

Real-Time Water Quality Deployment Report

Vale - Long Harbour Annual Report

2021



Government of Newfoundland & Labrador
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Introduction

Real-time water quality (RTWQ) monitoring of surface and groundwater quality on the Vale Long Harbour Processing plant site is carried out by the Department of Environment and Climate Change (ECC), 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 Stephenville to St. John's.

RTWQ work in Long Harbour has been ongoing for more than 15 years – beginning with the first station, Rattling Brook below Bridge, in late 2006. In 2009, two additional surface water stations were deployed in the headwaters of Rattling Brook (Big Pond station) and lower in the river system (Rattling Brook below Plant Discharge). These surface water stations were positioned to monitor for long-term changes and water quality events related to the construction and operation of Vale's nickel processing plant.

As the nickel processing plant began to move towards operation, Sandy Pond was chosen as a residue storage area (RSA) to contain solid waste material. A groundwater monitoring network of five stations was deployed around the RSA in late 2012.

Surface and groundwater monitoring stations are depicted in Figure 1 below (blue triangles are surface water monitoring stations on Rattling Brook and yellow arrows are groundwater monitoring stations around the RSA).

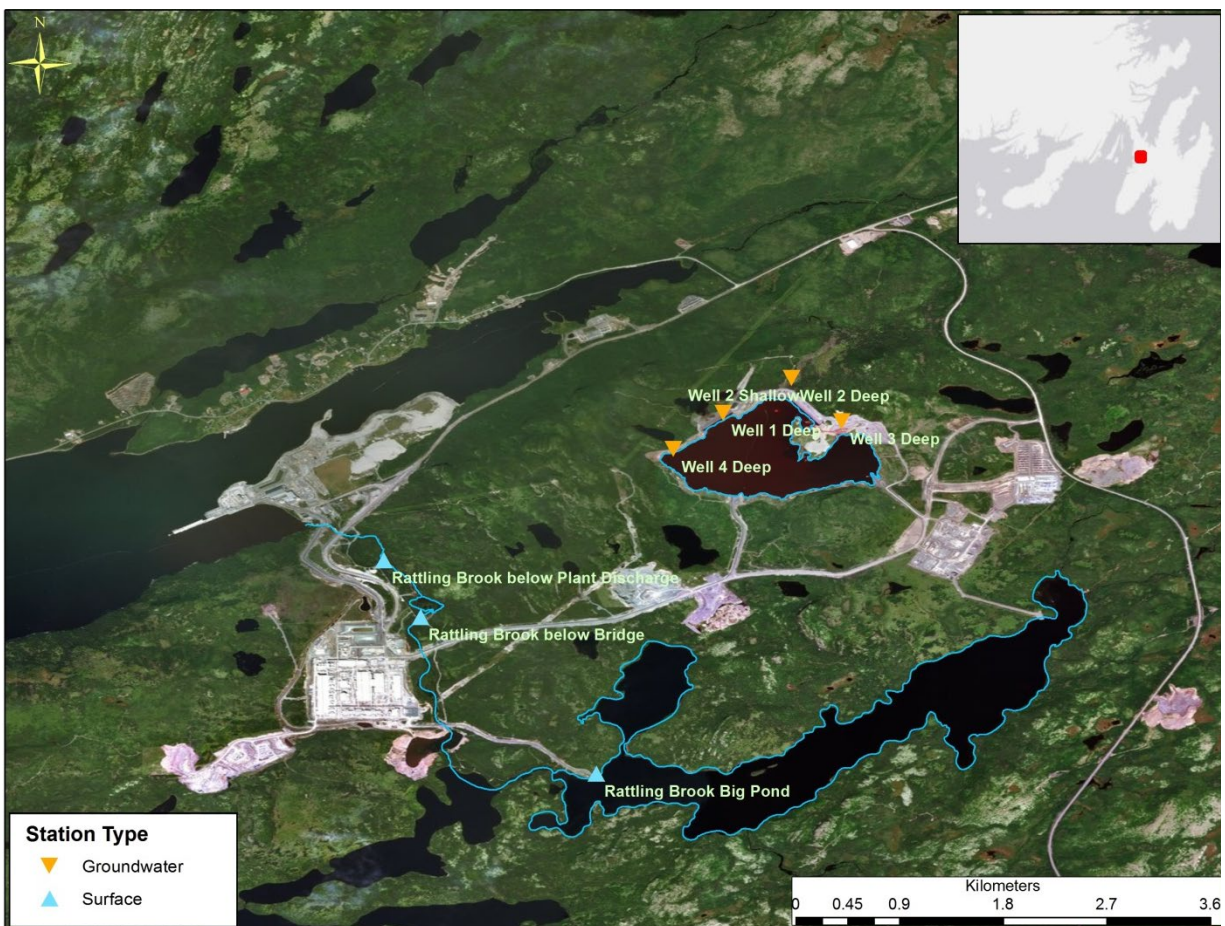


Figure 1: Real-time water quality monitoring stations in Long Harbour, Newfoundland

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 and weather data are presented for each surface and groundwater parameter in the next section. Each table lists the 2021 median, minimum, and maximum values. *Average median* values for each parameter are calculated from the median values of each previous year and are 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

In the next sections, data from both surface and groundwater networks are presented as a series of line and box plots for water quality visualization over time and between stations. Summary statistics are presented in the appendix by year and station.

¹ <https://www.gov.nl.ca/ecc/files/waterres-rti-rtwq-nl-rtwq-manual.pdf>

Surface Water Network

Water Temperature

Water temperatures for all stations were higher than 2020 with the exception of Big Pond as the sonde was taken out for winter 2020 to avoid damage from ice which in turn skewed the station median calculation (Table 1).

Table 1: Water temperatures at Rattling Brook

Station	Segment	Median	Min	Max
Big Pond	2020	12.72	0.25	21.77
	2021	8.16	0.0	20.96
Bridge	2020	6.83	-0.56	25.23
	2021	8.53	-0.5	24.29
Discharge	2020	7.63	-0.4	25.8
	2021	8.37	-0.49	25.02

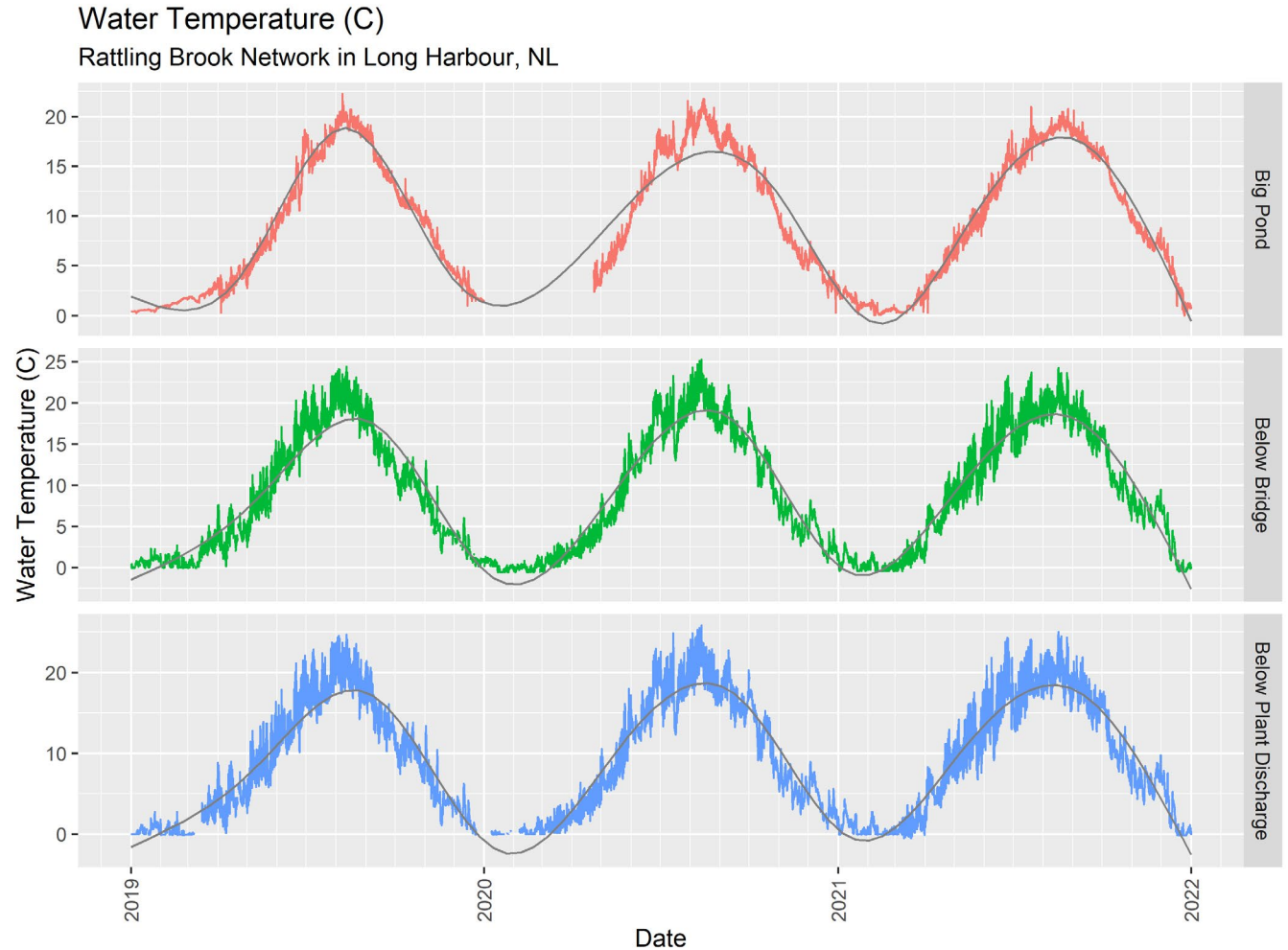


Figure 2: Water Temperature at Rattling Brook from 2019 to 2022

Boxplots in Figure 3 illustrate the spread of data at each of the Rattling Brook stations. In the past, water quality equipment has been removed from Big Pond over the winter to avoid damage from ice. During winter 2020-2021, however, equipment overwintered under the ice. This eliminated the sampling bias introduced the previous winter, resulting in the lower range for Big Pond in 2021.

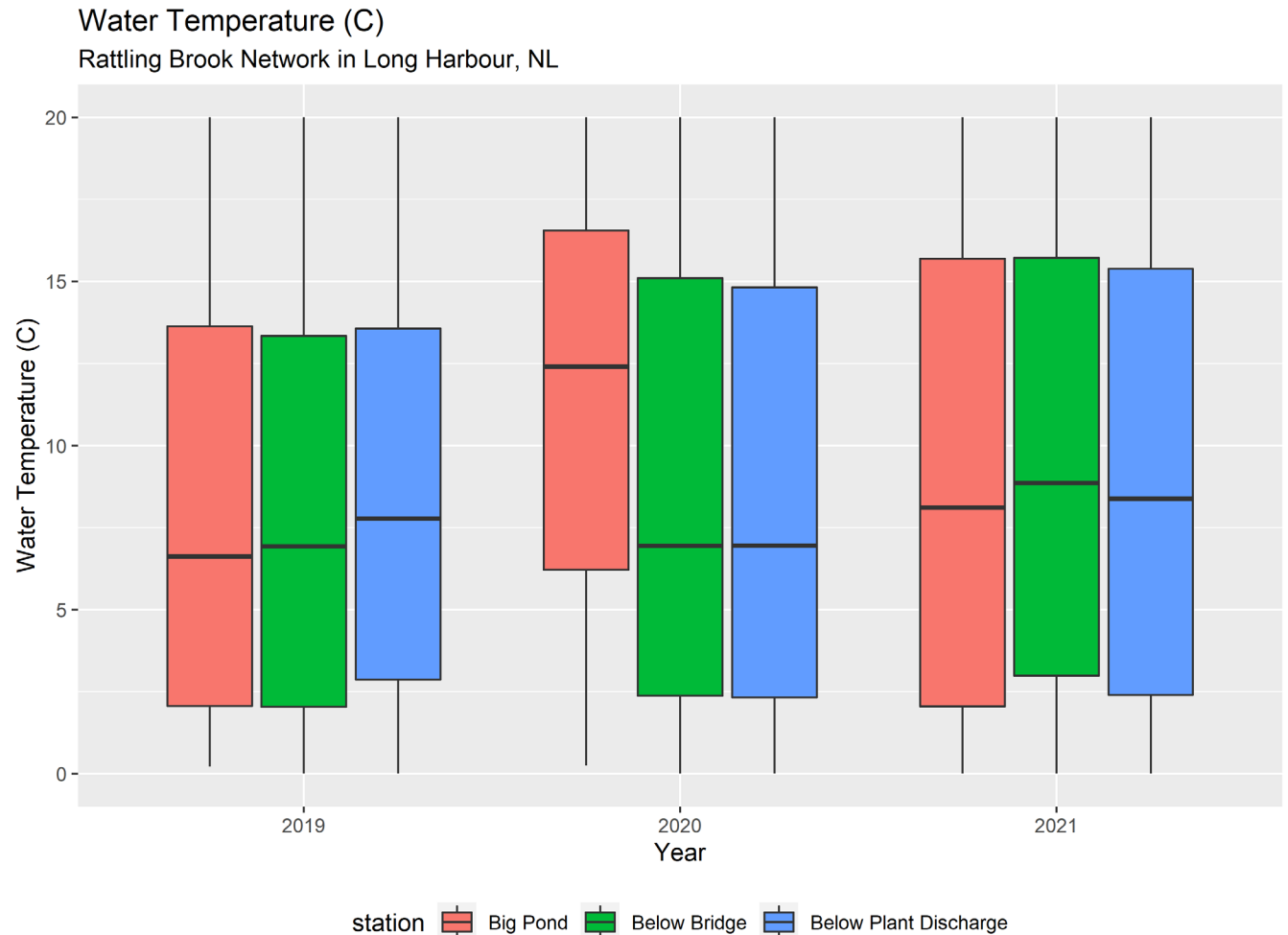


Figure 3: Boxplots of water temperature at Rattling Brook from 2019 to 2022

pH

In 2021, pH levels were above 2020 values at Bridge and Big Pond stations, but relatively similar between years at Plant Discharge station, according to median values (Table 2).

