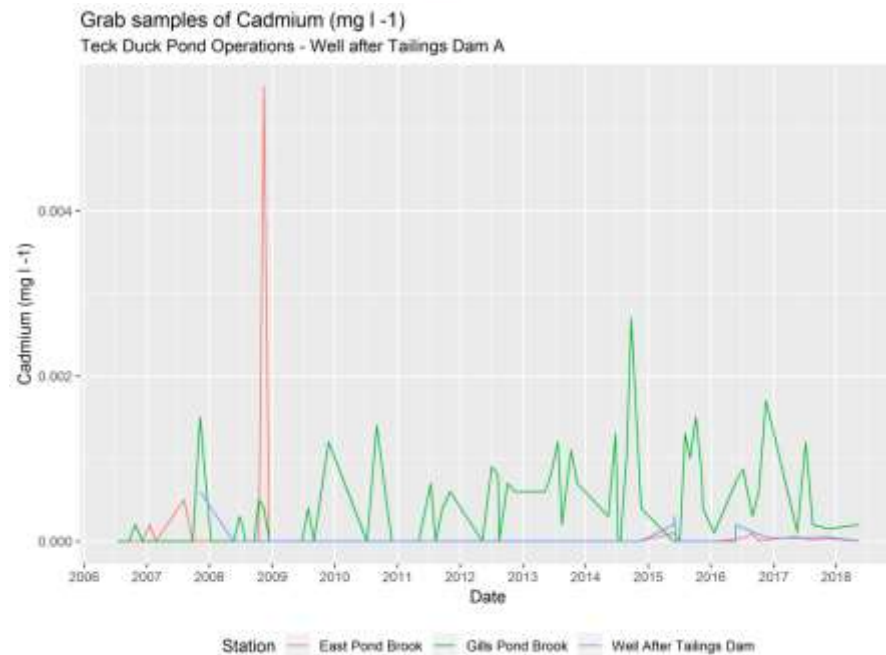
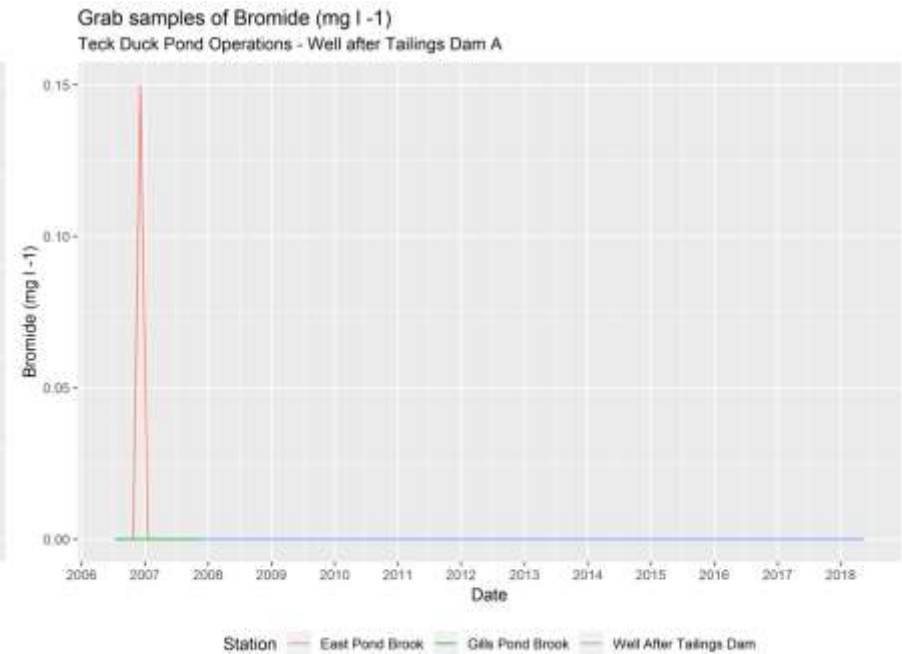
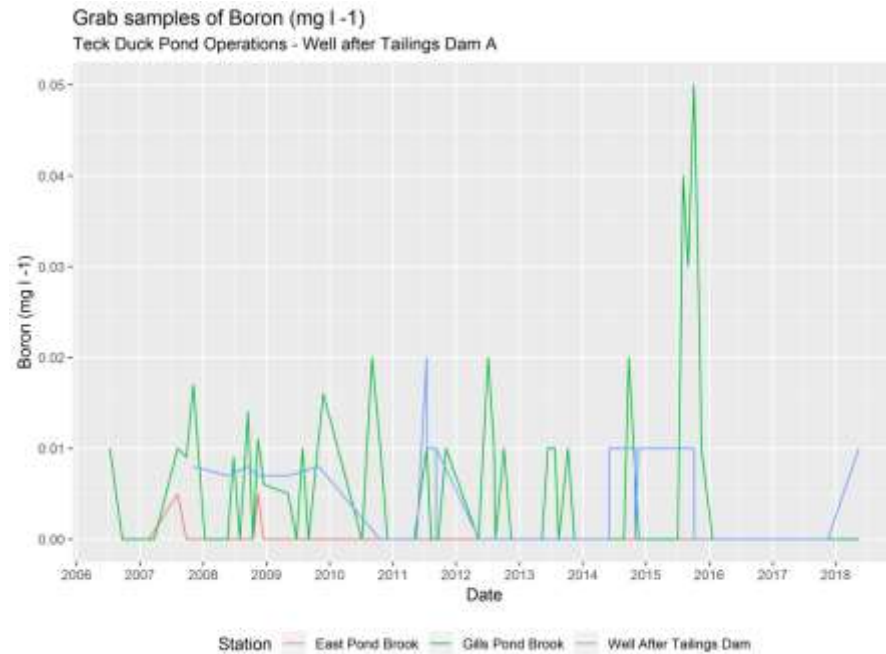
Grab samples of Barium (mg l⁻¹)

