Real-Time Water Quality 2016 Annual Report

Lower Churchill River Network

May 25 to November 8, 2016

Government of Newfoundland & Labrador
Department of Environment and Climate Change
Water Resources Management Division

TABLE OF CONTENTS

Acknowledgements

The Real-Time Water Quality (RTWQ) monitoring network on the Lower Churchill River is successful in tracking emerging water quality issues as well as creating a database of baseline water quality data due to the hard work and diligence of certain individuals. The management and staff of Nalcor work in cooperation with the management and staff of the Department of Environment and Climate Change (ECC) as well as Environment and Climate Change Canada (ECCC) to ensure the protection of ambient water resources in the Lower Churchill River.

ECC employees have been integral in ensuring the smooth operation of such a technologically advanced network. In 2016, ECC Environmental Scientist Kelly Maher was responsible for deployment and removal of instruments including cleaning, calibration and maintenance. Kyla Brake was responsible for the preparation of monthly deployment reports. Maria Murphy, Ryan Pugh and Paul Rideout are acknowledged for their efforts during deployment and removal procedures in 2016.

ECCC staff, with the Water Survey of Canada play an essential role in the data logging/communication aspect of the network. These individuals visit the site regularly to ensure the data logging equipment is operating properly and transmitting the data efficiently. Finally, they play the lead role in dealing with hydrological quantity and flow issues.

The managers from each agency (Peter Madden/David Haley – Nalcor; Renee Paterson – ECC; Howie Wills – ECCC) are fully committed to improving this network and ensuring it provides meaningful and accurate water quality/quantity data that can be used in the decision-making process. Throughout the summer and fall months in 2016, there was continued communication in the form of small meetings and email correspondence between ECC and Nalcor. This network is continually successful due to the participation and collaboration of all three agencies.

Abbreviations

ECCC	Environment and Climate Change Canada
ECC	NL Department of Environment and Climate Change
CRaboveMF	Station at Churchill River above Muskrat Falls
CRbelowGR	Station at Churchill River below Grizzle Rapids
CRbelowMF	Station at Churchill River below Muskrat Falls
CRatEP	Station at Churchill River at English Point
DO	Dissolved Oxygen
NL	Newfoundland and Labrador
QAQC	Quality Assurance and Quality Control
RTWQ	Real-Time Water Quality
WRMD	Water Resources Management Division
%Sat	Percent Saturation

History

- The RTWQ monitoring network on the Lower Churchill River was successfully established by ECC and ECCC in cooperation with Nalcor Energy in September 2008.
- The objective of the network is to identify and track emerging water quality or quantity management issues and ensure protection of ambient water resources along the Lower Churchill River. The information being collected will serve as a baseline from which changes throughout the several phases of the Lower Churchill Hydroelectric Generation Project can be monitored.
- The original network, established in 2008, consisted of 4 water quality/quantity monitoring stations along the Lower Churchill River from just below the confluence with Metchin River to just below Muskrat Falls. In addition, there were two water quantity monitoring stations on the Churchill River below the Tailrace and above Grizzle Rapids, which strictly recorded stage level continuously. There were also hydrometric stations on select tributaries to the Churchill River (ie. East Metchin River, Pinus River, Minipi River (Figure 1).
- In 2011, ECC in cooperation with ECCC established another water quality/quantity monitoring station at the mouth of the Churchill River (Churchill River at English Point). This station is included in this annual report for comparison purposes (Figure 1). A water quantity station was also established at Lake Melville east of Little River in 2011.
- During the 2014 deployment year, one water quality/quantity monitoring station (Churchill River below Metchin River) and three water quantity monitoring stations (Churchill River above Churchill Falls Tailrace, East Metchin River below Highway Bridge and Minipi River below Minipi Lake) were discontinued as per changes to the Memorandum of Agreement between ECC and Nalcor. An additional water quantity monitoring station (Churchill River Mid Pool) was added to the agreement in 2014.
- Continuous monitoring at four water quality/quantity monitoring stations in the Lower Churchill River Network recommenced in spring 2016. This annual deployment report illustrates, discusses and summarizes water quality related events from May 25 to November 8, 2016. During this time, five visits were made to each of the four RTWQ sites. Instruments were deployed for four 30-40 day intervals referred to as deployment periods.
- Issues were encountered at a few of the stations during the deployment season. Due to the presence of an ice wall at below Grizzle Rapids it was not deployed until the end of June. The Below Muskrat Falls station was also not installed until the end of June due to accessibility issues. 2016 is the first year this station has been deployed for more than a month since sand became an issue in 2014 and threatened to damage station instrumentation.
- Construction at the Muskrat Falls Hydroelectric Generation site began in 2013. In 2016, construction continued on the worksite with progress on the powerhouse and spillway. Site water controls at Muskrat Falls directed run-off flows to one of three discharge points either above or below the lower falls. Significant forestry activity continued, including transmission line and reservoir clearing. On August 3, water was diverted through the spillway at the dam for the first time. On November 5, initial reservoir impoundment commenced, however, due to unforeseen issues, the flood gates were reopened on November 18, allowing water levels in the reservoir to return to their natural levels. Construction is scheduled to continue through 2017.

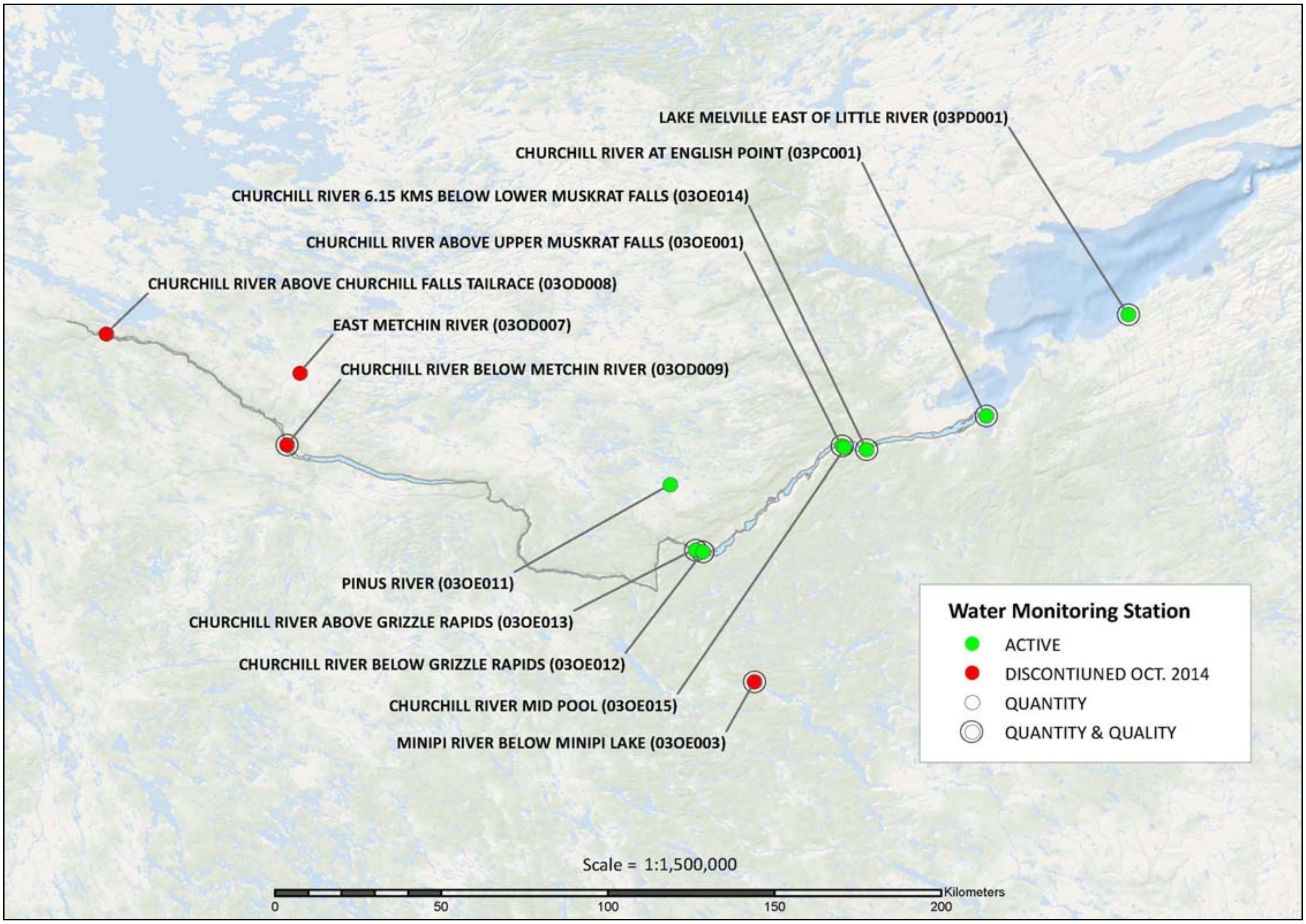


Figure 1: Lower Churchill River Station Map

Maintenance and Calibration

- Regular maintenance and calibration of the instruments is required to ensure data accuracy. This procedure is the responsibility of ECC staff and is performed generally every 30-50 days.
- Maintenance includes a thorough cleaning of the instrument and replacement of any small sensor parts that are damaged or unsuitable for reuse. Once the instrument is cleaned, ECC staff carefully calibrate each sensor attachment for pH, specific conductivity, dissolved oxygen and turbidity.
- Installation and removal dates for each station in the 2016 deployment season are summarized in Table 1.

Table 1: Installation and removal dates for 2016 deployment periods

Installation	Removal	Deployment
May 25	June 29/30	34-35 days
June 29/30	August 3/4	33-34 days
August 3/4	September 15/20	42-46 days
September 15/20	Oct 11/Oct 26/Nov 8	26-43 days

Quality Assurance and Quality Control

- As part of the Quality Assurance and Quality Control protocol (QAQC), an assessment of the reliability of data recorded by an instrument is made at the beginning and end of the deployment period. The procedure is based on the approach used by the United States Geological Survey (USGS).
  - ► At deployment and removal, a QAQC Instrument is temporarily deployed alongside the Field Instrument. Values for temperature, pH, conductivity, dissolved oxygen and turbidity are compared between the two instruments**.** Based on the degree of difference between parameters recorded by the Field Instrument and QAQC Instrument at deployment and at removal, a qualitative statement is made on the data quality (Table 2).

Table 2: Ranking classifications for deployment and removal

	Rank				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (°C)	<=+/-0.2	>+/-0.2 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	<+/-1
pH (unit)	<=+/-0.2	>+/-0.2 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Sp. Conductance (µS/cm)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Sp. Conductance > 35 µS/cm (%)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Dissolved Oxygen (mg/L) (% Sat)	<=+/-0.3	>+/-0.3 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Turbidity <40 NTU (NTU)	<=+/-2	>+/-2 to 5	>+/-5 to 8	>+/-8 to 10	>+/-10
Turbidity > 40 NTU (%)	<=+/-5	>+/-5 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20

- It should be noted that the temperature sensor on any instrument is the most important. All other parameters can be broken down into three groups: temperature dependent, temperature compensated and temperature independent. Because the temperature sensor is not isolated from the rest of the instrument the entire instrument must be at the same temperature before the sensor will stabilize. The values may take some time to climb to the appropriate reading; if a reading is taken too soon it may not accurately portray the water body.

- Comparison rankings for the Lower Churchill River stations, deployed for four deployment periods from May 25 to November 8, 2016, are summarized in Table 3.
- For additional information and explanations of rankings including "n/a" rankings, please refer to the monthly deployment reports.

