Real-Time Water Quality Deployment Report

Rattling Brook Network

Annual Report 2012

January 1, 2012 to December 31, 2012

Newfoundland Labrador

Government of Newfoundland & Labrador
Department of Environment and Conservation
Water Resources Management Division
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Table of Contents

Table of Figures

Acknowledgements

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Introduction

Background

Since 2006, the Department of Environment and Conservation has been monitoring the water quality and quantity of the Rattling Brook River system using a network of three stations. These stations are systematically located to provide insight in near real-time into the condition of Rattling Brook from the headwaters to the lower reaches near the ocean (Figure 1). The three stations include Rattling Brook Big Pond, Rattling Brook below Bridge, and Rattling Brook below Plant Discharge.

Figure 1: Rattling Brook Water Quality Network and Watershed

Each station is set to monitor temperature, pH, specific conductivity, total dissolved solids, dissolved oxygen, and turbidity on an hourly basis. In addition, these monitors are co-located with Water Survey of Canada hydrometric stations which monitor water heights and discharge.

Construction efforts have been underway since 2009 to construct a nickel-processing plant for Vale, a Brazil-based mining company. Ongoing work in the area has the potential to cause serious impact to the Rattling Brook river system which Vale and the Department seek to avoid. Since ground was initially broken, both partners have collaborated to ensure that the project continues with the least possible impact to Rattling Brook.

Maintenance and Calibration

Carefully planned maintenance and calibration procedures ensure that the data gathered by the three Rattling Brook Stations produce the highest quality data possible. Generally, deployment periods are restricted to approximately one month. At the end of each deployment, the instrument is removed from the water and returned to St. John’s for cleaning and calibration in a controlled laboratory environment. Upon its return to the water, a grab sample is taken to confirm the initial readings from the sensors. The following three tables outline the deployment periods for each station in 2012.

Table 1: Deployment Schedule for Rattling Brook Big Pond

Deployment Date	Removal Date	Duration of Deployment
2012-01-01	2012-01-12	11
2012-01-13	2012-02-16	34
2012-02-17	2012-03-29	41
2012-05-10	2012-07-03	54
2012-07-04	2012-08-23	50
2012-08-24	2012-09-27	34
2012-09-28	2012-11-01	34
2012-11-02	2012-12-20	48
2012-12-21	2012-12-31	10
Average Duration of Deployment		**35.1**
Efficiency:	**316 of 365 days**	**86.6%**

From late March to early April, the Hydrolab was removed from Big Pond due to possible damage from mobile, heavy ice pans. In total, a Hydrolab was deployed for 86.6% of 2012.

Table 2: Deployment Schedule for Rattling Brook below Bridge

Deployment Date	Removal Date	Duration of Deployment
2012-01-01	2012-01-12	11
2012-01-13	2012-02-16	34
2012-02-17	2012-03-29	41
2012-03-30	2012-05-10	41
2012-05-11	2012-07-03	53
2012-07-04	2012-08-23	50
2012-08-24	2012-09-27	34
2012-09-28	2012-11-01	34
2012-11-02	2012-12-20	48
2012-12-21	2012-12-31	10
Average Duration of Deployment		**35.6**
Efficiency:	**356 of 365 Days**	**97.5%**

Temporary removal of the Hydrolab for maintenance from below Bridge station amounted to a total of nine days in 2012. A Hydrolab was deployed for 97.5% of 2012.

Table 3: Deployment Schedule for Rattling Brook below Plant Discharge

Deployment Date	Removal Date	Duration of Deployment
2012-01-01	2012-01-12	11
2012-01-13	2012-02-16	34
2012-02-16	2012-03-29	42
2012-03-30	2012-05-10	41
2012-05-11	2012-07-03	53
2012-07-04	2012-08-23	50
2012-08-24	2012-09-27	34
2012-09-28	2012-11-01	34
2012-11-02	2012-12-20	48
2012-12-21	2012-12-31	10
Average Duration of Deployment		**35.7**
Efficiency:	**357 of 365 Days**	**97.8%**

Turbidity conditions at Plant Discharge station tend to be higher than those recorded upstream. Because of this, when maintenance periods occur during high turbidity events, a choice is made to leave the QAQC Sonde in place overnight while the Field Sonde is being calibrated. In 2012, this resulted in a total of 357 days of deployment versus 356 at Bridge station.

Deployment periods were somewhat longer than the ideal 30 day deployment period, but were not sufficiently long to result in a significant number of "Poor" data quality rankings.

Table 4: QAQC Rankings for 2012

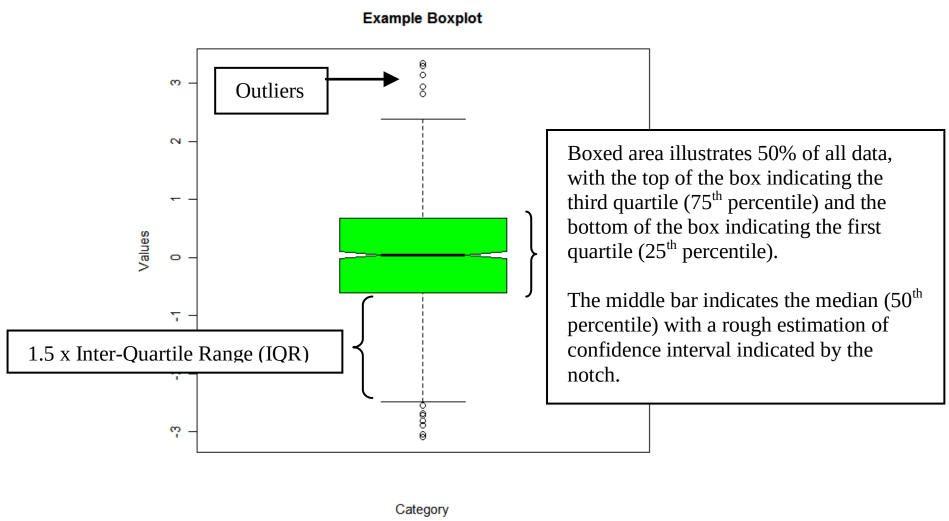
Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Rattling Brook Big Pond	2012-01-13	Deployment	Excellent	Poor	Excellent	NA	Excellent
	2012-02-16	Removal	Fair	Fair	Excellent	Fair	Fair
Rattling Brook below Bridge	2012-01-12	Deployment	Good	Good	Excellent	NA	Excellent
	2012-02-16	Removal	Excellent	Good	Excellent	Excellent	Good
Rattling Brook below Plant Discharge	2012-01-13	Deployment	Excellent	Poor	Good	Good	Excellent
	2012-02-16	Removal	Good	Excellent	Excellent	Fair	Poor
Rattling Brook Big Pond	2012-02-17	Deployment	Good	Excellent	Good	Poor	Excellent
	2012-03-29	Removal	Excellent	Excellent	Good	Good	Excellent
Rattling Brook below Bridge	2012-02-16	Deployment	Excellent	Excellent	Excellent	Fair	Good
	2012-03-29	Removal	Good	Excellent	Excellent	Excellent	NA
Rattling Brook below Plant Discharge	2012-02-17	Deployment	Good	Good	Excellent	Fair	Poor
	2012-03-29	Removal	Excellent	Marginal	Excellent	Good	Excellent
Rattling Brook Big Pond	2012-03-30	Instrument not deployed due to unfavourable ice conditions					
	2012-05-10						
Rattling Brook below Bridge	2012-03-30	Deployment	Good	Good	Excellent	Good	Excellent
	2012-05-10	Removal	Excellent	Excellent	Marginal	Excellent	Poor
Rattling Brook below Plant Discharge	2012-03-30	Deployment	Excellent	Good	Excellent	Excellent	Poor
	2012-05-10	Removal	Good	Fair	Fair	Excellent	Excellent
Rattling Brook Big Pond	2012-05-10	Deployment	Good	Good	Excellent	Excellent	Excellent
	2012-07-03	Removal	Excellent	Poor	Fair	NA	Poor
Rattling Brook below Bridge	2012-05-11	Deployment	Excellent	Good	Good	Excellent	Excellent
	2012-07-03	Removal	Excellent	Excellent	Fair	Excellent	Good

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Rattling Brook below Plant Discharge	2012-05-11	Deployment	Good	Good	Good	Excellent	Good
	2012-07-03	Removal	Fair	Excellent	Marginal	Excellent	Excellent
Rattling Brook Big Pond	2012-07-04	Deployment	Excellent	Fair	NA	Excellent	Excellent
	2012-08-23	Removal	Marginal	Fair	Excellent	Excellent	Excellent
Rattling Brook below Bridge	2012-07-04	Deployment	Excellent	Fair	NA	Excellent	Excellent
	2012-08-23	Removal	Excellent	Good	Good	Excellent	Good
Rattling Brook below Plant Discharge	2012-07-04	Deployment	Excellent	Good	NA	Excellent	Excellent
	2012-08-23	Removal	Excellent	Excellent	Excellent	Excellent	Excellent
Rattling Brook Big Pond	2012-08-24	Deployment	Excellent	Good	Excellent	Good	Excellent
	2012-09-27	Removal	Excellent	Excellent	Good	NA	Excellent
Rattling Brook below Bridge	2012-08-24	Deployment	Excellent	Fair	Excellent	Excellent	Good
	2012-09-27	Removal	Good	Good	Excellent	Excellent	Good
Rattling Brook below Plant Discharge	2012-08-24	Deployment	Excellent	Good	Good	Excellent	Good
	2012-09-27	Removal	Excellent	Good	Poor	Excellent	Excellent
Rattling Brook Big Pond	2012-09-28	Deployment	Excellent	Excellent	Good	Excellent	Excellent
	2012-11-01	Removal	Excellent	NA	Excellent	Excellent	Excellent
Rattling Brook below Bridge	2012-09-28	Deployment	Good	Fair	Poor	Excellent	Excellent
	2012-11-01	Removal	Fair	NA	Good	Marginal	Fair
Rattling Brook below Plant Discharge	2012-09-28	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	2012-11-01	Removal	Excellent	NA	Marginal	Excellent	Good
Rattling Brook Big Pond	2012-11-02	Deployment	Excellent	NA	Good	Good	Excellent
	2012-12-20	Removal	NA	NA	Good	Excellent	Excellent
Rattling Brook below Bridge	2012-11-02	Deployment	Excellent	NA	Marginal	Excellent	NA
	2012-12-20	Removal	NA	NA	Marginal	Excellent	Fair
Rattling Brook below Plant Discharge	2012-11-02	Deployment	Excellent	NA	Excellent	Excellent	NA
	2012-12-20	Removal	NA	NA	Good	Excellent	NA
Rattling Brook Big Pond	2012-12-21	Deployment	NA	Fair	Poor	Good	Excellent
	2013-02-27	Removal	Excellent	Good	Poor	NA	Excellent
Rattling Brook below Bridge	2012-12-21	Deployment	NA	Good	Good	Good	Good
	2013-02-27	Removal	Excellent	Excellent	Excellent	NA	Good
Rattling Brook below Plant Discharge	2012-12-21	Deployment	NA	Excellent	Good	Excellent	Fair
	2013-02-27	Removal	Excellent	Good	Excellent	NA	Good

Results and Discussion

The following graphs and figures attempt to illustrate high level trends in water quality parameters at each station in the Rattling Brook Network over a three year period, in addition to comparisons between each station. This discussion makes broad use of line graphs and boxplots to highlight changes. Generally, line graphs are self-explanatory; however, boxplots also provide an interesting perspective of data. Figure 2 illustrates the key features of a boxplot.

Figure 2: Anatomy of a Boxplot



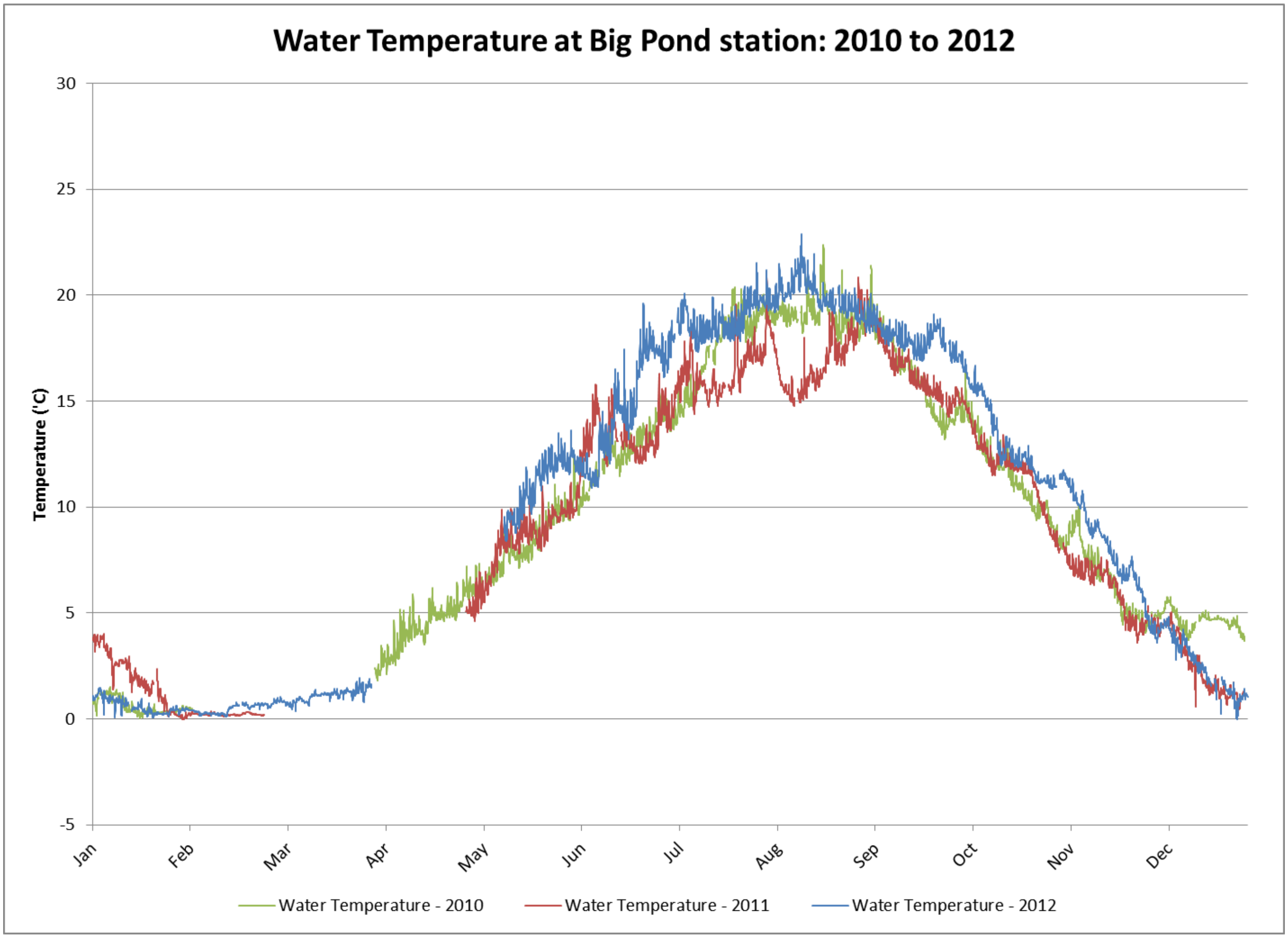
Parameters by Year

The following section discusses changes in water quality parameters at each station from 2010 – 2012. These long term changes from year to year gives insight into trends that may warrant some consideration or the efficacy of mitigation techniques, such as settling ponds and siltation control.

Rattling Brook Big Pond

Temperature

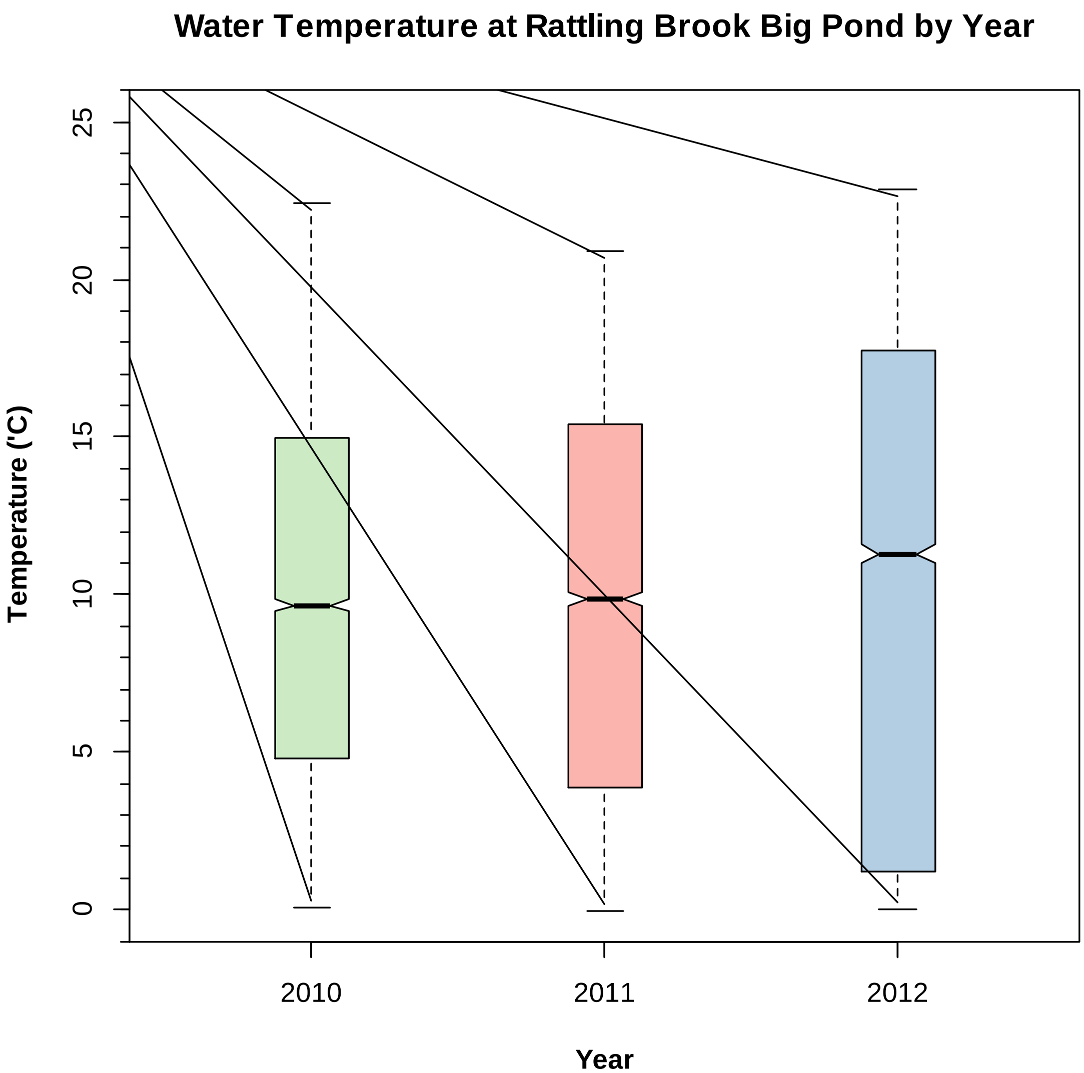
Figure 3: Water temperature at Big Pond station from 2010 to 2012



Water temperatures at Big Pond station were noticeable warmer through the late spring to late fall in 2012 compared to previous years. This comes as no surprise since the summer of 2012 has been generally described as one of the nicest summers in recent memory. For the year 2012, water temperatures ranged from 0.00°C to 22.87°C.

Year	Minimum	Maximum
2010	0.04	22.4
2011	-0.02	20.88
2012	0.00	22.87

Figure 4: Boxplots of water temperature at Big Pond station by year

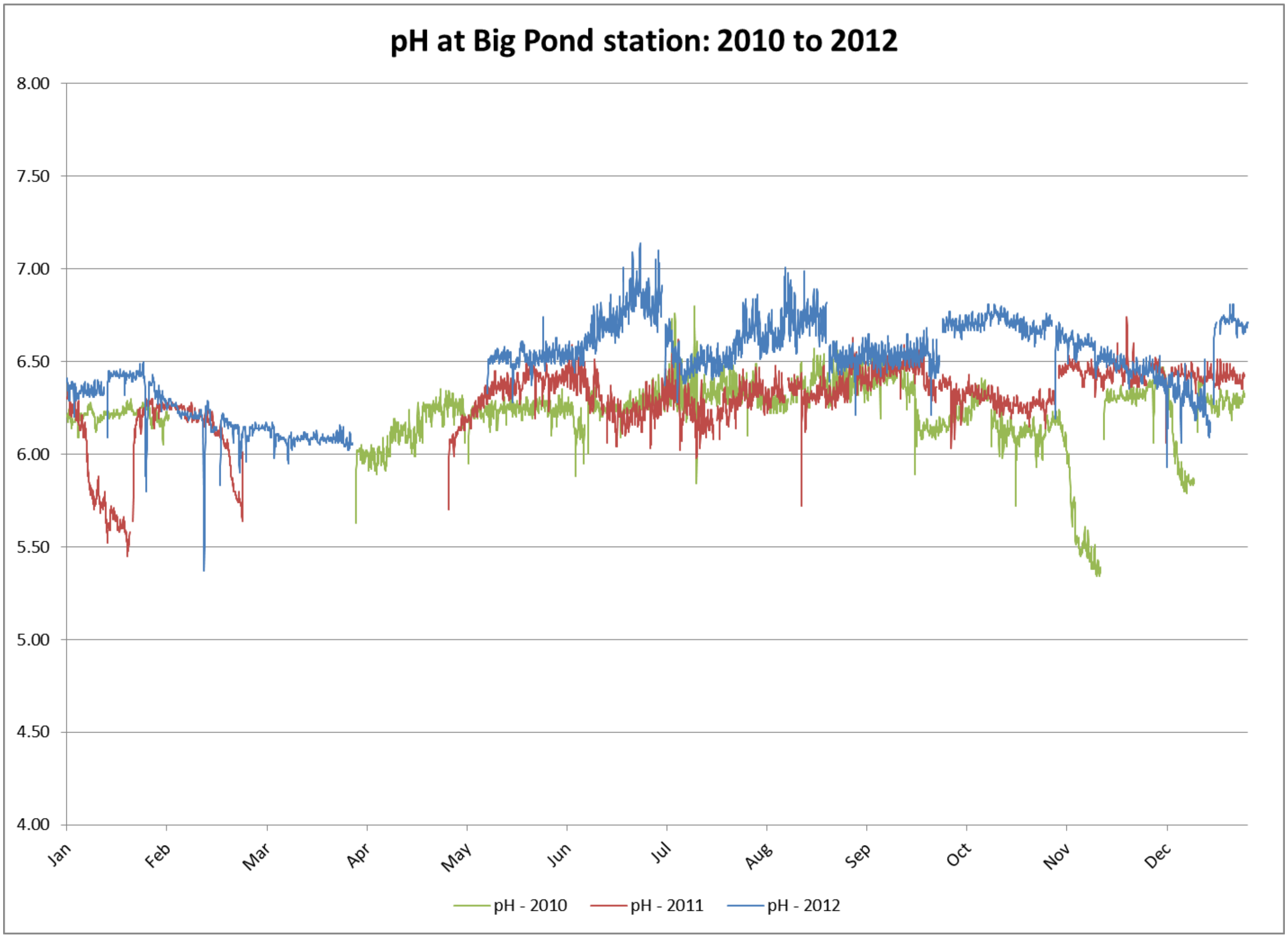


Year	Median	90% CI
2010	9.66	9.49 – 9.84
2011	9.87	9.76 – 10.13
2012	11.28	11.17 – 11.37