Teck Duck Pond Operations - Well after Tailings Dam A



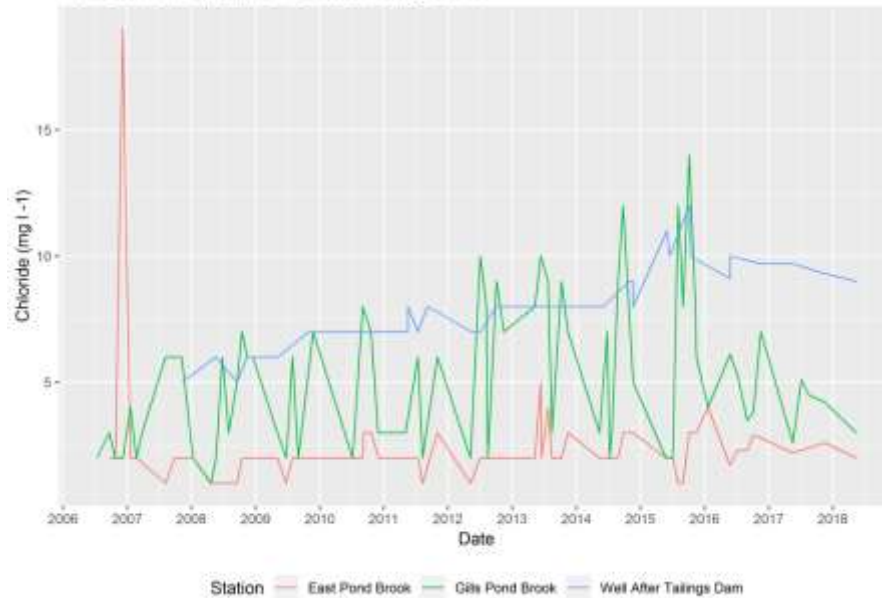
Station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Appendix

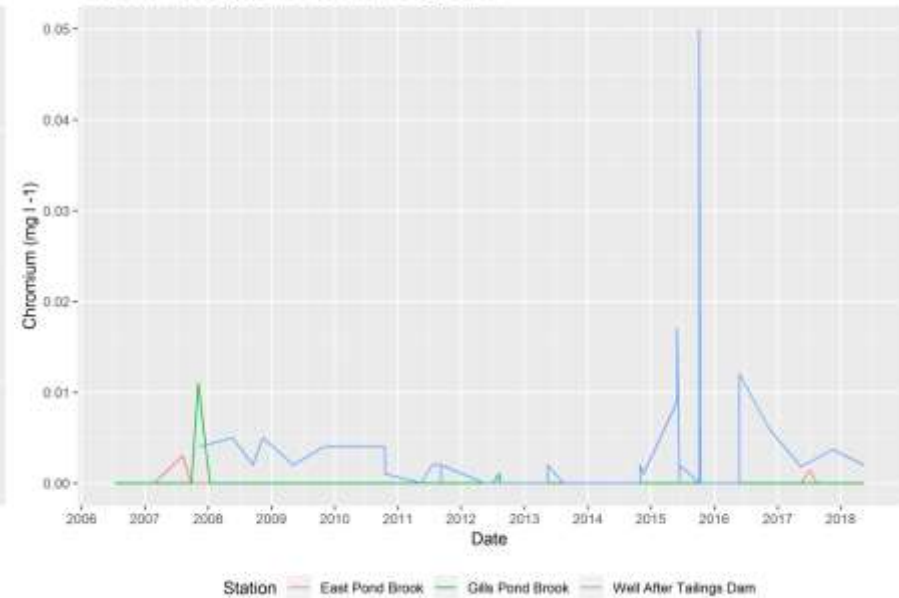


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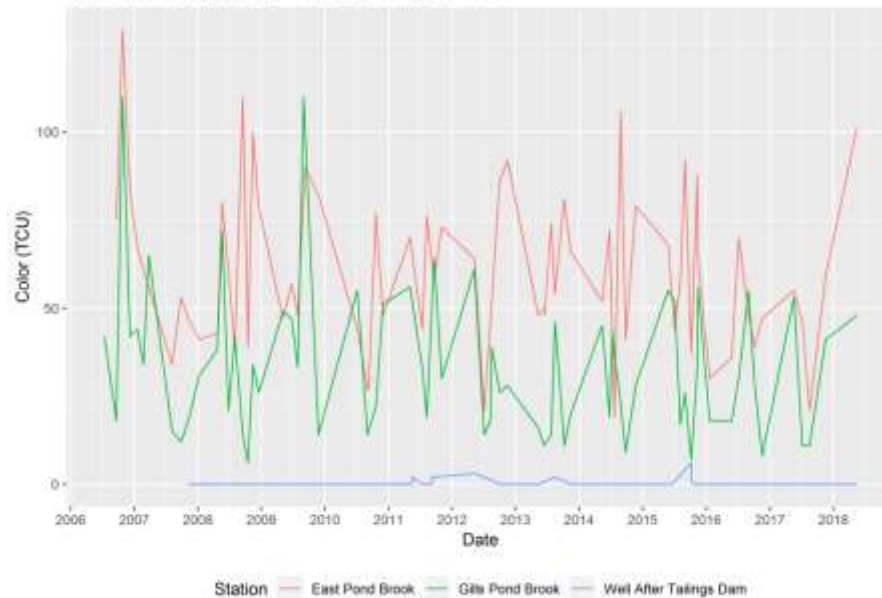
Grab samples of Chloride (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



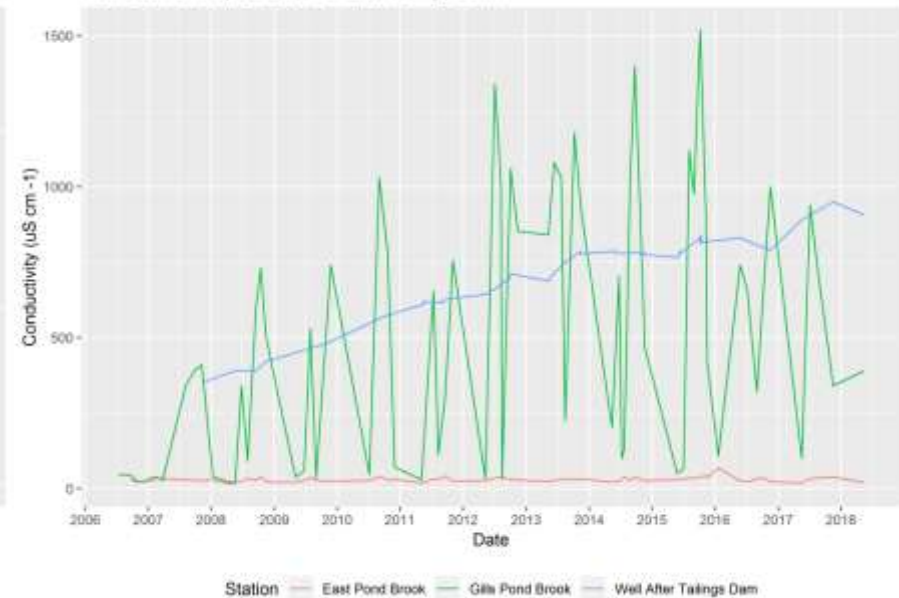
Grab samples of Chromium (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