In 2021, median pH values were within site-specific guidelines² (dashed lines) at each station as shown in Figure 4.

Table 2: pH at Rattling Brook

Station	Segment	Median	Min	Max
Big Pond	2020	6.13	4.81	6.38
	2021	6.24	4.72	6.83
Bridge	2020	6.28	4.9	6.91
	2021	6.44	5.34	6.79
Discharge	2020	6.44	5.77	7.41
	2021	6.45	5.48	6.88

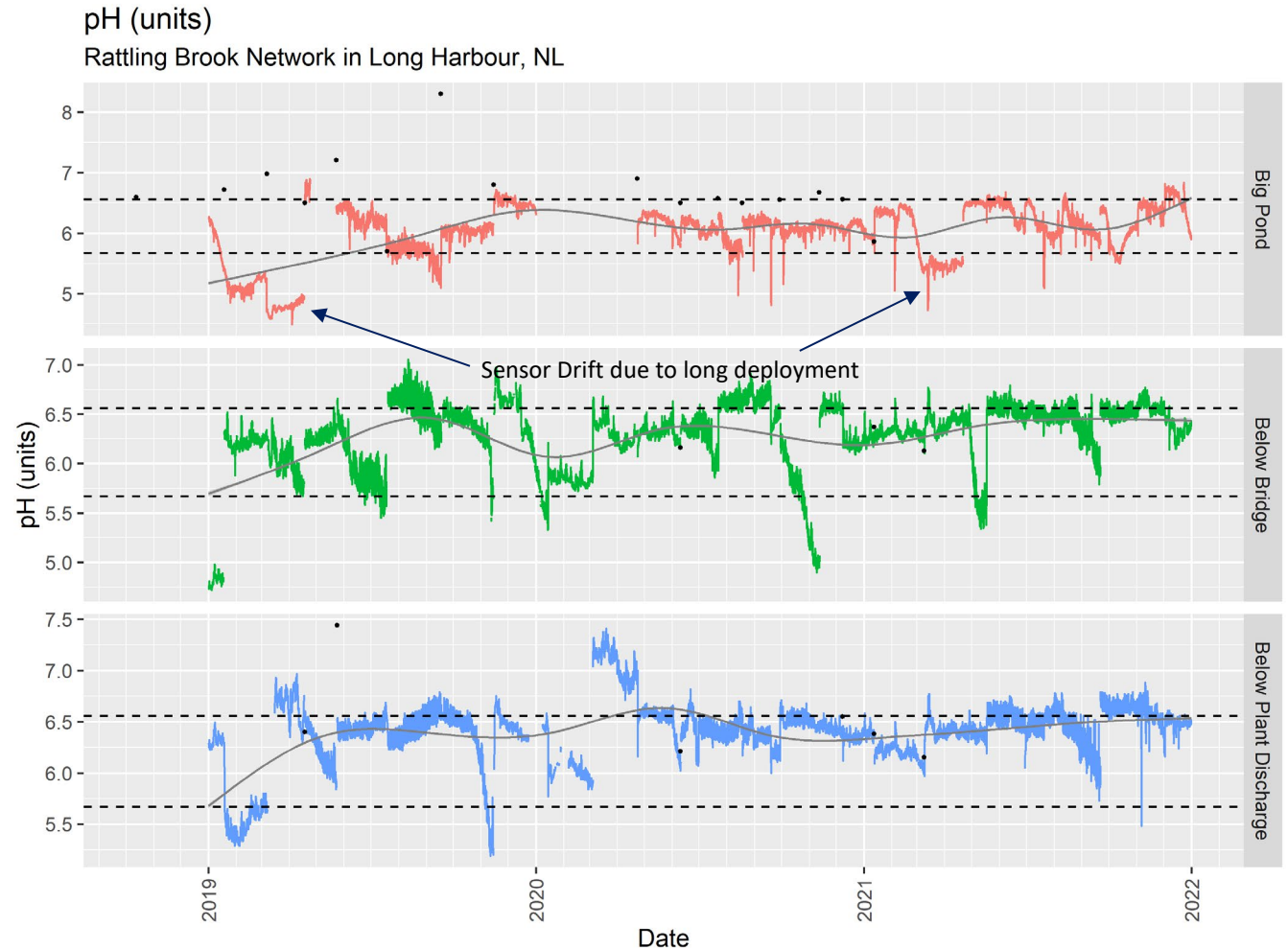


Figure 4: pH at Rattling Brook from 2019 to 2022

Specific Conductivity

In 2021, specific conductivity slightly decreased at Big Pond and slightly increased at Below Bridge and Plant Discharge stations when compared to 2020 data, according to Figure 5 and Table 3

Big Pond has been experiencing more fluctuations in conductivity since the water level rose in 2017. Conductivity may remain elevated until soil stabilizes.

Table 3: Specific Conductivity at Rattling Brook

Station	Segment	Median	Min	Max
Big Pond	2020	64.3	46.2	125.3
	2021	63.3	41.9	108.5
Bridge	2020	53.7	33.6	91.4
	2021	55.5	33.1	140.1
Discharge	2020	56.7	45.9	188.1
	2021	57.9	47	168.3

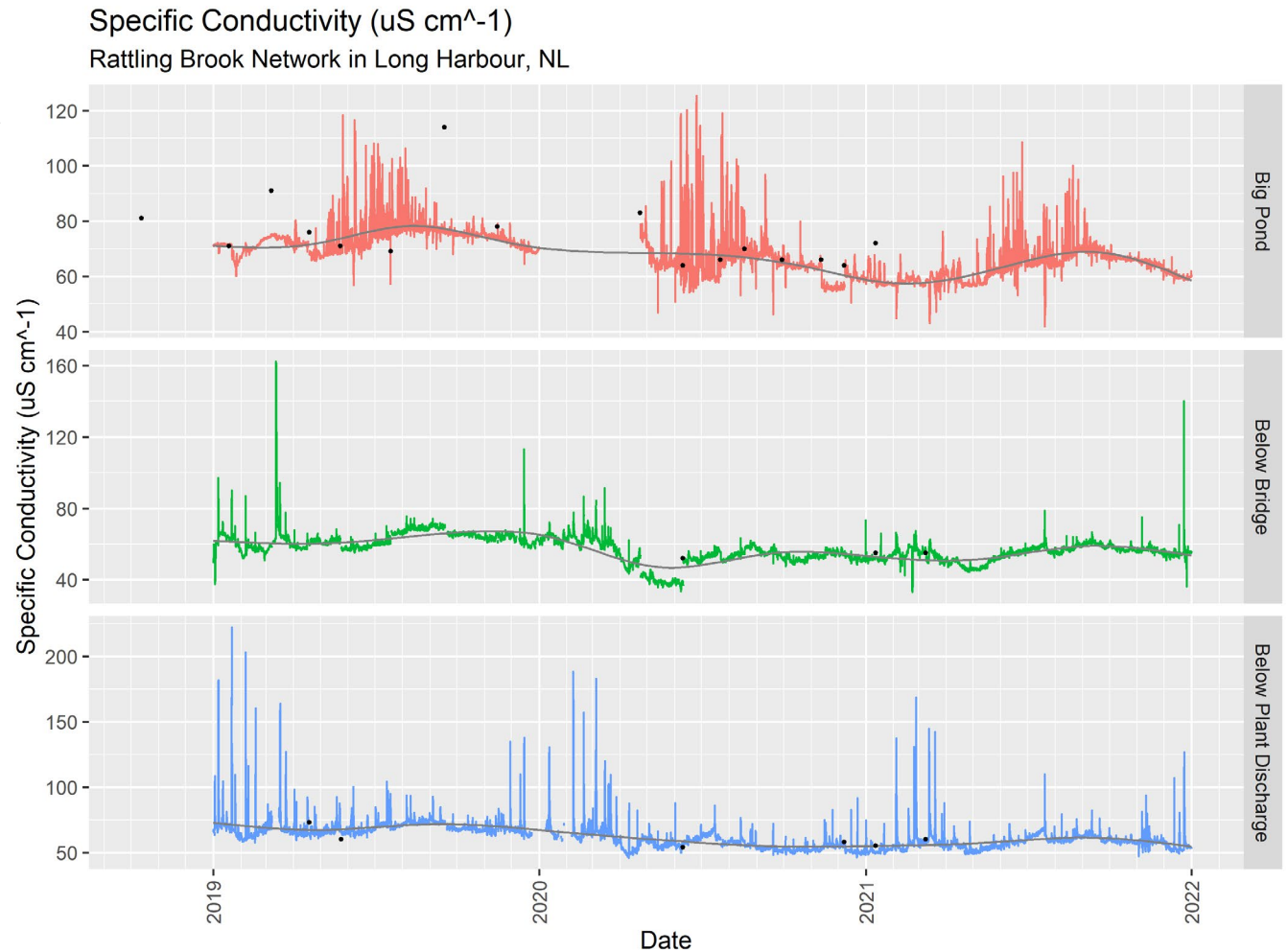


Figure 5: Specific Conductivity at Rattling Brook from 2019 to 2022

Dissolved Oxygen

In 2021, dissolved oxygen levels were within normal ranges for all stations. All values at Bridge and Plant Discharge stations were found to be above the minimum guideline for other life stages (min values in Table 4). Big Pond experiences lower dissolved oxygen due to warmer temperatures as the large waterbody holds heat longer.

Two CCME minimum guidelines shown as dashed lines give a conservative value of 9.5 mg/l for early life stage organisms and another value of 6.5 mg/l for other life stages.

Table 4: Dissolved Oxygen at Rattling Brook

Station	Segment	Median	Min	Max
Big Pond	2020	9.83	7.26	13.1
	2021	10.97	6.98	13.68
Bridge	2020	11.7	8.02	14.48
	2021	10.99	8.04	14.48
Discharge	2020	11.37	7.56	14.13
	2021	11.09	7.68	14.51

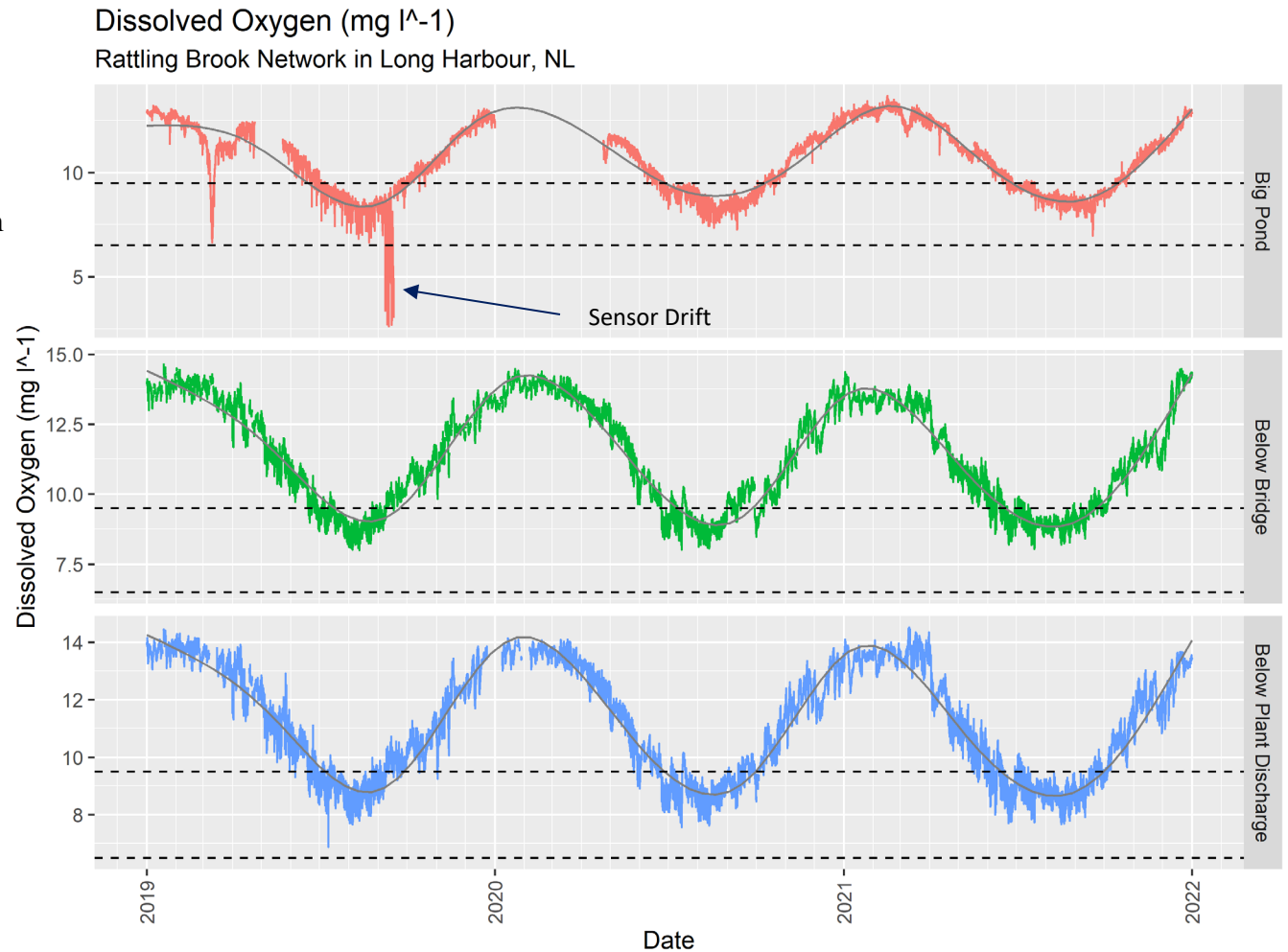


Figure 6: Dissolved oxygen at Rattling Brook from 2019 to 2022

Figure 7 shows the range of dissolved oxygen concentrations at each station for the past three years.

In 2021, the low-end of dissolved oxygen concentrations and the medians at all stations were very similar.