Table 3: Comparison rankings for Lower Churchill River stations, May 25 – November 8, 2016

Station	Date	Action	Instrument #	Temperature	pH	Specific Conductivity	Dissolved Oxygen	Turbidity
Below Grizzle Rapids	May 25	Deployment	n/a	Not deployed due to ice wall limiting access to station				
	June 29	Removal						
	June 29	Deployment	45699	Good	Fair	Excellent	Excellent	Excellent
	August 3	Removal		Good	Good	Excellent	Excellent	Excellent
	August 3	Deployment	45709	Fair	Excellent	Excellent	Excellent	Excellent
	Sept 15	Removal		Good	Excellent	Excellent	Good	Excellent
	Sept 15	Deployment	47384	Excellent	Excellent	Excellent	Excellent	n/a
	October 26	Removal		Excellent	Fair	Excellent	n/a	n/a
Above Muskrat Falls	May 25	Deployment	47590	Excellent	Excellent	Excellent	Excellent	Excellent
	June 29	Removal		Instrument out of the water upon retrieval				
	June 29	Deployment	45708	Excellent	Excellent	Excellent	Excellent	Excellent
	August 3	Removal		Excellent	Excellent	Excellent	Excellent	n/a
	August 3	Deployment	47590	Excellent	Excellent	Excellent	Excellent	Good
	Sept 15	Removal		Excellent	Excellent	Excellent	Good	Excellent
	Sept 15	Deployment	47589	Excellent	Good	Excellent	Excellent	Excellent
	October 11	Removal		Excellent	Good	Excellent	Excellent	n/a
Below Muskrat Falls	May 25	Deployment	n/a	Instrument not deployed due to inaccessibility				
	June 30	Removal						
	June 30	Deployment	47589	Excellent	Fair	Excellent	Excellent	Poor
	August 3	Removal		Good	Excellent	Excellent	Excellent	Good
	August 3	Deployment	45700	Excellent	Good	Excellent	Excellent	n/a
	Sept 15	Removal		Good	Fair	Excellent	Excellent	n/a
	Sept 15	Deployment	45708	Excellent	Excellent	Excellent	Excellent	Excellent
	November 8	Removal		Good	Poor	Excellent	Good	Fair
At English Point	May 25	Deployment	45042	Good	Excellent	Excellent	Excellent	Poor
	June 30	Removal		Good	Excellent	Good	Excellent	Poor
	June 30	Deployment	47384	Excellent	Fair	Excellent	Excellent	Marginal
	August 4	Removal		Excellent	Excellent	Excellent	Excellent	Good
	August 4	Deployment	45699	Excellent	Good	Good	Excellent	Excellent
	Sept 20	Removal		Good	Excellent	Excellent	Fair	Excellent
	Sept 20	Deployment	45709	Good	Excellent	Good	Good	Fair
	November 8	Removal		Good	Fair	Excellent	Excellent	Good

Data Interpretation and Review

- The following graphs and discussion illustrate significant water quality-related trends from May 25 to November 8 in the Lower Churchill River Network. In this summary of the deployment periods for 2016, general patterns will be discussed. More detailed analysis and discussion of specific events can be found in the monthly deployment reports.
- With the exception of water quantity data (stage), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QAQC protocol. Water Survey of Canada (ECCC) is responsible for QAQC of water quantity data. Corrected data can be obtained upon request.
- For a general comparison, 2014 and 2015 data have been included in the following graphs to show differences in trends in water quality on the Lower Churchill River over the past 3 years.
- Summary statistics are calculated using the entire data set. This means that the number of values used to calculate the median, min and max vary from year to year depending on the length of the deployment season. The 2016 deployments season was 163 days long while the 2015 and 2014 seasons used for comparison purposes in this report are 163 and 156 days each, respectively.

Churchill River below Grizzle Rapids

- Water temperature ranges from 4.6°C to 20.0°C during the 2016 deployment season, with a median value of 14.4°C (Figure 2).
- Water temperatures during summer were cooler than in 2014 and warmer than in 2015. Temperature trends into the fall months are on par with the previous two years.

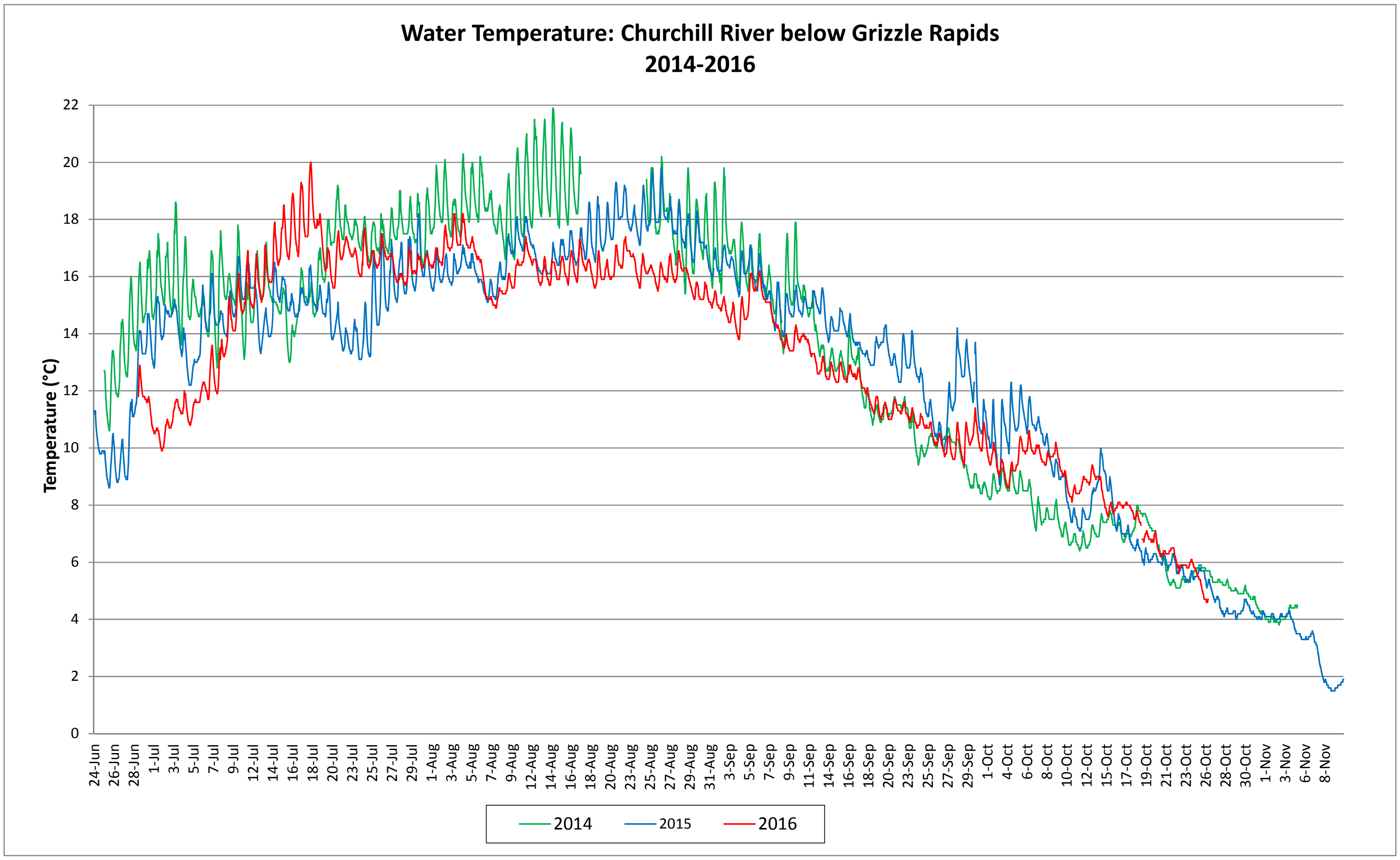


Figure 2: Water temperature at Churchill River below Grizzle Rapids

Temperature	2016	2015	2014
Min	4.6	1.5	3.8
Max	20.0	19.8	21.9
Median	14.4	14.1	14.7

- Water temperature values show a typical seasonal trend (Figure 3). Water and air temperatures are increasing throughout the spring and summer with water temperatures peaking in mid-July before steadily decreasing into the fall months.

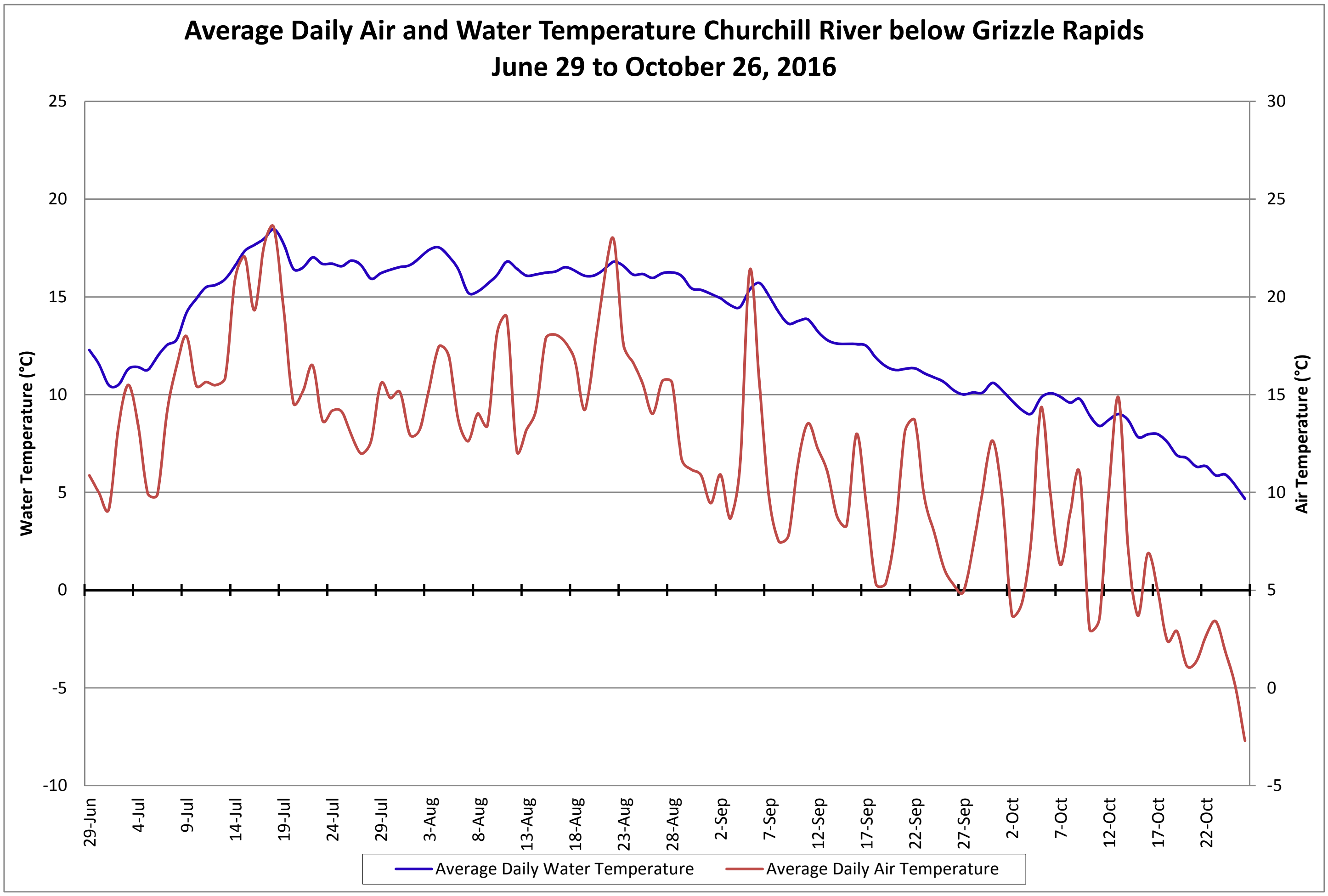


Figure 3: Average daily air and water temperatures at Churchill River below Grizzle Rapids (weather data recorded at Muskrat Falls)

- pH ranges between 6.50 and 7.40 pH units during the 2016 deployment season, with a median value of 7.00 pH units (Figure 4). The median values from 2014-2016 are similar, showing consistency over the past three seasons.
- pH values are consistent throughout the deployment season with a clear diurnal fluctuation.
- A drop in pH values during the August deployment is lower than expected and is likely due to significant rain events.
- All values during the 2016 deployment season are within the CCME Guidelines for the Protection of Aquatic Life (>6.5 and <9.0 pH units). The guidelines are indicated in red on Figure 4.