Grab samples of Color (TCU)
Teck Duck Pond Operations - Well after Tailings Dam A



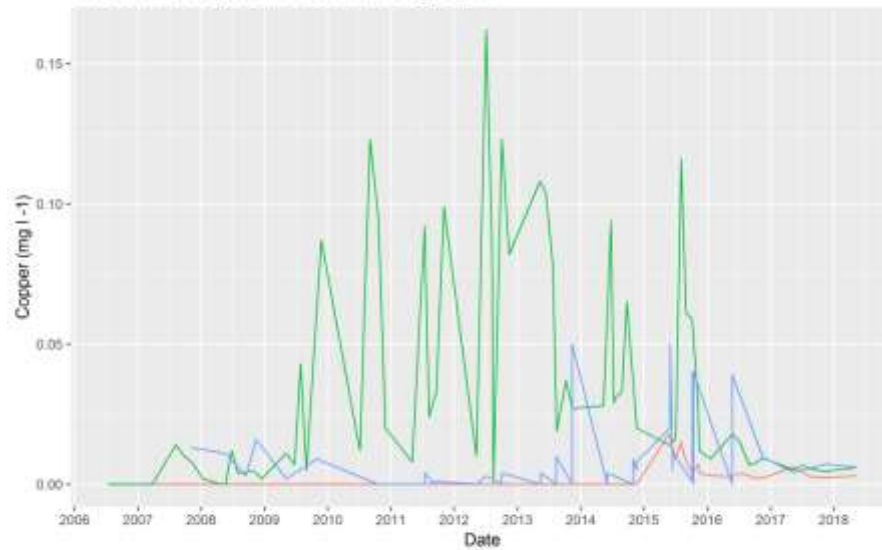
Grab samples of Conductivity (uS cm⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



Appendix

Grab samples of Copper (mg l⁻¹)

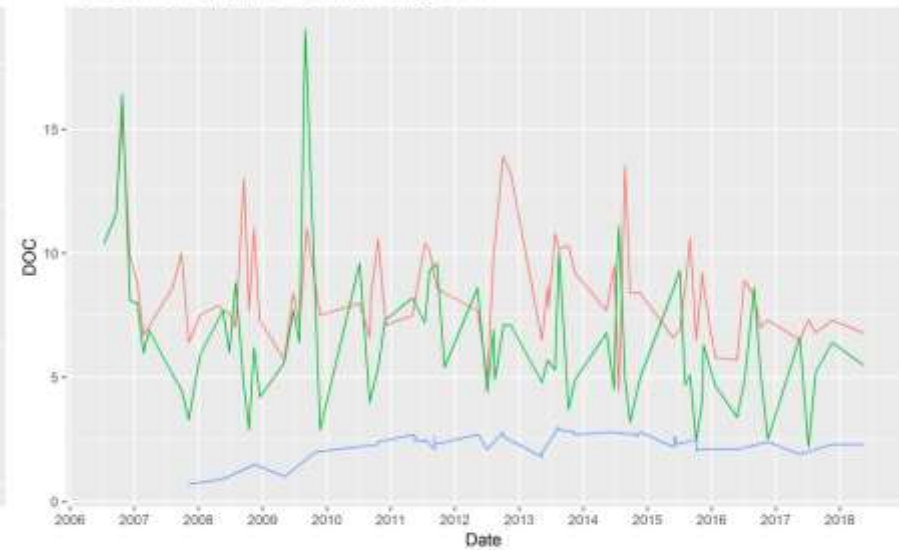
Teck Duck Pond Operations - Well after Tailings Dam A



Station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of DOC

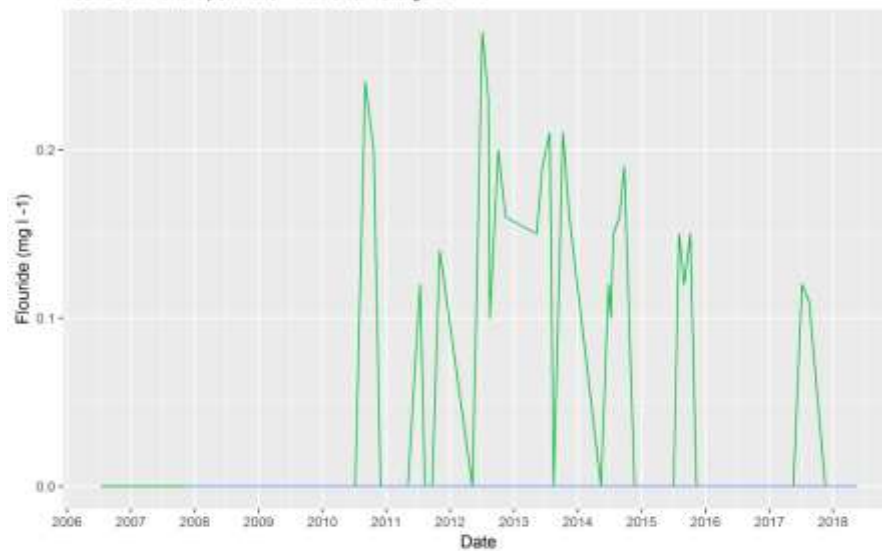
Teck Duck Pond Operations - Well after Tailings Dam A



Station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Fluoride (mg l⁻¹)