Median water temperature was found to be higher in 2012 compared to the previous two years. Some caution should be exercised in comparing the range of temperatures from 2012 to the other years. In 2010 and 2011, the Hydrolab was removed from Big Pond for portions of February through April to prevent damage from ice. Because of this, some of the lowest temperatures would not have been recorded in those two years as opposed to 2012 where the instrument was only out of the water for the month of April when water temperatures are slightly warmer.

pH

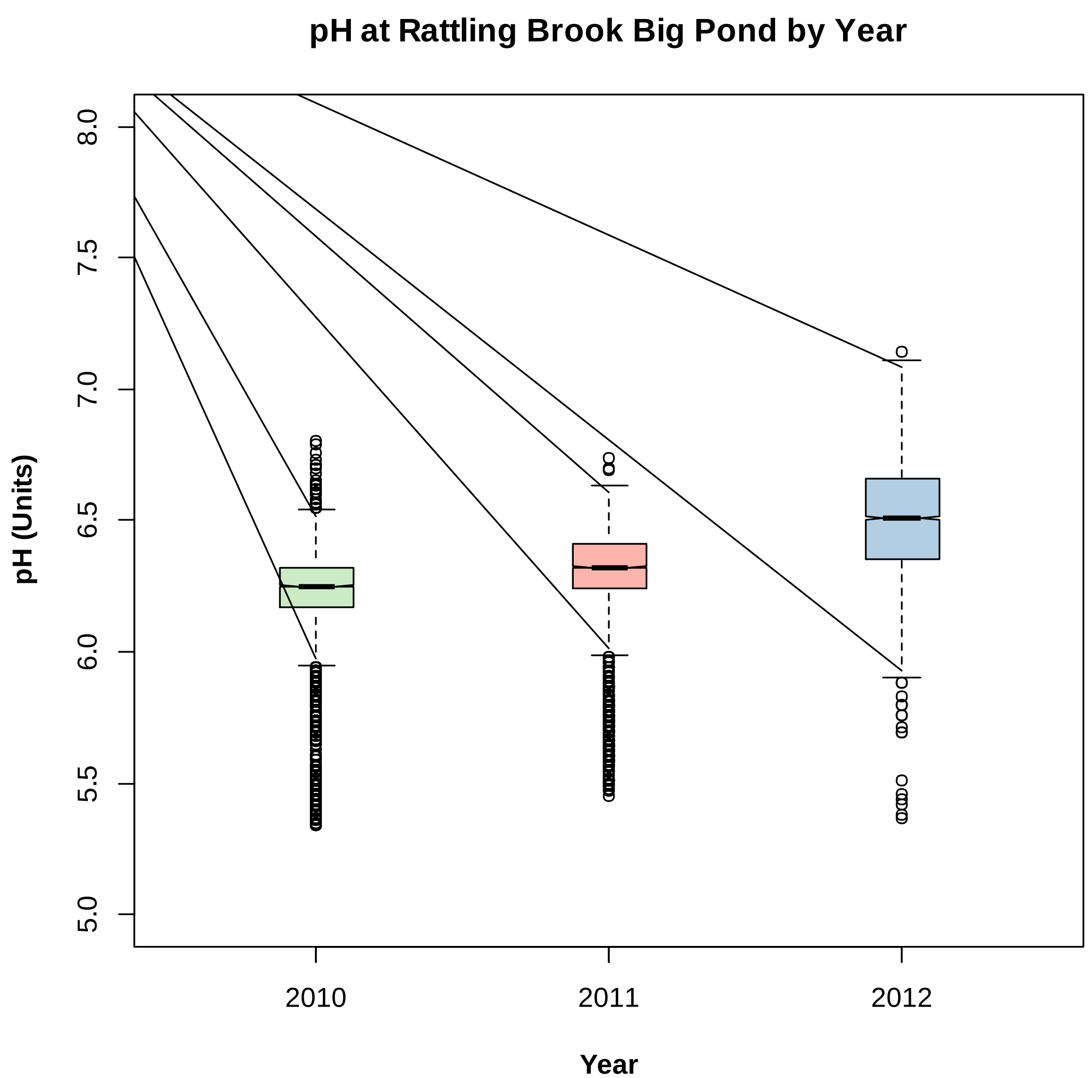
Figure 5: pH at Big Pond station from 2010 to 2012



pH values appeared to be higher through the summer months compared to previous years. It is difficult to say why this may have been the case, however, warmer water temperatures may be responsible for biochemical processes that would drive a higher alkalinity.

Year	Minimum	Maximum
2010	5.34	6.80
2011	5.45	6.74
2012	5.37	7.14

Figure 6: Boxplots of pH at Big Pond station by year

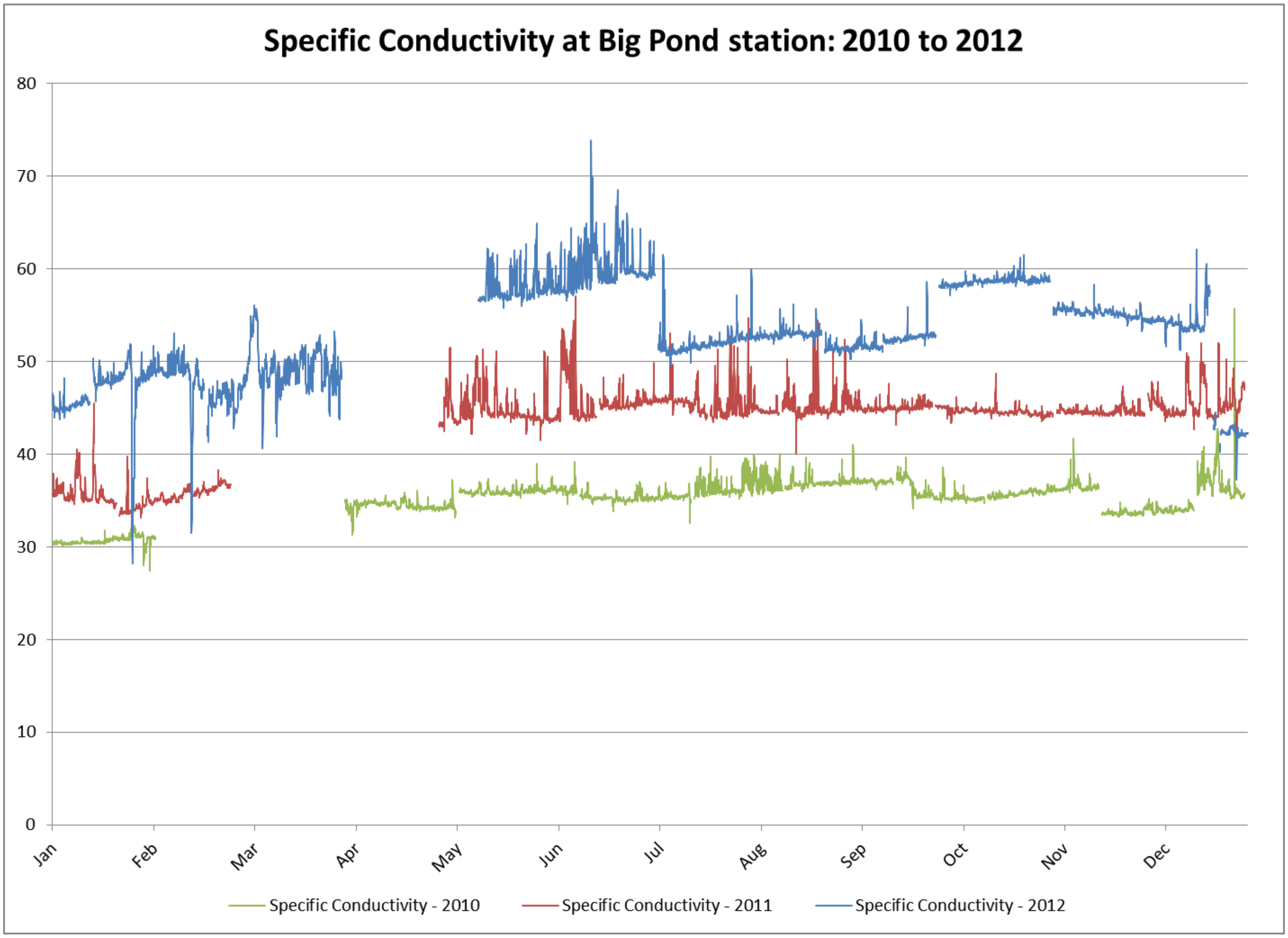


An upward trend in pH is ongoing from 2010 through 2012. This may be the result of warming temperatures or some other process. Also apparent is an increasing range in temperatures from 2010 to 2012.

Year	Median	90% CI
2010	6.25	6.25 – 6.25
2011	6.32	6.32 – 6.33
2012	6.51	6.51 – 6.52

Specific Conductivity

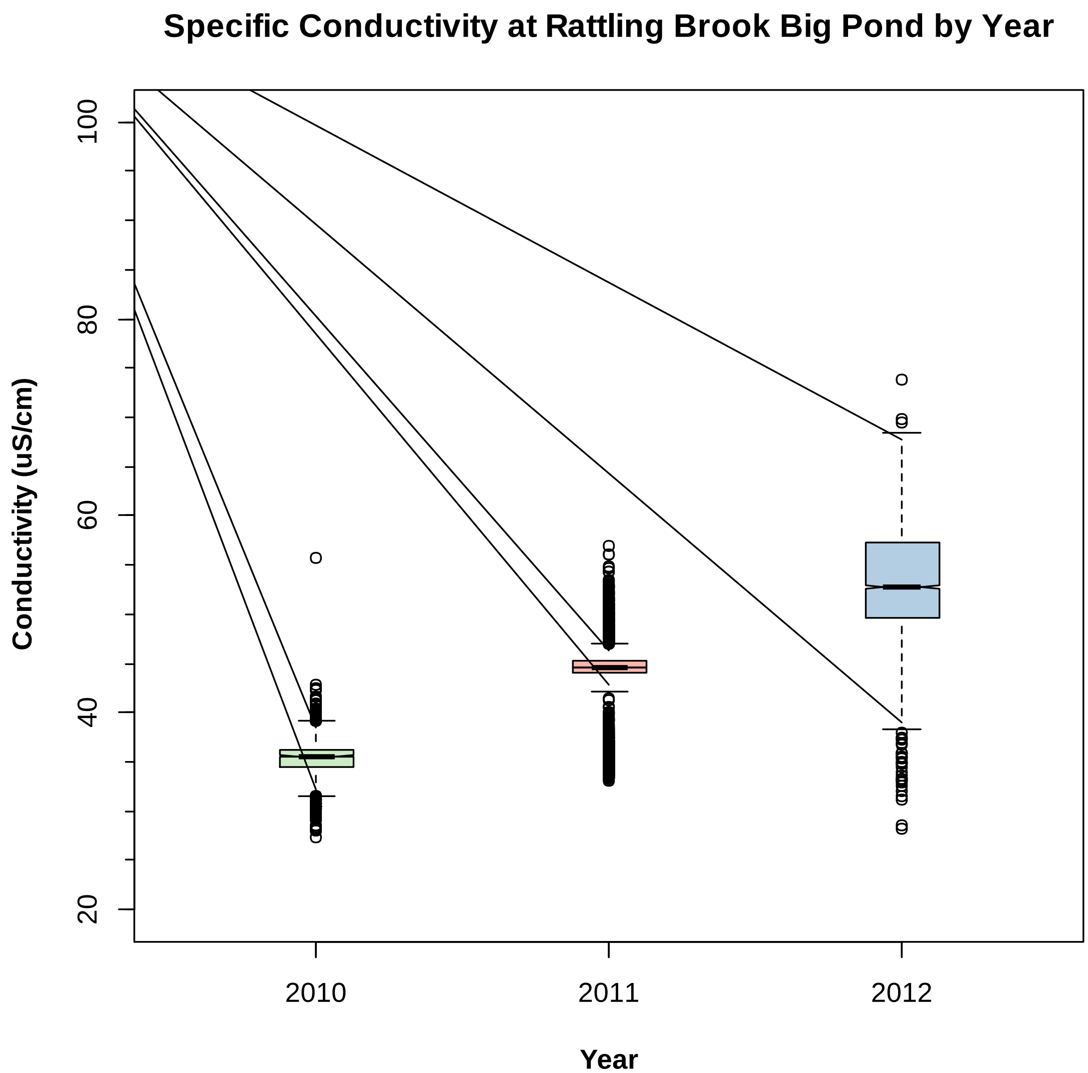
Figure 7: Specific Conductivity at Big Pond station from 2010 to 2012



An apparent trend in specific conductivity has been underway since 2010. Development in the Big Pond watershed may be responsible for increased liberation of previously stable sediments and soils. As a result, dissolved solids and salts appear to be making their way into the water.

Year	Minimum	Maximum
2010	27.4	55.7
2011	33.1	57.0
2012	28.2	73.8

Figure 8: Boxplots of Specific Conductivity at Big Pond station by year

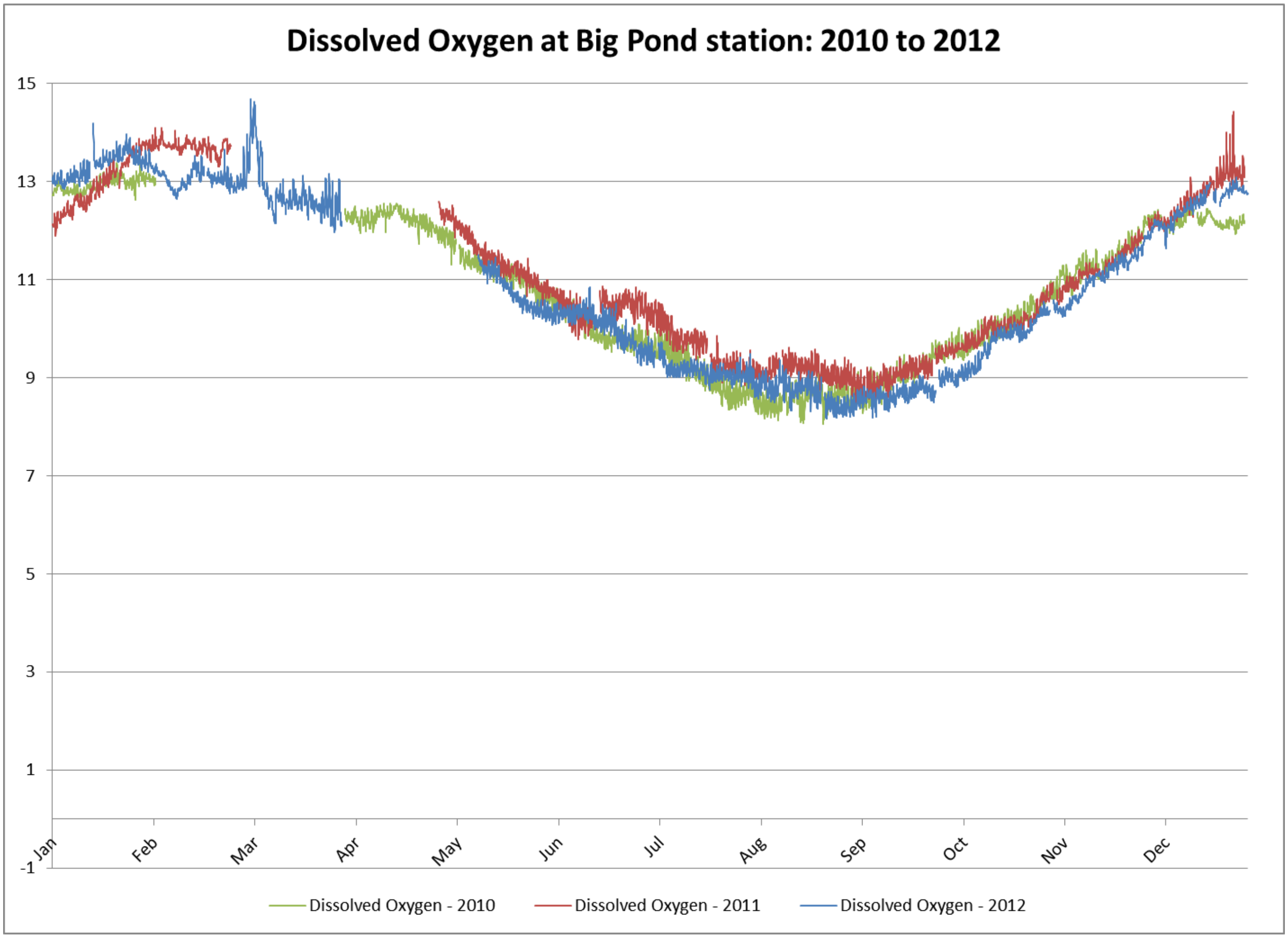


Conductivity is increasing in range and magnitude annually from 2010 to 2012. The increase in conductivity indicates that there is a greater amount of dissolved solids in Rattling Brook Big Pond. Since 2010, the median conductivity value has increased 33% from 35.6 to 52.8 µS/cm.

Year	Median	90% CI
2010	35.6	35.6 – 35.6
2011	44.6	44.5 – 44.6
2012	52.8	52.7 – 52.8

Dissolved Oxygen

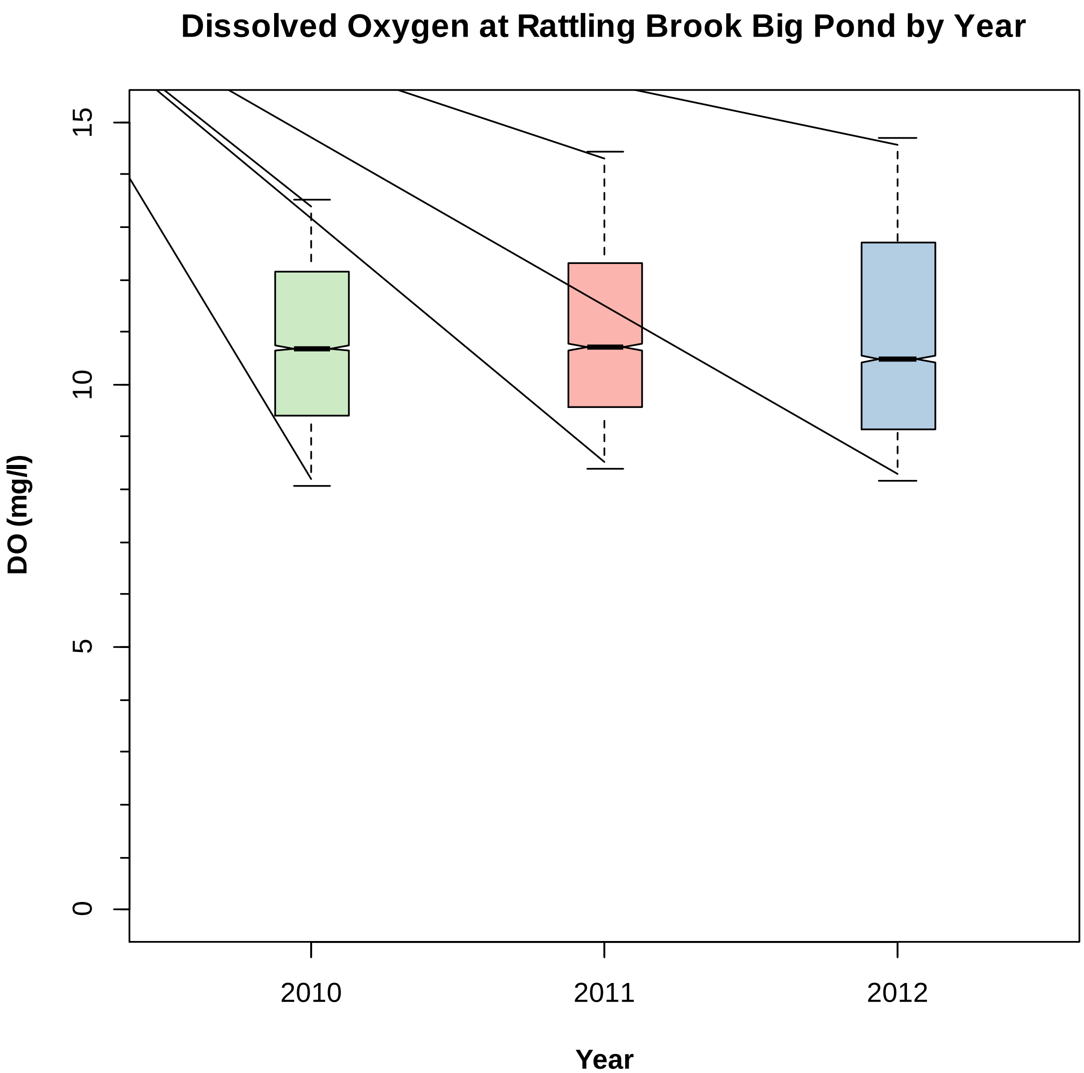
Figure 9: Dissolved Oxygen at Big Pond station from 2010 to 2012



Dissolved oxygen concentration has not changed appreciably from 2010 to 2012. Variation in oxygen concentration is highly dependent on water temperature which explains the high values in winter and low values in summer. Additionally, it explains the marginally lower DO content in the latter parts of summer 2012 compared to previous years.