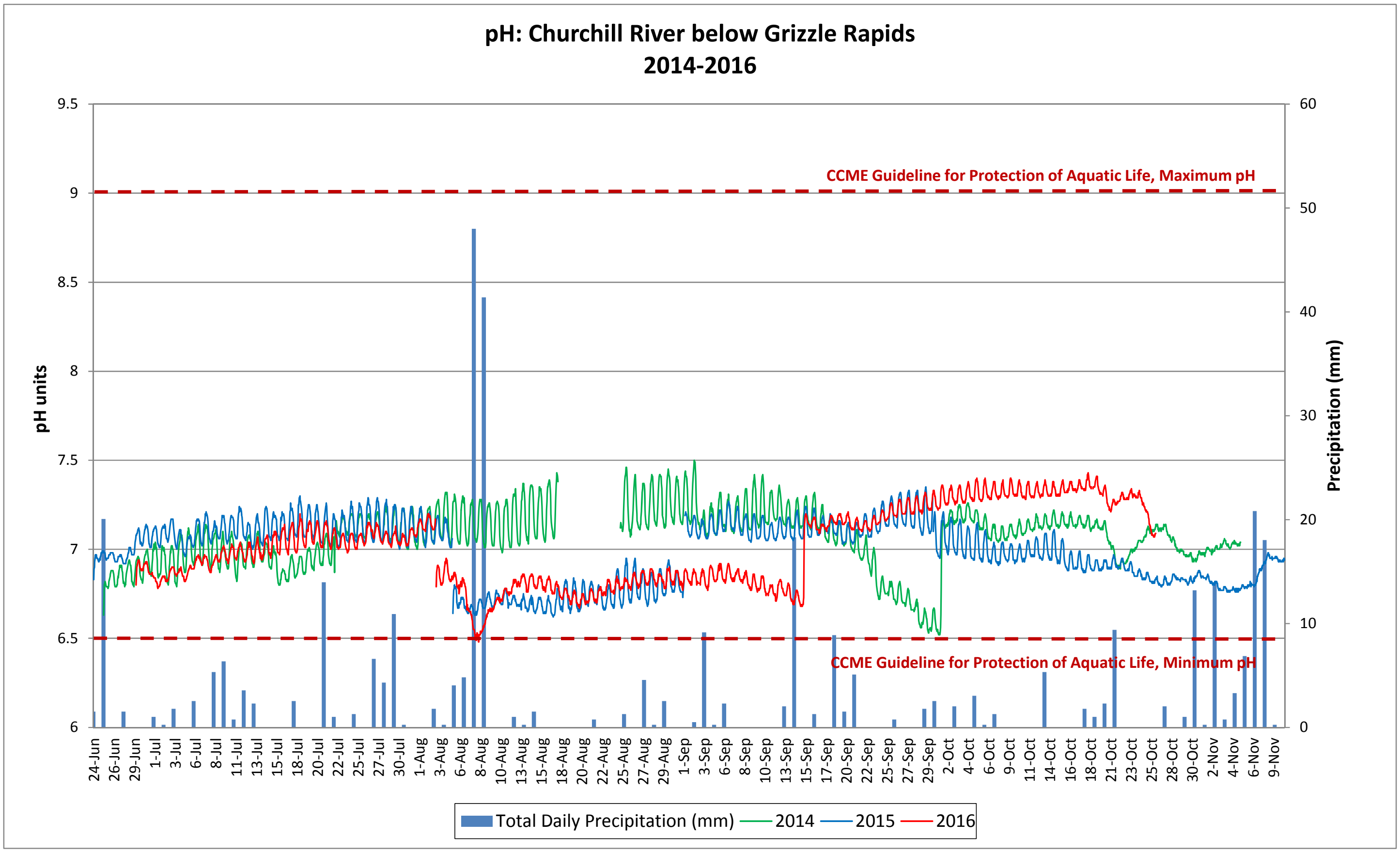


Figure 4: pH at Churchill River below Grizzle Rapids

pH (units)	2016	2015	2014
Min	6.50	6.62	6.52
Max	7.40	7.35	7.50
Median	7.00	7.02	7.09

- Specific conductivity ranges from 13.7µS/cm to 21.9µS/cm during the 2016 deployment season, with a median value of 19.0µS/cm (Figure 5).
- Specific conductivity is increasing in the spring and early summer, peaking in early September. Specific conductivity then begins to decrease throughout the remainder of the deployment season into the fall months.
- Increases and decreases in specific conductivity are generally related to fluctuations in stage. As stage decreases, specific conductivity usually increases as the concentration of dissolved solids increases. Inversely, when stage increases due to runoff from precipitation events, specific conductivity decreases due to the dilution of dissolved solids in the water column.
- Specific conductivity trends in 2014 and 2015 are somewhat similar, increasing throughout the summer when stage is typically decreasing and decreasing again in the fall season when stage typically increases. The majority of 2016 values are on par with the previous two years, with an overall slightly higher median than for 2014-2015.

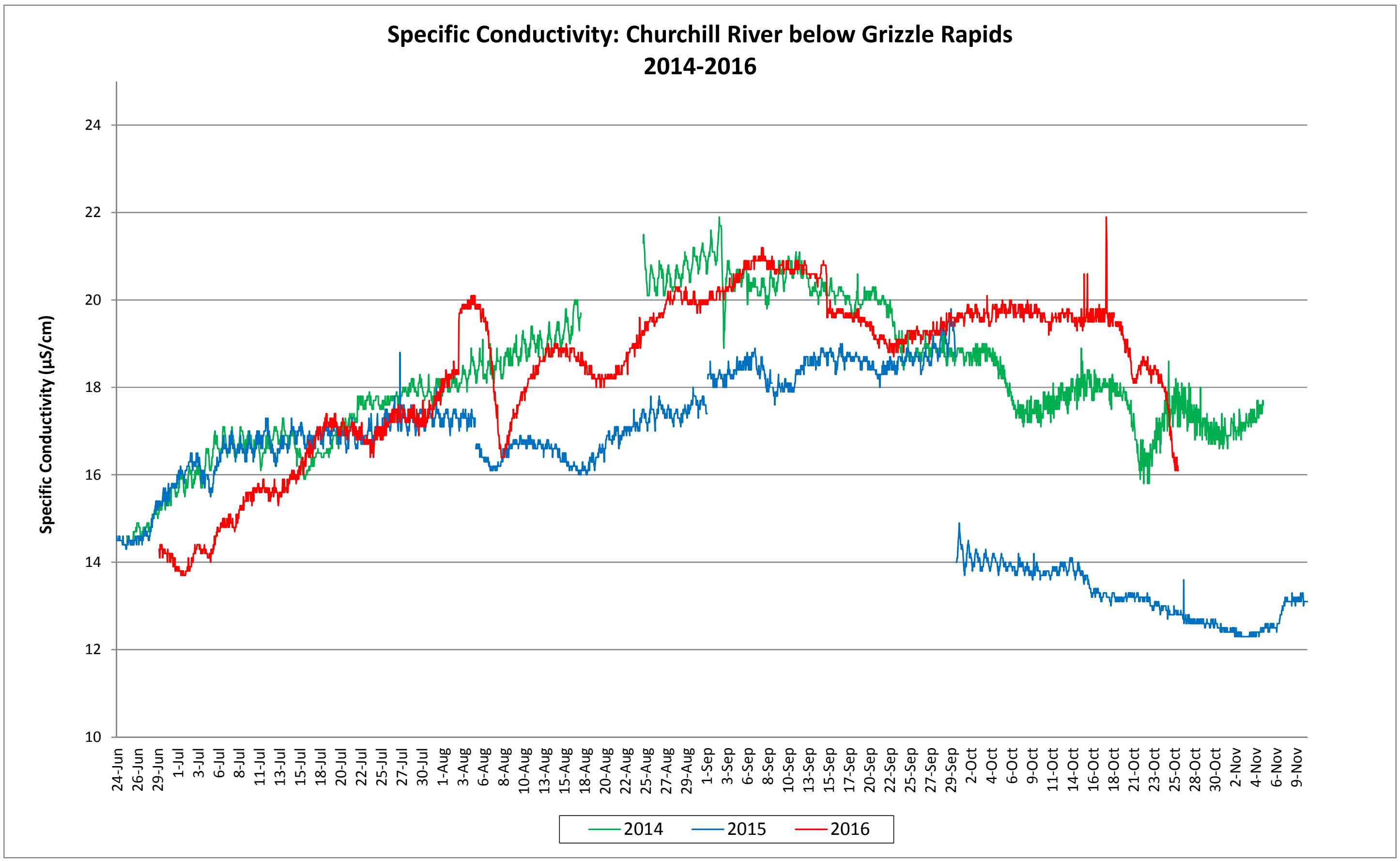


Figure 5: Specific conductivity at Churchill River below Grizzle Rapids

Specific Conductivity (µS/cm)	2016	2015	2014
Min	13.7	12.3	14.4
Max	21.9	19.8	21.9
Median	19.0	16.6	18.0

- During the 2016 deployment season, dissolved oxygen ranges from 9.03mg/l to 11.94mg/l, with a median value of 9.77mg/l, while percent saturation ranges from 91.5% to 103%, with a median value of 95.9% (Figure 6).
- Dissolved oxygen content shows a typical seasonal fluctuation in 2016, though the median value is slightly lower than during the previous two seasons. Dissolved oxygen content fluctuates regularly on a daily basis. Percent saturation is generally consistent throughout the deployment season.
- All values were above the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages (6.5 mg/l). During late July to early September, dissolved oxygen values hovered around the minimum CCME Guideline for the Protection of Aquatic life at Early Life Stages (9.5mg/l), coinciding with warm temperatures recorded at this time which decrease the amount of oxygen the water can hold. As air and water temperatures cool into the fall, the dissolved oxygen content increases above 9.5mg/l. The guidelines are indicated in red on Figure 6.
- Dissolved oxygen and percent saturation values are comparable to the data collected in 2014 and 2015.