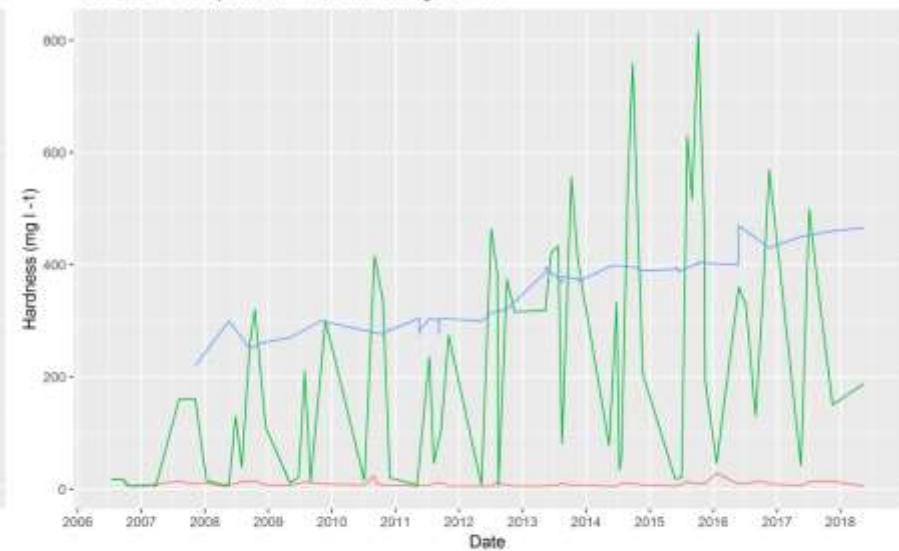
Teck Duck Pond Operations - Well after Tailings Dam A



Station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

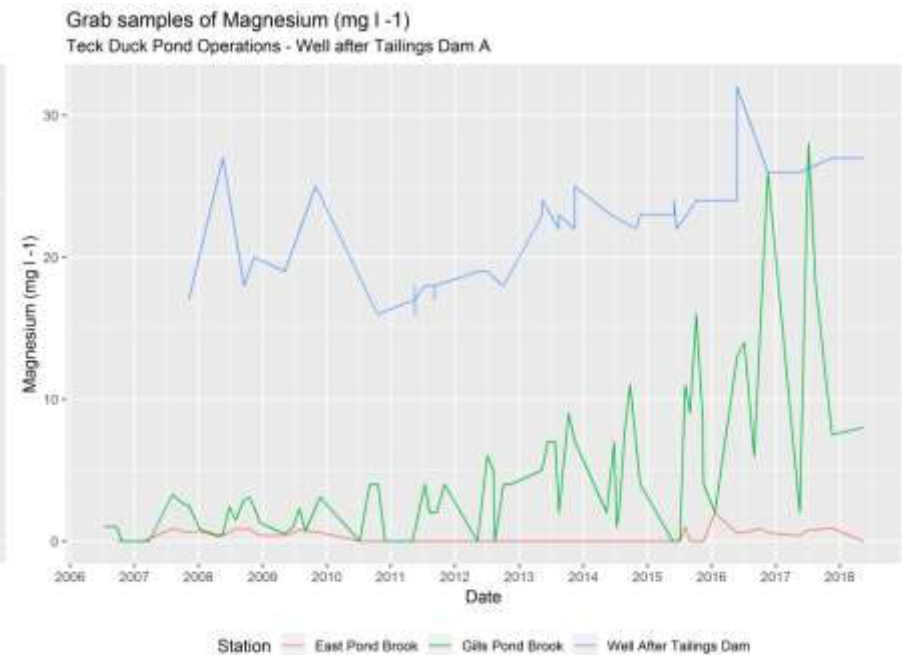
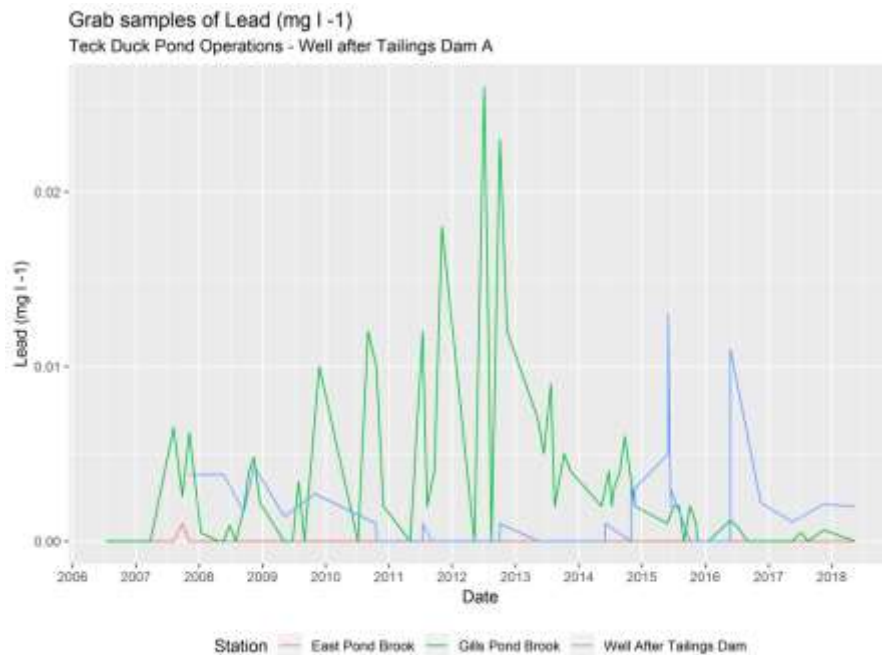
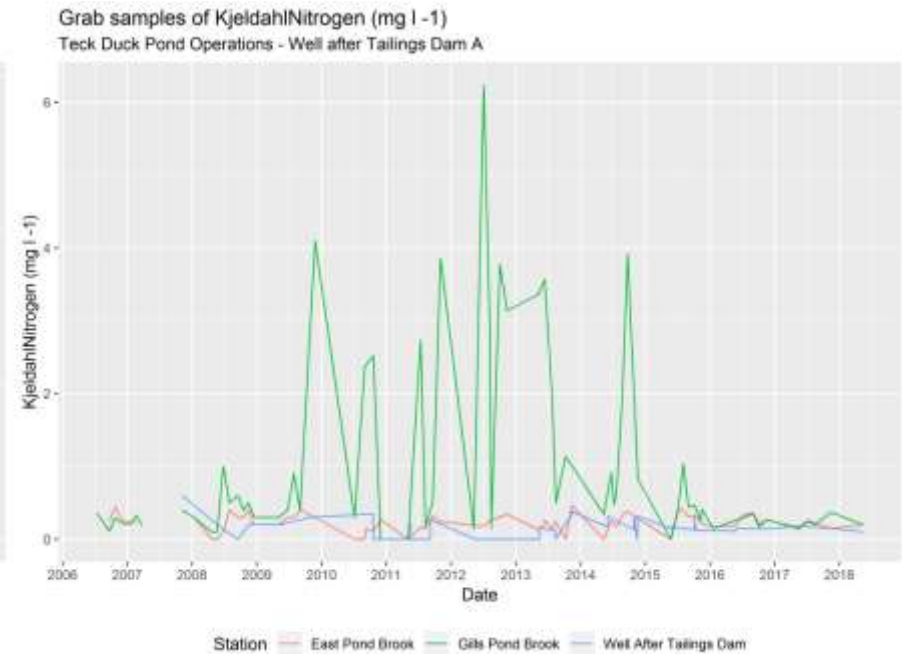
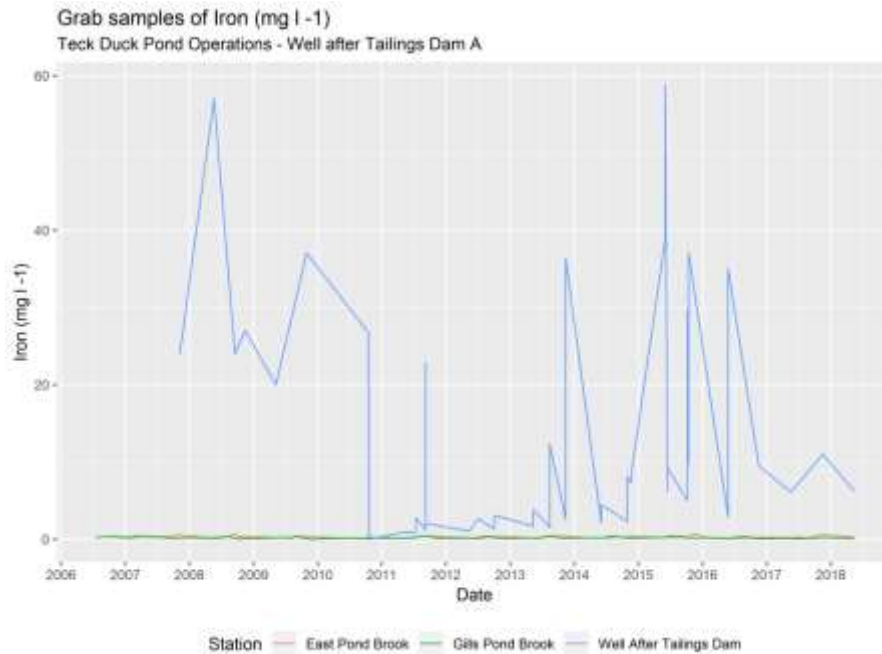
Grab samples of Hardness (mg l⁻¹)