Year	Minimum	Maximum
2010	8.06	13.53
2011	8.39	14.42
2012	8.17	14.69

Figure 10: Boxplots of Dissolved Oxygen at Big Pond station by year

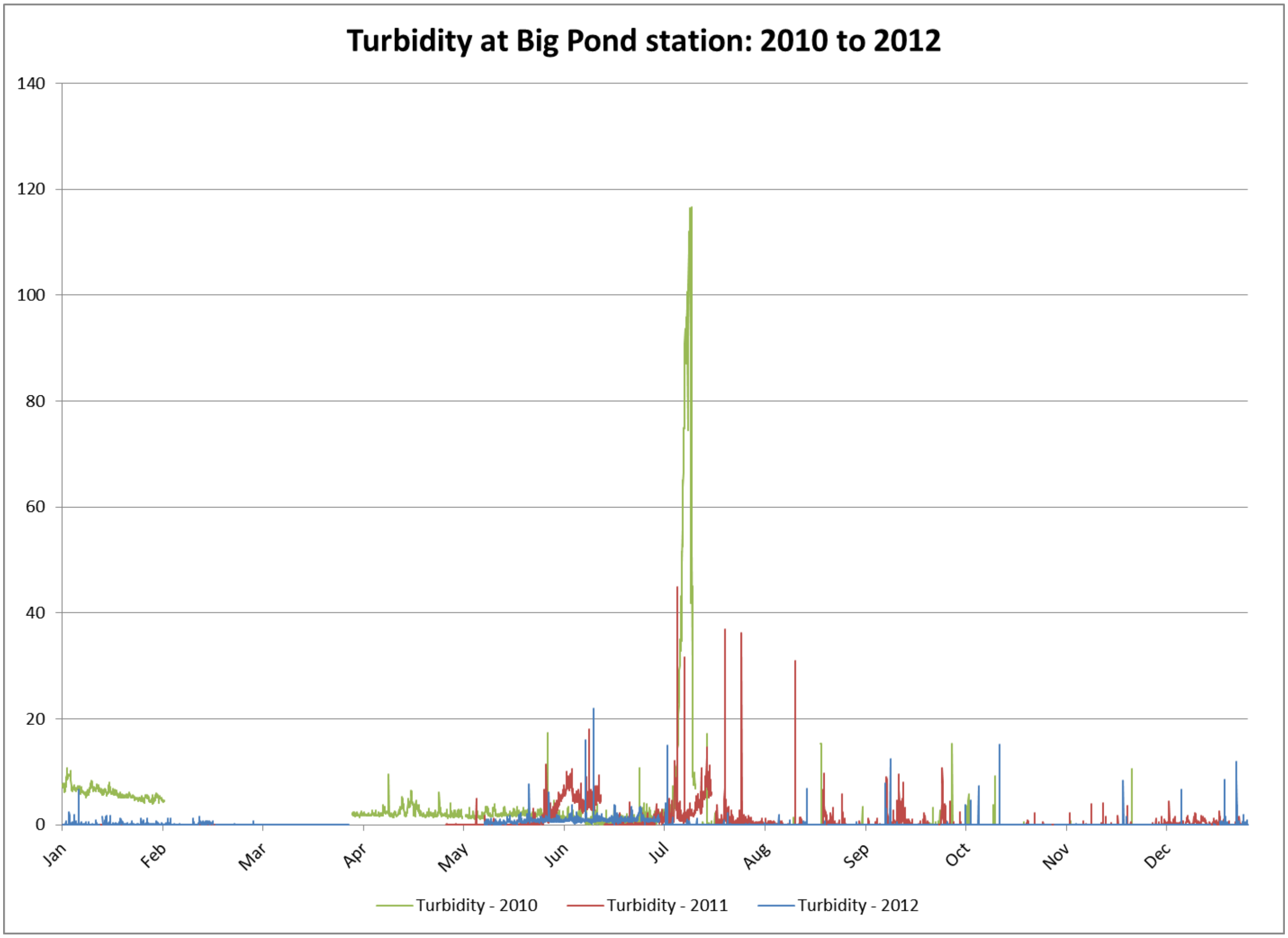


There were no major differences between DO concentrations from 2010 through 2012. A slight increase in range was seen in 2012; however, this is likely just annual variation.

Year	Median	90% CI
2010	10.69	10.62 – 10.76
2011	10.71	10.67 – 10.77
2012	10.47	10.44 – 10.51

Turbidity

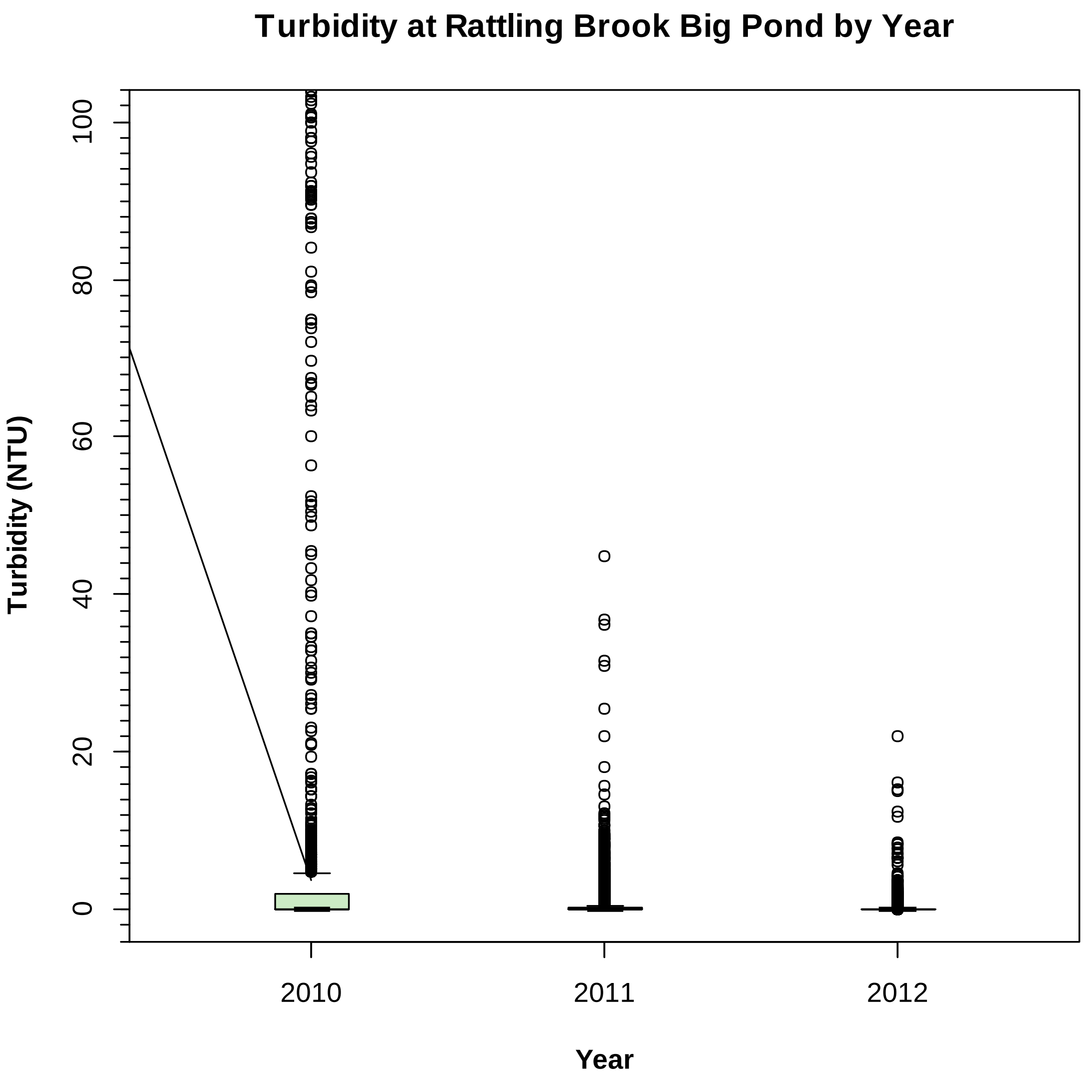
Figure 11: Turbidity at Big Pond station from 2010 to 2012



Turbidity levels in 2012 tended to be lower than previous years. While the minimum values recorded were 0.0 NTU from 2010 to 2012, the maximum values recorded at Big Pond station have declined substantially. From 2011 to 2012, an intake structure was constructed approximately 70 meters away. The structure involved some earthworks and shoreline modification which would cause localised fluctuations in suspended solids.

Year	Minimum	Maximum
2010	0.0	116.6
2011	0.0	44.9
2012	0.0	22.0

Figure 12: Boxplots of Turbidity at Big Pond station by year



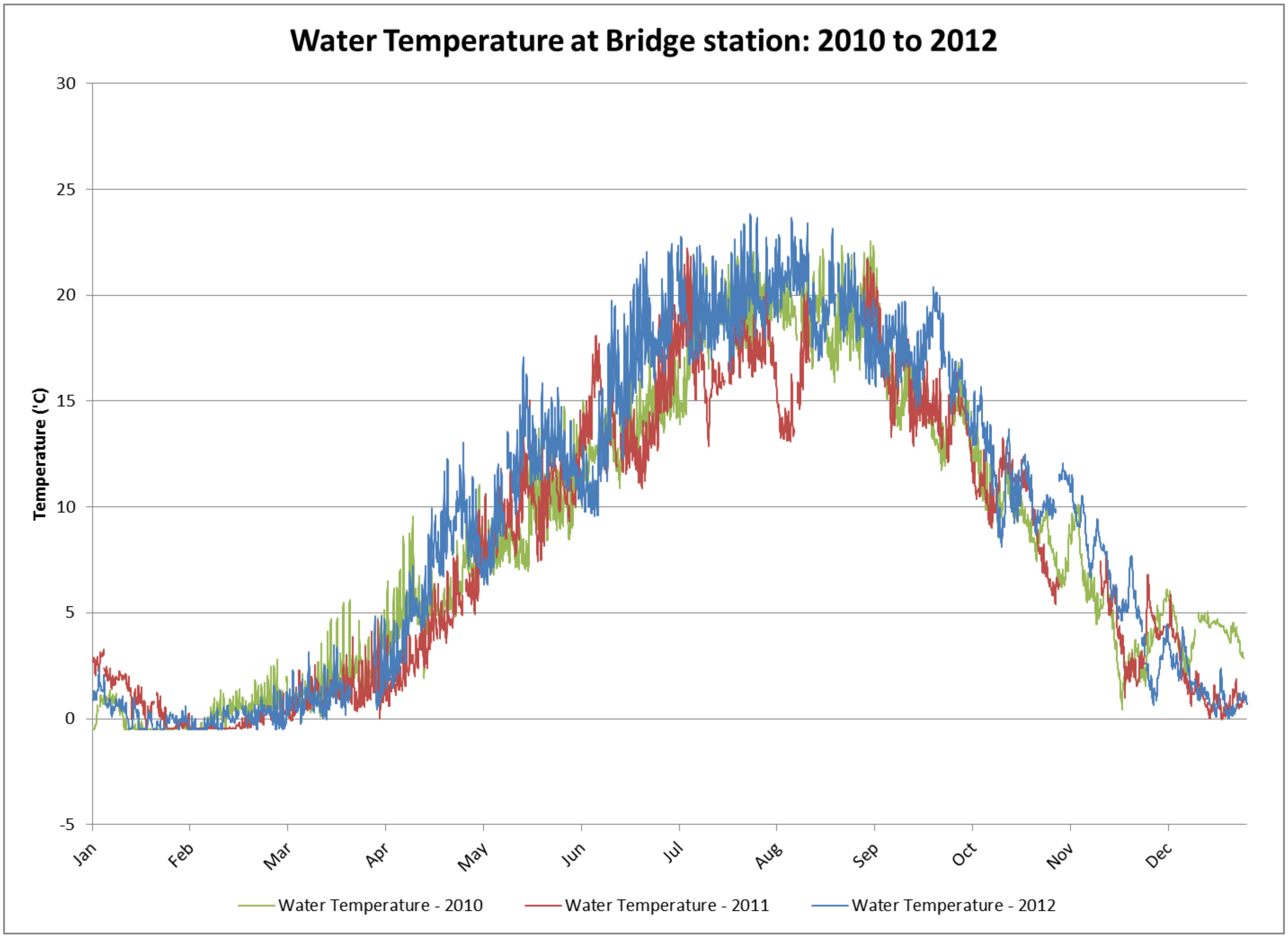
Median values have consistently been 0.0 NTU since 2010, however, there is an obvious decline in the extreme values (seen as hollow circles in the boxplot above). Additionally, the inter-quartile range (distance between the top and bottom of box) has shrunk from 2010 to 2012.

Year	Median	90% CI
2010	0.0	0.0 – 0.0
2011	0.0	0.0 – 0.0
2012	0.0	0.0 – 0.0

Rattling Brook below Bridge

Temperature

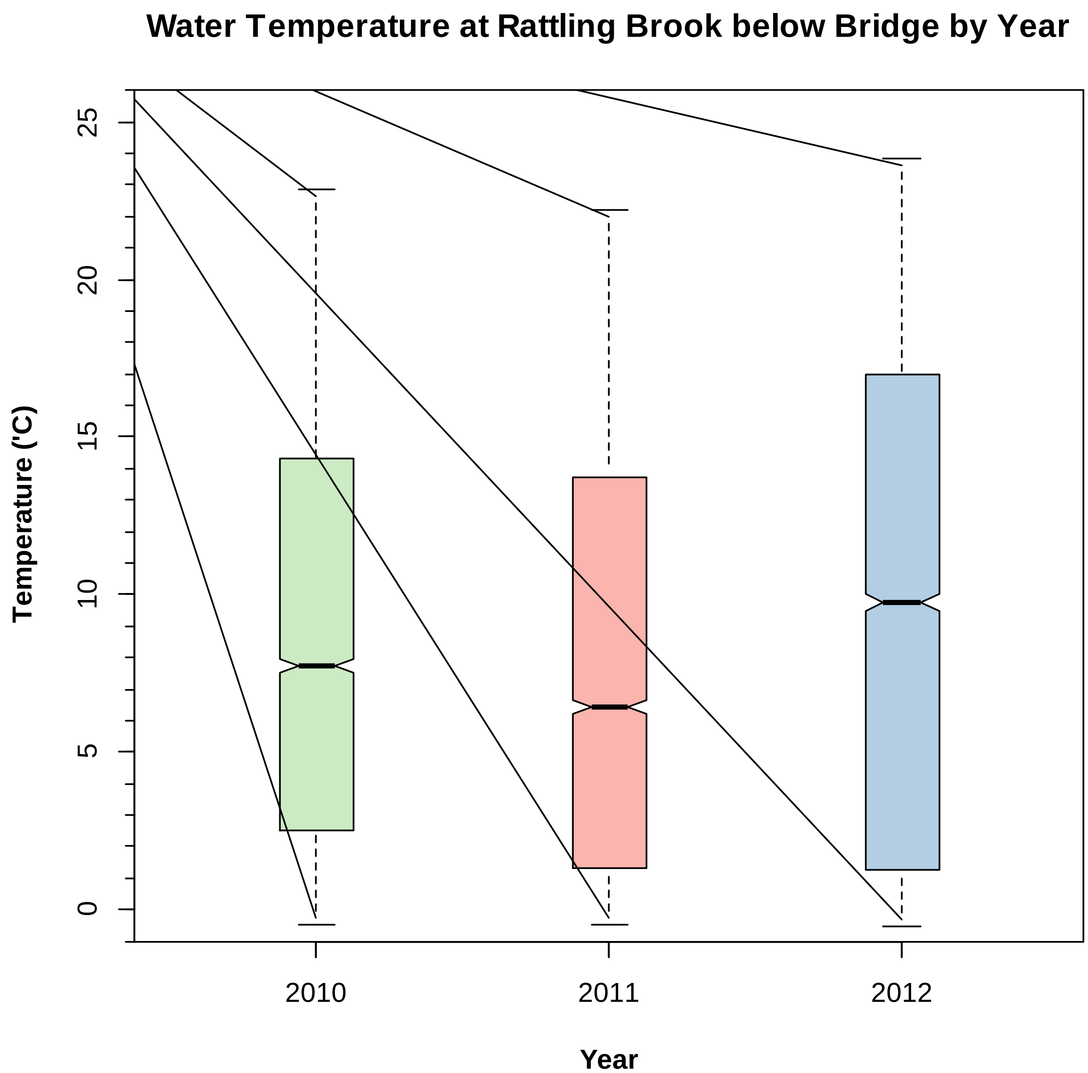
Figure 13: Water Temperature at Bridge station from 2010 to 2012



Water temperatures were notably higher in the summer and fall of 2012 compared to the summer and fall of 2011. For the year 2012, water temperatures ranged from -0.51^{o}C to 23.82^{o}C.

Year	Minimum	Maximum
2010	-0.50	22.84
2011	-0.48	22.2
2012	-0.51	23.82

Figure 14: Boxplots of Water Temperature at Bridge station by year

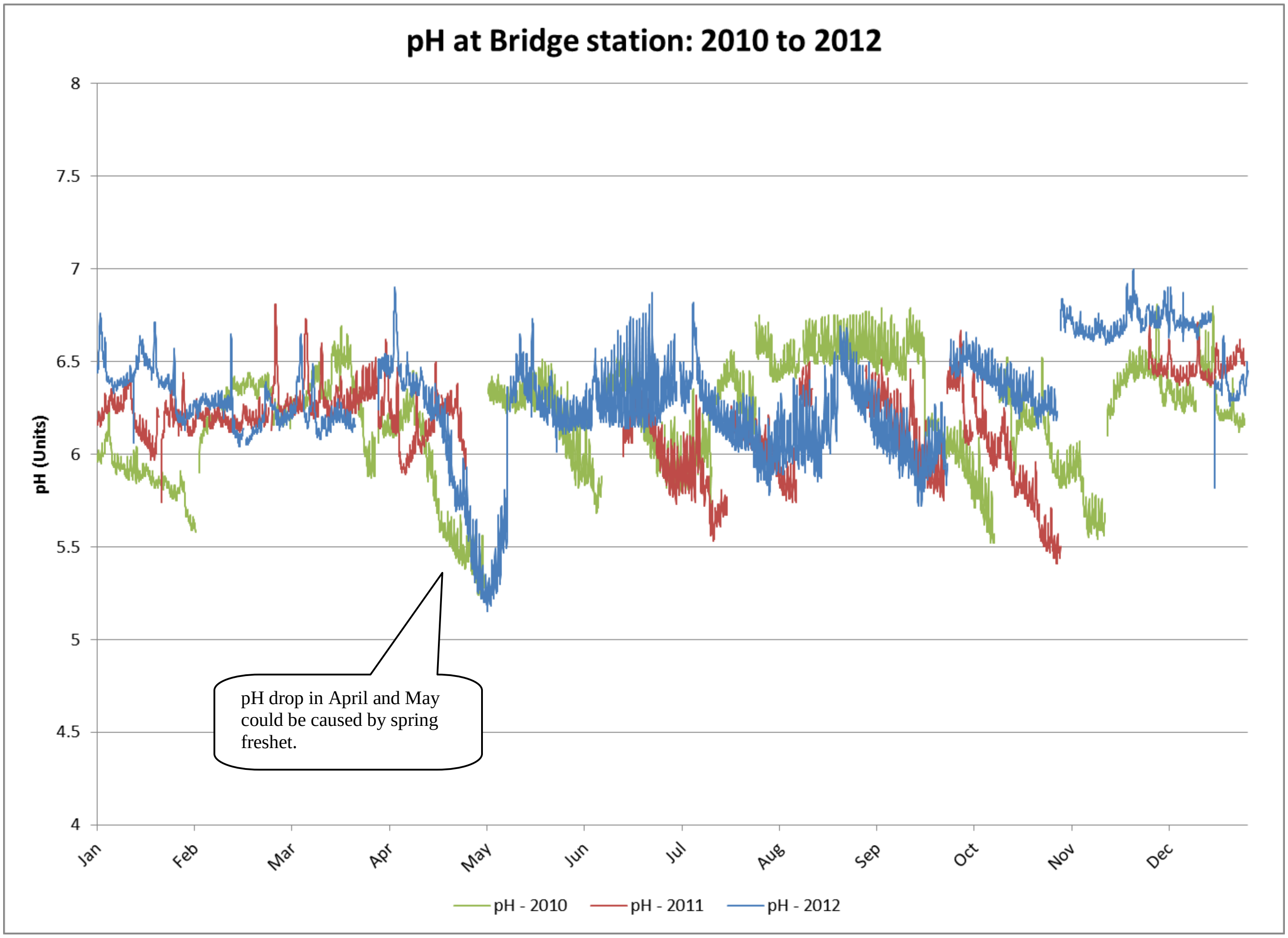


A wider range of temperatures was observed in 2012 compared to 2010 and 2011.

Year	Median	90% CI
2010	7.73	7.51 – 7.94
2011	6.43	6.15 – 6.79
2012	9.77	9.59 – 9.89

pH

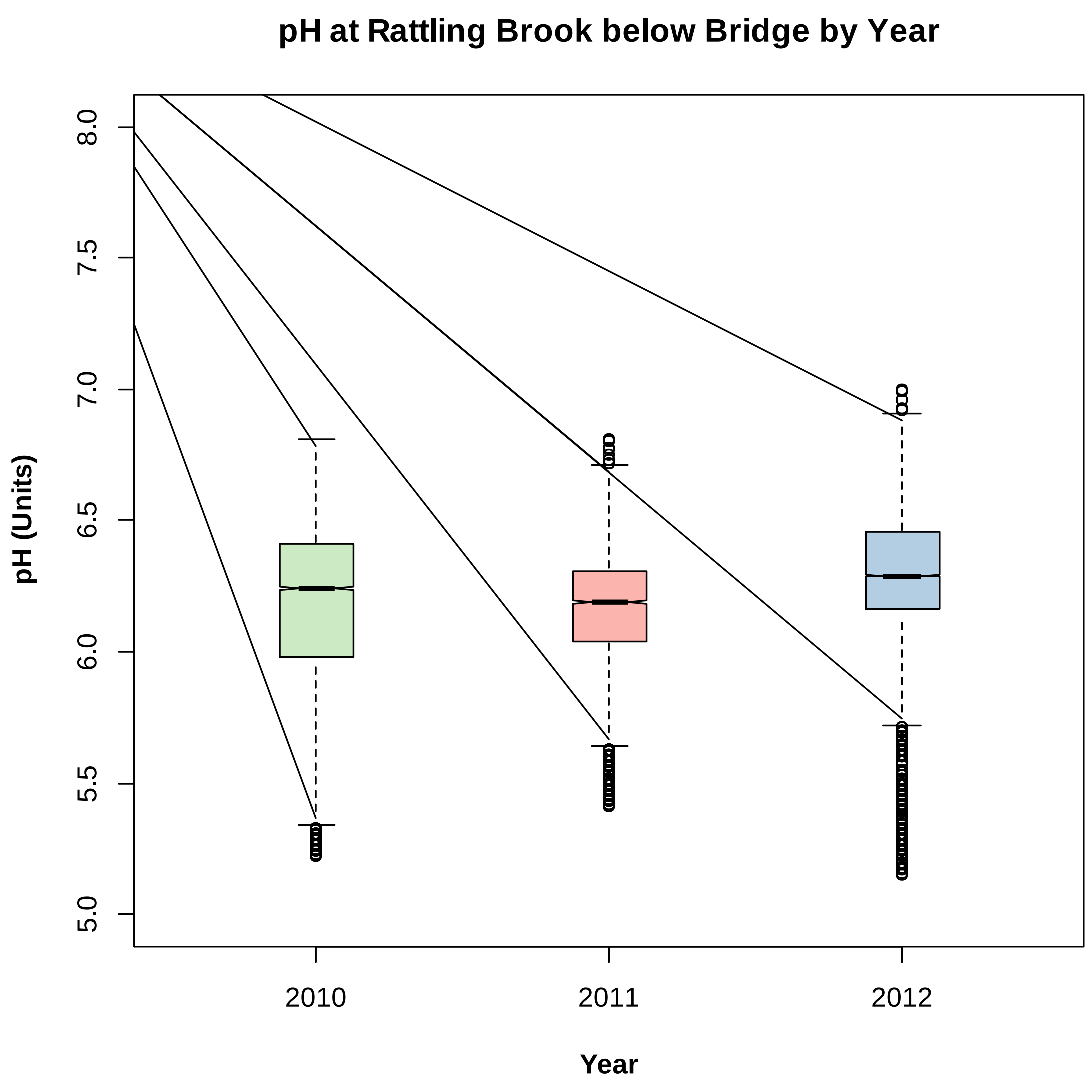
Figure 15: pH at Bridge station from 2010 to 2012



From 2010 to 2012, there does not appear to be a major trend in pH values. For all three years, pH has tended to be acidic. Interestingly, pH values tend to fluctuate to a greater extent during the warm water periods from May to November. December through April, pH does not vary throughout the day. This is likely due to biochemical processes active during the summer months but suspended in the winter.