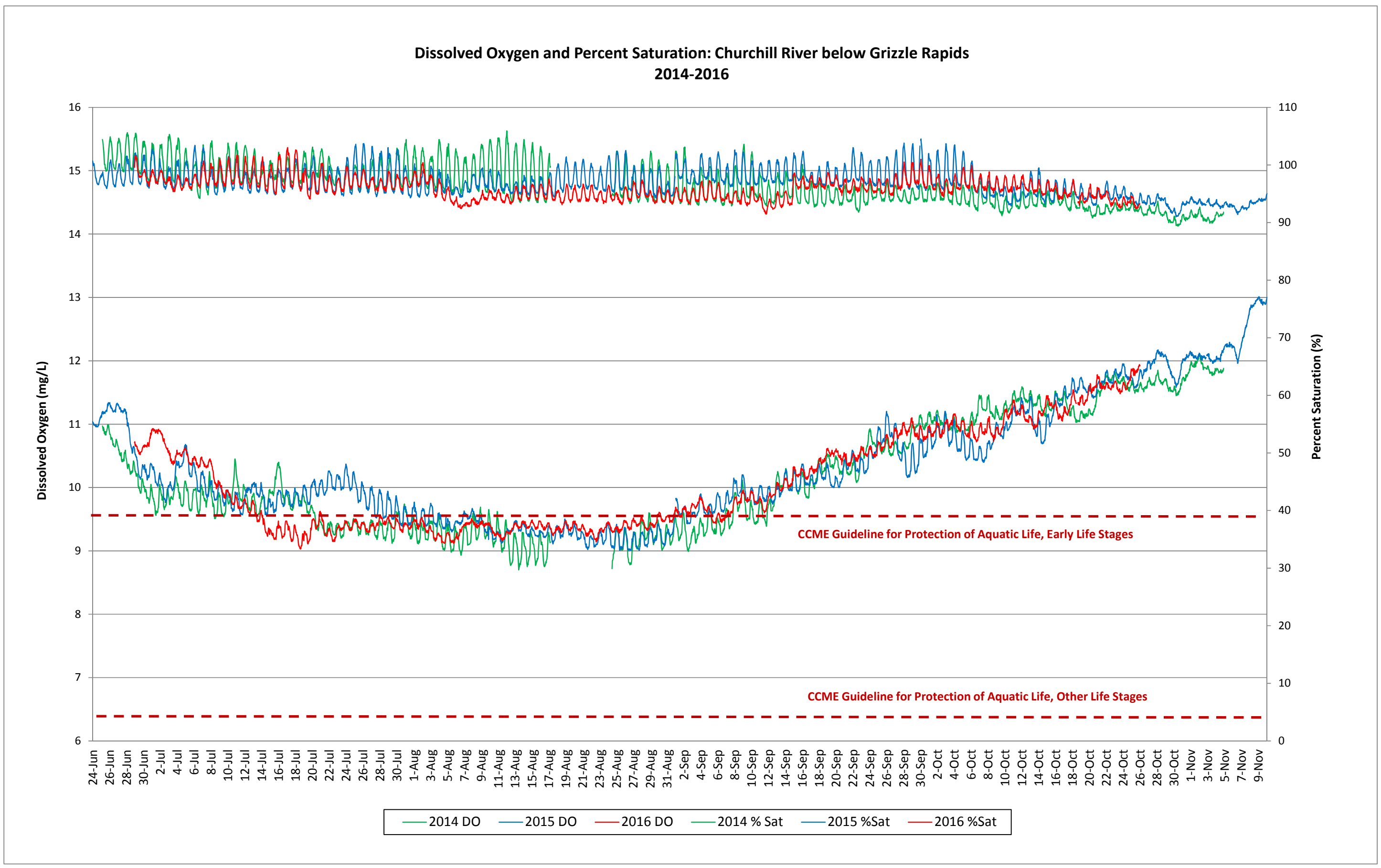


Figure 6: Dissolved oxygen and percent saturation at Churchill River below Grizzle Rapids

Dissolved Oxygen (mg/L)	2016	2015	2014		Percent Saturation	2016	2015	2014
Min	9.03	9.00	8.70		Min	91.5	91.0	89.4
Max	11.94	13.01	12.11		Max	103.0	104.5	105.9
Median	9.77	10.07	9.93		Median	95.9	96.7	95.8

- Turbidity generally remains near 0NTU for the majority of the 2016 deployment season (Figure 7). A median value of 0 NTU from 2014 to 2015 indicates there is no natural background turbidity value at this station. The slightly higher value for 2016 may be due to increases from precipitation events. Turbidity was fluctuating at this station in July and early August.
- There are a couple of instances where turbidity increases in 2016 to 26.5NTU. These are not considered water quality events as they are isolated and infrequent occurrences, likely caused by debris interfering with the turbidity sensor.
- Similar trends have been identified in the 2014 and 2015 datasets for this station.
- Water Survey of Canada (ECCC) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

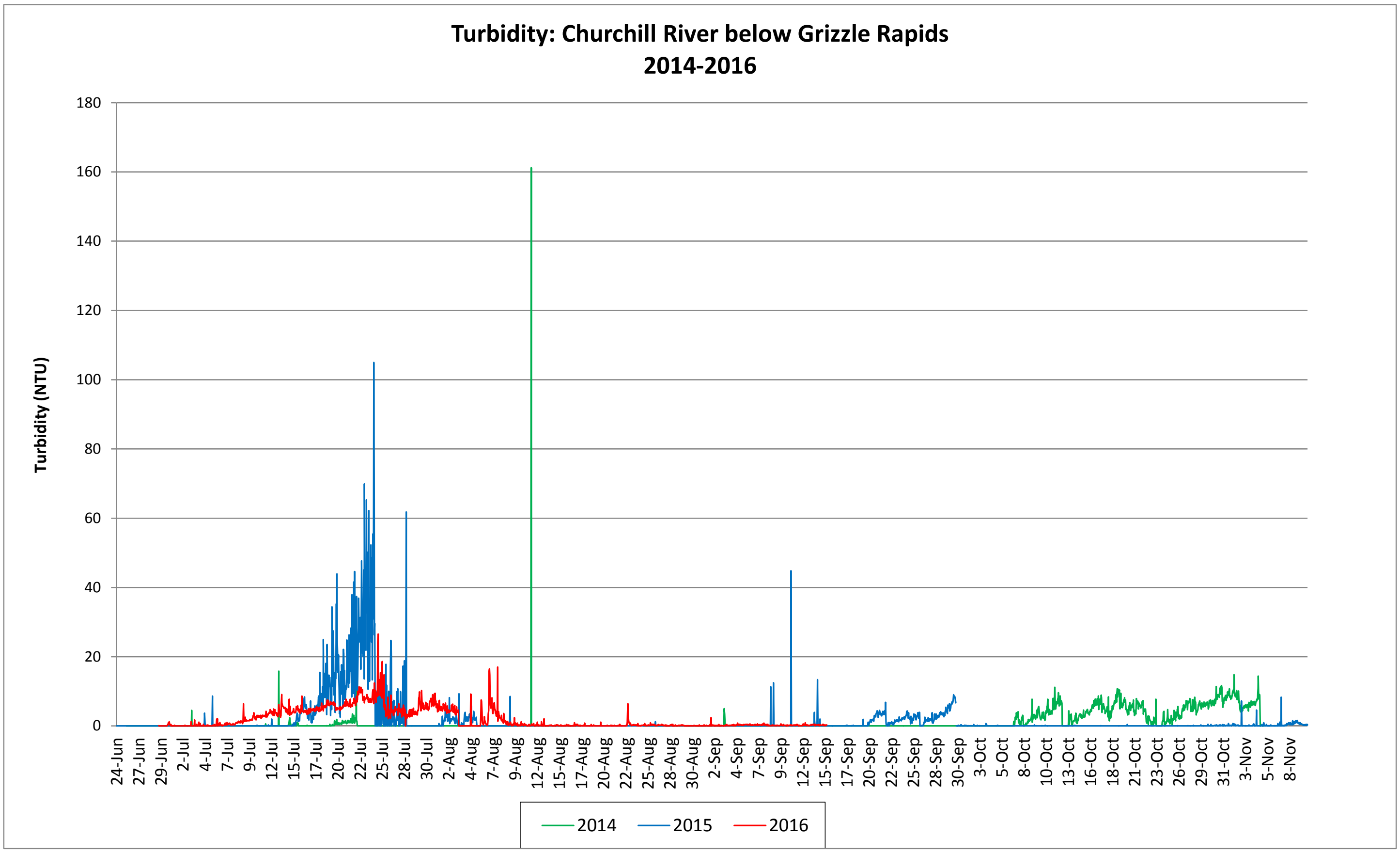


Figure 7: Turbidity at Churchill River below Grizzle Rapids

Turbidity (NTU)	2016	2015	2014
Min	0.0	0.0	0.0
Max	26.5	105.0	161.2
Median	0.3	0.0	0.0

- Stage levels in 2016 decreased after the spring freshet, before rising again due to precipitation events in July and August, with a maximum high reached after significant precipitation August 6/7. Stage remained relatively stable into the fall season and was on the rise at the end of deployment (Figure 8).
- Stage levels from 2014-2015 are graphed below to show how stage levels vary throughout the season and from year to year. The seasonal low of 2014 was reached in mid-August and was significantly lower than levels reached during the 2015 and 2016 seasons. The stage range for 2015 is larger overall at 1.584m, due to a large volume of water from the spring freshet. 2016 saw the largest summer increase in stage of the three year period.
- Water Survey of Canada (ECCC) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

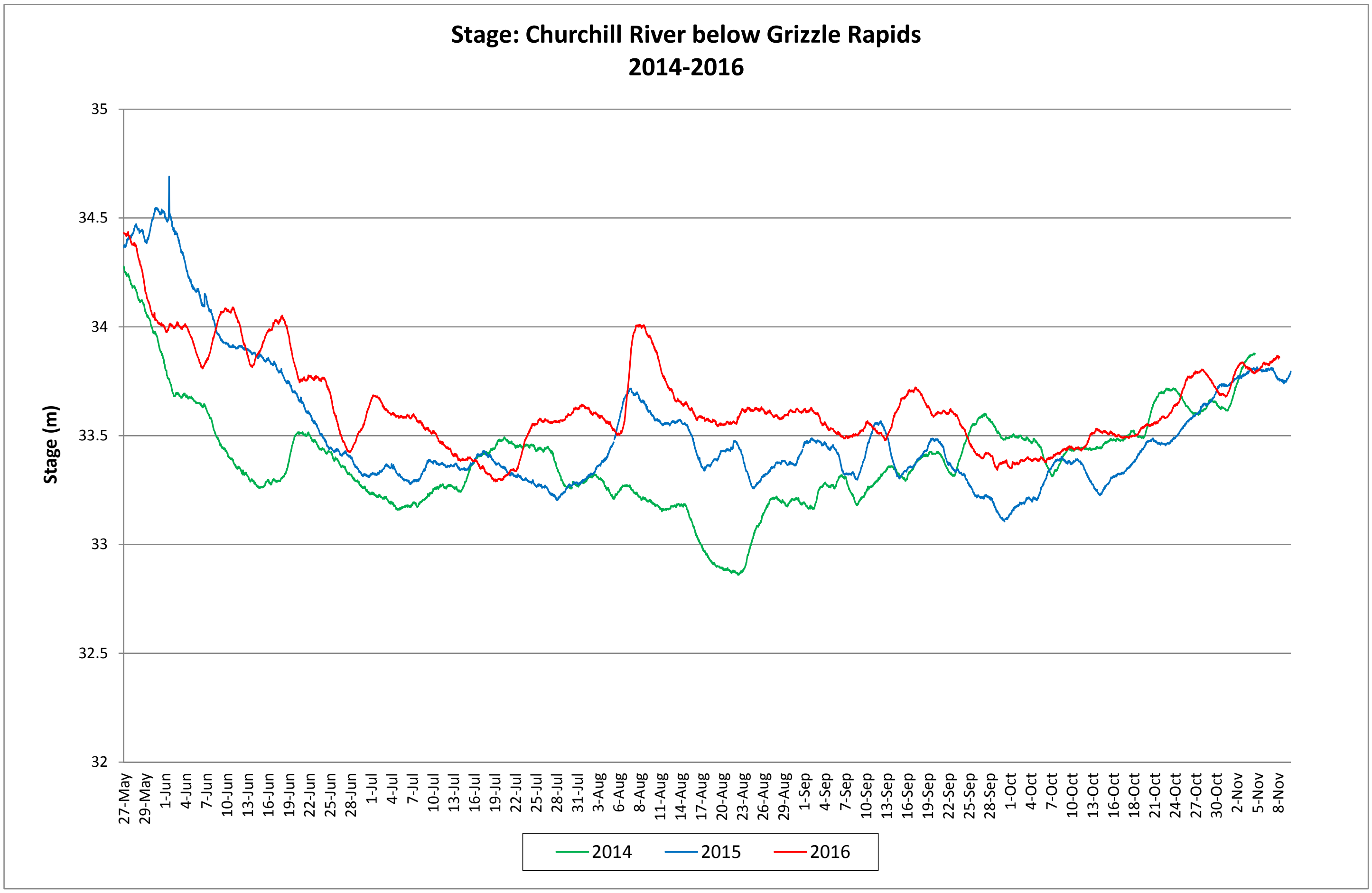


Figure 8: Stage level at Churchill River below Grizzle Rapids

Stage (m)	2016	2015	2014
Min	33.289	33.106	32.860
Max	34.436	34.690	34.278
Median	33.594	33.410	33.362
Range	1.147	1.584	1.418