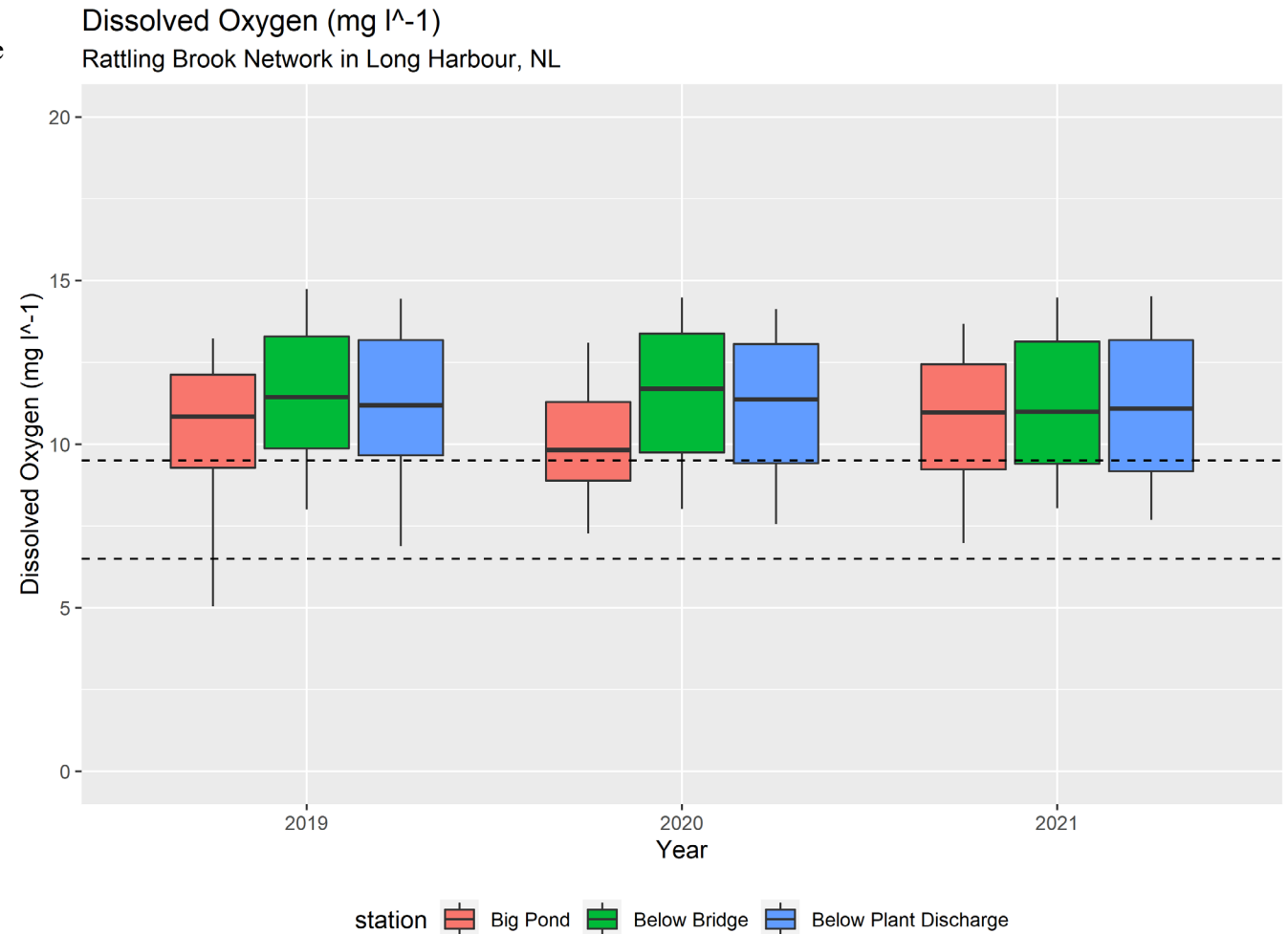


Figure 7: Boxplots of dissolved oxygen at Rattling Brook from 2019 to 2022

Turbidity

In 2021, median turbidity level at Big Pond and Below Bridge stations was 0.0 NTU – equal to the long-term average. For Plant Discharge, turbidity level median was 0.4 NTU (Table 5).

Maximum turbidity levels at Big Pond and Below Bridge were higher in 2021 than 2020, while Plant Discharge was lower.

Table 5: Turbidity at Rattling Brook

Station	Segment	Median	Min	Max
Big Pond	2020	0.2	0.0	114.5
	2021	0.0	0.0	215.4
Bridge	2020	0.0	0.0	251.6
	2021	0.0	0.0	784
Discharge	2020	0.1	0.0	415
	2021	0.4	0.0	243.8

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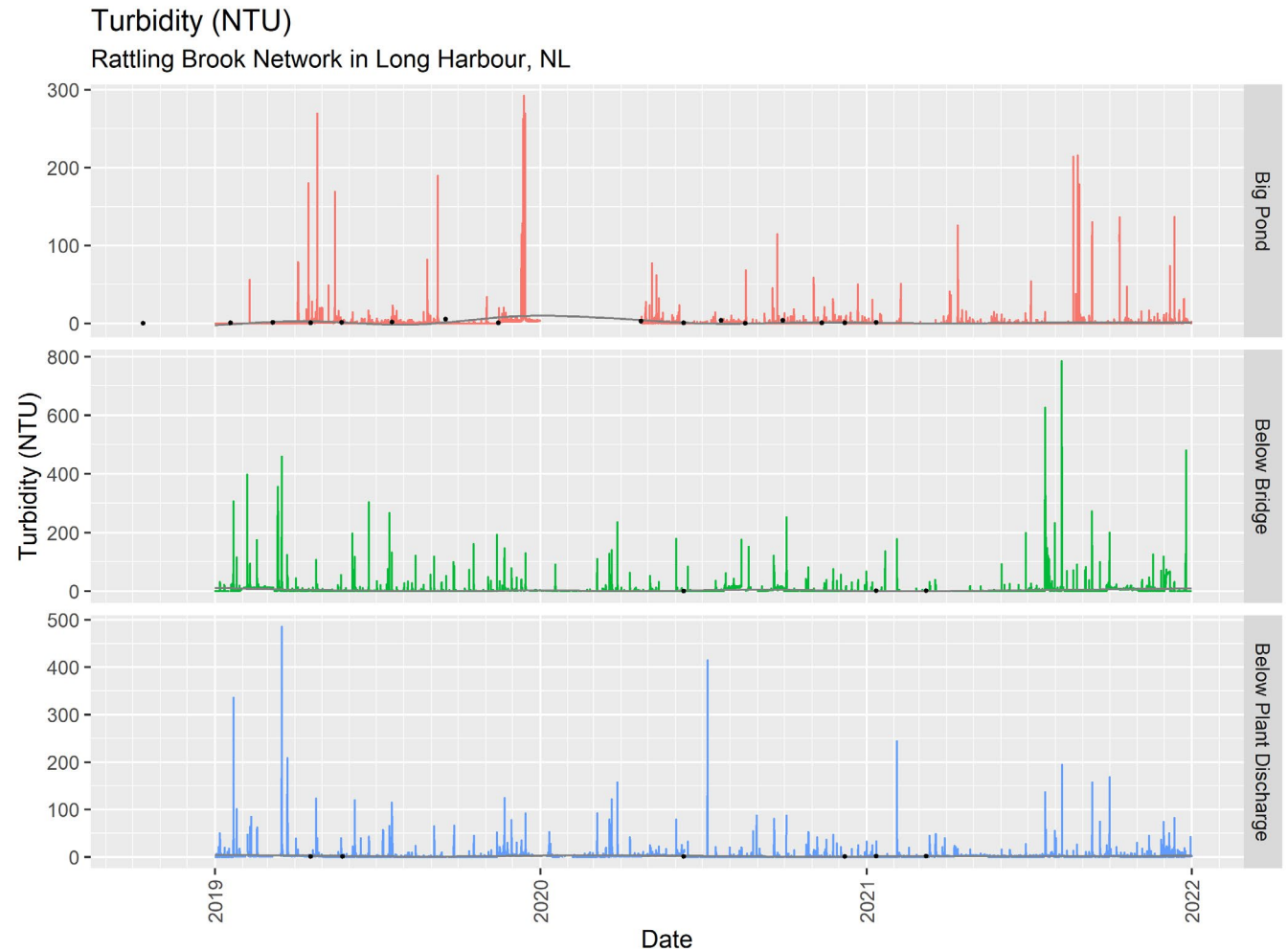


Figure 8: Turbidity at Rattling Brook from 2019 to 2022

Groundwater Network

Water Temperature

As shown in Table 6, in 2021, median water temperature did not substantially deviate from 2020 levels: within 0.09°C at well 1 Deep, 0.33°C at well 2 Deep, 1.735°C at well 2 Shallow, 0.26°C at well 3 Deep and 0.16°C at well 4 Deep (Table 6).

The narrow range and stability of water temperatures is reinforced by the scale of the y-axes in Figure 9.

Table 6: Temperature at Residue Storage Area

Station	Segment	Median	Min	Max
1 Deep	2020	6.74	6.54	7.08
	2021	6.83	6.64	7.06
2 Shallow	2020	5.925	3.18	11.22
	2021	7.66	3.79	11.62
2 Deep	2020	6.04	5.64	6.47
	2021	6.37	6.03	6.94
3 Deep	2020	6.57	6.44	6.82
	2021	6.83	6.67	7.17
4 Deep	2020	6.41	5.76	6.5
	2021	6.57	6.43	6.96

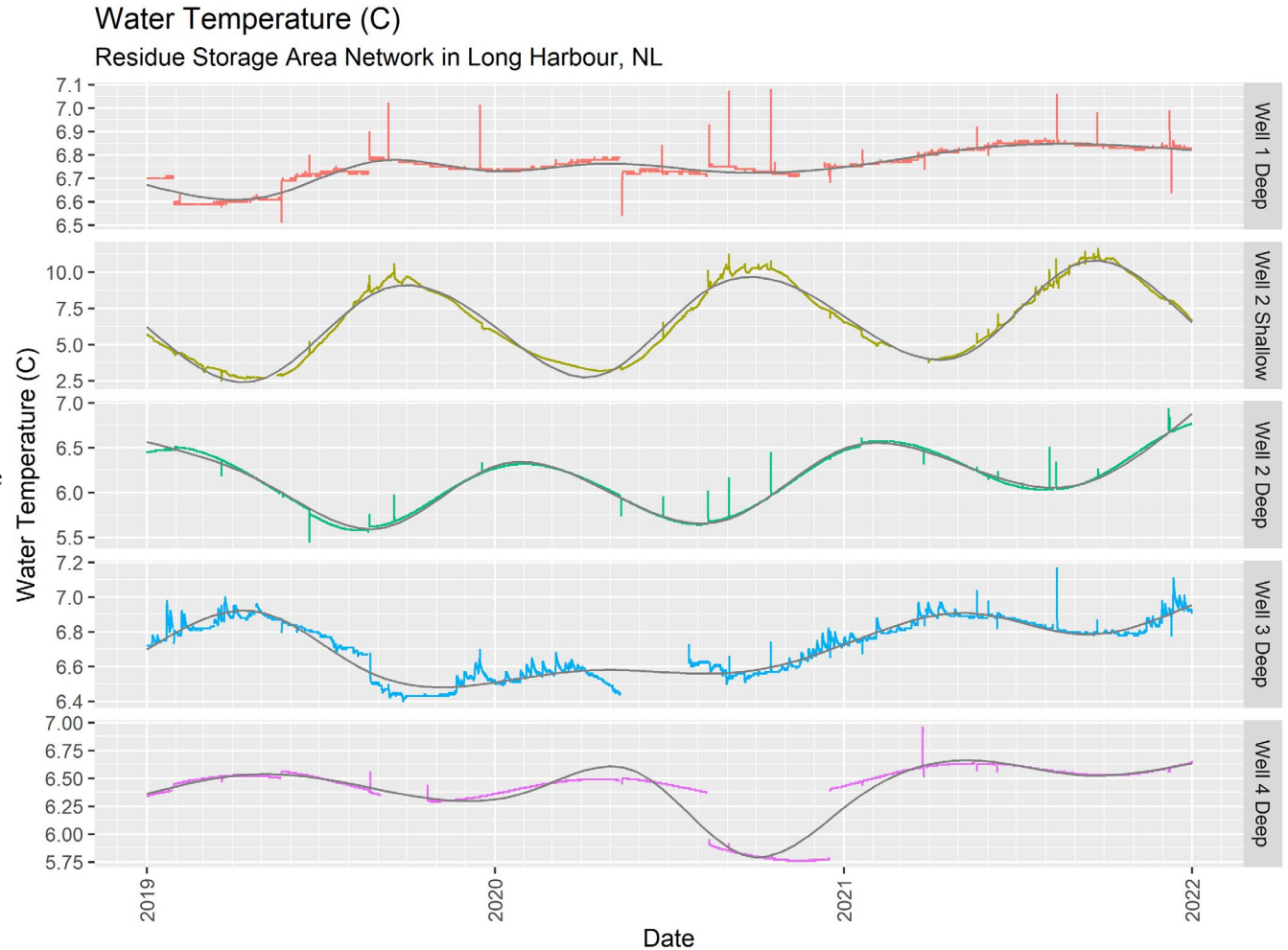


Figure 9: Water temperature at the Residue Storage Area from 2019 to 2022

Within each well, water temperature ranges were similar in 2021 compared to previous year (Figure 10). Note a gradual rise in Temperature at Well 2 Shallow.