Year	Minimum	Maximum
2010	5.22	6.81
2011	5.41	6.81
2012	5.15	7.00

Figure 16: Boxplots of pH at Bridge station by year

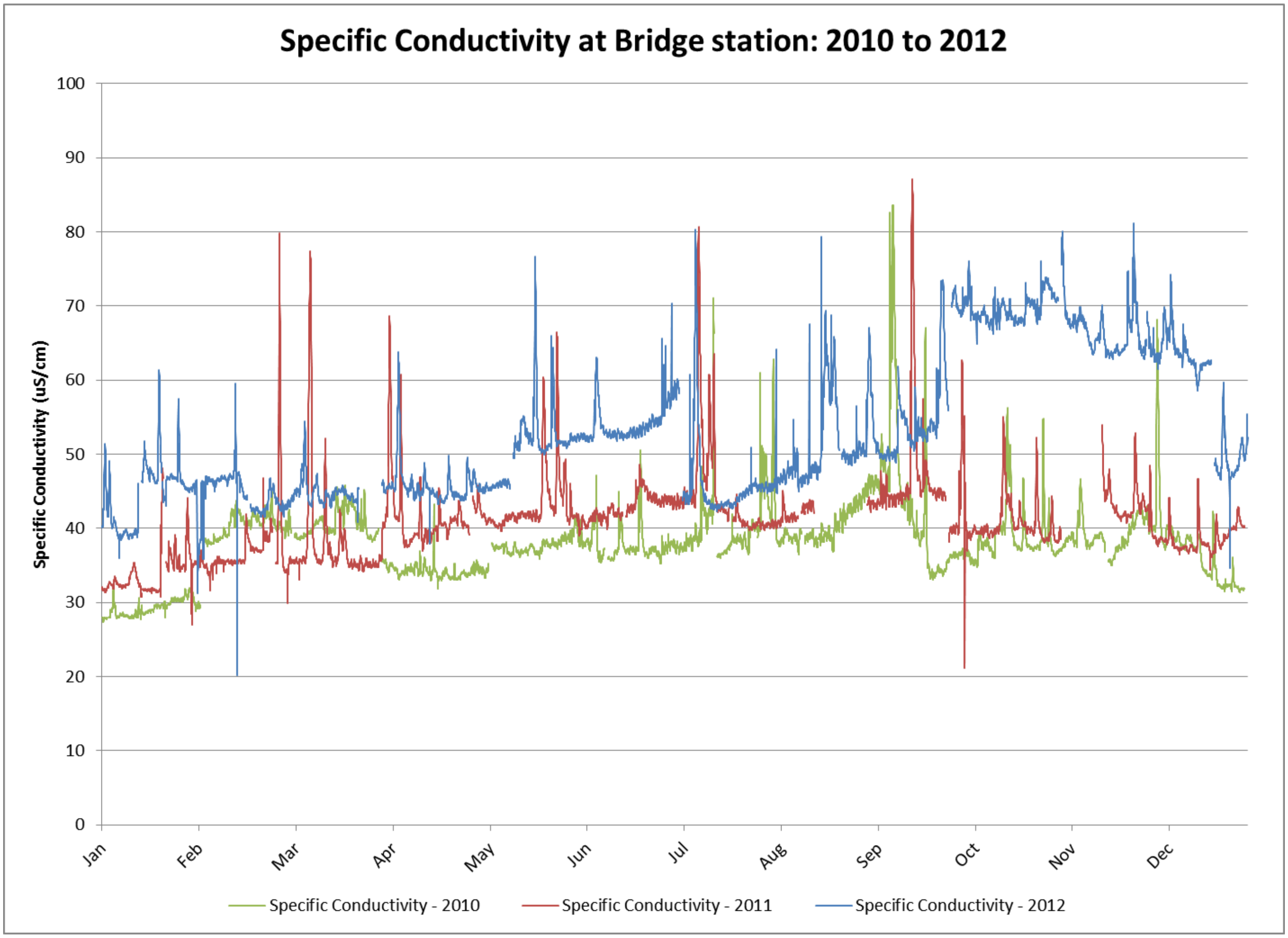


The median pH value was marginally higher in 2012 than in the previous two years, but not to the extent that concern is warranted.

Year	Median	90% CI
2010	6.24	6.24 – 6.25
2011	6.19	6.18 – 6.19
2012	6.29	6.29 – 6.30

Specific Conductivity

Figure 17: Specific Conductivity at Bridge station from 2010 to 2012

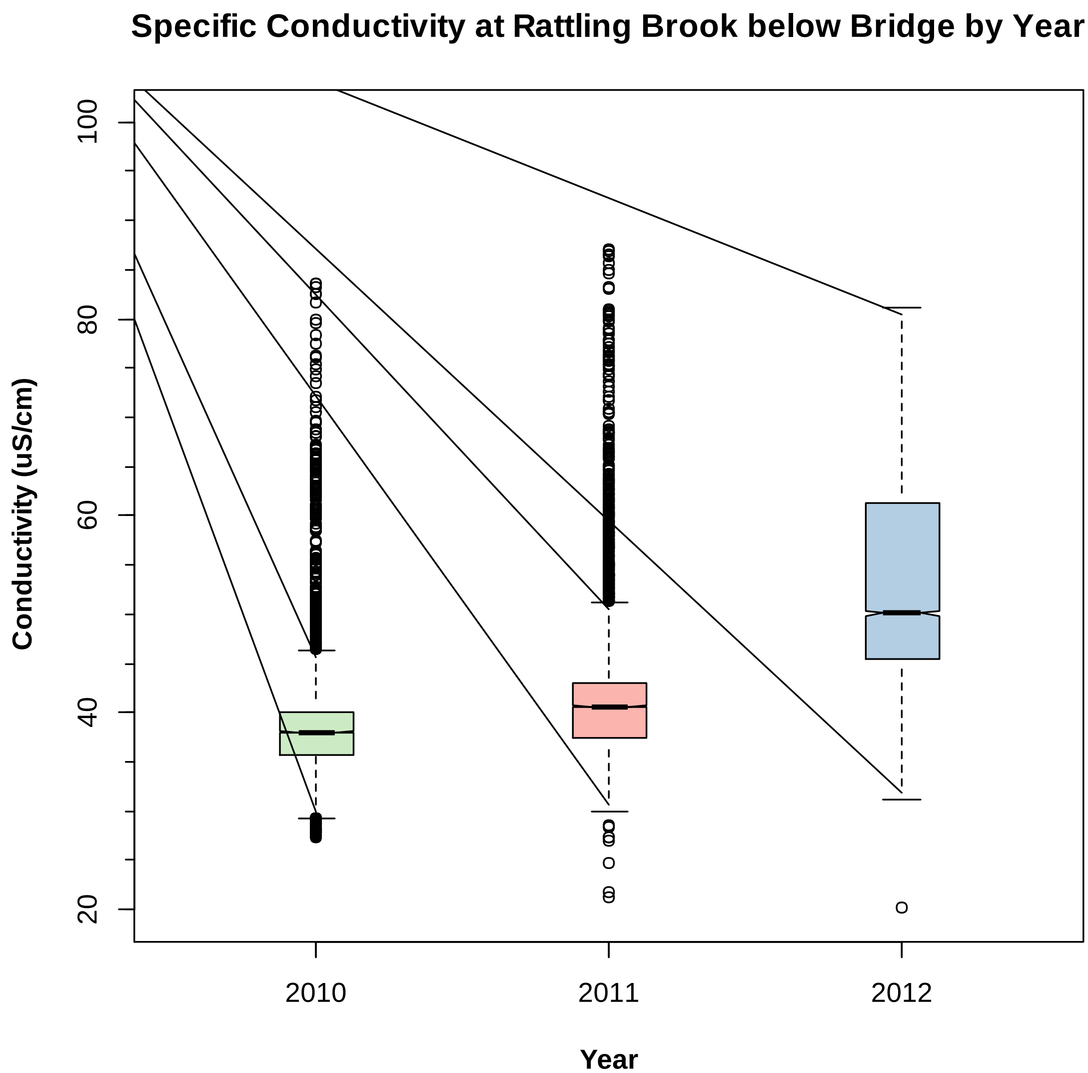


Specific conductivity has increased steadily from 2010 to 2012 according to the figure above. Increasing work in and around the Rattling Brook system have allowed for higher mobility of dissolved solids that were previously stabilized by vegetation and ground cover.

Increased conductivity is also the result of intensive habitat restoration activities that have occurred downstream of Big Pond – within Forgotten Pond (above Bridge and Discharge stations) in 2012 and at Bridge station itself in 2011.

Year	Minimum	Maximum
2010	27.4	83.6
2011	21.2	87.1
2012	20.2	81.1

Figure 18: Boxplots of Specific Conductivity at Bridge station by year

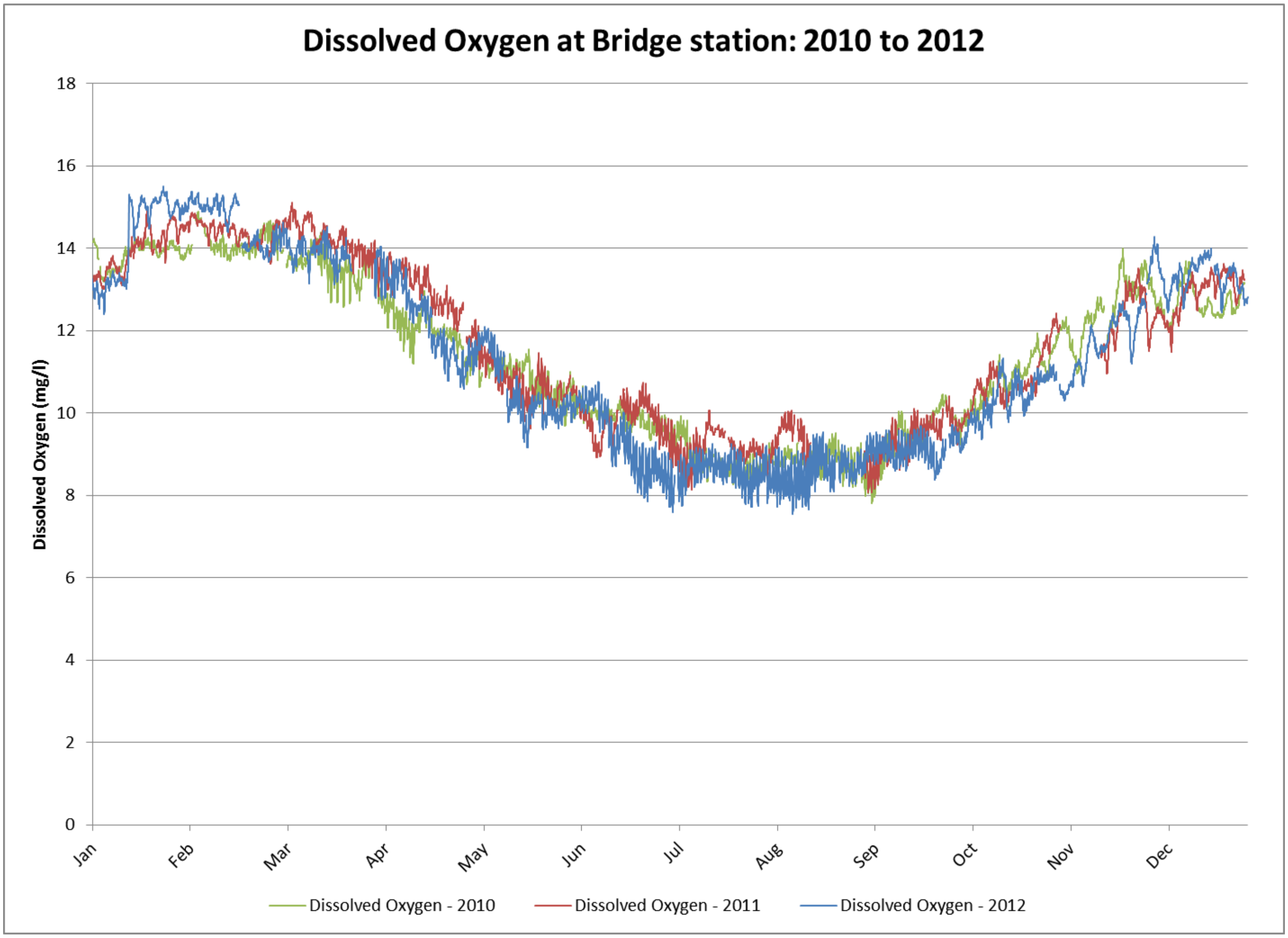


Since 2010, a 29% increase in median conductivity levels has been observed. Given the amount of construction and development in the Rattling Brook watershed since 2010, this is not surprising. It is expected that the increase in conductivity will plateau and possibly even decrease once construction of the plant site is complete and bare ground areas are stabilized.

Year	Median	90% CI
2010	35.6	35.6 – 35.6
2011	38.0	37.9 – 38.0
2012	50.1	49.9 – 50.3

Dissolved Oxygen

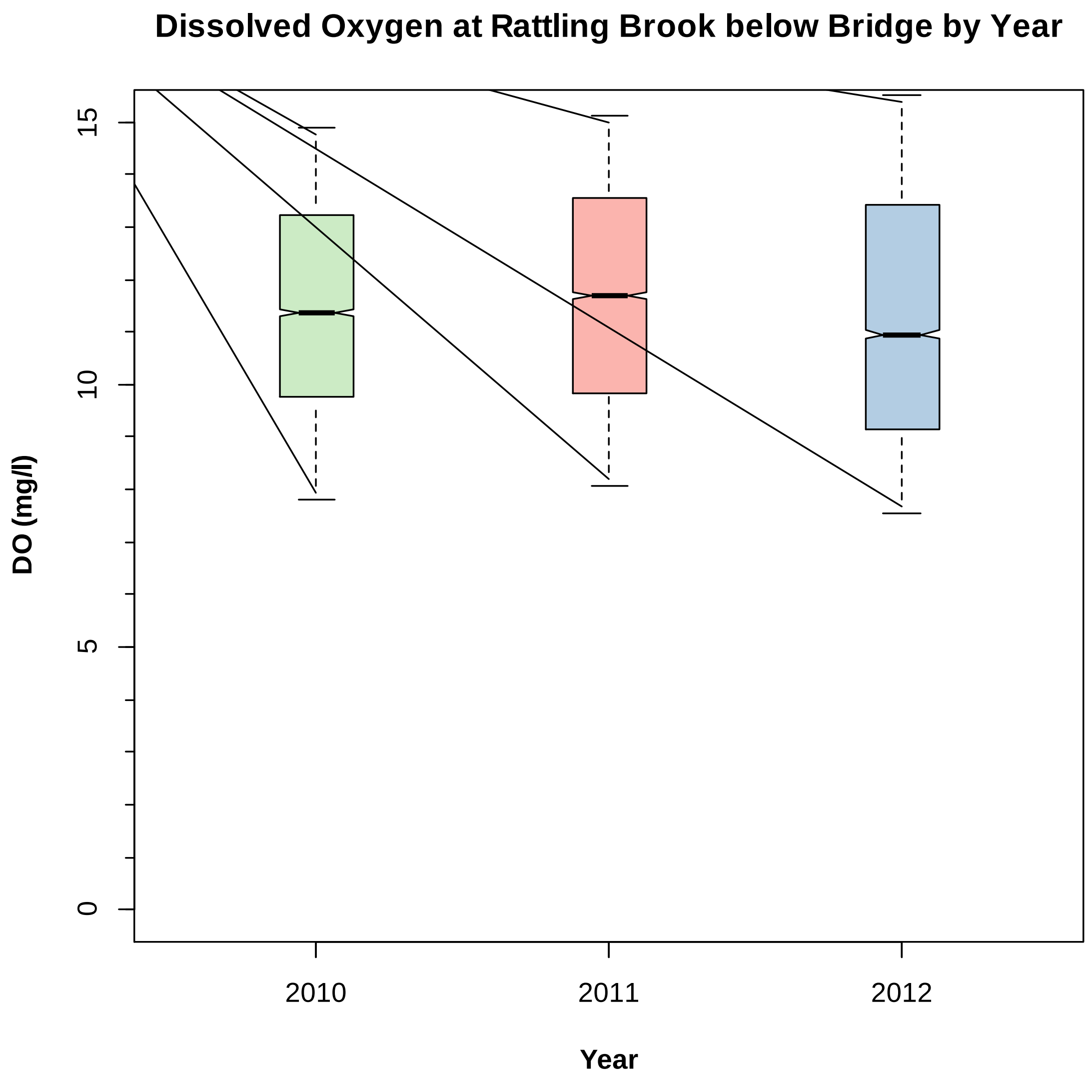
Figure 19: Dissolved Oxygen at Bridge station from 2010 to 2012



Dissolved oxygen concentration has remained stable from 2010 to 2012 with no major perturbations. Values were slightly lower in 2012 due to the higher water temperatures.

Year	Minimum	Maximum
2010	7.81	14.90
2011	8.08	15.11
2012	7.54	15.51

Figure 20: Boxplots of Dissolved Oxygen at Bridge station by year

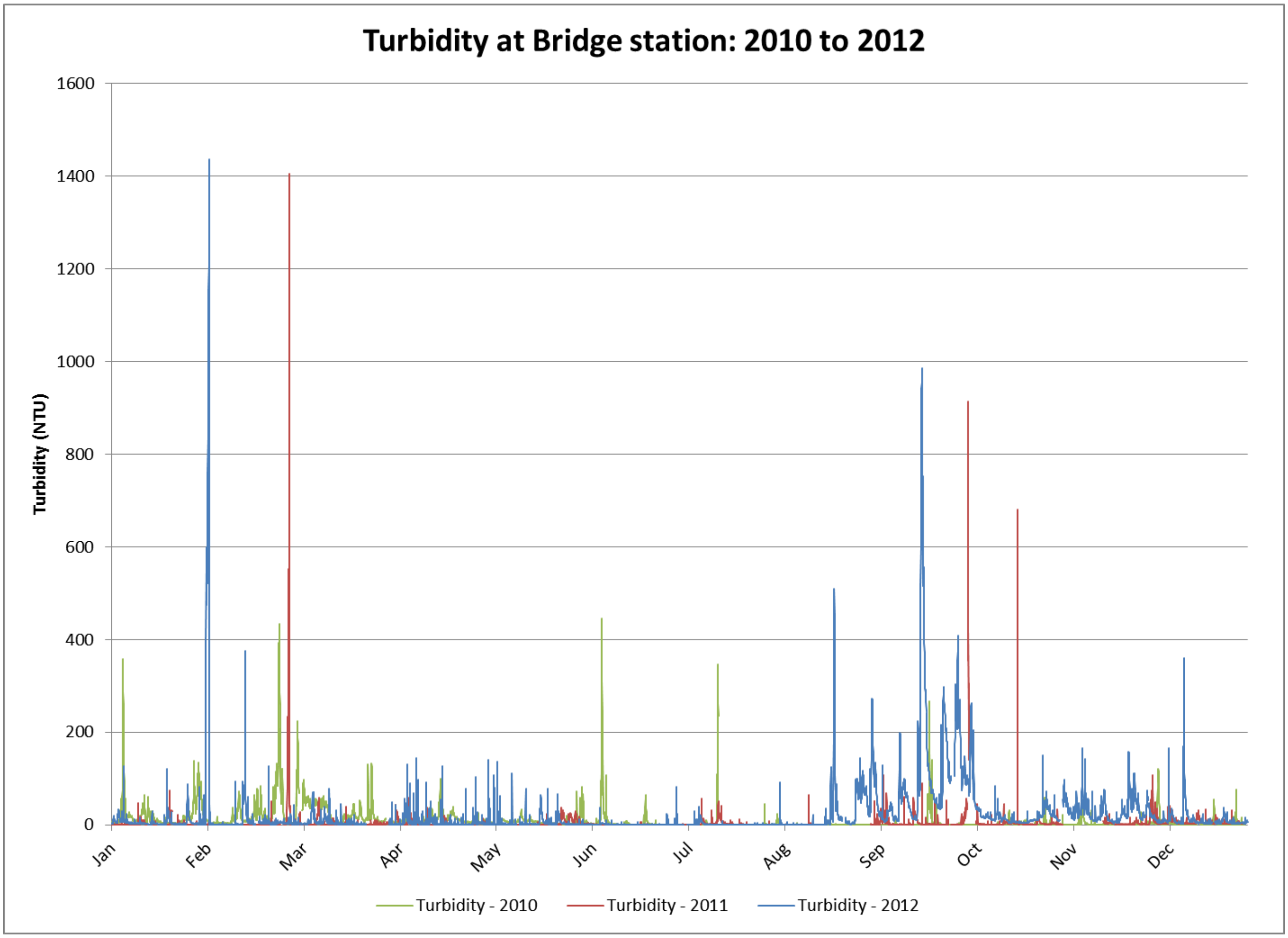


Owing to warmer water temperatures, the median concentration of dissolved oxygen was somewhat lower in 2012 than in previous years. This is almost certainly an unusual circumstance and concentrations are likely to return to the previous 11.36 mg/l to 11.70 mg/l range.