Teck Duck Pond Operations - Well after Tailings Dam A



Station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

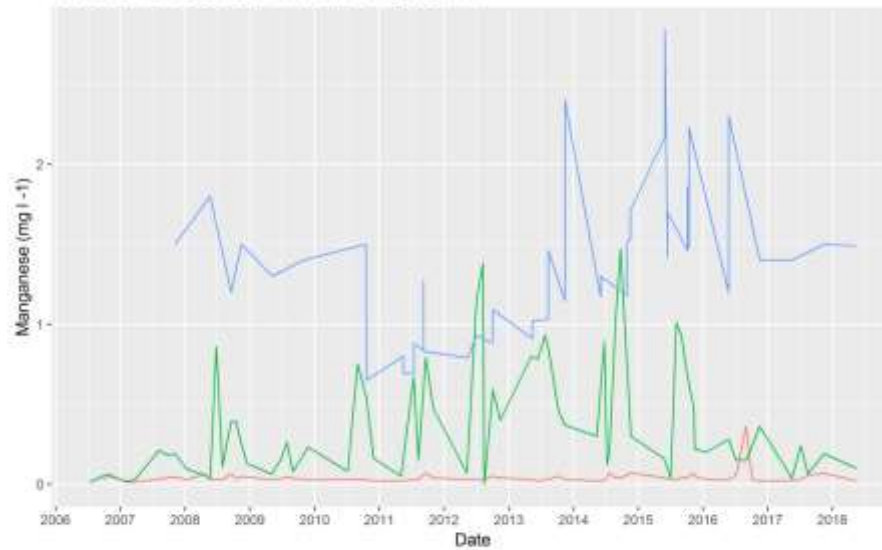
Appendix



Appendix

Grab samples of Manganese (mg l⁻¹)

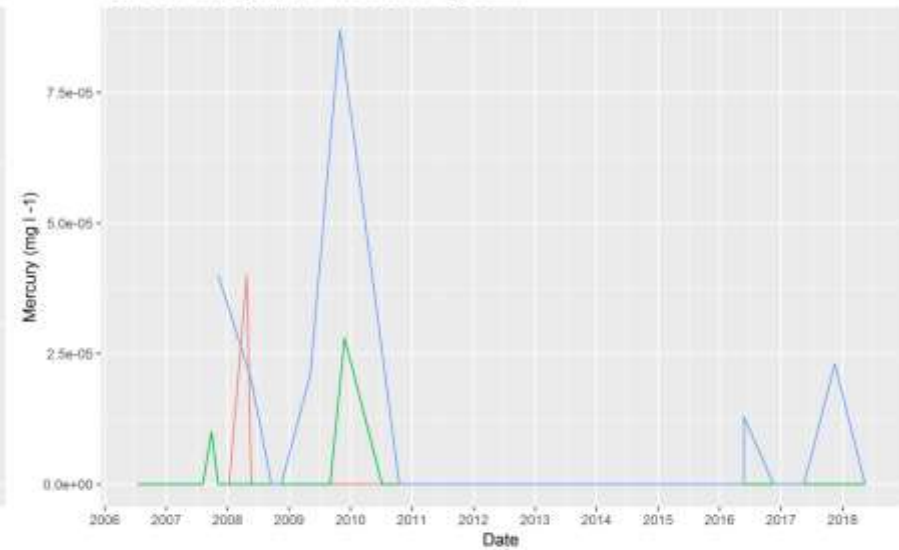
Teck Duck Pond Operations - Well after Tailings Dam A