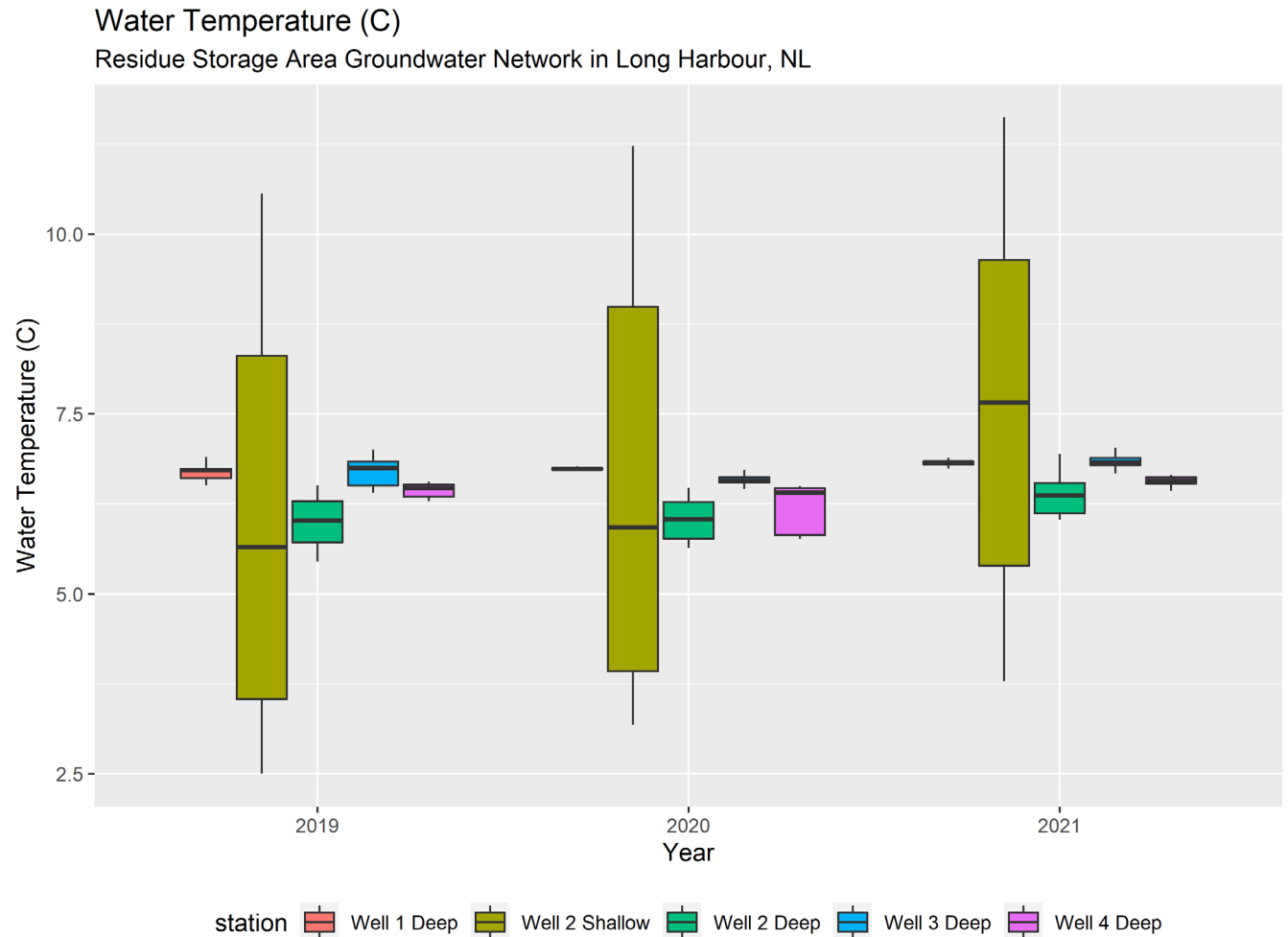


Figure 10: Boxplots of water temperature at the Residue Storage Area from 2019 to 2022

pH

2021 Median pH values were found to be below 2020 levels at all stations (Table 7).

Long term trends are difficult to extrapolate from Figure 11, but the gray trend lines show pH plateaus at all Deep stations for 2021. Well station equipment was upgraded late 2020 - early 2021.

Table 7: pH at Residue Storage Area

Station	Segment	Median	Min	Max
1 Deep	2020	5.95	5.46	6.41
	2021	5.59	5.32	7.23
2 Shallow	2020	6.57	5.6	6.96
	2021	5.59	5.02	6.92
2 Deep	2020	7.83	6.67	9.35
	2021	6.98	5.56	7.89
3 Deep	2020	5.87	5.6	6.28
	2021	5.84	5.24	6.06
4 Deep	2020	8	7.53	8.6
	2021	7.62	6.91	8.06

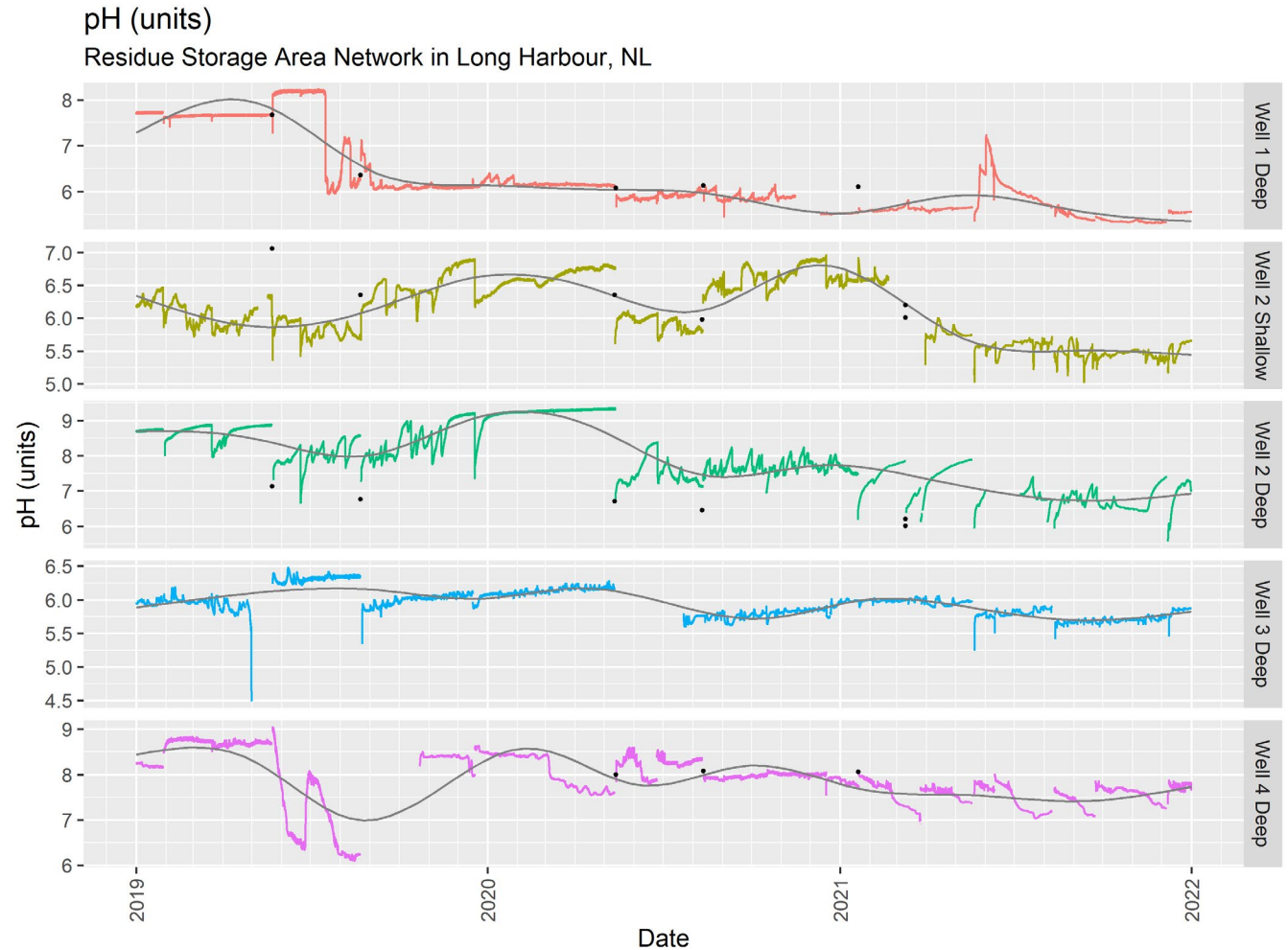


Figure 11: pH at the Residue Storage Area from 2019 to 2022

Figure 12 shows the range of pH at each station for the past three years.

With the exception of station 2 Shallow, pH at all stations has been trending downward the past three years.

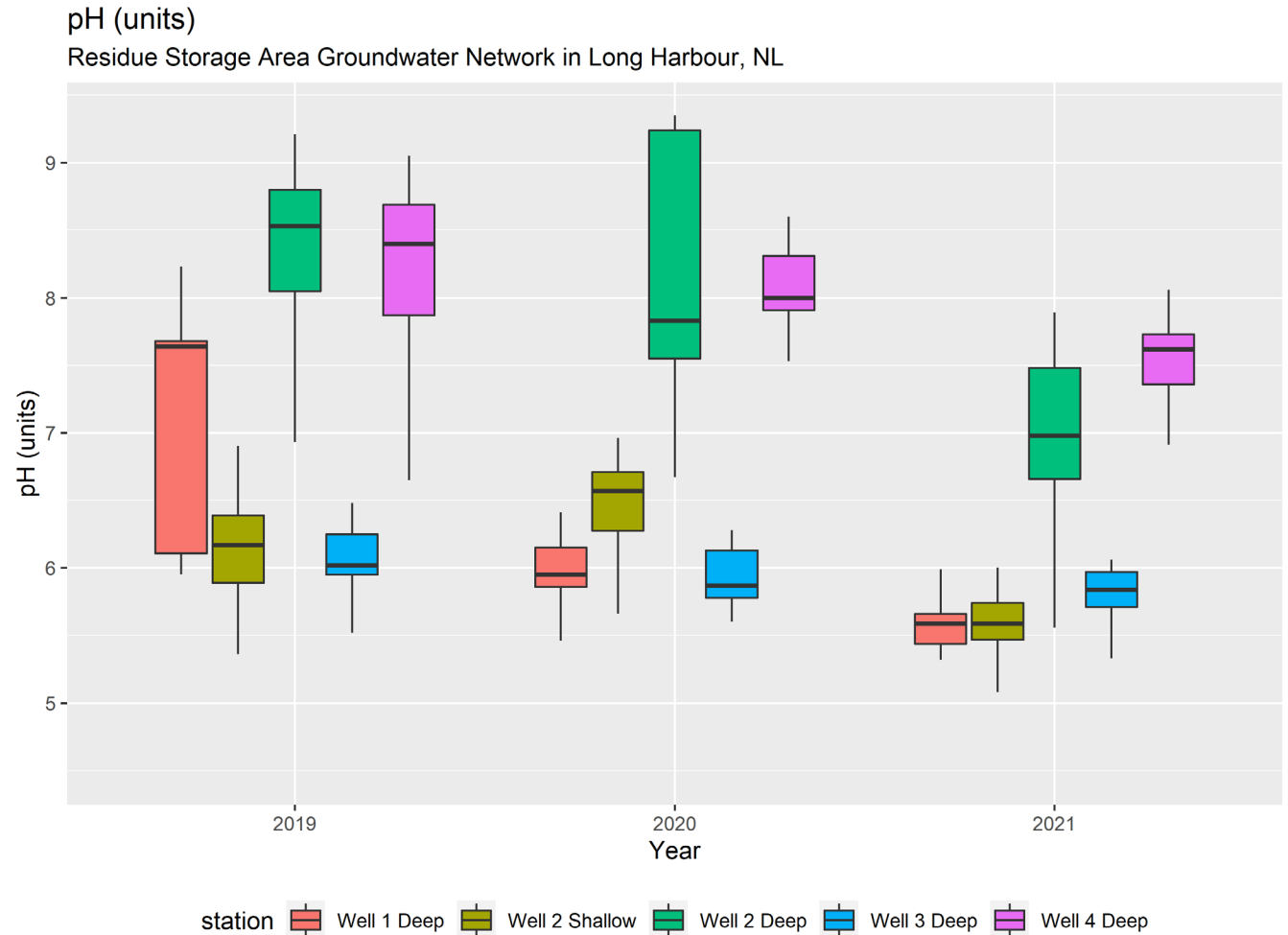


Figure 12: Boxplots of pH at the Residue Storage Area from 2019 to 2022

Specific Conductivity

In 2021, median specific conductivity values were above 2020 values at each station surrounding the Residue Storage Area – except well 1 Deep.

For 2021, figure 13 shows a plateau in conductivity at well 1, 3 and 4 Deep and continued and steady increase at 2 Shallow and decreasing at 2 Deep.

Figure 13 also shows grab samples taken during routine maintenance (black circles).