Year	Median	90% CI
2010	11.36	11.28 – 11.43
2011	11.70	11.58 – 11.86
2012	10.95	10.89 – 11.03

Turbidity

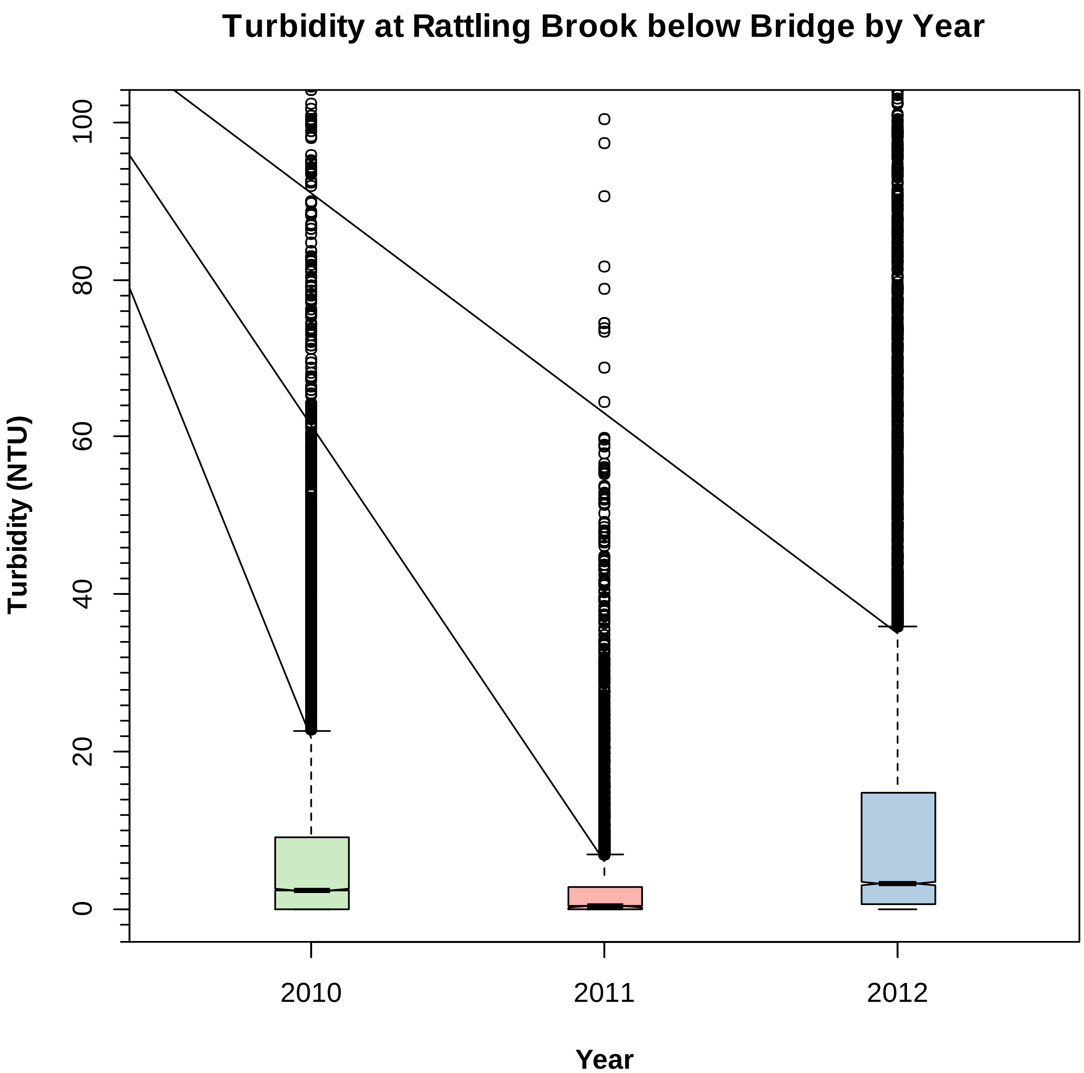
Figure 21: Turbidity at Bridge station from 2010 to 2012



Turbidity levels at Rattling Brook below Bridge have fluctuated greatly throughout the course of Vale's development in Long Harbour. Initial clearing operations in 2010 involved the construction of roads and removal of trees and unsuitable materials from the development area. This initial work mobilized previously undisturbed soils in the area. In the summer of 2011, habitat rehabilitation work in Rattling Brook saw some alteration in the streambed over the course of a few months. Then, in 2012, habitat rehabilitation in the Forgotten Pond area upstream of Bridge station saw a great deal of silt laden water wash downstream over many weeks.

Year	Minimum	Maximum
2010	0.0	445.0
2011	0.0	1405
2012	0.0	1437

Figure 22: Boxplots of turbidity at Bridge station by year



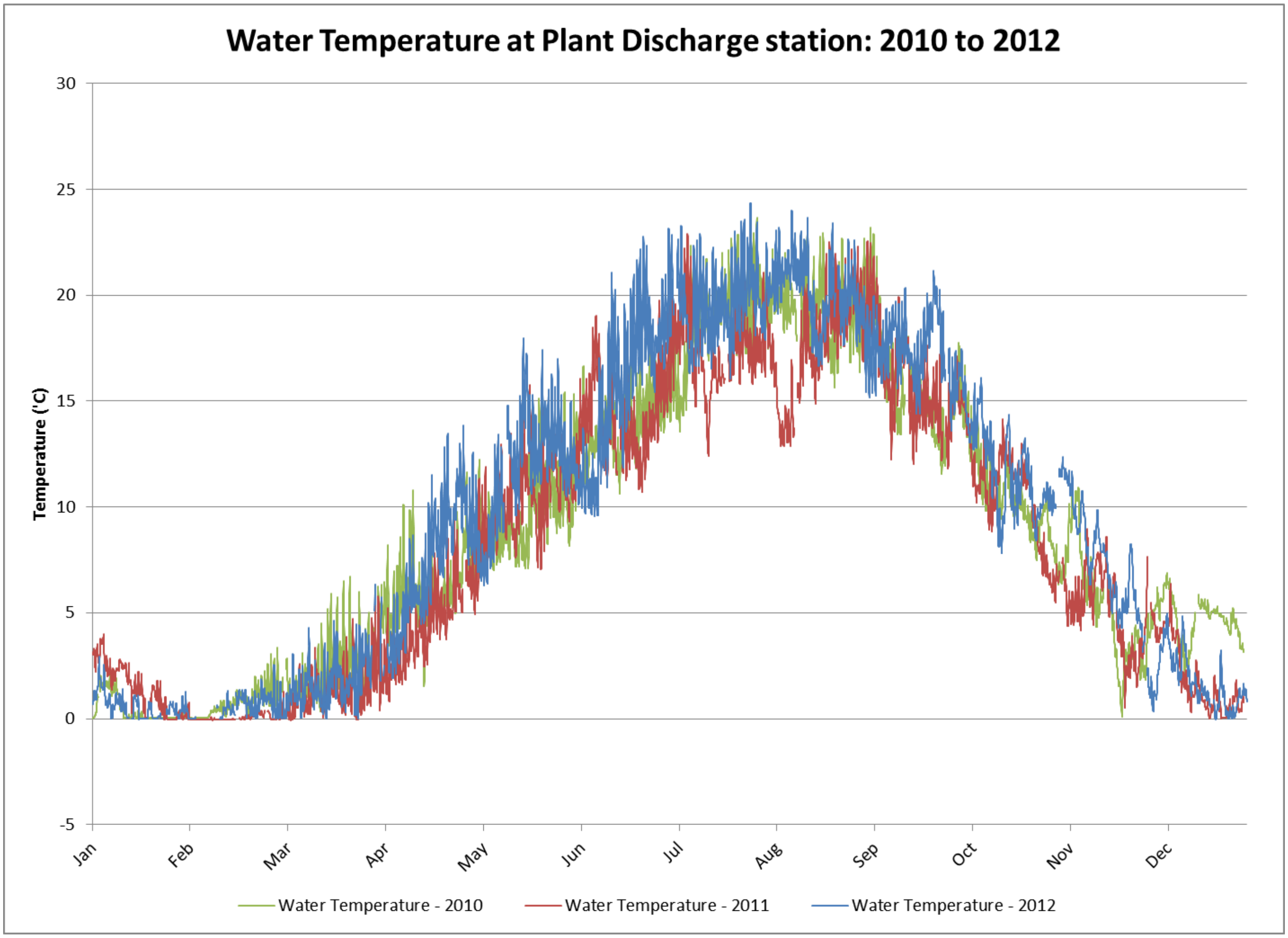
The boxplots above give an indication of the turbidity levels since the beginning of major construction in the Long Harbour area. With the completion of habitat rehabilitation in Forgotten Pond, turbidity should eventually fall to normal levels in time.

Year	Median	90% CI
2010	2.5	2.3 – 2.7
2011	0.4	0.3 – 0.4
2012	3.4	3.2 – 3.5

Rattling Brook below Plant Discharge

Temperature

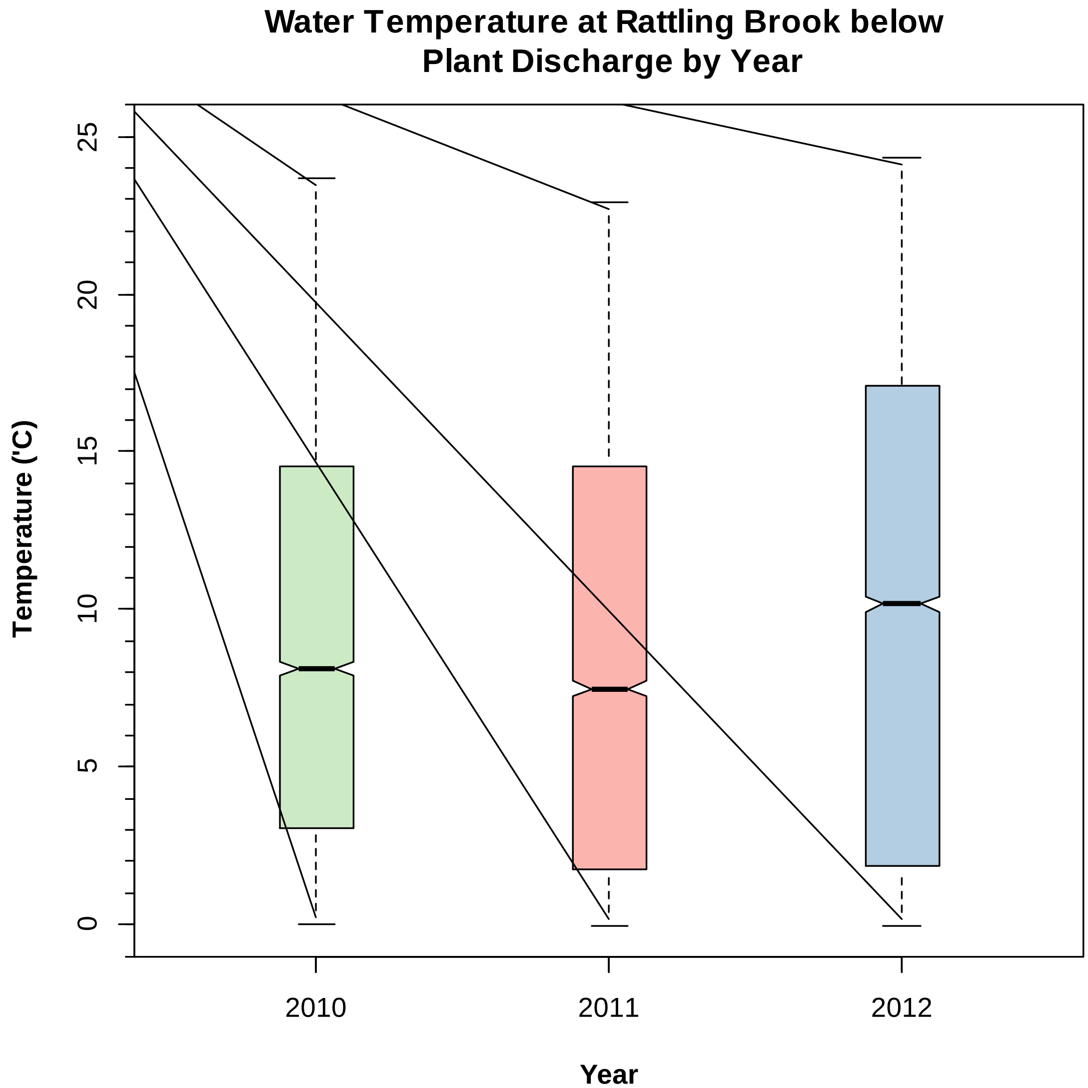
Figure 23: Water temperature at Plant Discharge station from 2010 to 2012



Like those stations upstream, Plant Discharge station saw higher water temperatures in 2012 compared to previous years, especially comparing August 2011 to August 2012.

Year	Minimum	Maximum
2010	0.02	23.67
2011	-0.07	22.89
2012	-0.30	24.33

Figure 24: Boxplots of Water Temperature at Plant Discharge station by year

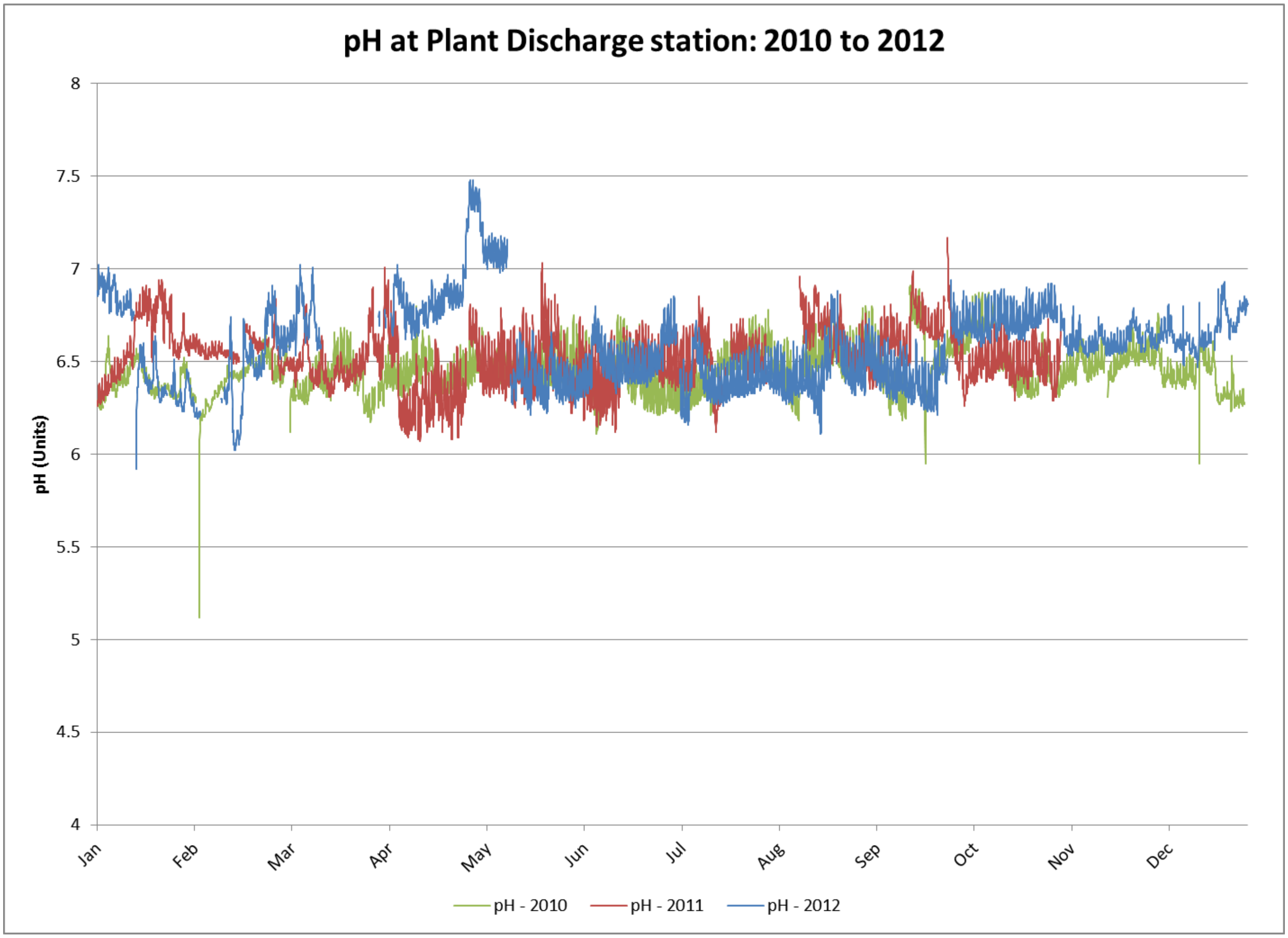


Median water temperature was notably higher in 2012 compared to previous years.

Year	Median	90% CI
2010	8.11	7.89 – 8.32
2011	7.49	7.17 – 7.79
2012	10.17	10.00 – 10.40

pH

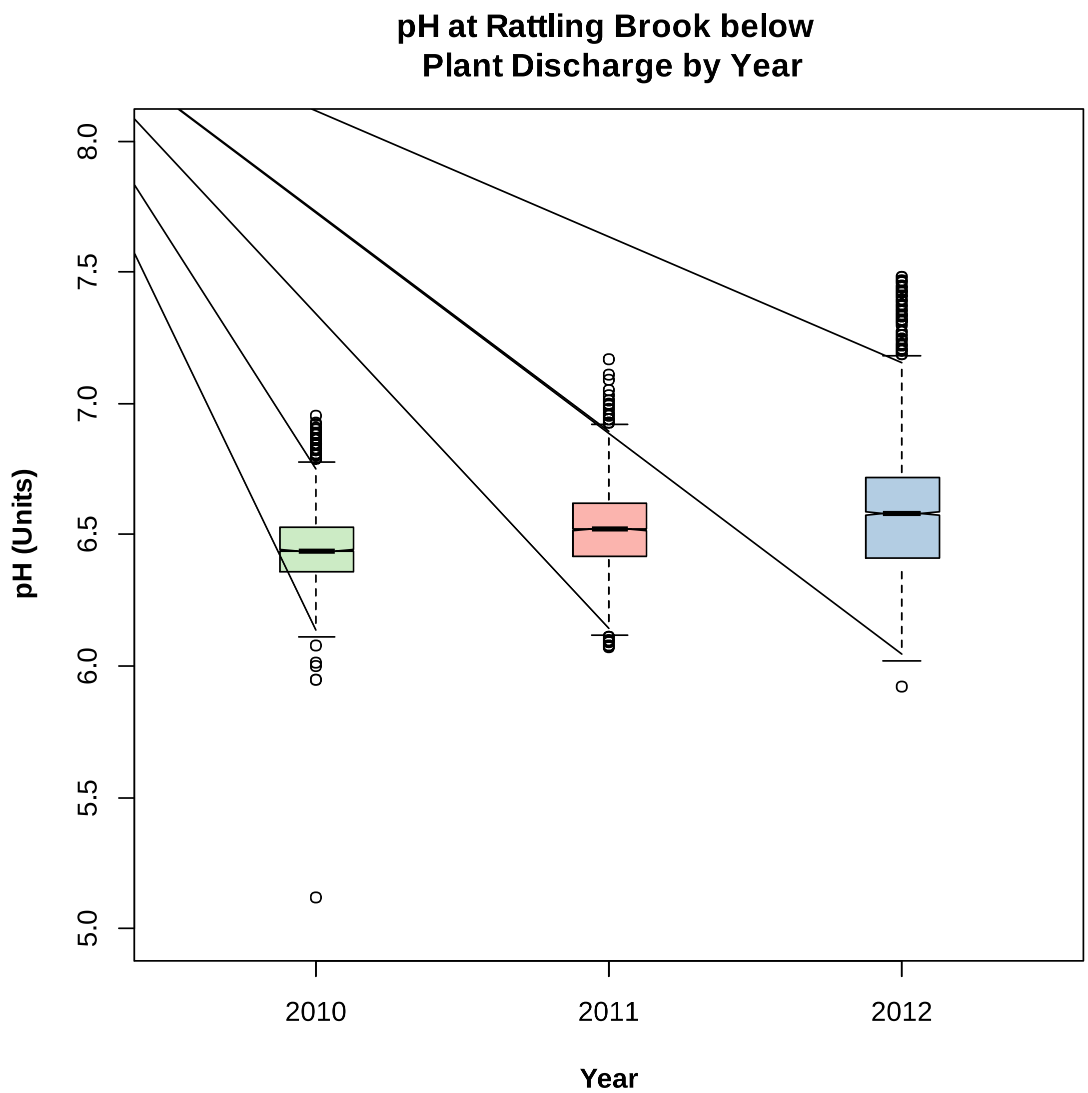
Figure 25: pH at Plant Discharge station from 2010 to 2012



pH values have increased marginally from 2010 to 2012 and appear to be moving towards more neutral conditions rather than acidic ones. This change may simply be a natural fluctuation over time, or could be related to changes in the watershed as a whole.

Year	Minimum	Maximum
2010	5.12	6.95
2011	6.07	7.17
2012	5.92	7.48

Figure 26: Boxplots of pH at Plant Discharge station by year

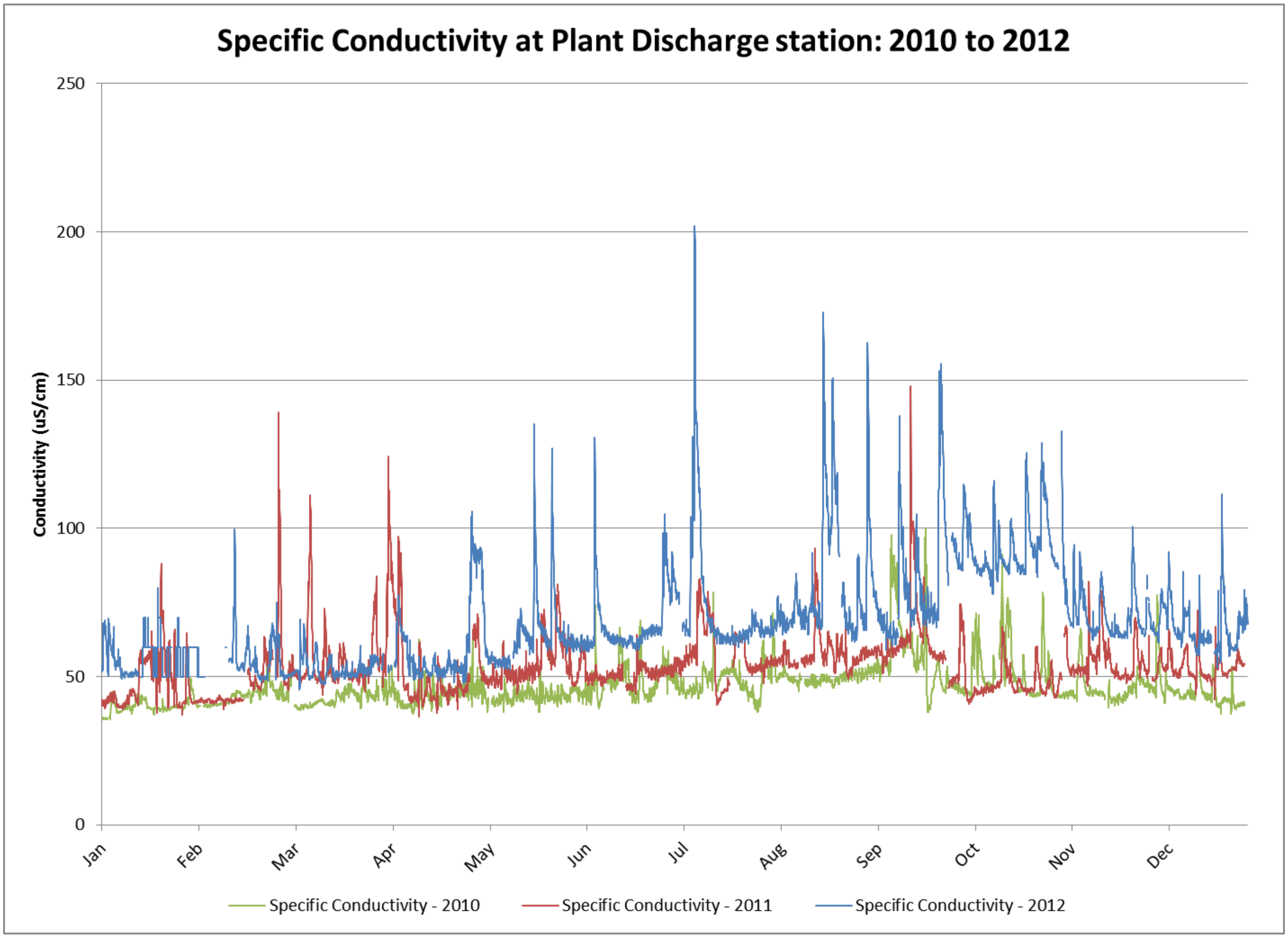


The median pH and range in values has increased since 2010 as shown by the upward movement and increased width in boxplots above.