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 9).
- Stage is decreasing in the first month of the deployment season, as expected after the spring freshet, reaching a seasonal low on July 19th. Stage then increases late July and early August after several large precipitation events before gradually decreasing into October. The majority of precipitation events in the fall were small and did not affect stage significantly. Water levels at this station do not fluctuate as greatly when compared to other stations in the network.
- Precipitation events are frequent and range from low to high in magnitude, with the largest event occurring over two days in early August and increasing the stage levels substantially.
- Water Survey of Canada (ECCC) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

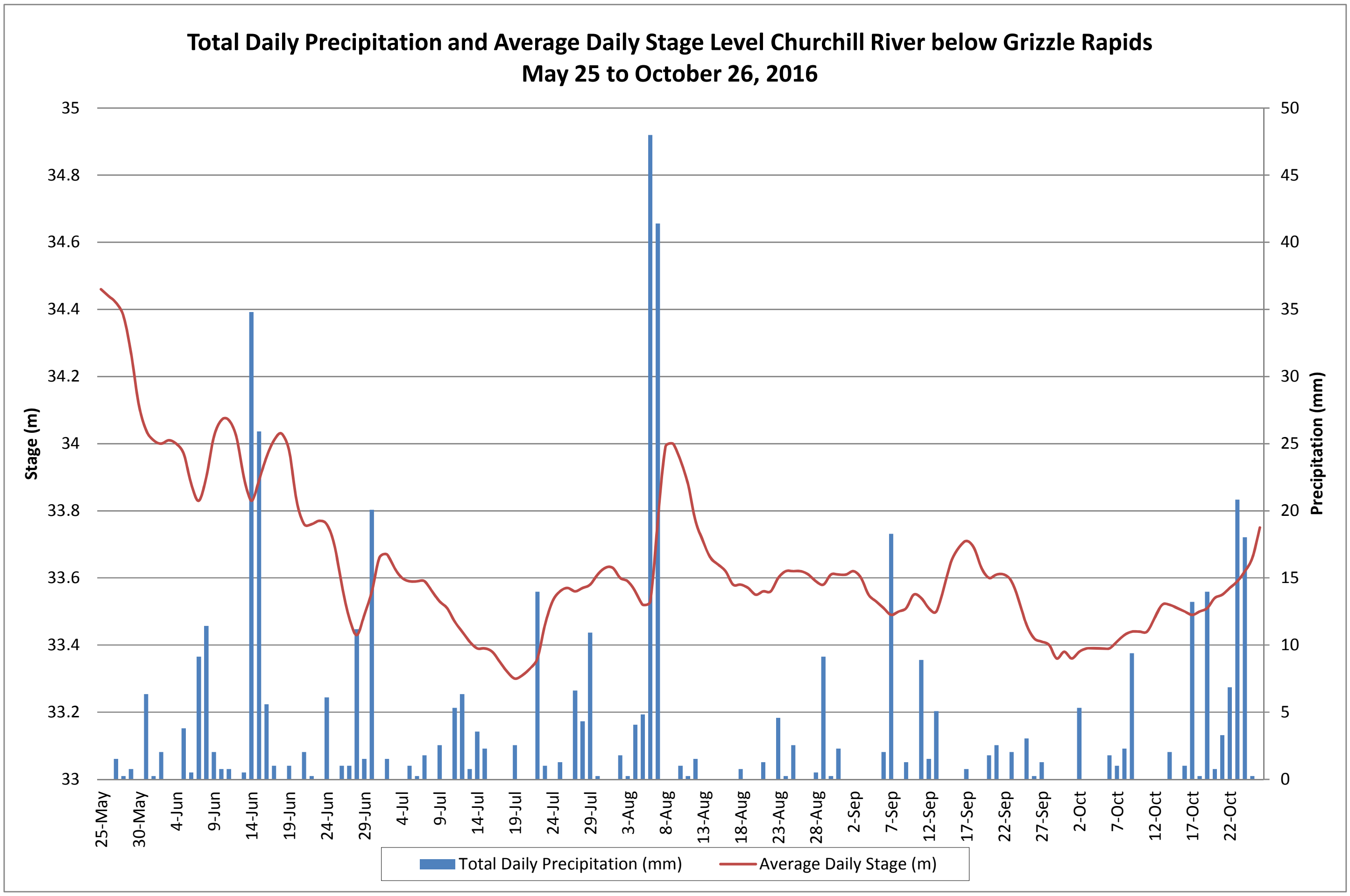


Figure 9: Daily precipitation and average daily stage level at Churchill River below Grizzle Rapids (weather data recorded at Muskrat Falls)

Churchill River above Muskrat Falls

- Water temperature ranges from 2.79°C to 20.08°C during the 2016 deployment season, with a median value of 13.35°C (Figure 10).
- Water temperatures appear slightly cooler at times in 2016, especially during the summer season, when compared to data collected in 2014 and 2015. Temperature in the fall months is on par to the previous years.

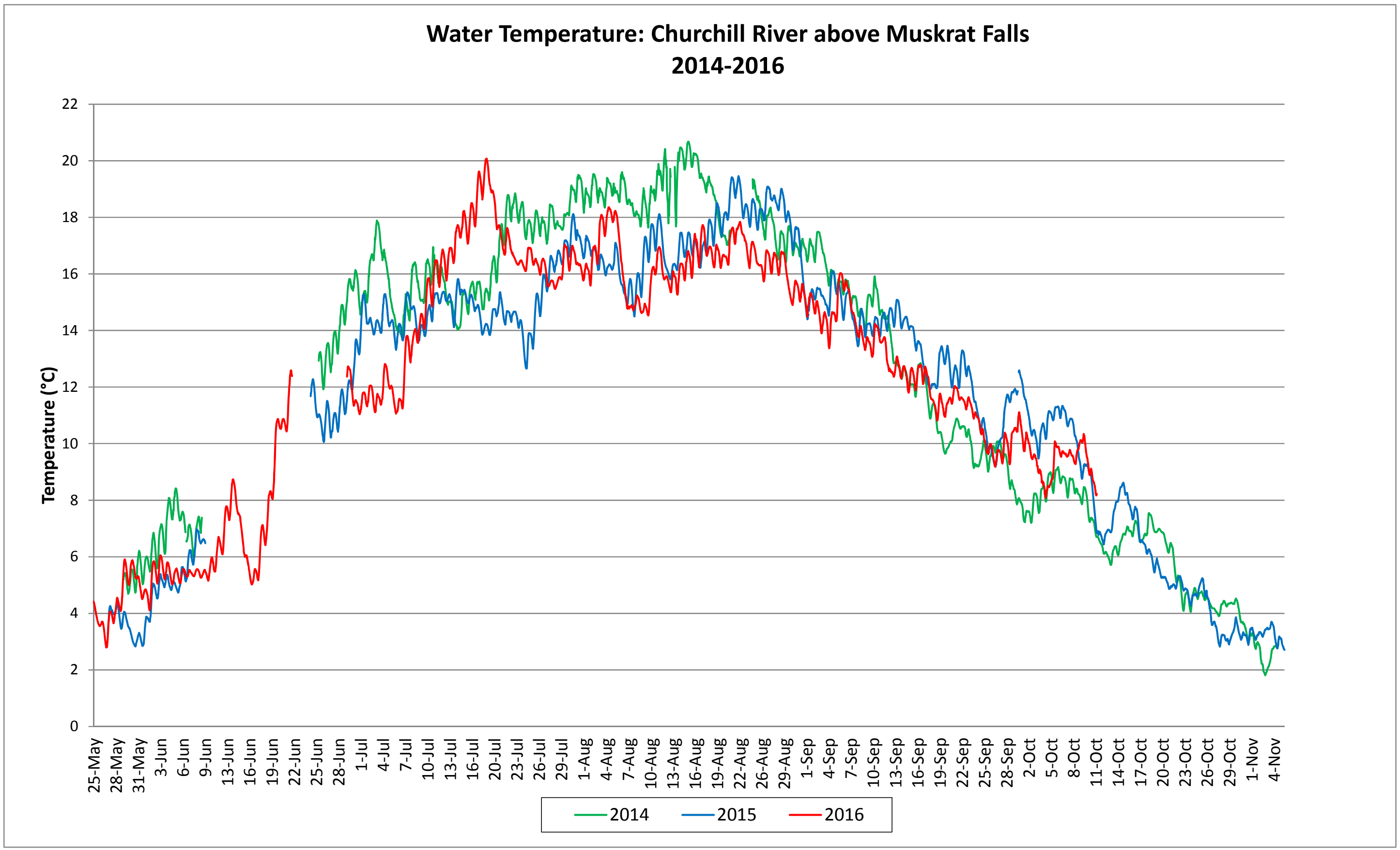


Figure 10: Water temperature at Churchill River above Muskrat Falls

Temperature	2016	2015	2014
Min	2.79	2.71	1.81
Max	20.08	19.46	20.68
Median	13.35	13.79	14.29

- Water temperature values show a typical seasonal trend (Figure 11). Average water and air temperatures are increasing throughout the spring and early summer before gradually declining again into the fall season.