Table 8: Specific conductivity at Residue Storage Area

Station	Segment	Median	Min	Max
1 Deep	2020	231	168	306
	2021	186	158	236
2 Shallow	2020	195	131	236
	2021	227	118	397
2 Deep	2020	251	218	467
	2021	294	220	454
3 Deep	2020	132	103	166
	2021	134	97	153
4 Deep	2020	276	195	288
	2021	280	202	308

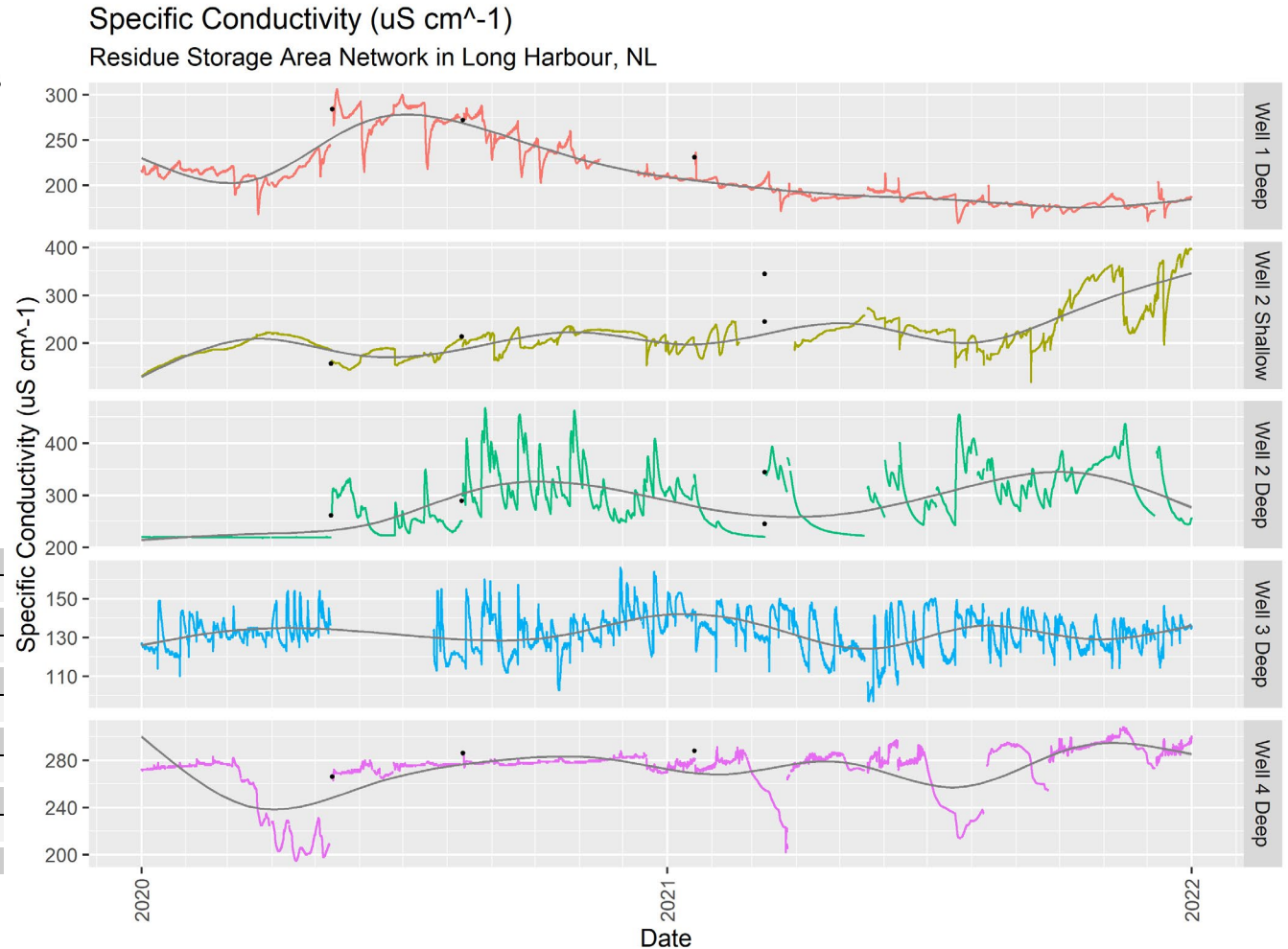


Figure 13: Specific conductivity at the Residue Storage Area from 2019 to 2022

From 2019-2021 (Figure 14), specific conductivity appears to be trending upwards at wells 2 Shallow and 2 Deep, and downwards at well 1 Deep. Wells 3 Deep and 4 Deep appear relatively stable over the past three years, exhibiting minimal variability.

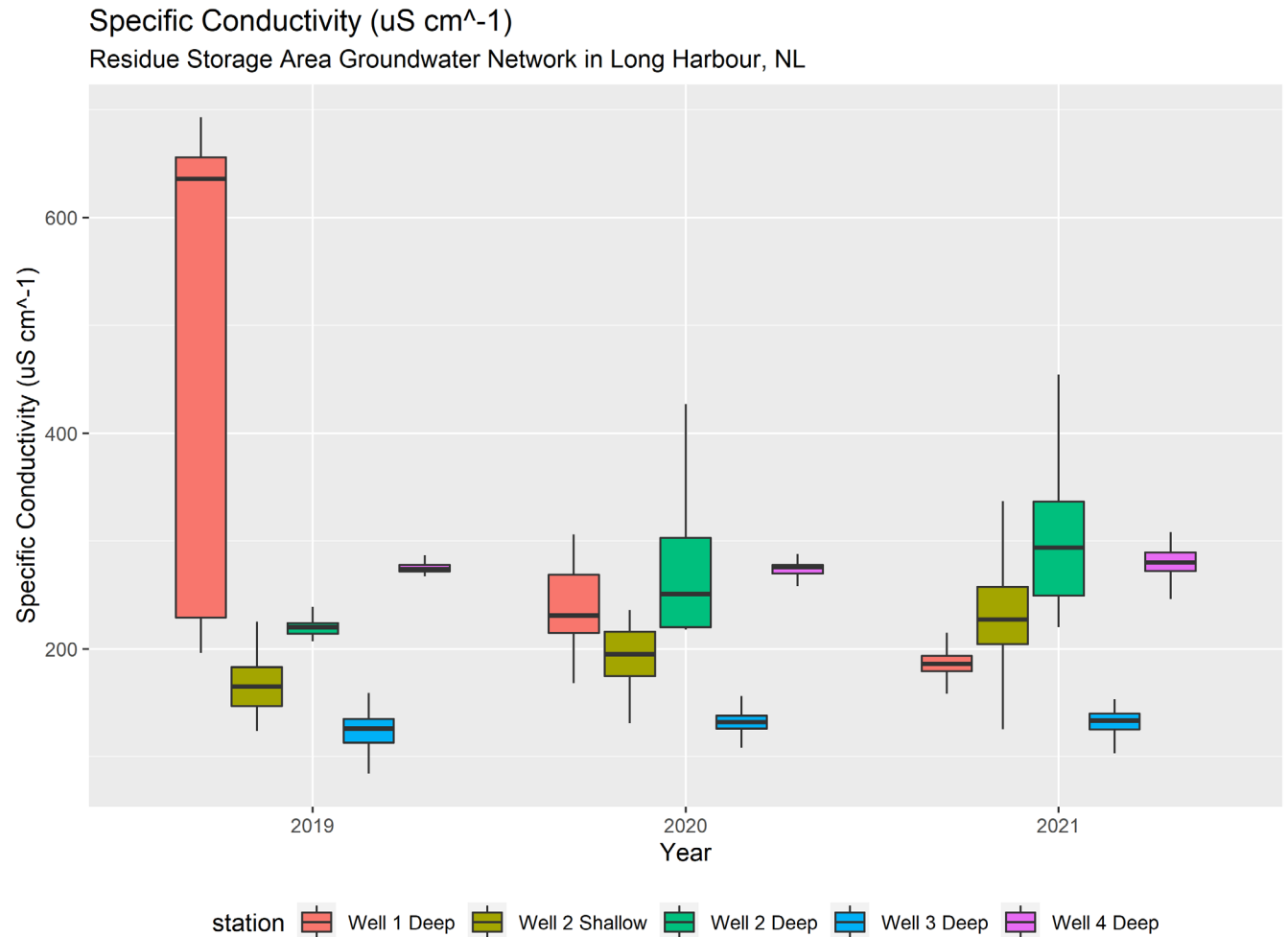


Figure 14: Boxplots of specific conductivity at the Residue Storage Area from 2019 to 2022

Oxidation-Reduction Potential (ORP)

Due to the high variability in ORP values following equipment maintenance, raw ORP values can be challenging to observe. As such, the gray trend lines in Figure 15 give a more intuitive indication of ORP tendency over time.

Table 9 shows that median ORP values from 2021 are greater than 2020 at all stations with the exceptions of well 1 and 3 Deep.

Table 9: ORP at Residue Storage Area

Station	Segment	Median	Min	Max
1 Deep	2020	338.68	176.1	442.5
	2021	356.88	116.05	443.93
2 Shallow	2020	58.3	-298.2	419.3
	2021	81.04	-264.16	352.08
2 Deep	2020	-367.5	-478.4	50.2
	2021	-152.06	-547.3	186.96
3 Deep	2020	417.4	176.55	48.5
	2021	390.18	231.02	446.21
4 Deep	2020	-402.5	-465.7	236.1
	2021	322.29	-146.76	487.44

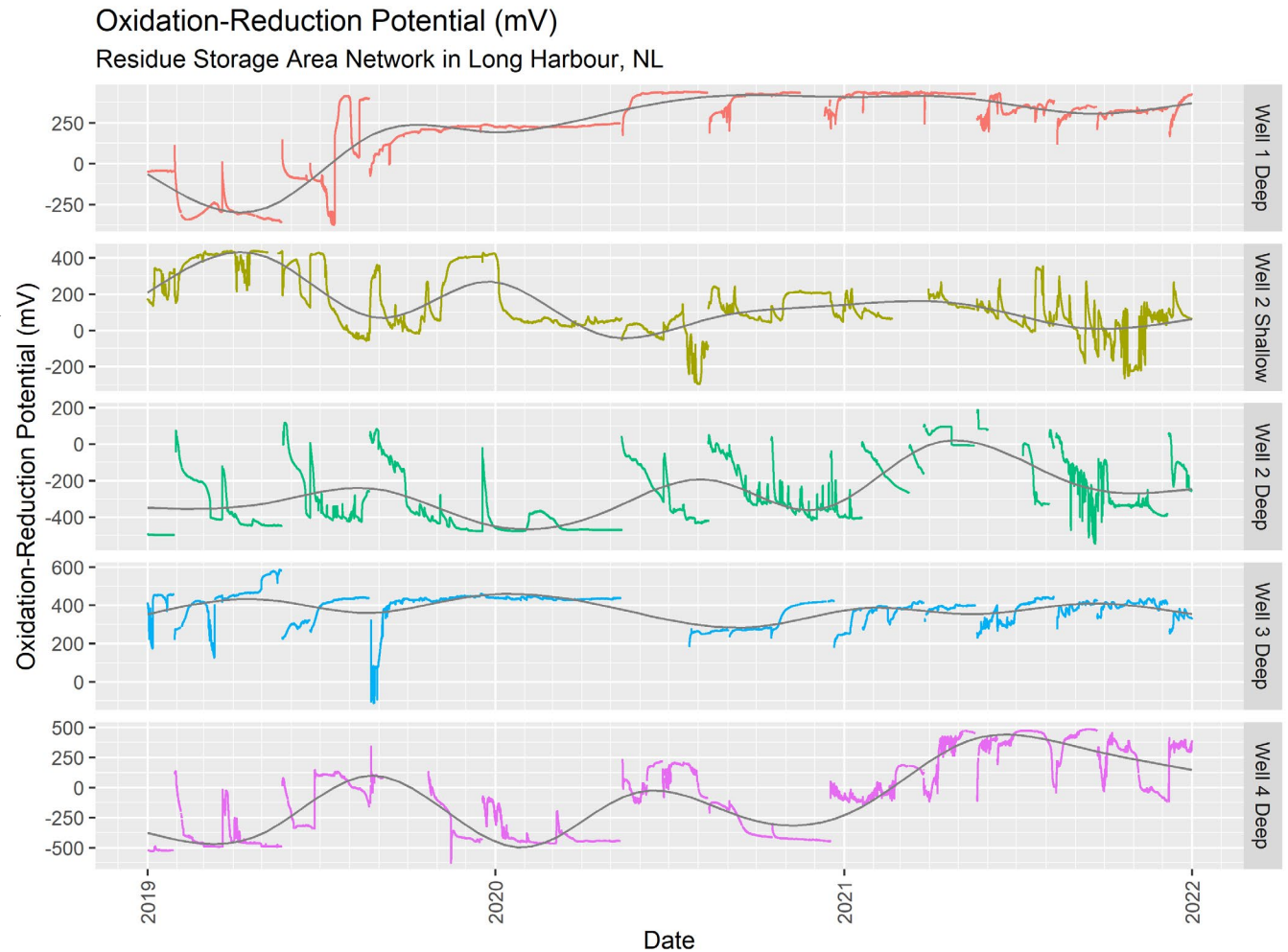


Figure 15: Oxidation-Reduction Potential at the Residue Storage Area from 2019 to 2022

Figure 16 shows the range of ORP at each station for the past three years.

Year-over-year tendency in ORP values are most clearly shown in Figure 16. Well 4 and 2 Deep experienced a larger degree of change from 2020 to 2021 than wells 1 Deep, 2 Shallow and 3 Deep.