Station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Mercury (mg l⁻¹)

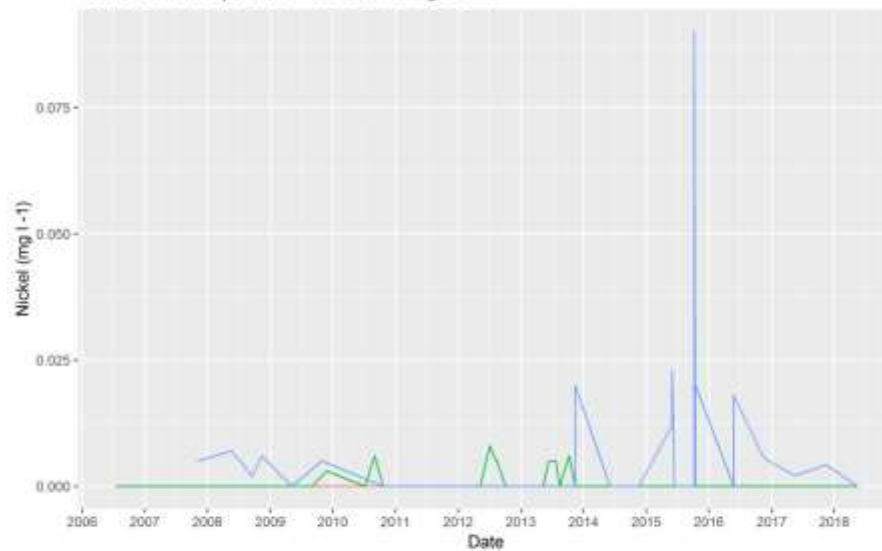
Teck Duck Pond Operations - Well after Tailings Dam A



Station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Nickel (mg l⁻¹)

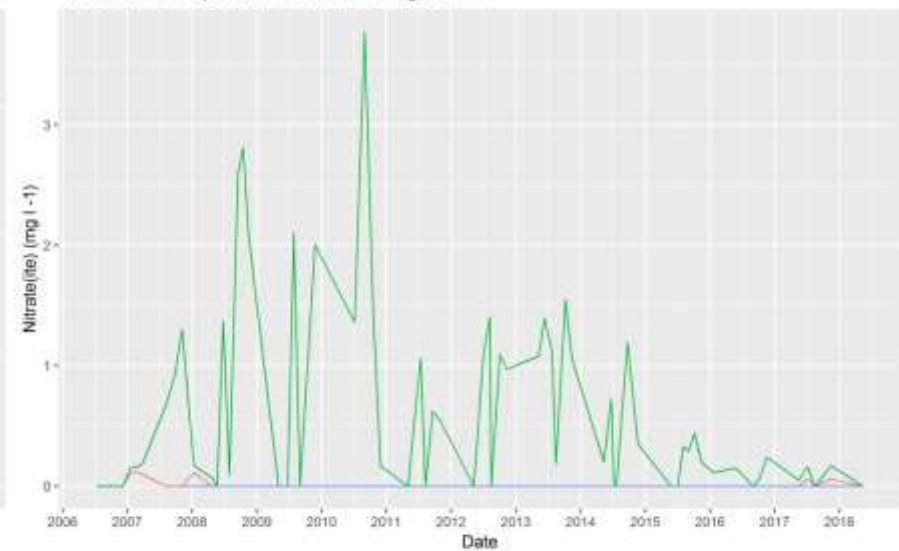
Teck Duck Pond Operations - Well after Tailings Dam A



Station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Nitrate(ite) (mg l⁻¹)

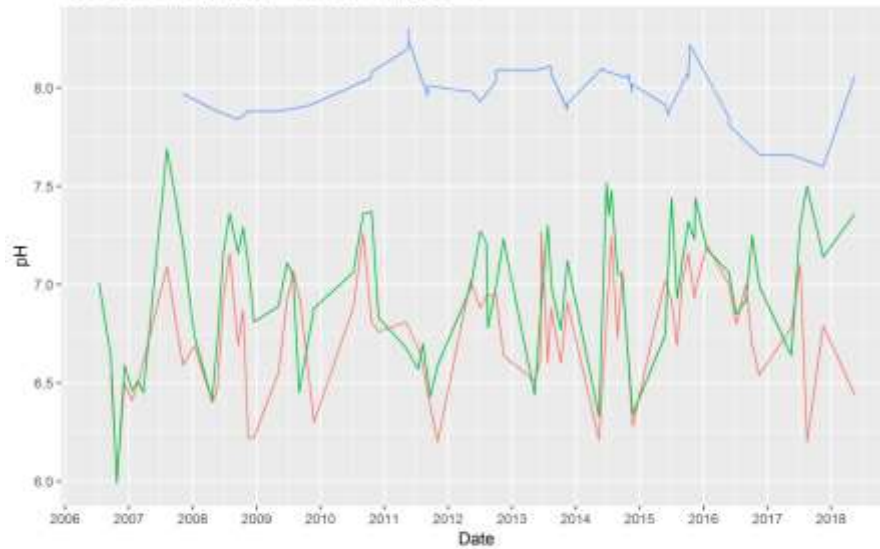
Teck Duck Pond Operations - Well after Tailings Dam A