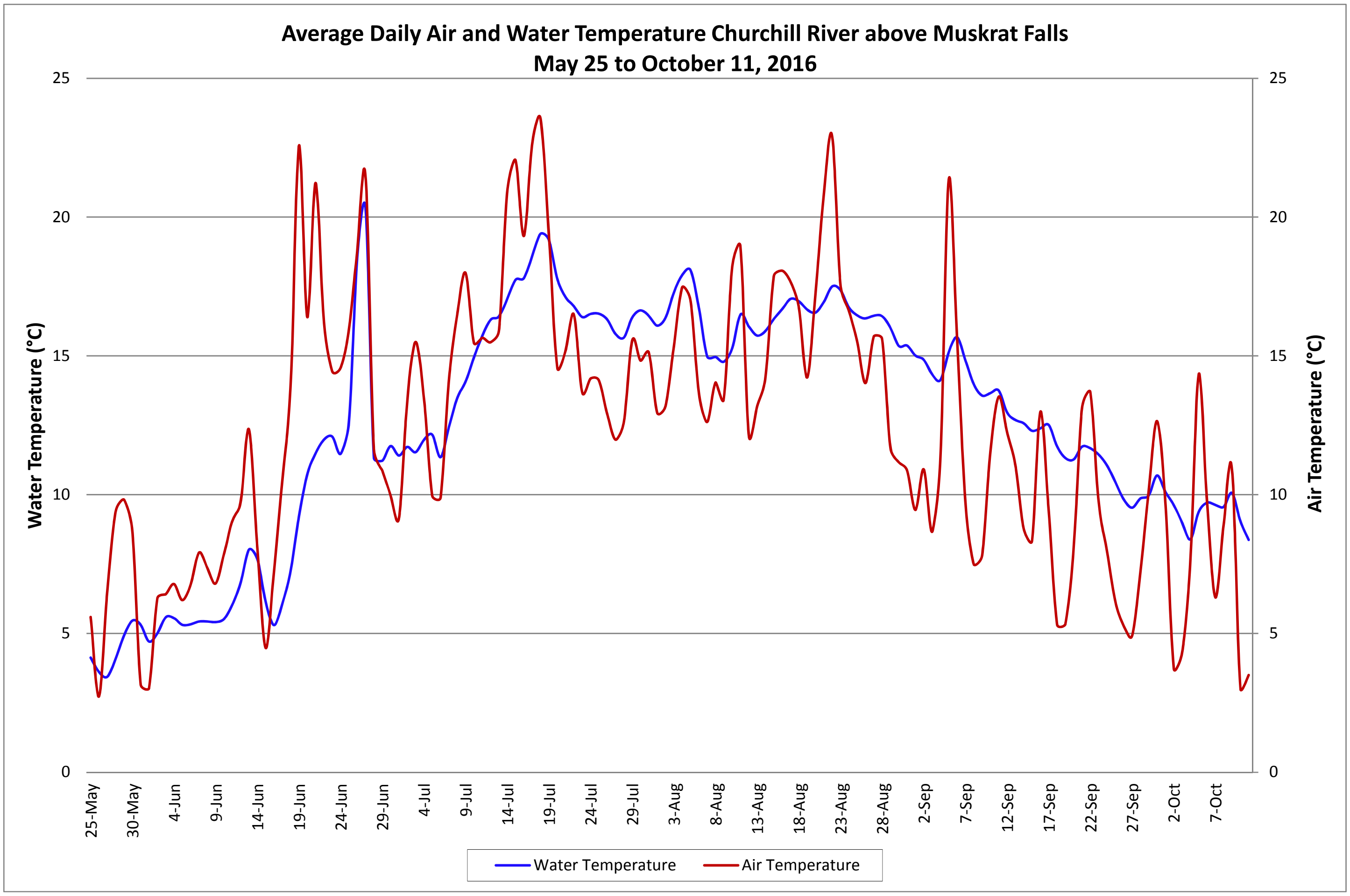


Figure 11: Average daily air and water temperatures at Churchill River above Muskrat Falls (weather data recorded at Muskrat Falls)

- pH ranges between 6.46 and 6.99 pH units during the 2016 deployment season, with a median value of 6.75 pH units (Figure 12). These values are noticeably lower than for each of the previous two years.
- pH values increased gradually throughout the deployment period. There are notable drops in pH, generally occurring after large precipitation events.
- All values during the 2016 deployment season are within the CCME Guidelines for the Protection of Aquatic Life (>6.5 and <9.0 pH units) except during a brief period August 8th after a two day rain event of 89.4mm.

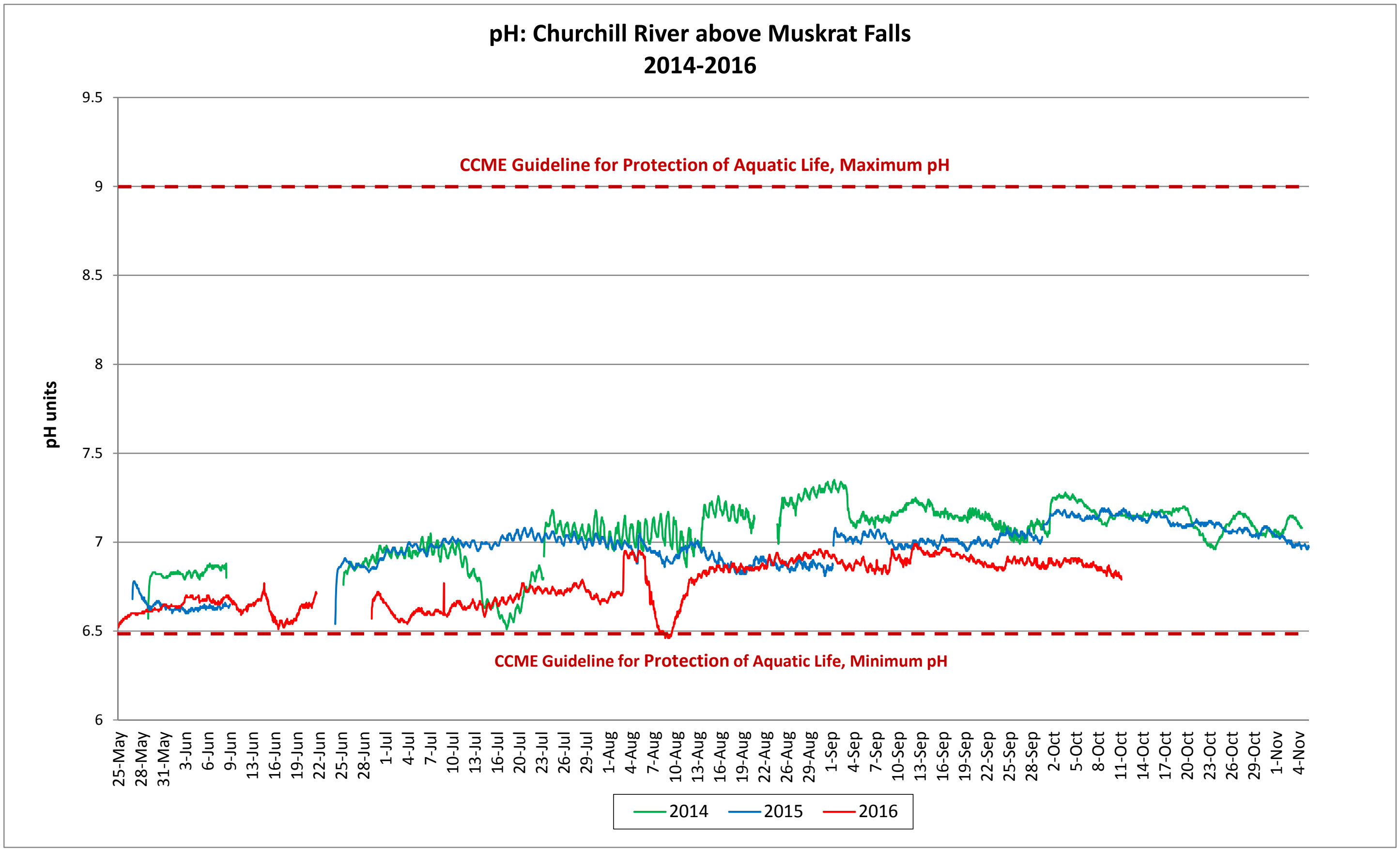


Figure 12: pH at Churchill River above Muskrat Falls

pH (units)	2016	2015	2014
Min	6.46	6.54	6.51
Max	6.99	7.19	7.35
Median	6.75	7.00	7.09

- Specific conductivity ranges from 9.3µS/cm to 22.9µS/cm during the 2016 deployment season, with a median value of 17.5µS/cm (Figure 13).
- Specific conductivity is increasing throughout the spring and most of the summer during 2016. Generally, specific conductivity does not vary greatly in the Lower Churchill River.
- Increases and decreases in specific conductivity are generally related to fluctuations in stage. As stage decreases, specific conductivity usually increases as the concentration of dissolved solids increases. Inversely, when stage increases, specific conductivity decreases due to the dilution of dissolved solids in the water column. A notable event of 89.4mm in early August is evident in 2016 as a rapid decline in conductivity.
- Data collected in 2014-2015 is similar in trend to the 2016 data, with a median value between the 2014 and 2015 median values.

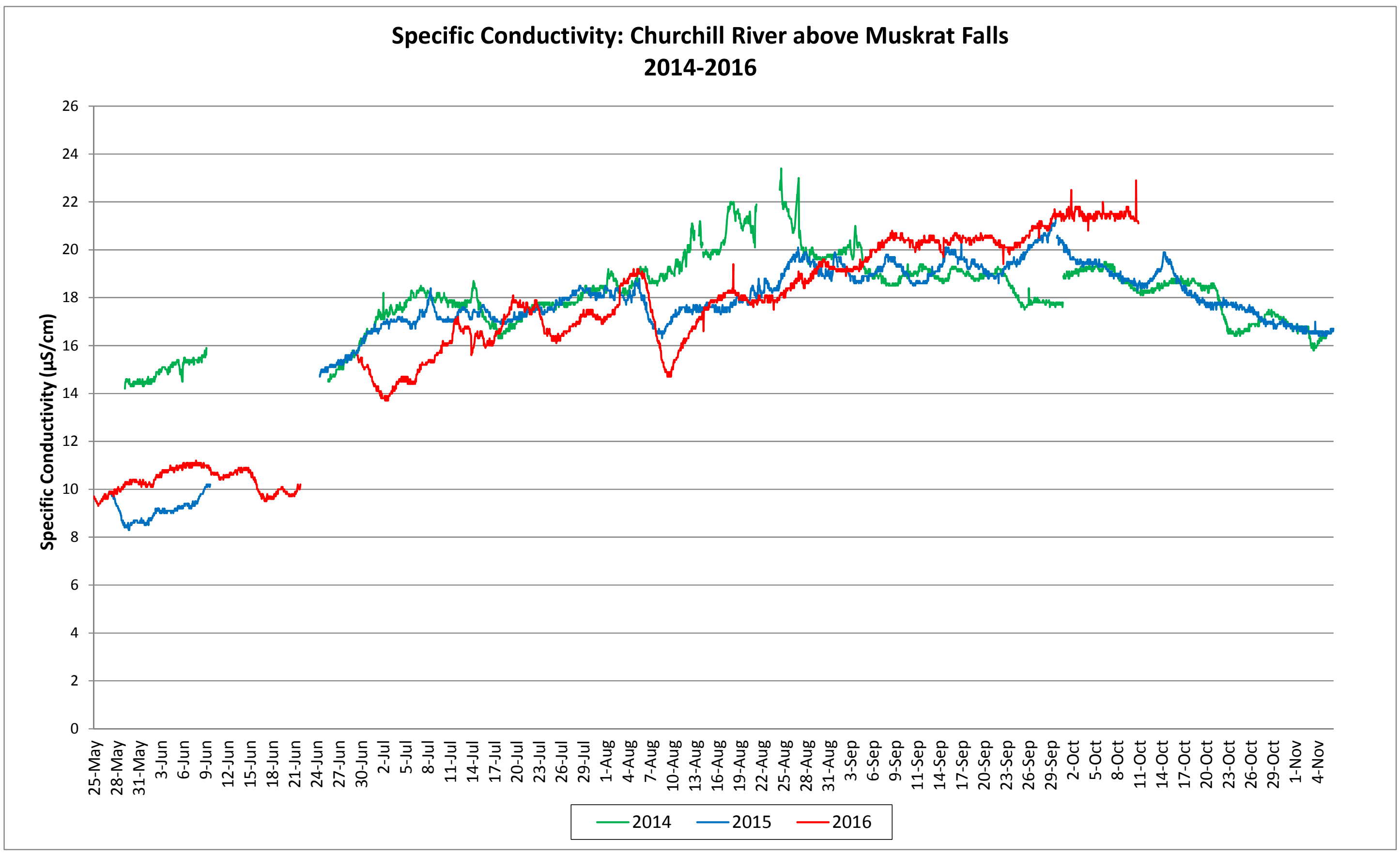


Figure 13: Specific conductivity at Churchill River above Muskrat Falls

Specific Conductivity (µS/cm)	2016	2015	2014
Min	9.3	8.3	14.2
Max	22.9	21.4	23.4
Median	17.5	17.8	18.3

- Throughout the 2016 deployment season, dissolved oxygen ranges from 9.01mg/l to 12.80mg/l, with a median value of 9.99mg/L, while percent saturation ranges from 92.2% to 102.8%, with a median value of 96.8% (Figure 14).
- Dissolved oxygen content shows a typical seasonal fluctuation in 2016 and is similar to data collected in previous years. Dissolved oxygen content fluctuates regularly on a daily basis and is lower during the summer (July-August). This corresponds to warmer temperatures during this time period, which decreases the amount of oxygen present in the water. Percent saturation is consistent throughout the season.
- All values were above the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages (6.5 mg/l). For the months of July and August, dissolved oxygen values hovered around the minimum CCME Guideline for the Protection of Aquatic life at Early Life Stages (9.5mg/l). In early September as air and water temperatures cool, the dissolved oxygen content increases above 9.5mg/l. The guidelines are indicated in red on Figure 14.
- Dissolved oxygen and percent saturation values are similar to data collected in 2014 and 2015.