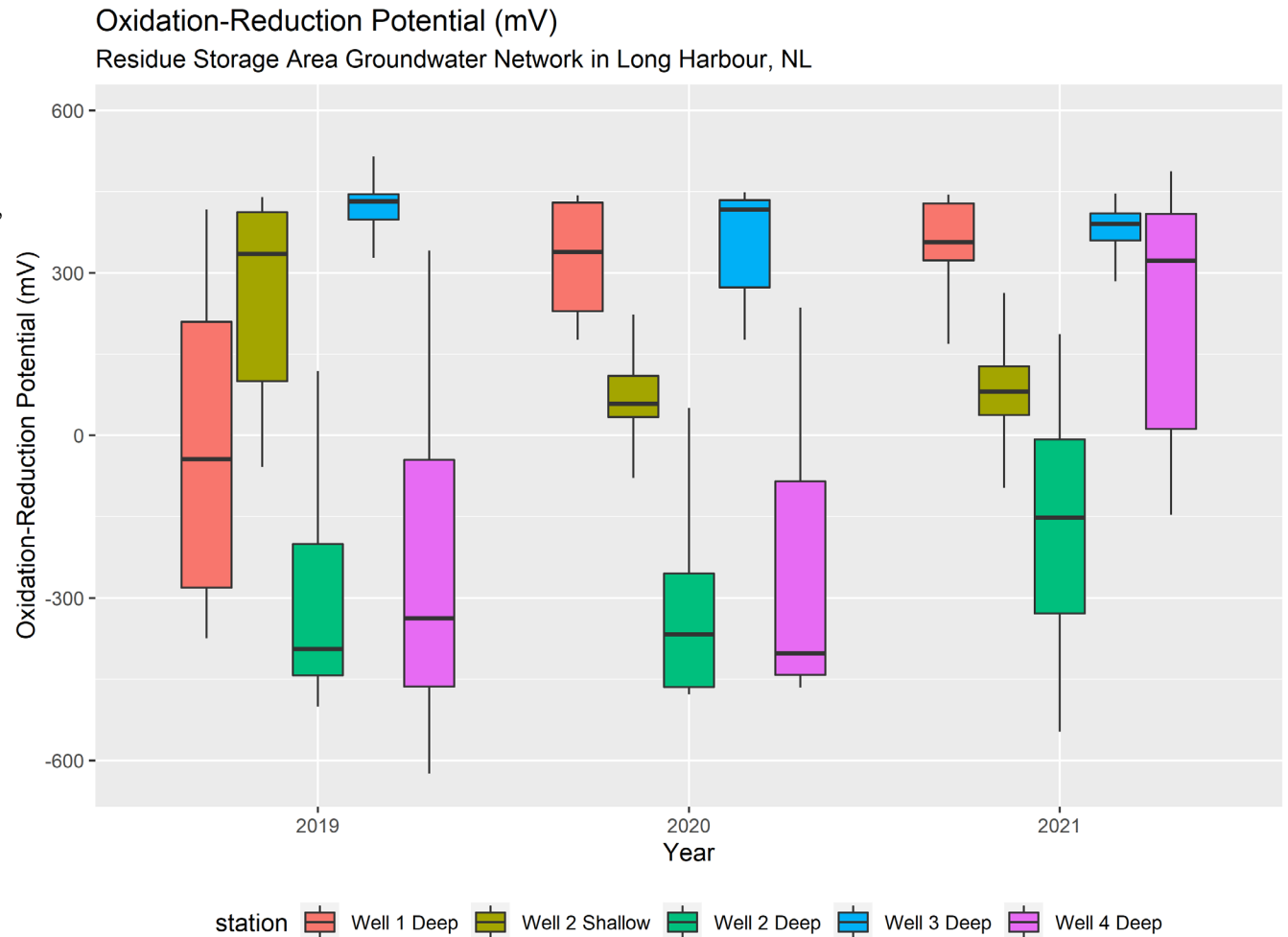


Figure 16: Boxplots of Oxidation-Reduction Potential at the Residue Storage Area from 2019 to 2022

Water Elevation

The local height of the aquifer surrounding each well is closely indicated by the water level in each well. These values are not expected to change a great deal over the long term, barring unforeseen circumstances or major changes to water level in nearby water bodies.

Periodic variation is commonplace as illustrated by Figure 17, but levels in 2021 were close to previous years as shown in Table 10. An equipment upgrade in Well 2 Shallow led to a noticeable adjustment in elevation in early 2021.

Table 10: Water level at Residue Storage Area

Station	Segment	Median	Min	Max
1 Deep	2020	131.9207	131.6256	133.2077
	2021	132.0208	131.5125	132.991
2 Shallow	2020	112.9037	112.591	113.0219
	2021	114.196	112.7591	114.8644
2 Deep	2020	113.5883	113.274	113.8842
	2021	113.5511	113.0675	114.1489
3 Deep	2020	132.5027	131.9855	134.9102
	2021	133.0799	131.8971	135.3918
4 Deep	2020	138.4218	135.7233	139.8605
	2021	138.9055	128.6848	139.9577

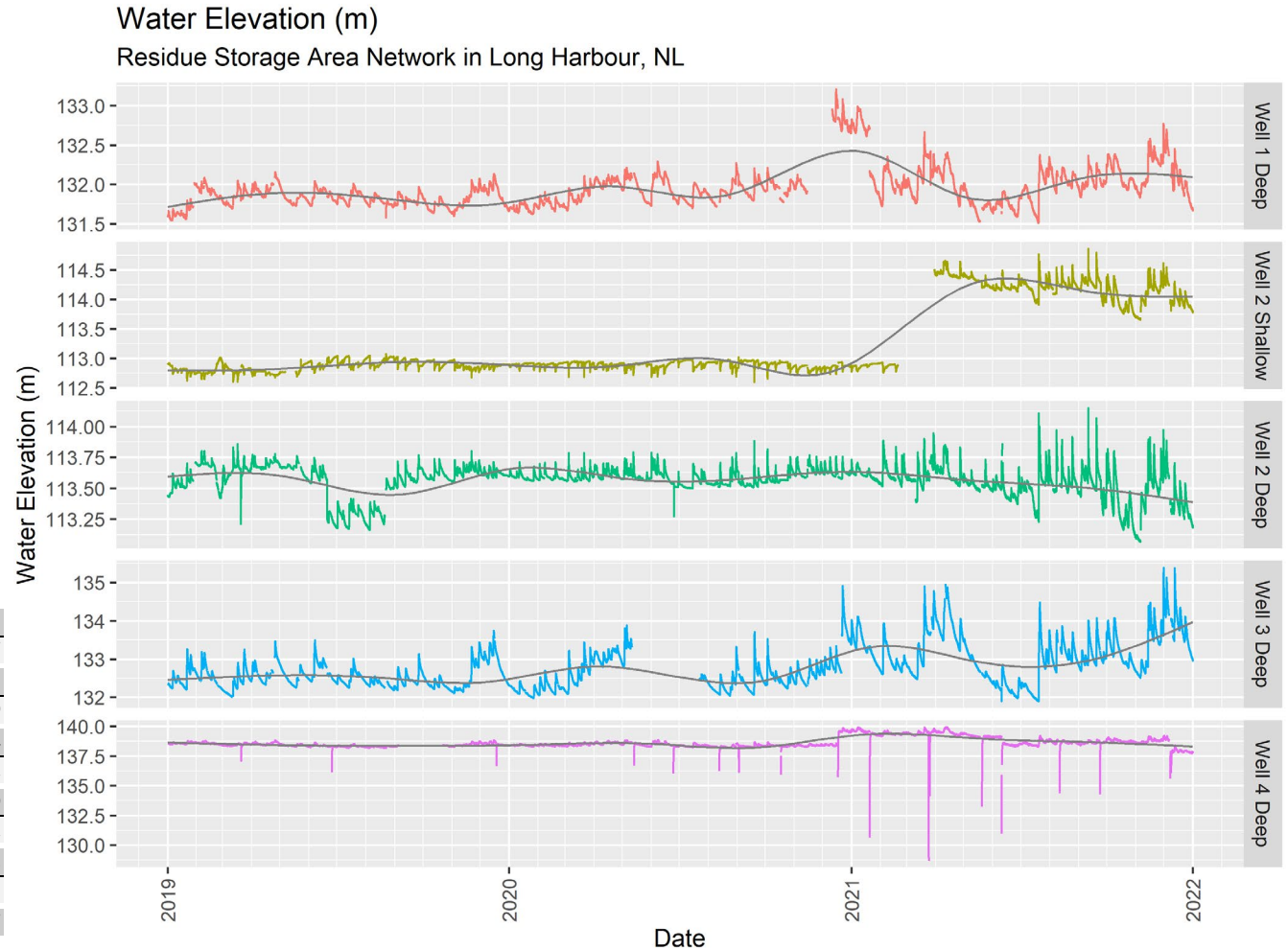


Figure 17: Water elevation at the Residue Storage Area from 2019 to 2022

Figure 18 shows the elevation of water levels in each well from 2019 to 2022. Values are largely stable at each well over the period of record.

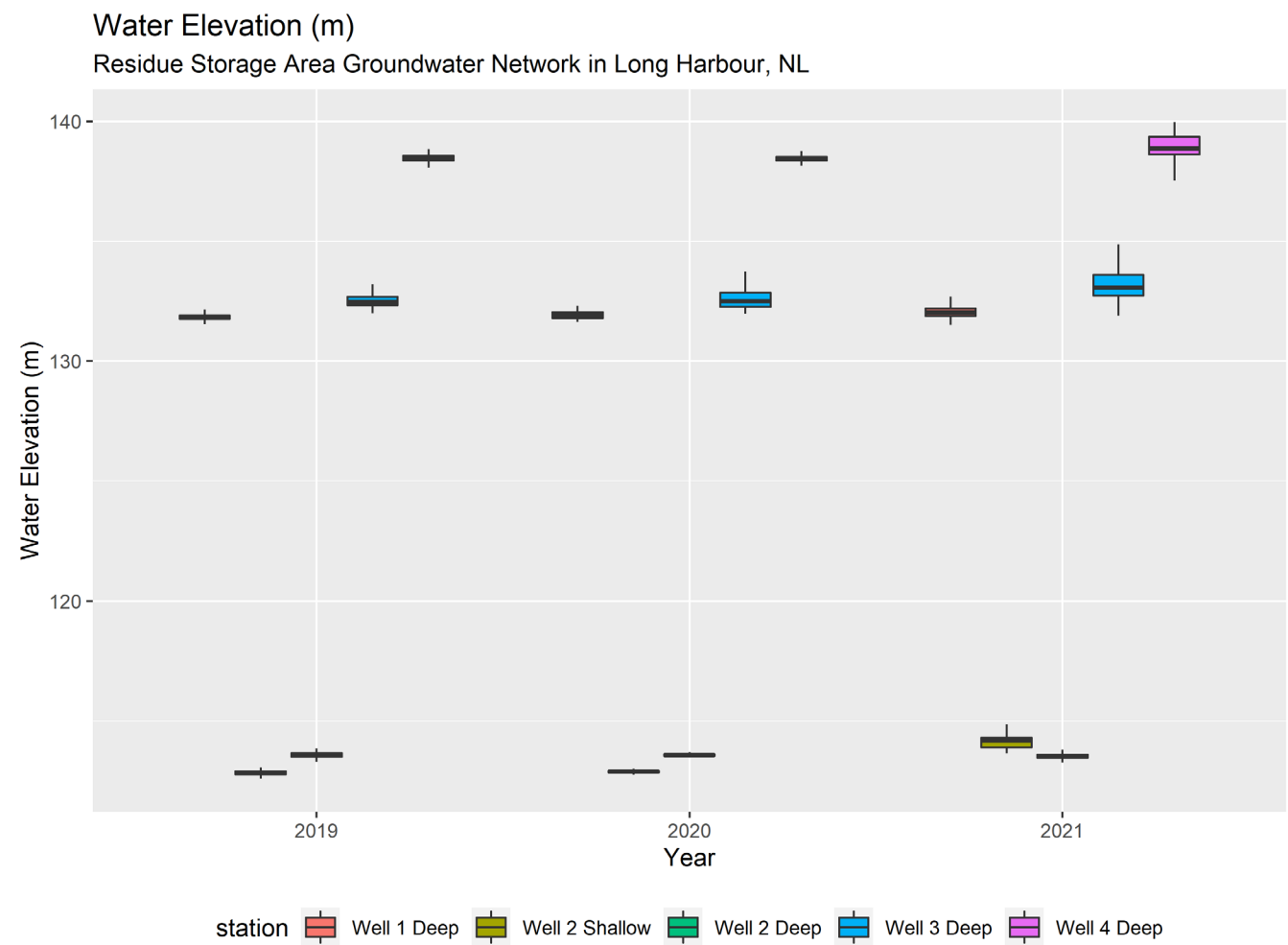


Figure 18: Boxplots of water elevation at the Residue Storage Area from 2019 to 2022

Path Forward

A 1.5 m water level increase at Rattling Brook Big Pond in November 2017 saw the inundation of shoreline vegetation and soils. As the organic matter decays, changes in water quality are expected over the short- to mid-term. In particular, dissolved oxygen concentrations may fall below guidelines set by the CCME during warm water conditions.

Station maintenance and calibration activities will continue to take place every six weeks at surface water stations while maintenance and calibration activities will occur four times per year at groundwater stations.

Reports on surface water stations will be generated at the end of each deployment period while a summary of the groundwater data will be included in the annual report, due to the relatively static nature of data from monitoring wells.

In partnership with ECC, a weather station was installed on site at Vale Long Harbour in December 2020 with plans to install an additional weather station in the Long Harbour community during spring of 2022.

Equipment upgrade was completed for stations at the Residue Storage in 2021.

Ongoing and cooperative efforts between the department of Environment and Climate Change and Vale to monitor water quality on a real-time basis have been successful in identifying areas worthy of attention.

Appendix

Table 1: Summary statistics of Water Temperature from 2008 to 2021

Station	Year	Mean	Median	Min	Max
Big Pond	2009	5.13	5.15	0.2	12.26
	2010	10.08	9.65	0.04	22.4
	2011	9.58	9.875	-0.02	20.88
	2012	10.00	11.28	0	22.87
	2013	9.67	10.04	-0.02	22.17
	2014	10.58	11.37	0.01	23.1
	2015	10.11	11.68	-0.39	21.46
	2016	10.87	11.52	-0.44	22.24
	2017	11.24	11.96	-0.47	20.61
	2018	8.07	8.44	-0.43	20.87
	2019	8.24	6.76	0.23	22.26
	2020	11.90	12.72	0.25	21.77
	2021	8.92	8.16	0	20.96
Below Bridge	2008	6.73	6.195	-0.42	21.93
	2009	9.14	8.025	-0.5	23.97
	2010	8.65	7.73	-0.5	22.84
	2011	7.70	6.43	-0.48	22.2
	2012	9.52	9.77	-0.51	23.82
	2013	9.03	9.16	-0.49	24.98
	2014	8.65	7.455	-0.5	24.93
	2015	7.91	6.69	-0.03	22.69
	2016	9.10	9.15	-0.54	24.69
	2017	8.30	7.25	-0.54	23.67
	2018	8.49	8.65	-0.41	23.98
	2019	8.65	7.39	-0.05	24.42
Plant Discharge	2020	8.85	6.83	-0.56	25.23
	2021	9.23	8.53	-0.5	24.29
	2009	4.02	4.2	0.02	11.37

2010	9.04	8.12	0.02	23.67
2011	8.43	7.49	-0.07	22.89
2012	9.98	10.16	-0.03	24.33
2013	10.05	10.9	-0.03	24.7
2014	9.27	9.36	0	25.48
2015	8.05	6.705	-0.51	23.25
2016	9.10	9.22	-0.55	25
2017	8.49	7.74	-0.52	24.13
2018	8.21	7.88	-0.53	24.77
2019	8.66	7.705	-0.07	24.67
2020	9.36	7.63	-0.04	25.8
2021	9.23	8.37	-0.49	25.02