Station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

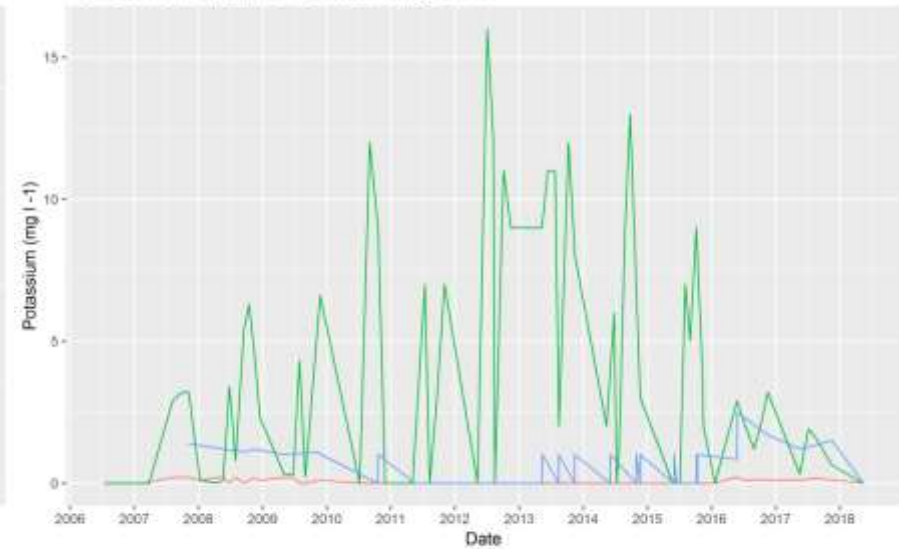
Appendix

Grab samples of pH
Teck Duck Pond Operations - Well after Tailings Dam A



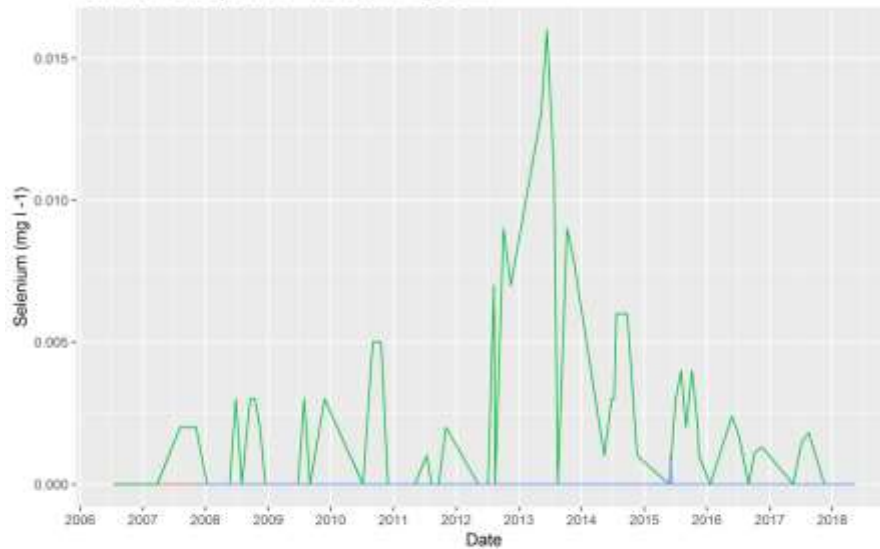
Station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Potassium (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



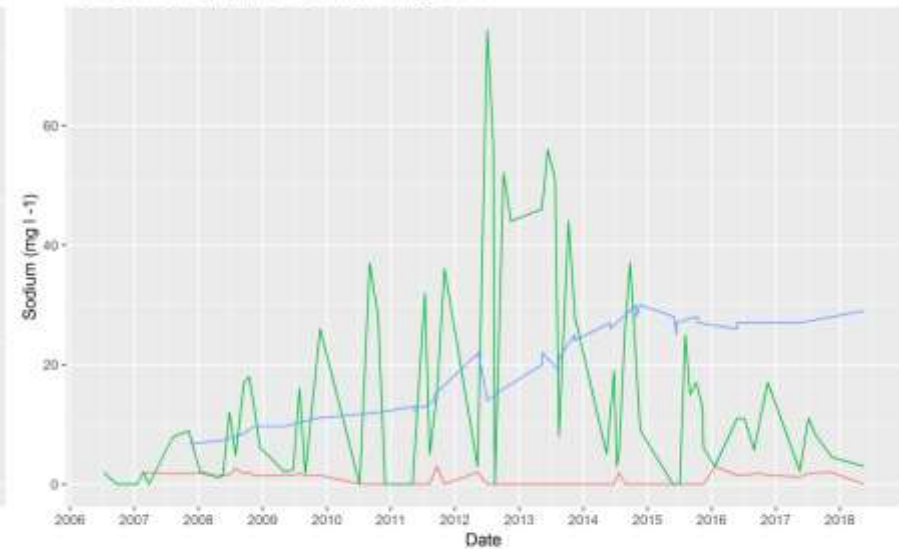
Station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Selenium (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