Year	Median	90% CI
2010	6.44	6.44 – 6.45
2011	6.52	6.52 – 6.53
2012	6.58	6.57 – 6.58

Specific Conductivity

Figure 27: Specific Conductivity at Plant Discharge station from 2010 to 2012

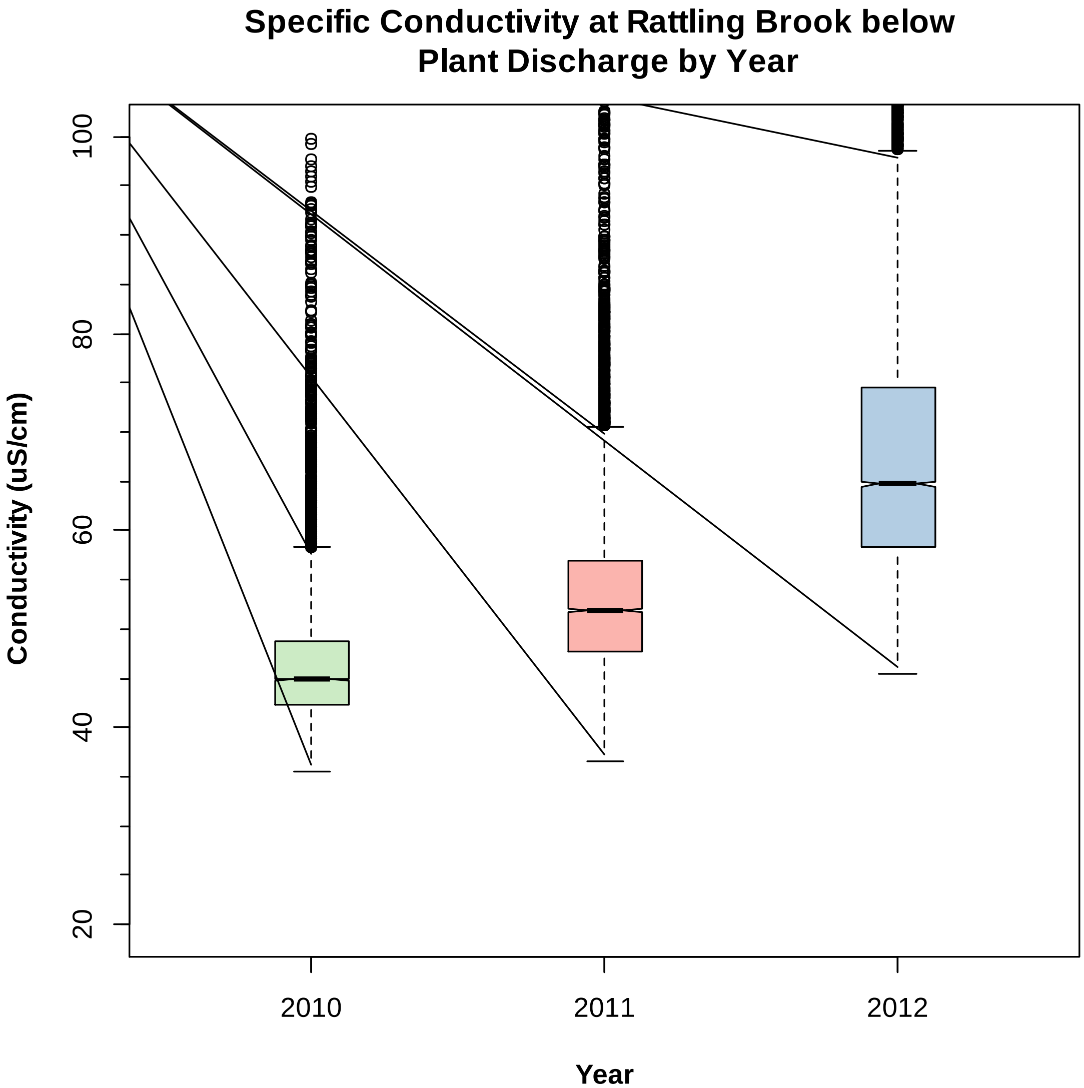


Specific conductivity has increased year over year at Plant Discharge station with higher minimum and maximum values from 2010 to 2012. Elevated conductivity levels are the result of dissolved solids moving into the river channel from overland flow and disturbed soils.

In-stream activities such as dredging and shoreline brush removal will impact water quality more so than activities outside the riparian zone. This is clearly illustrated from September through October, 2012 where conductivity is notably elevated compared to previous data.

Year	Minimum	Maximum
2010	35.5	99.8
2011	36.5	147.9
2012	45.5	202.0

Figure 28: Boxplots of Specific Conductivity at Plant Discharge station by year

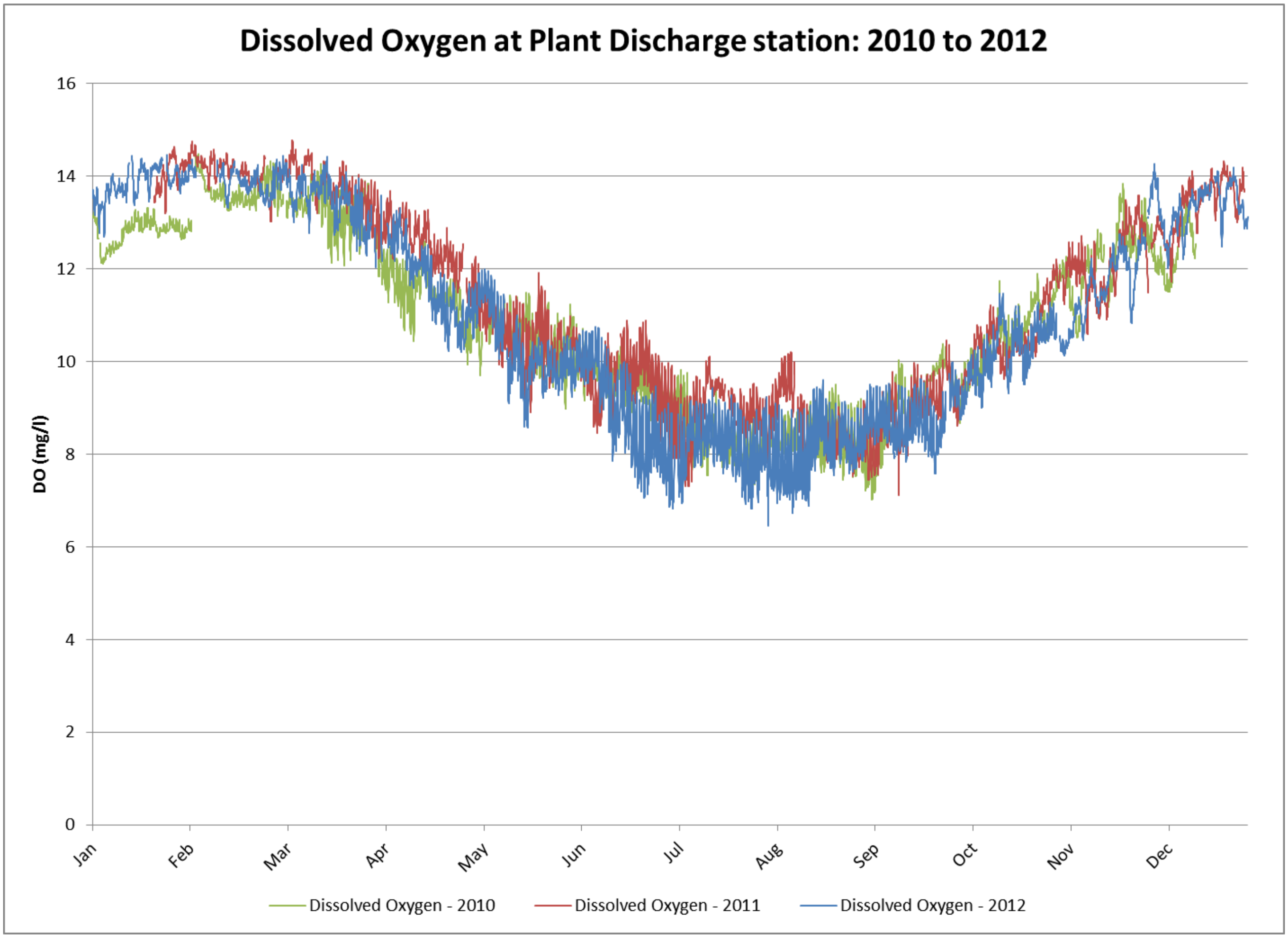


Increasing range and median conductivity values are obvious given the broadening and rising box plots above. As habitat rehabilitation work is completed upstream, the entry of dissolved solids into Rattling Brook should decrease over time.

Year	Median	90% CI
2010	44.9	44.8 – 44.9
2011	51.9	51.7 – 52.0
2012	64.7	64.6 – 64.9

Dissolved Oxygen

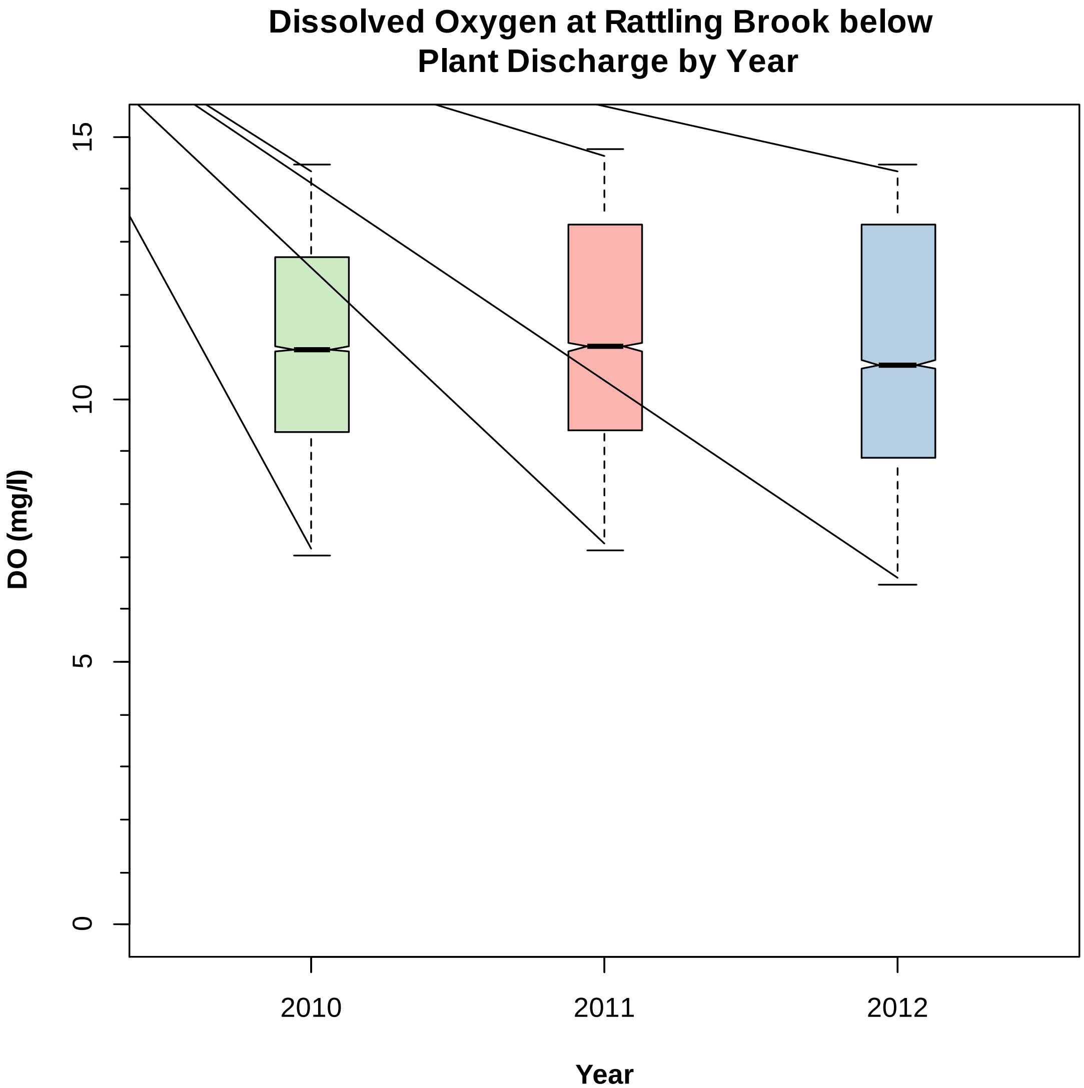
Figure 29: Dissolved oxygen at Plant Discharge station from 2010 to 2012



There are no major unexpected trends or changes in the concentration of dissolved oxygen from 2010 to 2012. Oxygen concentrations were marginally lower in August and September 2012 compared to previous years due to warmer water temperatures.

Year	Minimum	Maximum
2010	7.02	14.48
2011	7.12	14.76
2012	6.46	14.45

Figure 30: Boxplots of Dissolved Oxygen at Plant Discharge station by year

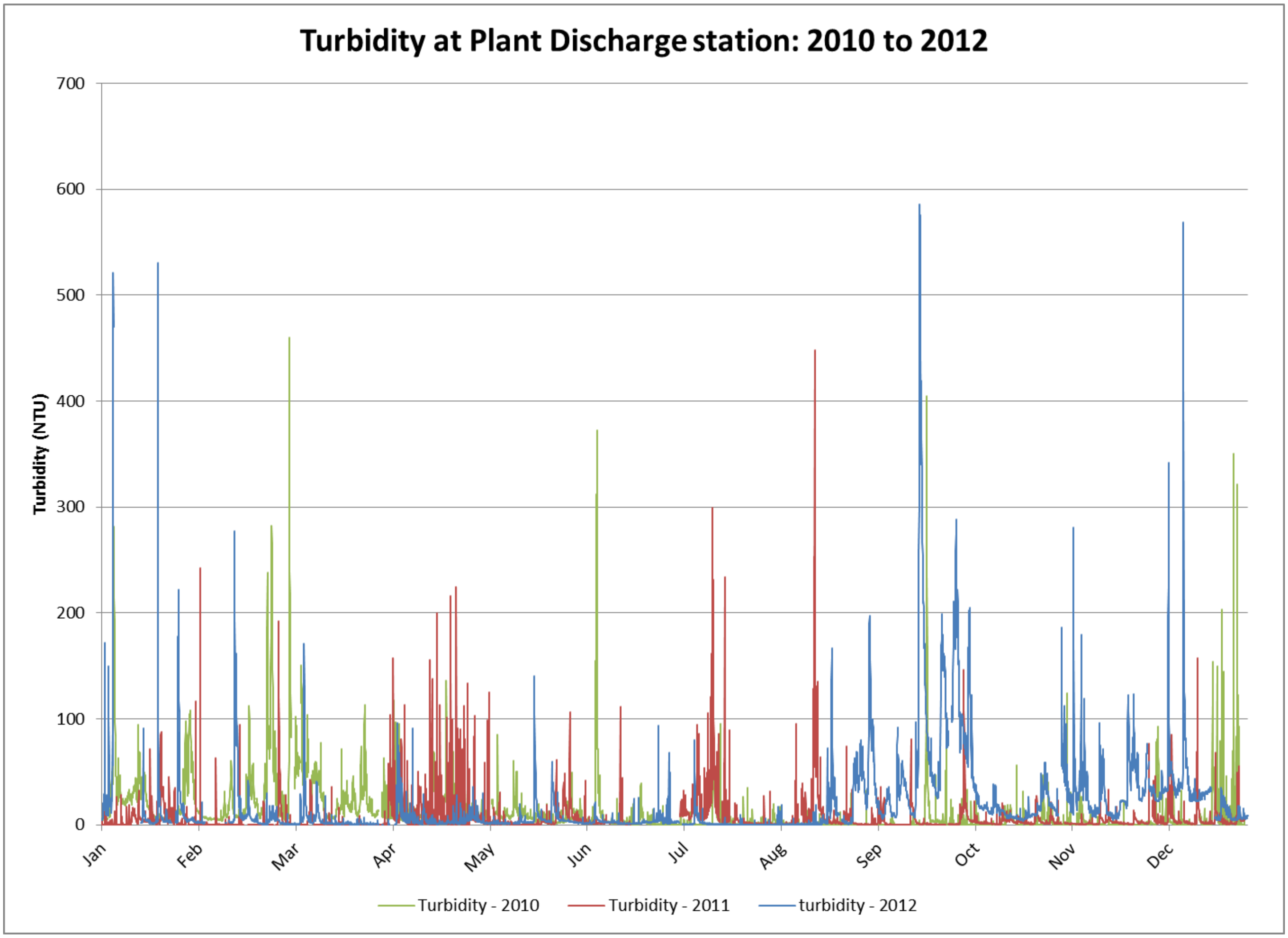


A large overlap in concentration values from 2010 to 2012 indicated that there is no major deviation in concentrations from one year to the next.

Year	Median	90% CI
2010	10.94	10.91 – 11.01
2011	10.99	10.90 – 11.10
2012	10.66	10.60 – 10.74

Turbidity

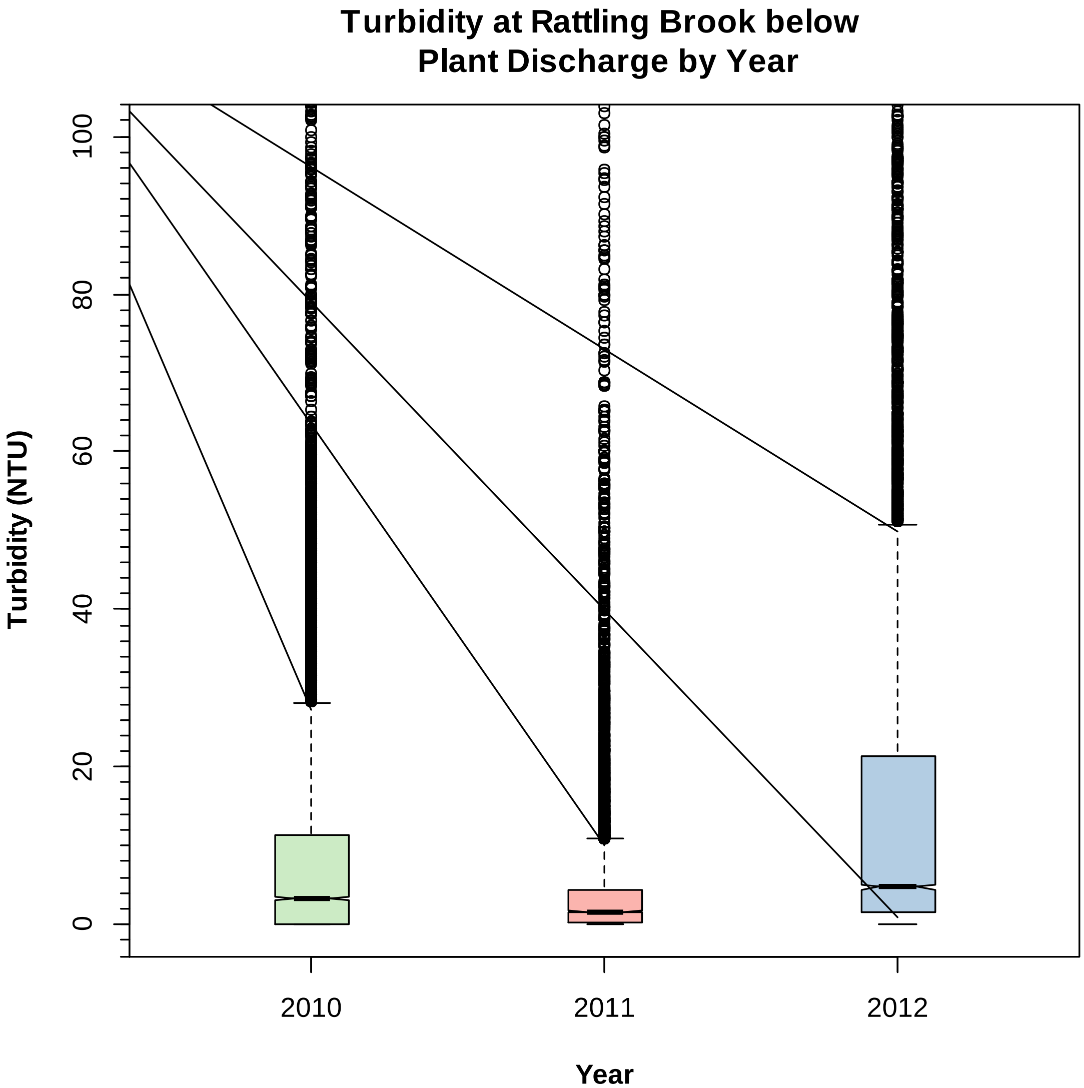
Figure 31: Turbidity at Plant Discharge station from 2010 to 2012



Turbidity levels have fluctuated significantly depending on the major construction activities ongoing around Rattling Brook. In 2010, major efforts included clear cutting of the project site and the removal of unsuitable materials. This disturbed soils, freeing silt and sediment to move into the river channel. In 2011, habitat compensation work was initiated, disturbing the river bed and freeing trapped silt which washed away soon after. Next, in 2012 work upstream in Forgotten Pond liberated a great deal of silt and sediments that were suspended for a long period of time in relatively still waters. It will take some time for the sediments in the pond to stabilize.

Year	Minimum	Maximum
2010	0.0	460
2011	0.0	448
2012	0.0	586

Figure 32: Boxplots of Turbidity at Plant Discharge station by year



With the cessation of habitat compensation efforts in the Rattling Brook system, we can expect turbidity values to fall to low values in the future. Until sediments settle in a stable fashion, high flows will tend to produce longer duration and higher-than-normal turbidity events over the near to medium term.