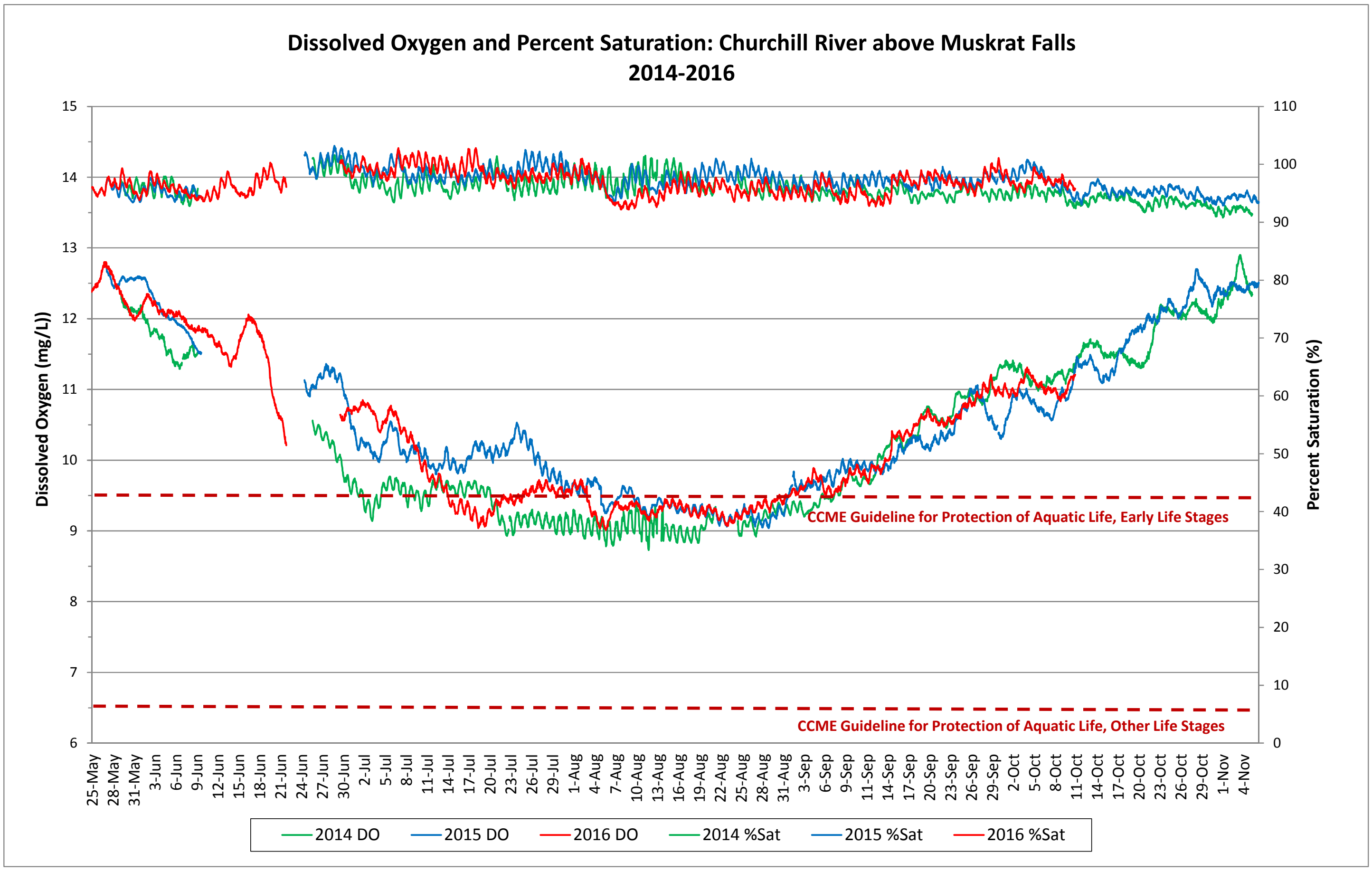
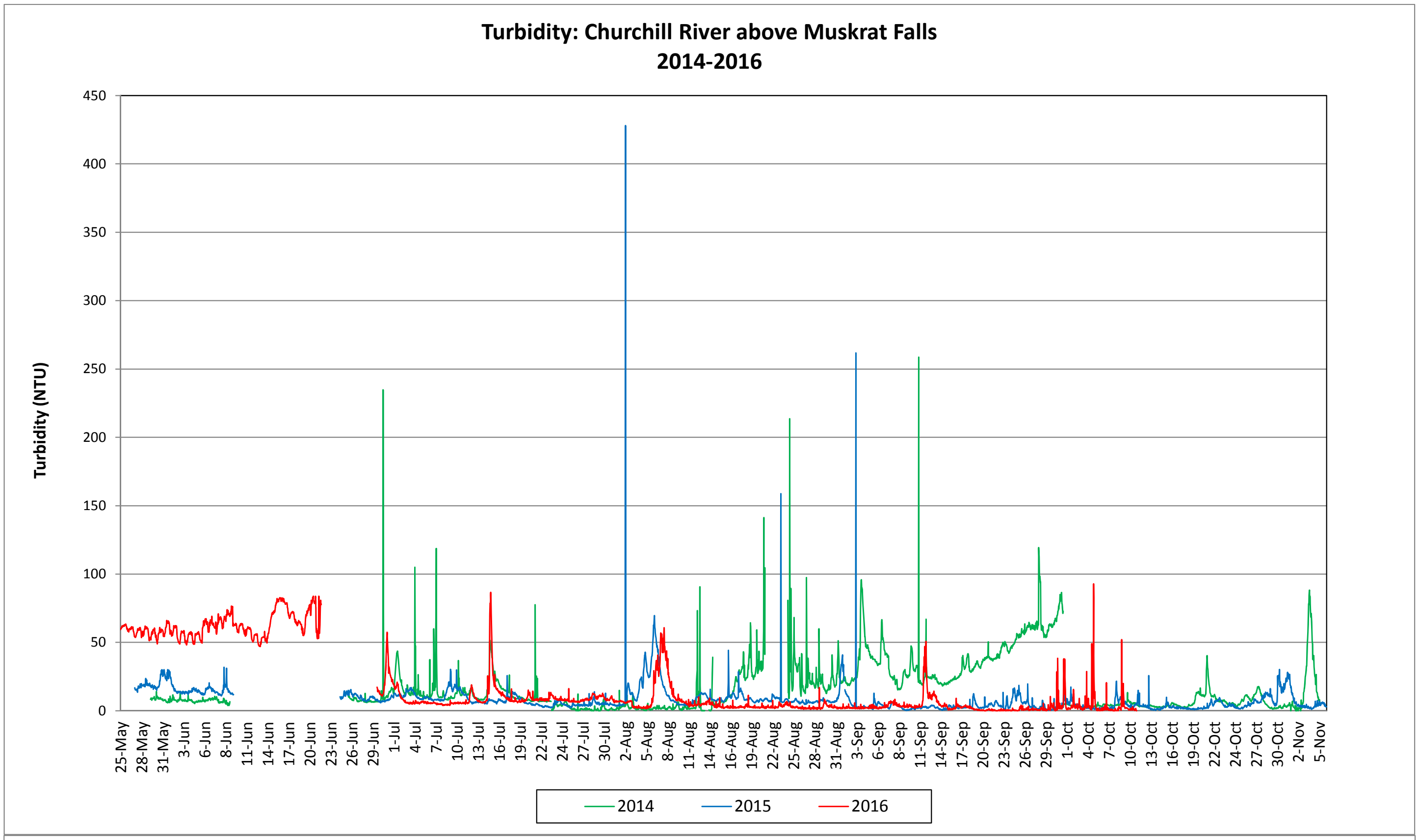


Figure 14: Dissolved oxygen and percent saturation at Churchill River above Muskrat Falls

Dissolved Oxygen (mg/L)	2016	2015	2014		Percent Saturation	2016	2015	2014
Min	9.01	9.04	8.73		Min	92.2	92.9	90.8
Max	12.80	12.77	12.90		Max	102.8	103.2	101.6
Median	9.99	10.24	9.76		Median	96.8	97.2	95.5

- The majority of turbidity values (95%) were <67.1NTU during the 2016 deployment season (Figure 15 a & b). A median value of 5.9NTU indicates there is consistent natural background turbidity at this station. Turbidity values from 2014 to 2016 are depicted in Figures 15 a & b.
- Figure 15a shows data on a scale up to 450NTU. On a number of occasions in 2016, turbidity increased above median background levels for short periods of time throughout the deployment season, to as high as 92.8NTU. 2016 values are notably lower than those from the previous two years. The turbidity during the first deployment was notably higher than during the following deployment, likely due to suspension of sediment around the sonde in shallow water as stage decreased rapidly during this period. The sonde was out of the water June 22 to June 29 due to rapidly dropping water levels.
- Figure 15b shows data at a smaller scale, focusing on the regular consistent background levels, below 70NTU. In the 2016 season, the median value was calculated to be 5.9NTU and the 95th percentile value was 67.1NTU. When data from all years is combined (2014 to 2016), the median value increases to 7.0NTU and the 95th percentile is 60.1NTU.

Turbidity (NTU)	2016	2015	2014	2014-16
Min	0	0.3	0	0
Max	92.8	428	258.7	428
Median	5.9	6.3	9	7
95%	67.1	20.01	58.1	60.1
75%	19.5	10.5	23.4	14.5



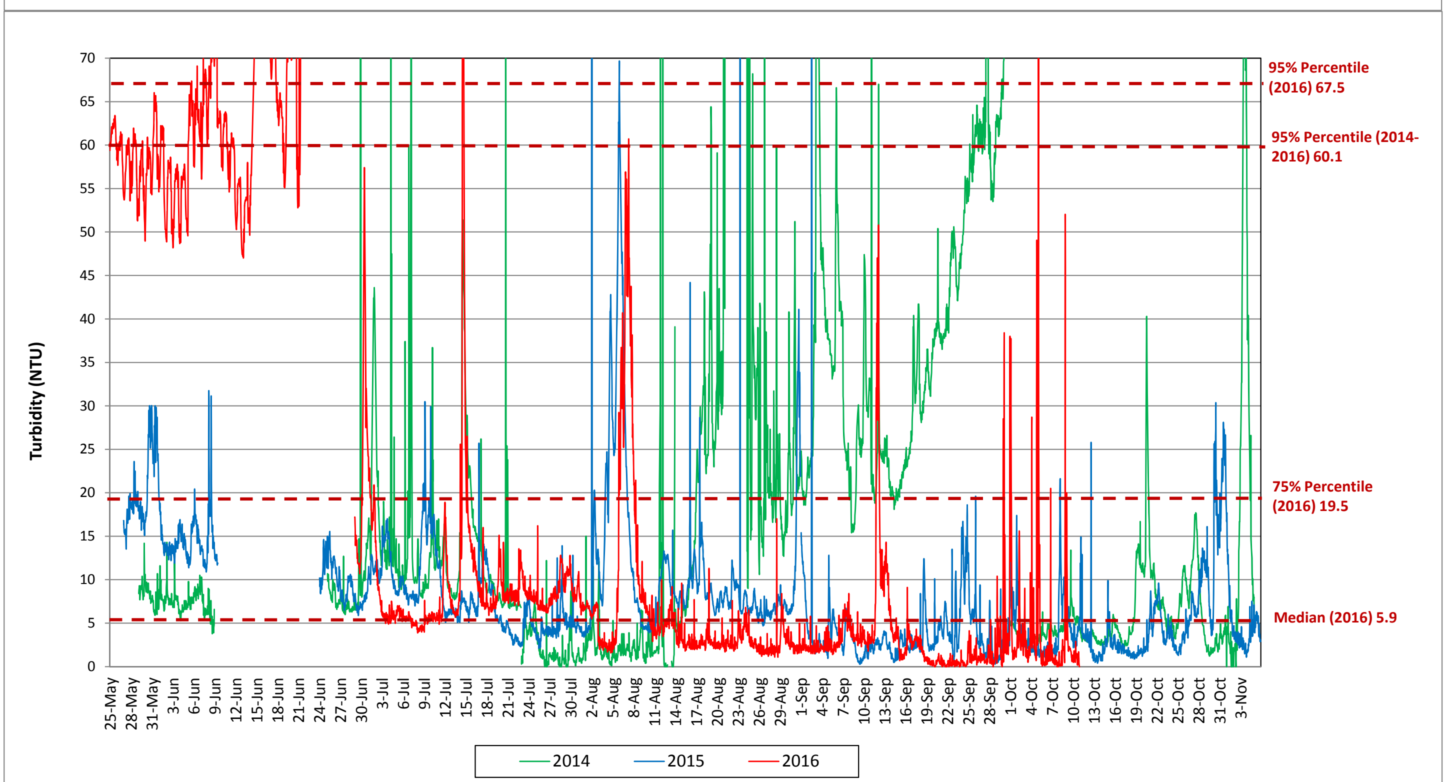


Figure 15a (top): Turbidity to 450NTU at Churchill River above Muskrat Falls
Figure 15b (bottom): Turbidity to 70NTU at Churchill River above Muskrat Falls