Table 2: Summary statistics of pH from 2008 to 2021

Station	Year	Mean	Median	Min	Max
Big Pond	2009	6.24	6.24	5.86	6.41
	2010	6.22	6.25	5.34	6.8
	2011	6.29	6.32	5.45	6.74
	2012	6.48	6.51	5.37	7.14
	2013	6.41	6.42	5.02	7.51
	2014	6.43	6.46	5.65	6.78
	2015	6.58	6.59	5.57	7.07
	2016	6.49	6.54	5.23	8.74
	2017	6.43	6.41	5.54	7.16
	2018	5.84	5.95	4.93	6.36
	2019	5.81	5.98	4.49	6.89
	2020	6.10	6.13	4.81	6.38
	2021	6.15	6.24	4.72	6.83
Below Bridge	2008	6.08	6.11	5.42	6.5
	2009	5.98	5.99	5.25	6.71
	2010	6.19	6.24	5.22	6.81

Appendix – Weather

	2011	6.16	6.19	5.41	6.81
	2012	6.29	6.29	5.15	7
	2013	6.14	6.21	4.89	6.94
	2014	6.09	6.09	5.13	7.1
	2015	6.34	6.37	5.45	6.94
	2016	6.21	6.39	4.84	7
	2017	6.31	6.38	5.15	7.2
	2018	6.08	6.25	4.74	6.92
	2019	6.21	6.26	4.72	7.05
	2020	6.21	6.28	4.9	6.91
	2021	6.39	6.44	5.34	6.79
Plant Discharge	2009	6.30	6.29	5.82	6.78
	2010	6.45	6.44	5.12	6.95
	2011	6.61	6.57	6.07	7.67
	2012	6.58	6.58	5.92	7.48
	2013	6.54	6.6	5.45	7.12
	2014	6.62	6.63	4.83	7.17
	2015	6.66	6.66	6.37	6.96
	2016	6.46	6.57	5.17	7.03
	2017	6.68	6.6	5.62	7.53
	2018	6.08	6.22	4.59	6.84
	2019	6.27	6.39	5.19	6.97
	2020	6.48	6.44	5.77	7.41
	2021	6.43	6.45	5.48	6.88

Table 3: Summary statistics of Conductivity from 2008 to 2021

Station	Year	Mean	Median	Min	Max
Big Pond	2009	33.05	33.2	29.6	35.4
	2010	35.18	35.6	27.4	55.7
	2011	43.38	44.6	33.1	57
	2012	52.99	52.8	28.2	73.8
	2013	54.82	56.5	32.5	77.4
	2014	58.35	58.8	30.6	68.1
	2015	60.56	60.8	39.1	70.3

	2016	62.13	62.4	37.6	76.3
	2017	67.23	68.3	45.8	110.9
	2018	76.12	76.6	54.2	135.8
	2019	73.73	73.8	56.8	118.3
	2020	65.25	64.3	46.2	125.3
	2021	63.12	63.3	41.9	108.5
Below Bridge	2008	32.17	31.8	21.6	44.4
	2009	36.91	36.5	27.5	51.6
	2010	38.06	38	27.4	83.6
	2011	40.80	40.6	21.2	87.1
	2012	52.87	50.1	20.2	81.1
	2013	55.11	53.9	29.3	116.6
	2014	56.08	57	20.3	120.7
	2015	59.01	58.3	50.6	82.6
	2016	59.15	58.7	47.3	119.1
	2017	60.79	61.9	38.8	94.1
	2018	66.42	66.6	37.3	96.2
Plant Discharge	2019	62.88	62.7	37.6	162.2
	2020	53.61	53.7	33.6	91.4
	2021	54.88	55.5	33.1	140.1
	2009	36.24	35.5	30.6	60
	2010	46.48	44.9	35.5	99.8
	2011	53.36	51.9	36.5	147.9
	2012	69.13	64.7	45.5	202
	2013	75.81	72.5	51	158.7
	2014	72.45	70.4	43.9	161.4
	2015	74.03	73	52.3	121
	2016	72.40	71	54.3	203
	2017	66.89	65.9	45.4	275
	2018	71.50	70.9	3.7	144.7
	2019	69.55	68	57.5	222
	2020	58.17	56.7	45.9	188.1
	2021	58.25	57.9	47	168.3

Table 4: Summary statistics of Total Dissolved Solids from 2008 to 2021

Station	Year	Mean	Median	Min	Max
Big Pond	2009	0.02	0.0213	0.0189	0.0226
	2010	0.02	0.0228	0.0175	0.0357
	2011	0.03	0.0285	0.0212	0.0365
	2012	0.03	0.0338	0.018	0.0473
	2013	0.03	0.0355	0.0208	0.0495
	2014	0.04	0.0376	0.0196	0.0436
	2015	0.04	0.0389	0.025	0.045
	2016	0.04	0.0399	0.022	0.0489
	2017	0.04	0.0437	0.022	0.071
	2018	0.05	0.049	0.0347	0.0869
	2019	0.05	0.0472	0.0364	0.0757
	2020	0.04	0.0412	0.0296	0.0802
Below Bridge	2021	0.04	0.0405	0.0268	0.0694
	2008	0.02	0.0204	0.0138	0.0284
	2009	0.02	0.0234	0.0176	0.033
	2010	0.02	0.0243	0.0176	0.0535
	2011	0.03	0.026	0.0136	0.0557
	2012	0.03	0.0321	0.0129	0.0519
	2013	0.04	0.0345	0.0187	0.0746
	2014	0.04	0.0365	0.013	0.0773
	2015	0.04	0.0373	0.0324	0.0528
	2016	0.04	0.0375	0.0303	0.0762
	2017	0.04	0.0396	0.0249	0.0602
	2018	0.04	0.0426	0.0239	0.0616
Plant Discharge	2019	0.04	0.0401	0.024	0.1038
	2020	0.03	0.0344	0.0215	0.0585
	2021	0.04	0.0355	0.0212	0.0896
	2009	0.02	0.0227	0.0196	0.0384
	2010	0.03	0.0287	0.0227	0.0639
	2011	0.03	0.0332	0.0234	0.0946
	2012	0.04	0.0414	0.0291	0.129

2013	0.05	0.0467	0.0329	0.1016
2014	0.05	0.0451	0.0281	0.1033
2015	0.05	0.0467	0.0335	0.0774
2016	0.05	0.0455	0.0347	0.13
2017	0.04	0.0422	0.0291	0.176
2018	0.05	0.0454	0.0023	0.0926
2019	0.04	0.0435	0.0368	0.142
2020	0.04	0.0363	0.0294	0.1204
2021	0.04	0.0371	0.0301	0.1077

Table 5: Summary statistics of of Dissolved Oxygen from 2008 to 2021

Station	Year	Mean	Median	Min	Max
Big Pond	2009	11.56	11.72	9.42	12.88
	2010	10.68	10.69	8.06	13.53
	2011	10.99	10.71	8.39	14.42
	2012	10.86	10.47	8.17	14.69
	2013	10.74	10.55	8.29	14.43
	2014	10.80	10.36	8.27	13.27
	2015	10.90	10.26	8.68	14.54
	2016	10.74	10.42	8.62	15.93
	2017	10.59	10.35	8.41	13.68
	2018	10.36	10.67	4.6	13.5
	2019	10.63	10.85	2.61	13.23
	2020	10.02	9.83	7.26	13.1
Below Bridge	2021	10.84	10.97	6.98	13.68
	2008	12.06	12.15	8.35	14.63
	2009	11.30	11.26	7.72	14.61
	2010	11.43	11.36	7.81	14.9
	2011	11.74	11.7	8.08	15.11
	2012	11.32	10.95	7.54	15.51
	2013	11.17	11.04	7.65	14.21
	2014	11.41	11.53	7.86	14.4
	2015	11.70	11.82	8.34	14.68
	2016	11.38	11.15	7.61	14.53

Appendix – Weather

Plant Discharge	2017	11.61	11.64	7.98	14.69
	2018	11.48	11.28	7.64	14.47
	2019	11.48	11.44	8	14.73
	2020	11.49	11.7	8.02	14.48
	2021	11.19	10.99	8.04	14.48
	2009	12.25	12.28	10.29	14.1
	2010	10.94	10.95	7.02	14.48
	2011	11.24	10.99	7.12	14.76
	2012	10.91	10.66	6.46	14.45
	2013	10.96	10.52	7.28	14.2
	2014	11.09	10.95	7.39	14.3
	2015	11.55	11.79	7.59	14.68
	2016	11.23	11.1	7.18	14.57
	2017	11.53	11.5	7.5	14.91
	2018	11.45	11.35	7.03	14.73
	2019	11.30	11.185	6.88	14.44
	2020	11.18	11.37	7.56	14.13
	2021	11.10	11.09	7.68	14.51

Table 6: Summary statistics of Percent Saturation from 2008 to 2021

Station	Year	Mean	Median	Min	Max
Big Pond	2009	92.14	91.8	86.8	98.9
	2010	94.06	94	85.9	104.4
	2011	94.67	94.2	87.3	109.3
	2012	93.94	93.1	84.8	109.6
	2013	92.31	91.9	81.4	109.1
	2014	95.00	95	82.7	106.4
	2015	95.10	95.1	86.8	106.2
	2016	95.00	94.5	84.8	106.8
	2017	95.07	95.7	82.5	104.8
	2018	85.82	87.2	46.9	99.9
	2019	89.99	91.2	26.7	108.6
	2020	91.71	92	77.8	102.2
	2021	92.75	92.7	71.5	107.2

Below Bridge	2008	96.07	96.3	89.8	100.6
	2009	96.09	96.3	88.3	102.6
	2010	96.65	96.7	88.9	103.3
	2011	95.93	96.05	88.2	104.4
	2012	96.04	96.5	85.6	105.3
	2013	94.36	94.3	88.7	101.6
	2014	94.80	94.9	87.7	101.5
	2015	96.91	97	89.5	103
	2016	96.72	96.8	88.9	103.5
	2017	96.38	96.7	89	102.5
	2018	95.99	96.2	88.9	102.9
	2019	97.17	96.9	91.2	104
	2020	96.75	96.2	88.7	108.9
	2021	95.92	95.8	89.4	102.5
	2009	94.94	95.5	88.1	101.6
	2010	93.63	94.1	80.1	105.7
	2011	94.33	95.1	72.5	103
	2012	93.33	94.8	70.8	103.4
	2013	94.37	94.3	83.1	103.6
	2014	93.47	94.1	84	101
Plant Discharge	2015	95.47	95.9	84.7	103.1
	2016	95.32	95.9	83.5	103.6
	2017	95.48	95.6	85.9	102.8
	2018	94.75	95.6	80.9	103.7
	2019	95.37	95.1	70.7	108
	2020	95.07	95.2	85.2	102.3
	2021	94.91	95	86.7	103

Table 7: Summary statistics of Turbidity from 2008 to 2021

Station	Year	Mean	Median	Min	Max
Big Pond	2009	3.37	1.7	0	22
	2010	2.36	0	0	116.6
	2011	0.63	0	0	44.9
	2012	0.20	0	0	22

Appendix – Weather

Below Bridge	2013	0.05	0	0	84.8
	2014	0.03	0	0	81.1
	2015	0.29	0	0	25.3
	2016	0.48	0	0	15
	2017	0.10	0	0	77
	2018	1.19	0	0	672
	2019	2.53	0	0	555
	2020	0.96	0.2	0	114.5
	2021	0.95	0	0	215.4
	2008	0.61	0	0	963
	2009	10.37	0	0	1486
	2010	10.24	2.5	0	445
	2011	6.00	0.4	0	2259
	2012	22.64	3.35	0	1437
	2013	6.42	2.4	0	998
	2014	2.31	0	0	886
	2015	2.91	0	0	396.9
	2016	5.42	0	0	781
	2017	1.80	0	0	371.7
	2018	1.91	0	0	353.5
	2019	3.77	0.3	0	460
	2020	2.39	0	0	251.6
Plant Discharge	2021	3.77	0	0	784
	2009	67.35	23.6	4.3	1094
	2010	11.48	3.3	0	460
	2011	6.69	1.7	0	734
	2012	19.41	4.8	0	586
	2013	11.10	4.5	0	580
	2014	2.57	0	0	277.2
	2015	2.51	0	0	282.5
	2016	7.66	0.6	0	314.6
	2017	1.79	0	0	430
	2018	1.93	0	0	548

2019	2.42	0.5	0	485
2020	1.83	0.1	0	415
2021	1.82	0.40	0	243.8

Table 8: Summary statistics of Water Temperature at the Residue Storage Area from 2013 to 2021

Station	Year	Mean	Median	Min	Max
Well 1 Deep	2012	7.40	7.43	7.2	7.49
	2013	6.78	6.87	6.3	7.45
	2014	6.69	6.68	6.59	6.97
	2015	6.63	6.63	6.56	6.7
	2016	6.62	6.62	6.59	6.68
	2017	6.64	6.64	6.58	6.71
	2018	6.68	6.67	6.64	6.73
	2019	6.70	6.72	6.51	7.02
	2020	6.74	6.74	6.54	7.08
	2021	6.82	6.83	6.64	7.06
Well 2 Shallow	2012	6.17	6.27	4.23	7.6
	2013	6.83	6.71	2.22	11.81
	2014	6.77	6.53	1.03	11.81
	2015	6.15	5.8	2.91	10.5
	2016	6.21	6.1	1.68	11.07
	2017	5.96	5.61	2.44	9.95
	2018	6.38	5.94	3.21	11.27
	2019	5.90	5.65	2.5	10.56
	2020	6.44	5.925	3.18	11.22
	2021	7.54	7.66	3.79	11.62
Well 2 Deep	2013	6.53	6.53	6.17	6.91
	2014	6.35	6.32	5.77	6.88
	2015	6.35	6.35	5.95	6.81
	2016	6.20	6.19	5.78	6.59
	2017	6.15	6.13	5.74	6.58
	2018	6.14	6.16	5.79	6.46
	2019	6.03	6.02	5.45	6.51
	2020	6.02	6.04	5.64	6.47
	2021	6.35	6.37	6.03	6.94
Well 3 Deep	2012	6.44	6.44	6.41	6.47
	2013	6.62	6.63	6.46	6.77