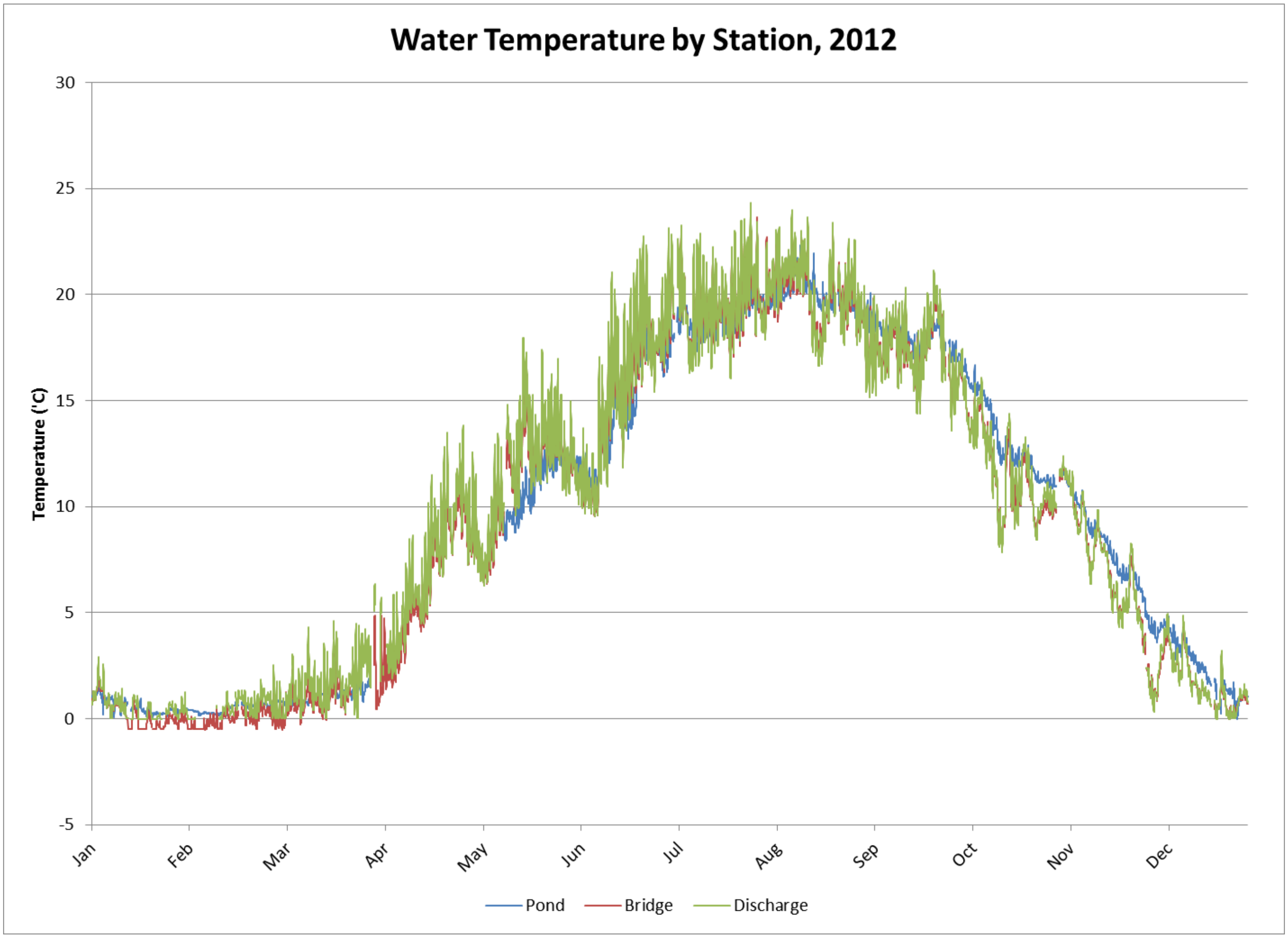
Year	Median	90% CI
2010	3.3	3.1 – 3.6
2011	1.6	1.6 – 1.7
2012	4.8	4.6 – 5.0

Parameters by Station

The following section plots water quality parameters measured simultaneously at each station through 2012. These plots give an indication of changes through Rattling Brook as water progresses downstream from Big Pond station to Plant Discharge station.

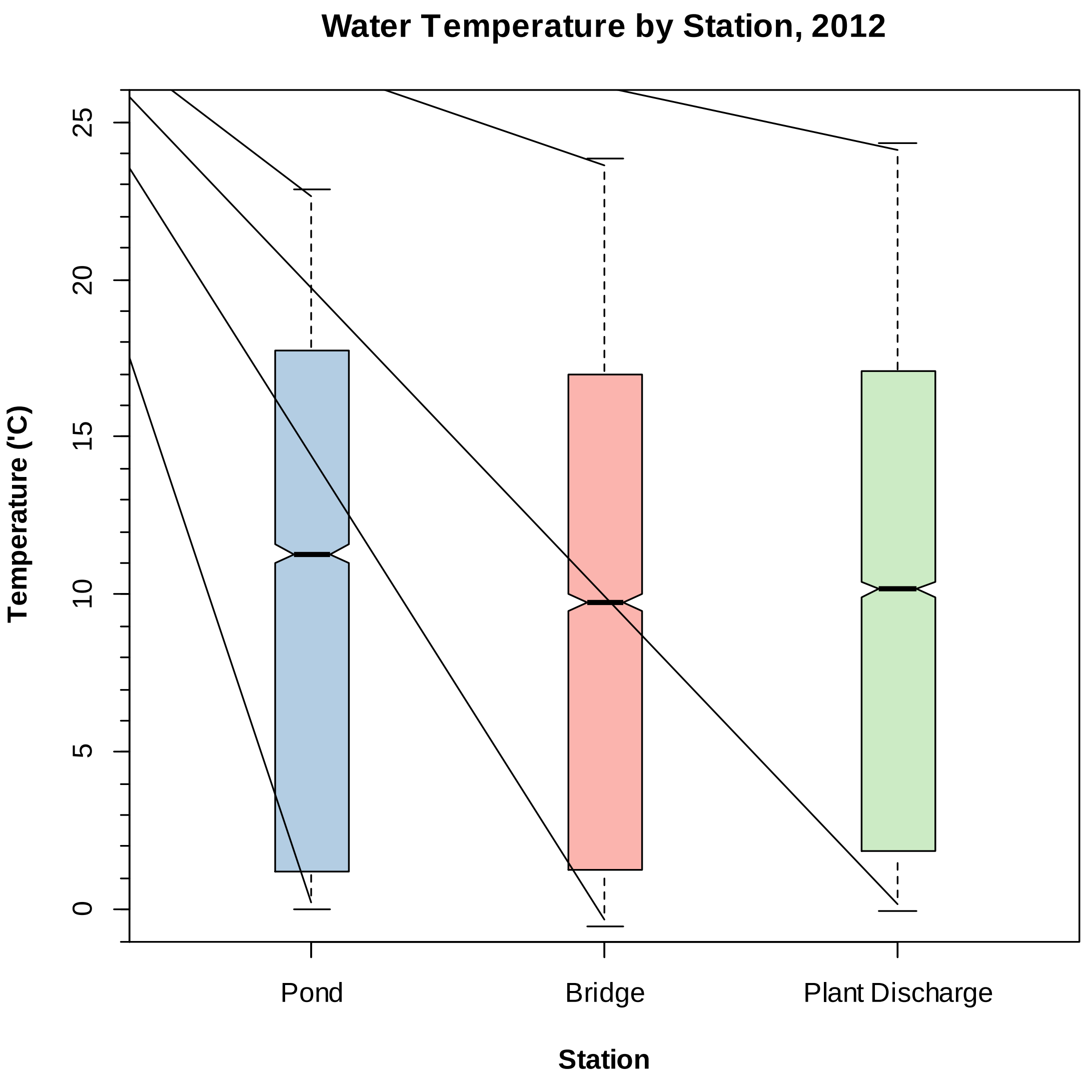
Temperature

Figure 33: Water temperature in 2012 by station



There is a large agreement between stations and water temperature in the Rattling Brook network. While the trends are similar between stations, however, as water progresses downstream, there is an increase in variation. As such, Big Pond tends to be very stable while Discharge tends to fluctuate to a large degree.

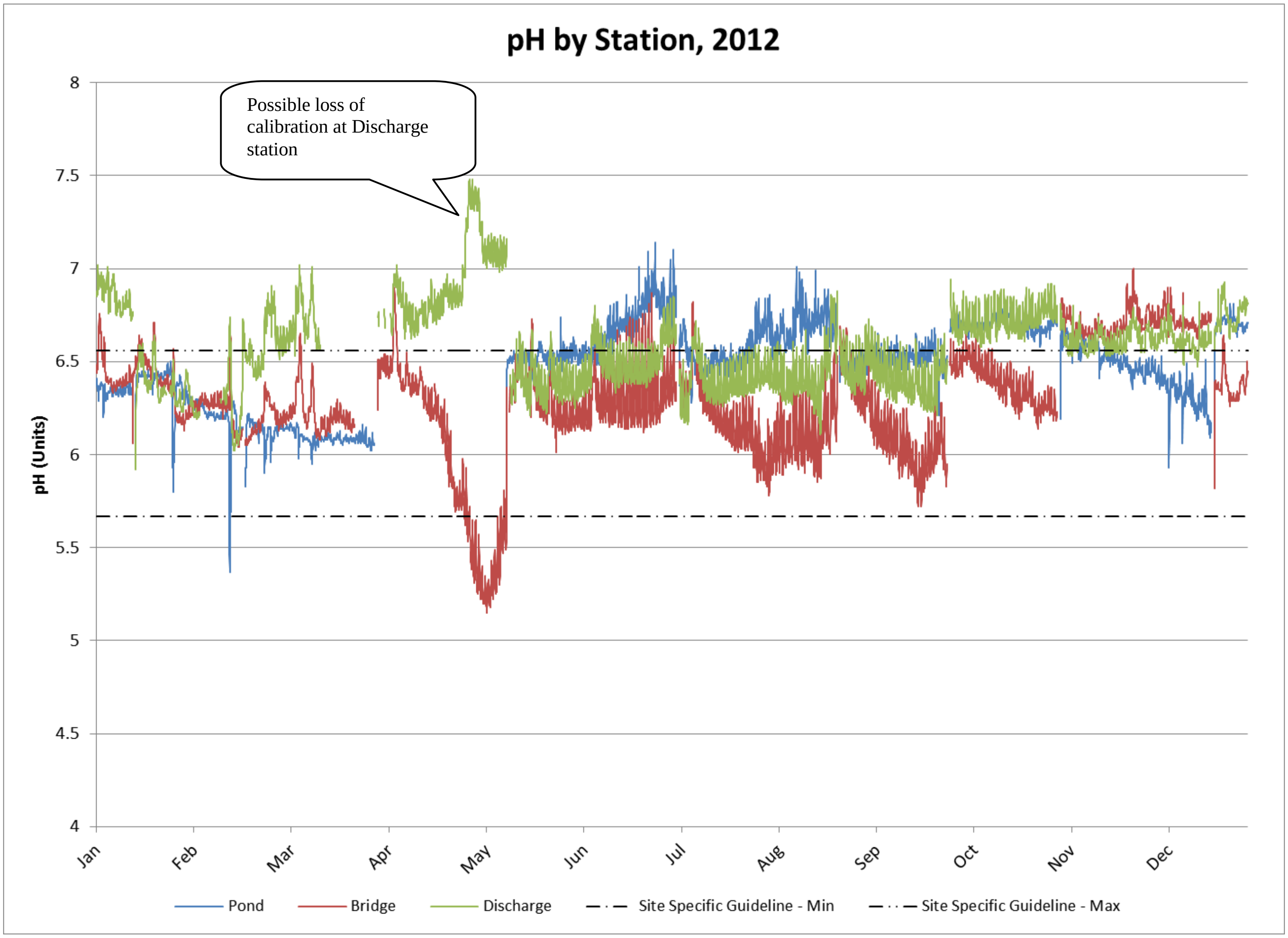
Figure 34: Boxplots of Water Temperature in 2012 by station



Big Pond tends to be marginally warmer than those stations downstream. This is likely due to a greater interface between cool winter and summer evening air temperature as the water flows over rapids and falls through the river, compared to the still and flat conditions of a pond.

pH

Figure 35: pH in 2012 by station



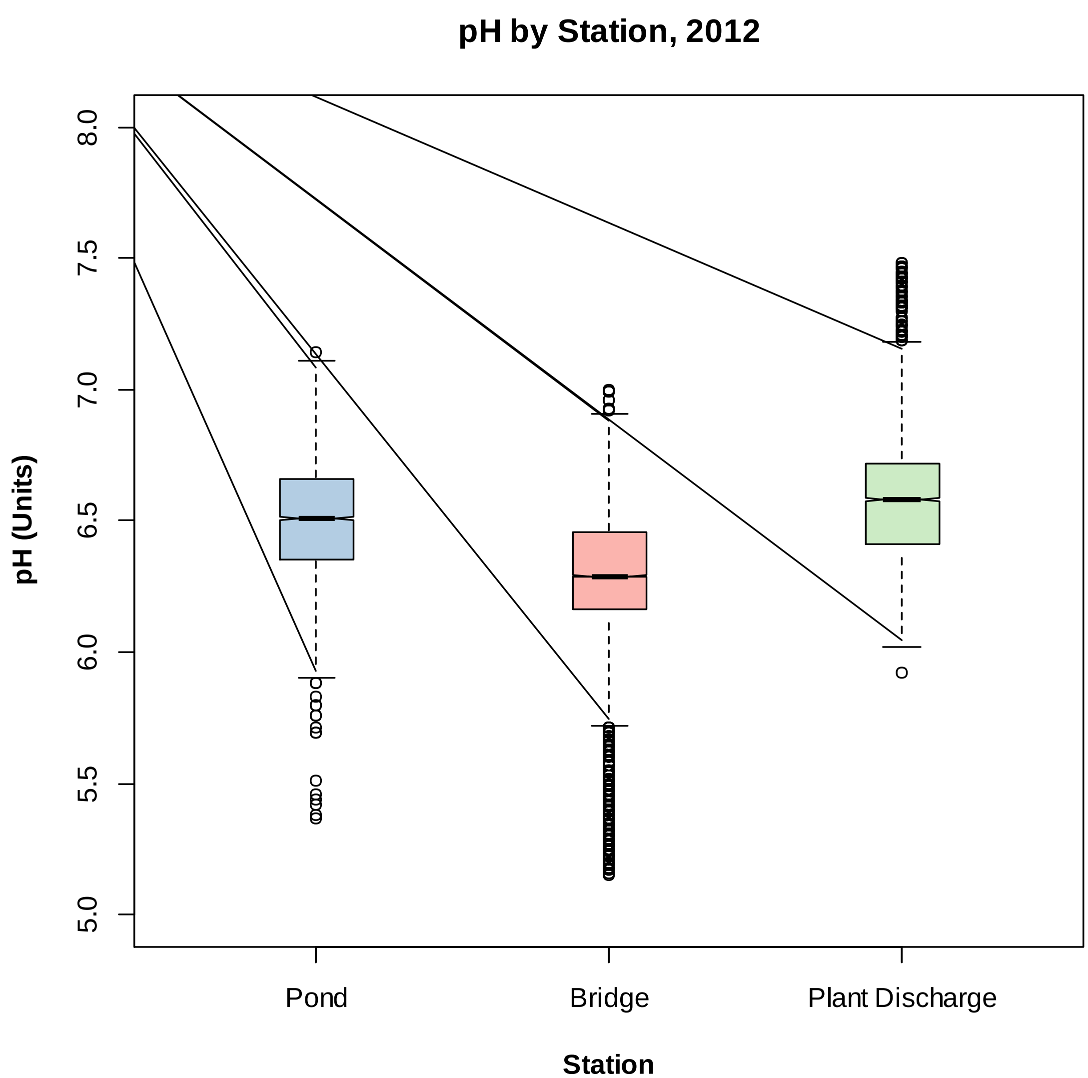
pH tends to fall within the same sort of range between the three stations, however, it is difficult to identify consistent trends between each location. In 2012, there was no consistency in the number of Site Specific Guideline exceedences between the three stations. Big Pond showed more values out of scope than Bridge station, but less than Discharge station. Logic would suggest that an upstream exceedence would result in one downstream, but this is not necessarily the case.

Station	Number of Exceedences
Pond	2881
Bridge	1756
Discharge	4159

In April and May, pH levels at Bridge and Discharge stations deviated significantly when they should be in relatively close agreement. This time of year can be troublesome for pH sensors as their calibration appears to be sensitive to a rapid influx of fresh water which occurs with rapid snow melt. At Removal on May 10th, pH at Bridge station ranked “Excellent” with identical measurements from the QAQC and Field sondes (6.22).

Discharge station, appears to have lost calibration and was ranked "Fair" with a7.18 reading on the Field sonde and 6.60 on the QAQC sonde.

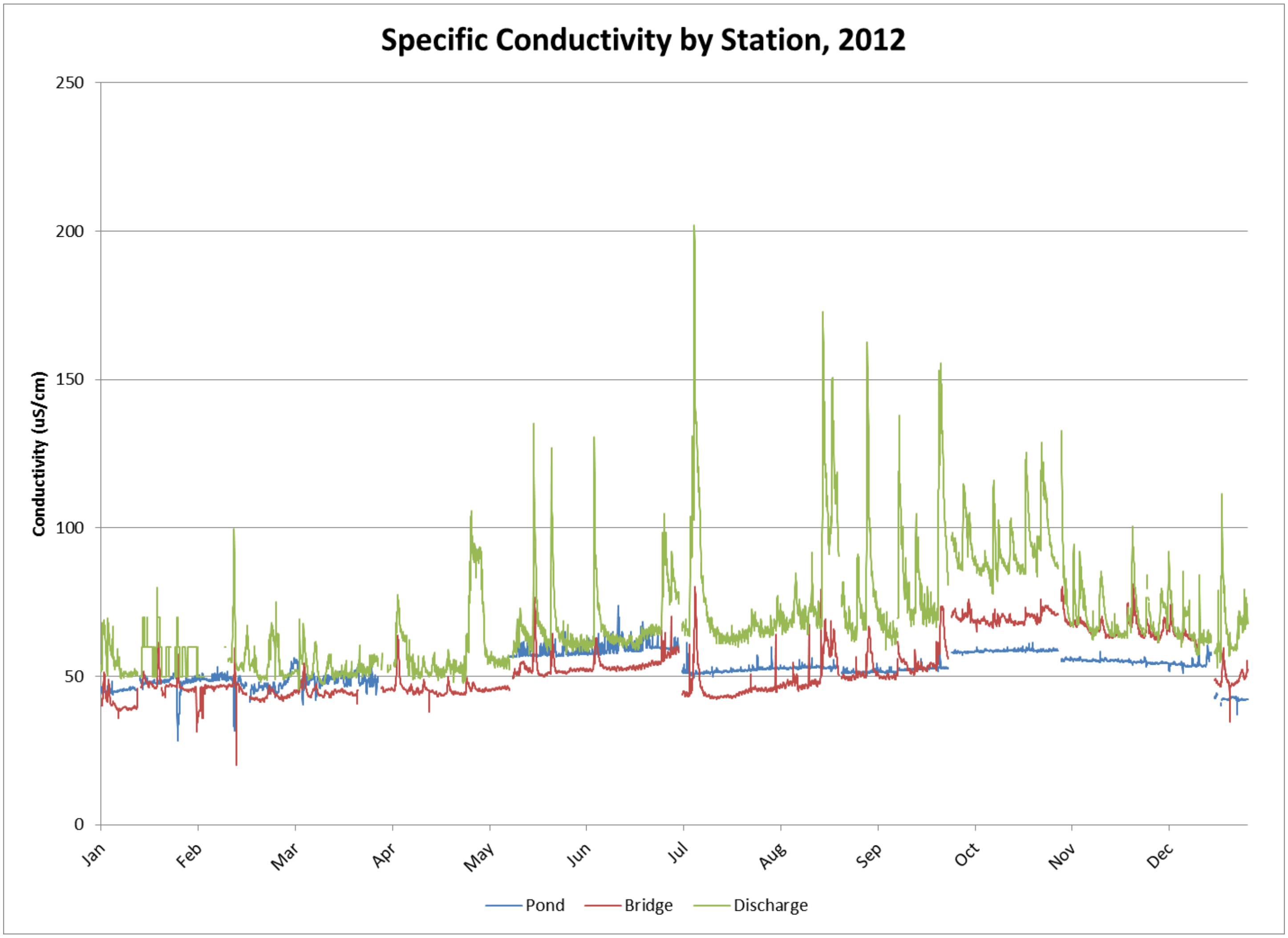
Figure 36: Boxplots of pH in 2012 by station



There is a large degree of overlap in pH between Big Pond and Plant Discharge stations; however Bridge station tended to be lower in value. This may be due to vigorous water flow just above Bridge station where a section of rapids and falls exist. Flow conditions at Big Pond and Plant Discharge are relatively calm, possibly limiting the dissolution of CO2, keeping carbonic acid concentration low and alkalinity high.

Specific Conductivity

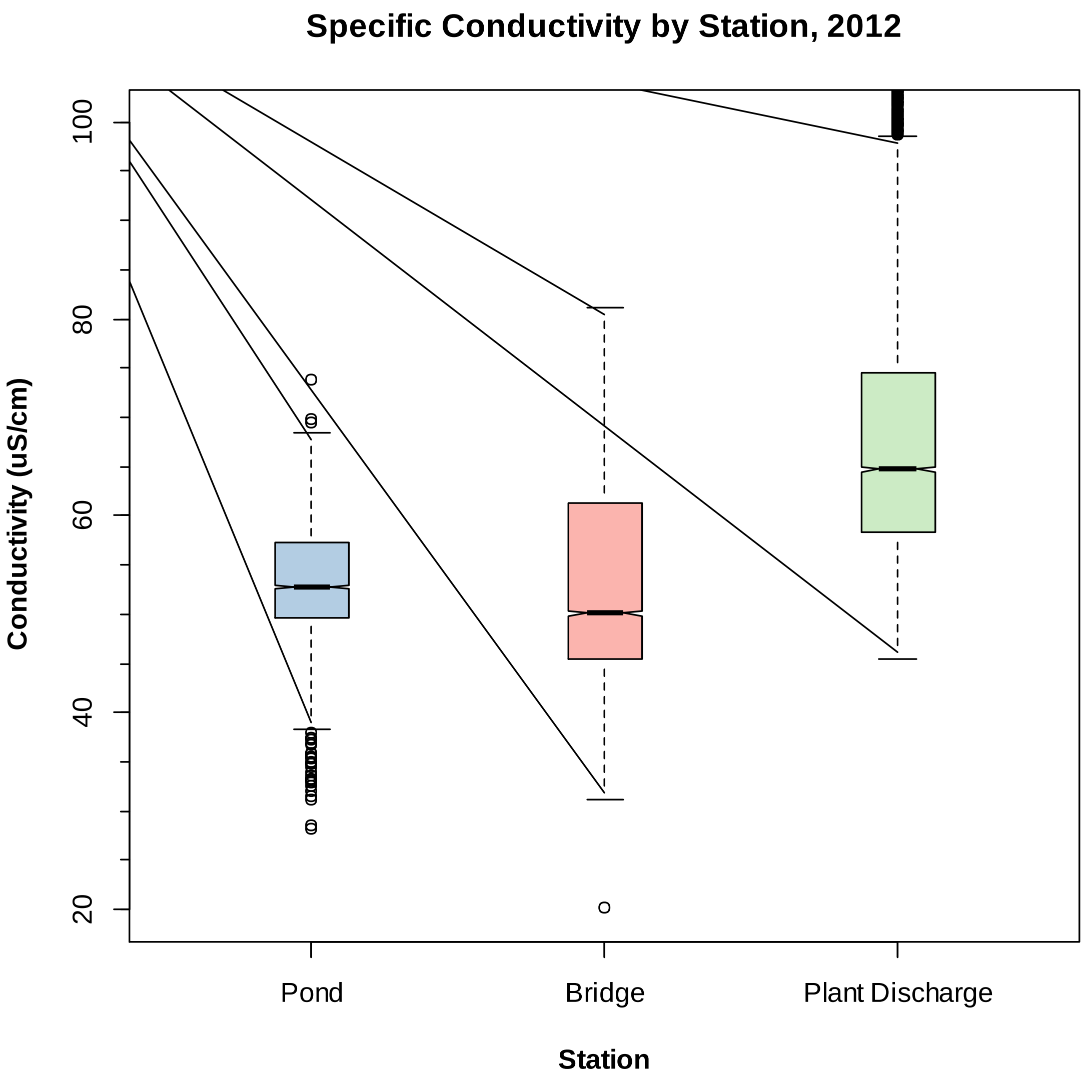
Figure 37: Specific Conductivity in 2012 by station



A rise in conductivity at all three stations over 2012 indicates that there is a definite rising trend in conductivity throughout the Rattling Brook network.