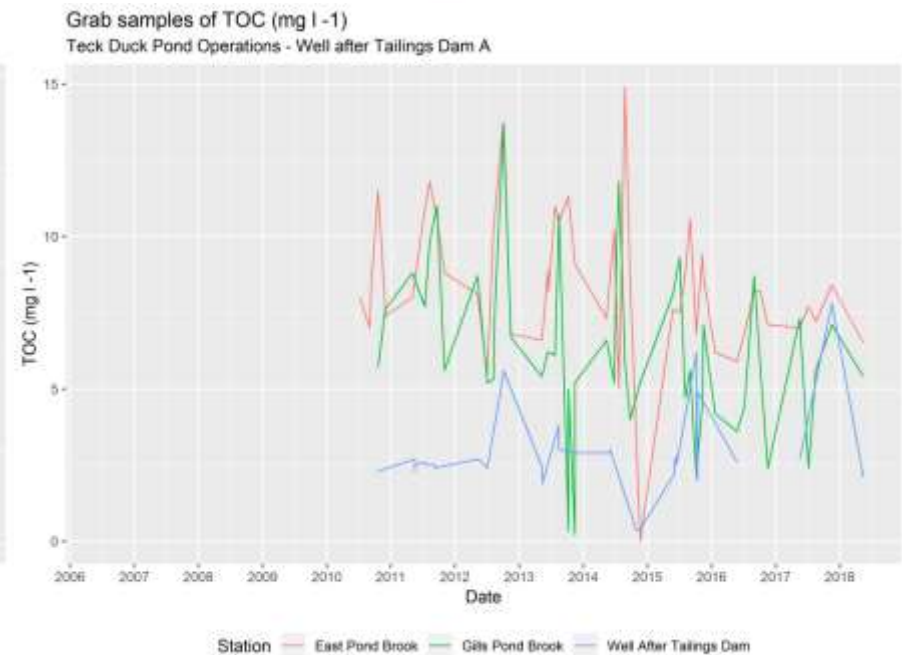
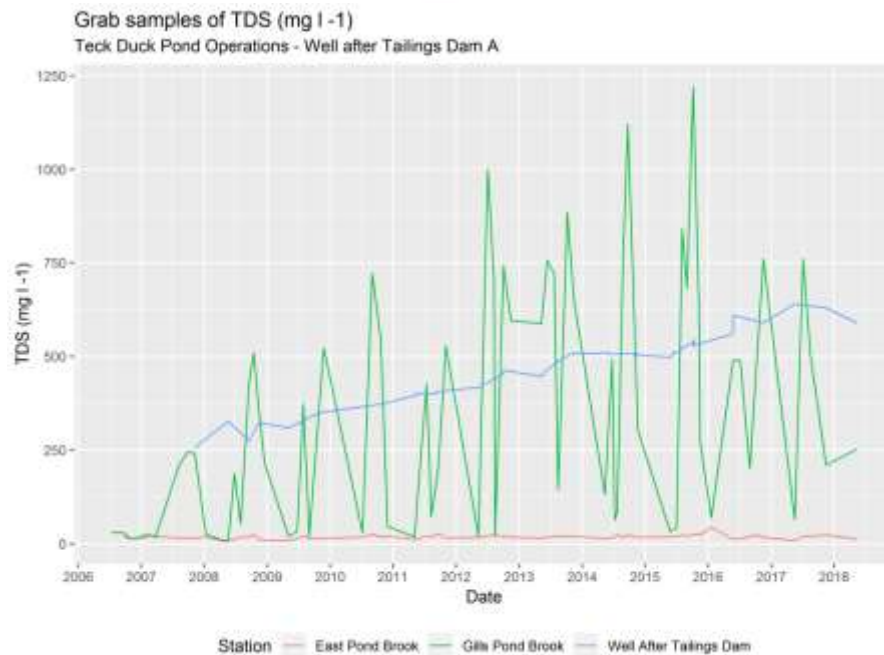
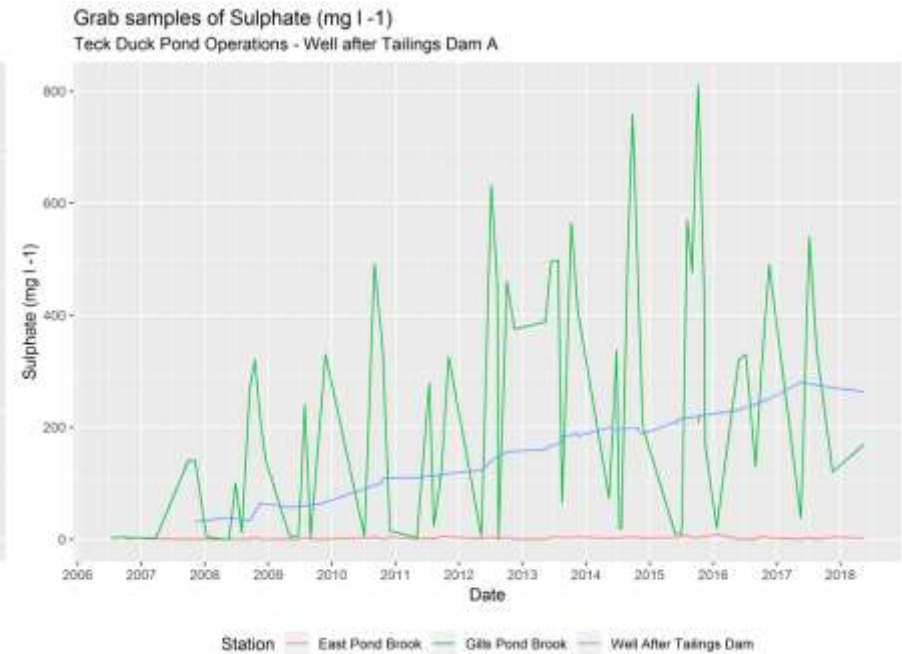
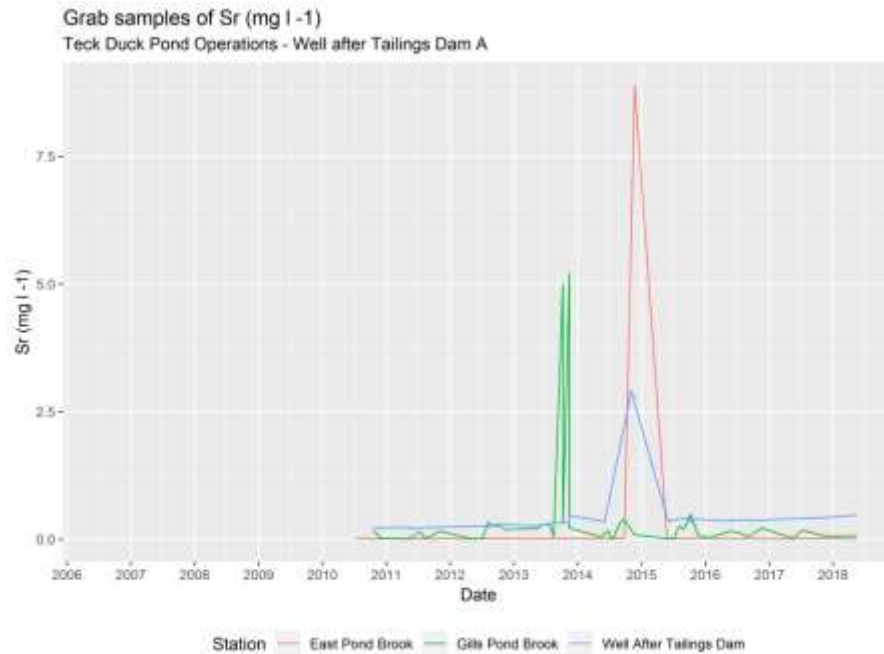
Station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Sodium (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



Station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Appendix



Appendix