Appendix – Weather

	2014	6.75	6.76	6.5	7.01
	2015	6.69	6.715	6.52	6.89
	2016	6.62	6.63	6.52	6.87
	2017	6.67	6.68	6.53	6.9
	2018	6.70	6.69	6.61	6.93
	2019	6.69	6.75	6.4	7
	2020	6.59	6.57	6.44	6.82
	2021	6.84	6.83	6.67	7.17
Well 4 Deep	2012	6.24	6.24	6.18	6.29
	2013	6.40	6.39	6.28	6.53
	2014	6.46	6.46	6.32	6.6
	2015	6.46	6.48	6.32	6.64
	2016	6.39	6.39	6.3	6.49
	2017	6.39	6.4	6.28	6.52
	2018	6.40	6.42	6.27	6.51
	2019	6.44	6.47	6.29	6.56
	2020	6.22	6.41	5.76	6.5
	2021	6.57	6.57	6.43	6.96

Table 9: Summary statistics of pH at the Residue Storage Area from 2013 to 2021

Station	Year	Mean	Median	Min	Max
Well 1 Deep	2012	5.90	5.89	5.81	6.02
	2013	5.75	5.76	5.51	5.92
	2014	5.68	5.72	5.15	5.88
	2015	6.46	6.67	5.15	7.43
	2016	7.55	7.57	6.51	7.77
	2017	7.64	7.72	7.37	7.9
	2018	7.82	7.85	7.66	7.94
	2019	7.06	7.64	5.95	8.23
	2020	5.98	5.95	5.46	6.41
	2021	5.64	5.59	5.32	7.23
Well 2 Shallow	2012	5.39	5.32	4.97	5.85
	2013	5.64	5.72	4.89	5.98
	2014	5.70	5.74	4.65	6.05
	2015	5.75	5.73	4.52	6.12
	2016	6.11	6.11	5.61	6.68
	2017	6.00	5.95	5.42	7.13
	2018	6.18	6.13	5.73	6.87
	2019	6.16	6.17	5.36	6.9

Well 2 Deep	2020	6.45	6.57	5.6	6.96
	2021	5.72	5.59	5.02	6.92
	2013	8.13	8.16	6.98	8.35
	2014	8.08	8.12	7.38	8.2
	2015	8.27	8.25	7.24	8.57
	2016	8.48	8.55	6.65	8.75
	2017	8.32	8.41	6.4	8.56
	2018	8.24	8.18	6.61	8.74
Well 3 Deep	2019	8.45	8.53	6.66	9.21
	2020	8.22	7.83	6.67	9.35
	2021	7.05	6.98	5.56	7.89
	2012	5.66	5.62	5.33	5.96
	2013	5.75	5.73	5.08	6.03
	2014	5.69	5.73	5.06	6.05
	2015	5.67	5.63	5.11	6.03
	2016	5.93	5.95	5.73	6.23
	2017	5.99	5.98	5.8	6.25
	2018	5.89	5.9	5.55	6.16
	2019	6.07	6.02	4.49	6.48
Well 4 Deep	2020	5.94	5.87	5.6	6.28
	2021	5.84	5.84	5.24	6.06
	2012	7.77	7.76	7.71	7.98
	2013	7.03	6.77	6.43	8.08
	2014	7.25	7.14	6.71	7.85
	2015	7.97	8.11	6.31	8.27
	2016	8.04	8.06	7.54	8.45
	2017	8.29	8.27	8.03	8.68
	2018	8.46	8.37	7.97	8.88
	2019	8.08	8.4	6.1	9.05
	2020	8.06	8	7.53	8.6
	2021	7.55	7.62	6.91	8.06

Table 10: Summary statistics of conductivity at the Residue Storage Area from 2013 to 2021

Station	Year	Mean	Median	Min	Max
Well 1 Deep	2012	125.97	126	118	136
	2013	135.18	136	116	161
	2014	149.98	149	129	179
	2015	233.45	253	151	273
	2016	278.12	282	234	296

Appendix – Weather

	2017	393.89	391	291	503
	2018	559.55	566	470	642
	2019	464.76	636	196	693
	2020	239.26	231	168	306
	2021	187.20	186	158	236
Well 2 Shallow	2012	87.69	87	76	123
	2013	84.76	85	62	131
	2014	96.49	94	72	154
	2015	97.46	96	83	120
	2016	127.69	115	92	208
	2017	127.23	126	90	206
	2018	138.43	137	104	194
	2019	166.57	165	124	225
	2020	194.06	195	131	236
Well 2 Deep	2021	242.33	227	118	397
	2013	227.55	228	179	233
	2014	226.41	226	209	236
	2015	222.67	224	212	233
	2016	213.16	213	141	220
	2017	219.07	219	159	233
	2018	217.58	218	198	229
	2019	222.41	220	207	283
	2020	268.80	251	218	467
Well 3 Deep	2021	296.94	294	220	454
	2012	111.26	106	96	141
	2013	104.79	102	84	144
	2014	115.43	116	88	157
	2015	128.63	127	104	163
	2016	133.51	132	104	182
	2017	123.96	121	81	178
	2018	129.30	128	99	173
	2019	124.12	126	84	159
Well 4 Deep	2020	132.54	132	103	166
	2021	132.59	134	97	153
	2012	313.74	314	299	316
	2013	206.24	173	135	315
	2014	237.23	234	152	297
	2015	231.61	227	178	283
	2016	263.85	268	226	283

2017	271.08	268	261	298
2018	265.54	269	245	284
2019	274.87	274	267	287
2020	266.99	276	195	288
2021	275.77	280	202	308

Table 11: Summary statistics of Total Dissolved Solids at the Residue Storage Area from 2013 to 2021

Station	Year	Mean	Median	Min	Max
Well 1 Deep	2012	0.08	0.082	0.077	0.088
	2013	0.09	0.088	0.075	0.105
	2014	0.10	0.097	0.084	0.116
	2015	0.15	0.165	0.098	0.178
	2016	0.18	0.183	0.152	0.192
	2017	0.26	0.254	0.189	0.327
	2018	0.36	0.368	0.305	0.417
	2019	0.30	0.413	0.127	0.451
	2020	0.16	0.15	0.109	0.199
Well 2 Shallow	2021	0.12	0.12	0.1	0.15
	2012	0.06	0.056	0.05	0.08
	2013	0.06	0.055	0.04	0.085
	2014	0.06	0.061	0.047	0.1
	2015	0.06	0.062	0.054	0.078
	2016	0.08	0.075	0.06	0.135
	2017	0.08	0.082	0.059	0.134
	2018	0.09	0.089	0.068	0.126
	2019	0.11	0.107	0.081	0.146
Well 2 Deep	2020	0.13	0.127	0.085	0.154
	2021	0.16	0.15	0.08	0.26
	2013	0.15	0.148	0.116	0.151
	2014	0.15	0.147	0.136	0.153
	2015	0.14	0.145	0.138	0.151
	2016	0.14	0.139	0.092	0.143
	2017	0.14	0.142	0.104	0.151
	2018	0.14	0.142	0.13	0.149
	2019	0.14	0.143	0.134	0.184
Well 3 Deep	2020	0.17	0.163	0.142	0.304
	2021	0.19	0.19	0.14	0.3
	2012	0.07	0.069	0.063	0.092
	2013	0.07	0.066	0.055	0.094

Appendix – Weather

	2014	0.08	0.075	0.057	0.102
	2015	0.08	0.082	0.068	0.106
	2016	0.09	0.0855	0.068	0.118
	2017	0.08	0.079	0.053	0.116
	2018	0.08	0.083	0.064	0.112
	2019	0.08	0.082	0.055	0.103
	2020	0.09	0.086	0.067	0.11
	2021	0.09	0.09	0.06	0.1
	2012	0.20	0.204	0.194	0.206
	2013	0.13	0.112	0.087	0.205
Well 4 Deep	2014	0.15	0.152	0.099	0.193
	2015	0.15	0.148	0.115	0.184
	2016	0.17	0.174	0.147	0.184
	2017	0.18	0.174	0.17	0.197
	2018	0.17	0.175	0.159	0.184
	2019	0.18	0.178	0.173	0.187
	2020	0.17	0.18	0.127	0.187
	2021	0.18	0.18	0.13	0.2

Table 12: Summary statistics of Oxidation Reduction Potential at the Residue Storage Area from 2013 to 2021

Station	Year	Mean	Median	Min	Max
Well 1 Deep	2012	-329.15	-351.9	-361.5	-116.6
	2013	-271.97	-266.4	-375.2	1.7
	2014	-134.61	-250.6	-291	347.3
	2015	-180.86	-251	-481.6	336.2
	2016	-299.52	-333	-426.9	99.8
	2017	-224.67	-193.55	-441.4	84.4
	2018	-57.77	-47.4	-201.6	189.2
	2019	-14.25	-43.9	-375.3	416.1
	2020	334.93	338.68	176.1	442.5
	2021	368.11	356.88	116.05	443.93
Well 2 Shallow	2012	298.19	310	120.1	341.5
	2013	208.00	309	-293.7	461.7

	2014	155.62	225.5	-269	466.5
	2015	252.57	325.35	-94.9	419.2
	2016	207.31	270.9	-284.9	453.5
	2017	133.60	206.1	-340.8	419.7
	2018	87.34	74.7	-357.6	415.8
	2019	261.99	334.8	-58.6	439.3
	2020	70.07	58.3	-298.2	419.3
	2021	73.23	81.035	-264.16	352.08
	2013	-428.69	-467.7	-499.5	131.9
	2014	-370.11	-411.1	-495.4	84.4
Well 2 Deep	2015	-339.74	-392.1	-486.3	114
	2016	-384.51	-424.8	-502.1	104.1
	2017	-350.22	-403.5	-502.9	130.9
	2018	-404.73	-461.3	-497.2	1.7
	2019	-324.12	-394.5	-501	118.4
	2020	-328.86	-367.5	-478.4	50.2
	2021	-164.04	-152.06	-547.3	186.96
	2012	260.80	253.7	210.3	306.5
	2013	364.17	375.9	119.7	442
	2014	388.15	422.1	147.2	448.4
Well 3 Deep	2015	401.78	440.2	143.2	462.9
	2016	411.14	430.4	179.2	462.7
	2017	364.46	415.6	-82.3	448.7
	2018	402.53	420.1	210.6	461.5
	2019	404.15	432.1	-112.1	587.1
	2020	367.73	417.4	176.55	448.5
	2021	378.08	390.18	231.02	446.21
	2012	-220.88	-337.6	-416.4	41.9
	2013	98.46	349.5	-439.7	404.7
	2014	44.72	63.95	-501	370.1

Appendix – Weather

2015	42.97	35.7	-597.8	378.1
2016	- 243.04	-287.95	-556.5	270.8
2017	- 289.34	-337.65	-500	244.4
2018	- 407.39	-448.5	-553.4	137.1
2019	- 263.38	-337.5	-625.1	341.4
2020	- 257.84	-402.5	-465.7	236.1
2021	241.54	322.29	-146.76	487.44

Table 13: Summary statistics of Water Elevation at the Residue Storage Area from 2013 to 2021

Station	Year	Mean	Median	Min	Max
Well 1 Deep	2012	131.87	131.9028	131.3874	132.1029
	2013	131.98	132.02045	131.4862	132.3255
	2014	131.84	131.874	131.2755	132.2039
	2015	131.95	131.969	131.4605	132.3551
	2016	131.99	131.99605	131.7217	132.3484
	2017	131.94	131.9131	131.6611	132.3429
	2018	132.06	132.0801	131.6035	132.4215
	2019	131.83	131.8278	131.5443	132.1565
	2020	131.96	131.92065	131.6256	133.2077
	2021	132.06	132.02075	131.5125	132.991
Well 2 Shallow	2012	113.93	113.9759	113.7681	114.1645
	2013	113.73	113.7411	113.4821	114.0309
	2014	113.71	113.7275	113.2566	114.0288
	2015	113.72	113.7245	113.4027	113.9952
	2016	113.79	113.7951	113.4259	113.9767
	2017	113.91	113.901	113.6009	114.1578
	2018	113.88	113.8941	113.5997	114.0373

Well 2 Deep	2019	112.86	112.8703	112.5978	113.0763
	2020	112.89	112.9037	112.591	113.0219
	2021	113.99	114.196	112.7591	114.8644
	2013	113.63	113.6258	113.2945	114.0146
	2014	113.55	113.555	113.2056	113.9122
	2015	113.62	113.6285	113.2716	113.8631
	2016	113.68	113.69145	113.4072	113.9247
	2017	113.58	113.6053	113.2709	113.8921
	2018	113.56	113.5582	113.3718	113.8193
	2019	113.56	113.6087	113.1624	113.8587
	2020	113.60	113.5883	113.274	113.8842
Well 3 Deep	2021	113.53	113.5511	113.0675	114.1489
	2012	133.86	133.8236	133.3948	134.8782
	2013	133.31	133.3025	132.5933	134.6628
	2014	133.03	133.0324	131.7996	135.0034
	2015	133.21	133.08375	132.4325	134.7668
	2016	132.84	132.8195	132.1306	134.1729
	2017	132.69	132.6946	131.7471	134.1696
	2018	132.76	132.72105	132.1707	134.0623
	2019	132.54	132.46745	131.9998	133.7396
	2020	132.60	132.5027	131.9855	134.9102
	2021	133.16	133.0799	131.8971	135.3918
Well 4 Deep	2012	137.94	137.942	137.7747	138.1268
	2013	138.03	138.07165	137.7004	138.3314
	2014	138.09	138.1236	137.6385	138.4492
	2015	138.34	138.442	137.585	138.8119
	2016	138.56	138.5831	137.6365	139.0317
	2017	138.63	138.6243	138.1569	139.1022
	2018	138.72	138.7313	138.3324	139.0918
	2019	138.46	138.44065	136.1444	138.8241
	2020	138.48	138.4218	135.7233	139.8605
	2021	138.91	138.86745	128.6848	139.9577