Normally conductivity increases steadily as water progresses through a river system and it is unusual that Pond station shows higher conductivity than bridge station for the first three quarters of 2012. No particular explanation can be made as to why this may be the case. Once work at Forgotten Pond began in August and September, conductivity levels at Bridge station surpassed those upstream at Big Pond station.

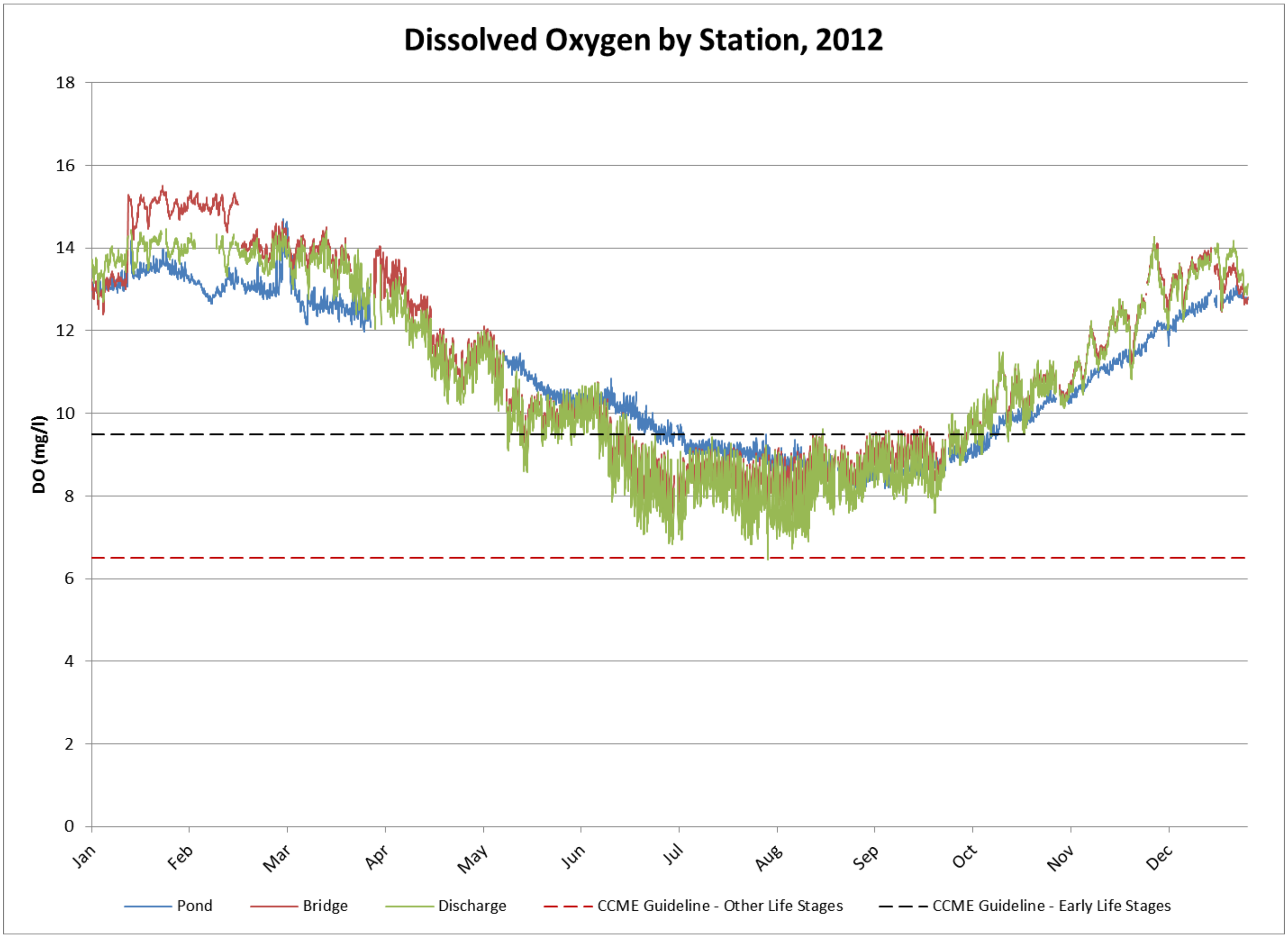
Figure 38: Boxplots of Specific Conductivity in 2012 by station



A downstream rise in conductivity is obvious (as expected) between Bridge and Plant Discharge stations. Interestingly, Pond station showed higher conductivity conditions throughout much of 2012 compared to Bridge station.

Dissolved Oxygen

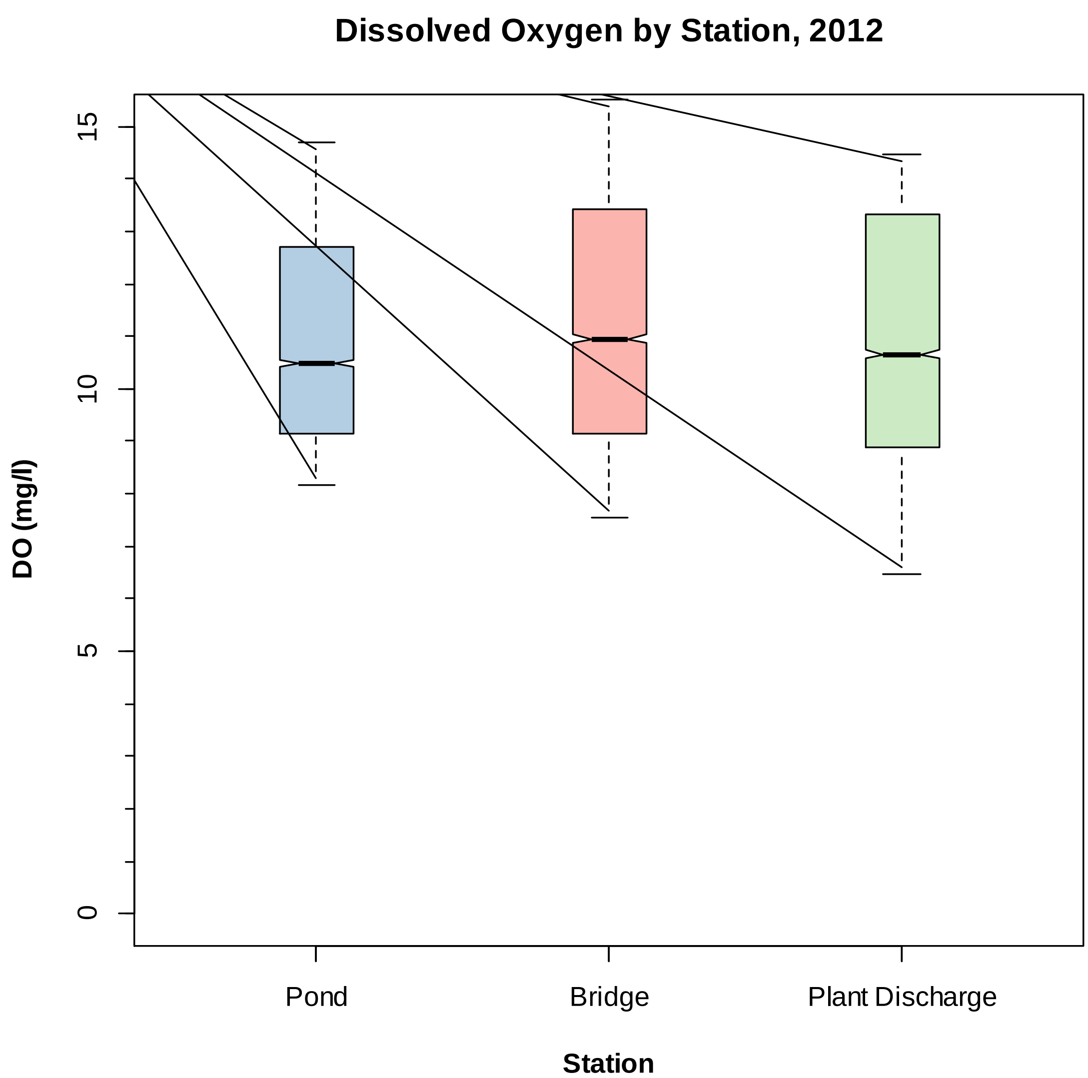
Figure 39: Dissolved Oxygen in 2012 by station



A temperature lag effect tends to moderate the concentration of dissolved oxygen at Big Pond station compared to Bridge and Discharge stations. Because of the time required for Big Pond to heat in the summer and cool in the winter, DO levels tend to remain lower in the winter but stay higher in the summer since the concentration is inversely proportional to water temperature.

Oxygen concentrations tended to remain above the CCME Guideline for the Protection of Other Life Stage Cold Water Biota throughout the whole year at all three stations. From June to October, when water is warm, concentrations tend to fall below the Early Life Stage guideline. However, it is likely that most aquatic biota has progressed beyond their most sensitive life by this point. This can be inferred by the fact that these DO concentrations are comparable to the ambient conditions that the Rattling Brook assemblages are acclimated.

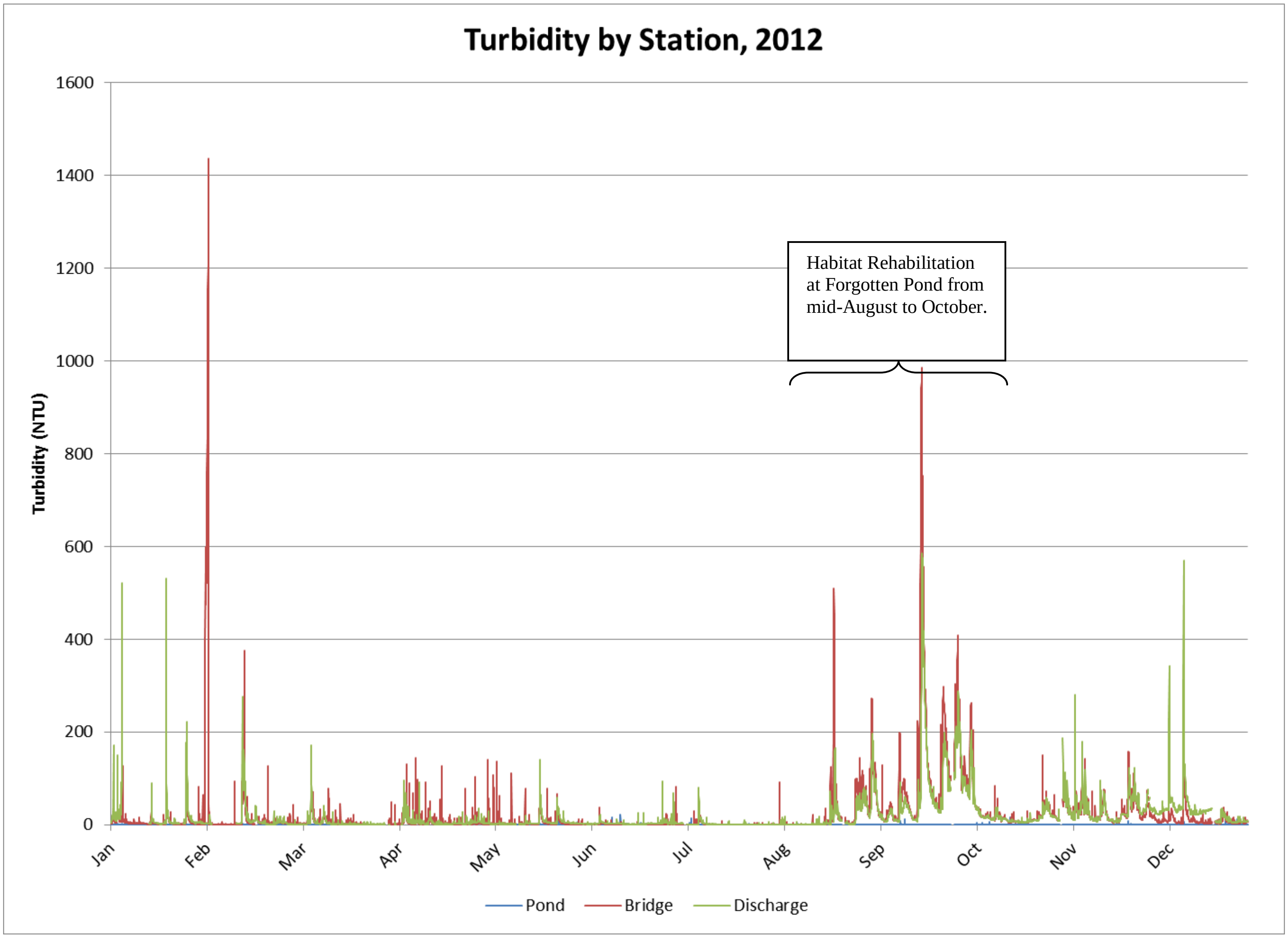
Figure 40: Boxplots of Dissolved Oxygen in 2012 by station



Dissolved oxygen concentrations are similar between each of the three stations in the Rattling Brook network.

Turbidity

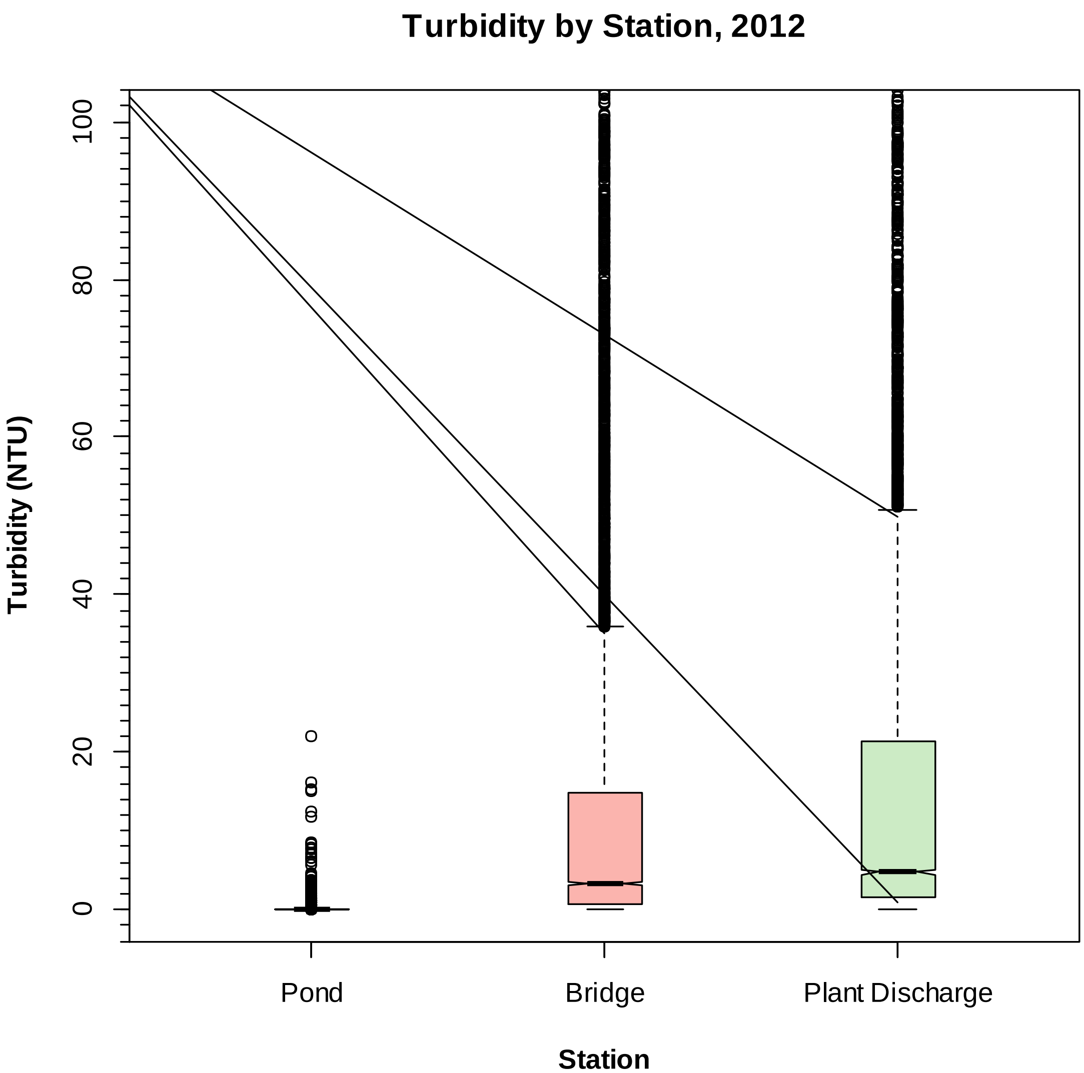
Figure 41: Turbidity in 2012 by station



Very few turbidity events were observed at Big Pond in 2012 – the majority were seen at Bridge and Discharge In 2011, habitat compensation work was undertaken on some stretches along Rattling Brook. This work disturbed sediments and altered the streambed causing silt to flow downstream. Following the work, sediment was prone to re-suspension during high flow events throughout 2012.

In August 2012, habitat compensation work began at Forgotten Pond between Big Pond and Bridge stations. The work included dredging that allowed heavy silting to flow downstream, despite controls. This work was largely completed by October.

Figure 42: Boxplots of Turbidity in 2012 by station



Turbidity levels increase progressively along Rattling Brook from values near zero at Big Pond to a median of 4.8 NTU at Discharge station.

Conclusions

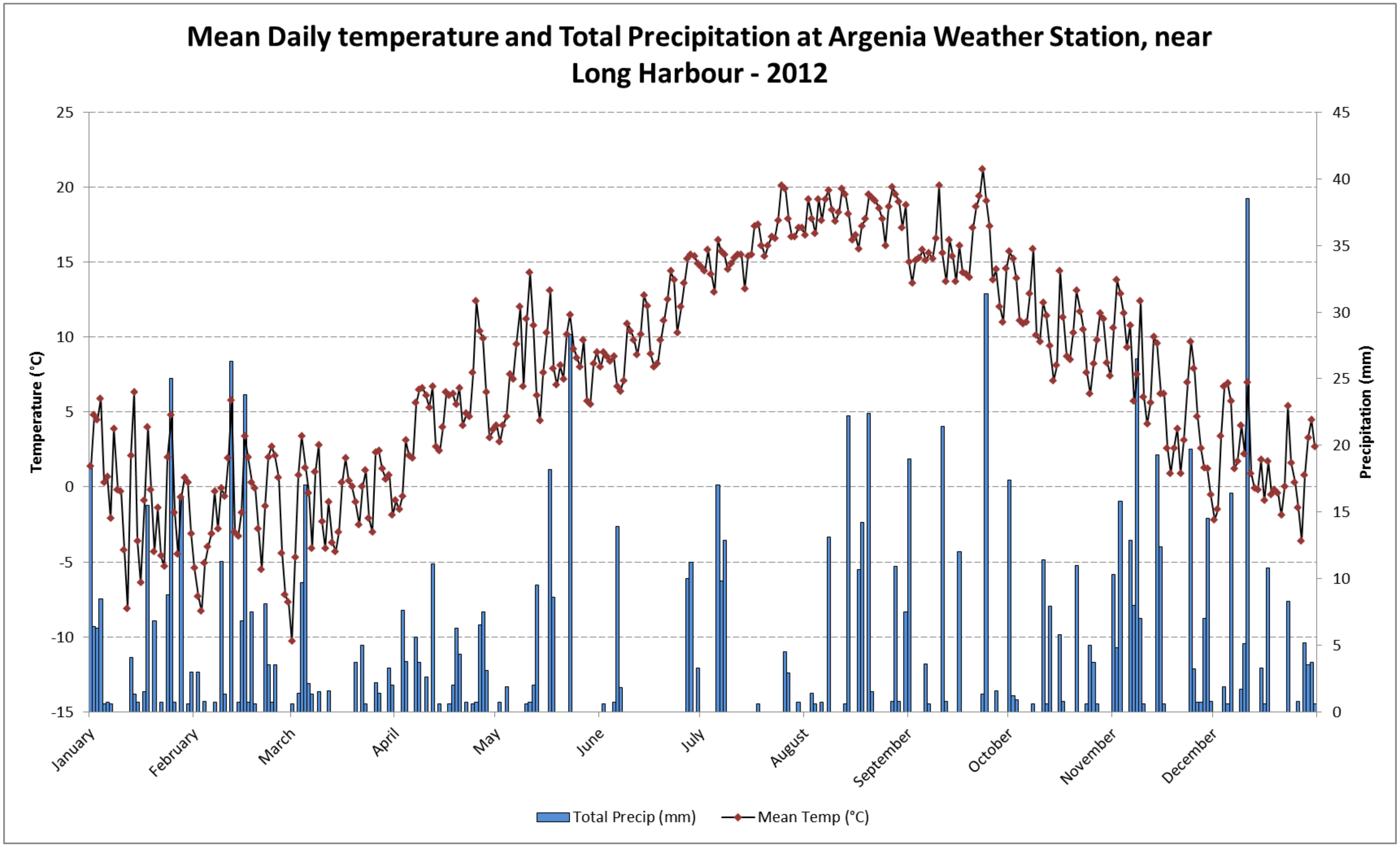
Habitat compensation work in Rattling Brook during 2011 has left some lingering impacts on the river in the form of frequent and prolonged turbidity events during heavy flow. Again, in 2012, compensation work on Forgotten Pond has caused more siltation in the river system. With these two projects complete, turbidity levels should begin to decline towards a baseline level over time, along with conductivity.

Over the last three years, it appears that Rattling Brook is becoming more alkaline as shown by the increasing pH levels. This may be linked to rising conductivity levels where dissolved solids are producing a more alkaline environment.

Path Forward

- The three Rattling Brook monitoring stations provided good insight into the impact from habitat compensation efforts throughout 2011 and 2012. It is expected that, though peak flows will produce prolonged and heavy turbidity events, they will decrease through 2013. Vale and the department of Environment and Conservation will closely monitor these changes over the next year.
- Monthly maintenance and calibration on the three Rattling Brook stations will continue into 2013 with consistent reports generated during each deployment period.
- Fine tuning of the Turbidity Alert system is ongoing with efforts being made to qualify each alert on a scale of criticality. Additionally, development will continue on refining the Turbidity-TSS model to produce more accurate alerts throughout the Rattling Brook network.
- In the fall of 2012, five groundwater monitors were installed around the Sandy Pond Residue Storage Area (RSA). These monitors will gather background data on the condition of groundwater in the area and will identify any unexpected flows in the vicinity of the RSA once the project is commissioned. These monitors will record temperature, pH, conductivity, total dissolved solids, and oxidative-reductive potential (ORP). The Long Harbour Annual Report will encompass the five RSA monitoring stations in 2013.
- Work will continue to develop the Automatic Data Retrieval System to incorporate new capabilities
- Creation of value-added products using real-time water quality data, remote sensing, and water quality indices.

Appendix



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