- Stage levels in 2016 decrease in the spring and summer months reaching a seasonal low in late July before increasing again due to summer precipitation events (Figure 16).
- Stage levels from 2014-2016 are graphed below to show how stage levels vary throughout the season and from year to year. The 2016 seasonal low was reached much earlier in the season than in 2014 and 2015. The 2016 season also saw a high summer stage reached that was much higher than in the previous two years. Stage ranges between 3.00m and 3.94m each year.
- Water Survey of Canada (ECCC) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

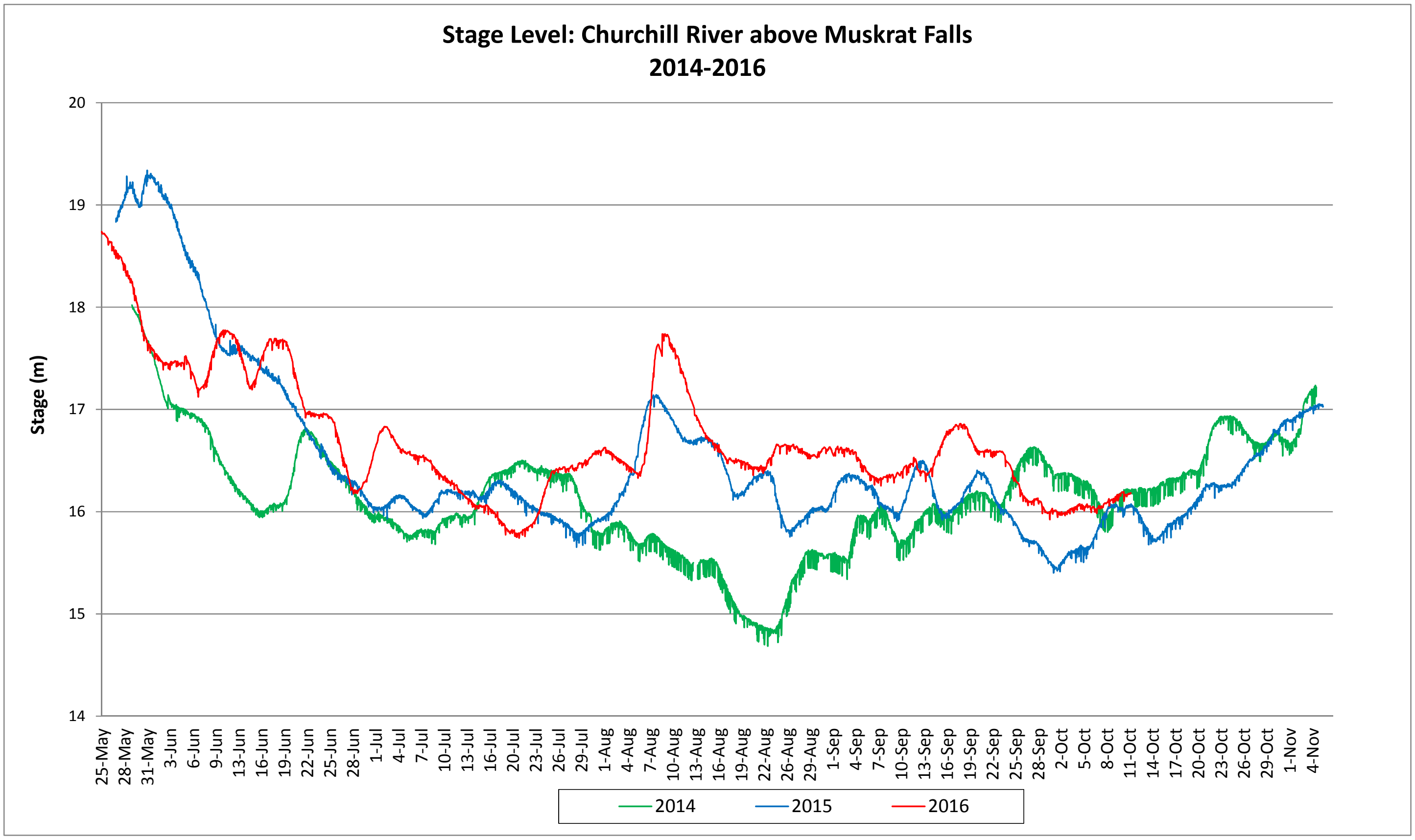


Figure 16: Daily stage level at Churchill River above Muskrat Falls

Stage (m)	2016	2015	2014
Min	15.743	15.041	14.685
Max	18.738	19.339	18.021
Median	16.555	16.217	16.12
Range	2.995	3.938	3.336

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 17).
- Stage is generally decreasing in the first half of the deployment season, reaching a low in late July before increasing into late summer and early fall due to numerous precipitation events, then falling again in late September.
- Precipitation events are frequent and range from low to high in magnitude.
- Water Survey of Canada (ECCC) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

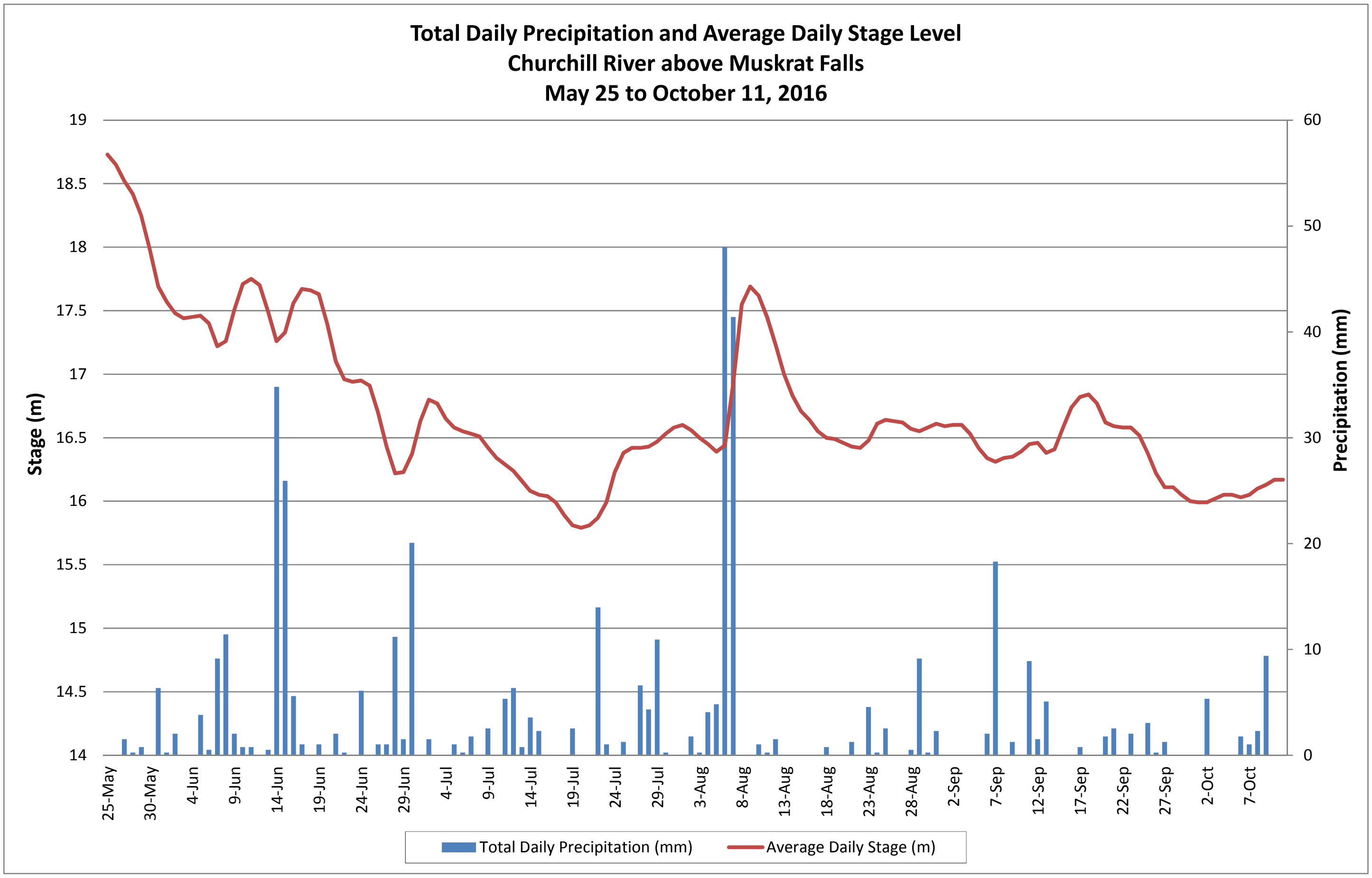


Figure 17: Daily precipitation and average daily stage level at Churchill River above Muskrat Falls (weather data recorded at Muskrat Falls)

Churchill River below Muskrat Falls

- During the 2014 and 2015 deployment seasons, the below Muskrat Falls station experienced sediment issues. The riverbed and shoreline significantly changed from a rocky composition to mainly sand which ended up burying the instrument and causing damage to the sensors. In addition, in the winter of 2014 large amounts of ice shifted the helicopter landing pad and hut.
- Subsequent deployment trips were able to avail of the shifting sand which had created a 'beach area', allowing the helicopter to land at the water's edge When the instrument was not deployed a grab sample was taken instead at the location to provide some information in the data gap period.
- The instrument was not redeployed from August 2014 until September 2015 when the shoreline saw a reappearance of a rocky substrate which is more ideal for deployment of the instrument. Water quality instrumentation was deployed at the station in 2016 from June 30 to November 8.
- The photos below show the evolution of the shoreline at the below Muskrat Falls station between 2014 and 2016 (Figure 18-22).

Figure 18: August 2014

Figure 19: May 2015

Figure 20: September 2015

Figure 21: May 2016

Figure 22: August 2016

- Water temperature ranges from 2.90°C to 19.90°C during the 2016 deployment season, with a median value of 13.10°C (Figure 23).
- Significant amounts of data are missing from the 2014 and 2015 season due to sediment conditions at the station below Muskrat Falls.
- Fall temperatures at this station are slightly higher than in 2015, though data for 2014 and 2015 is limited (Figure 23).

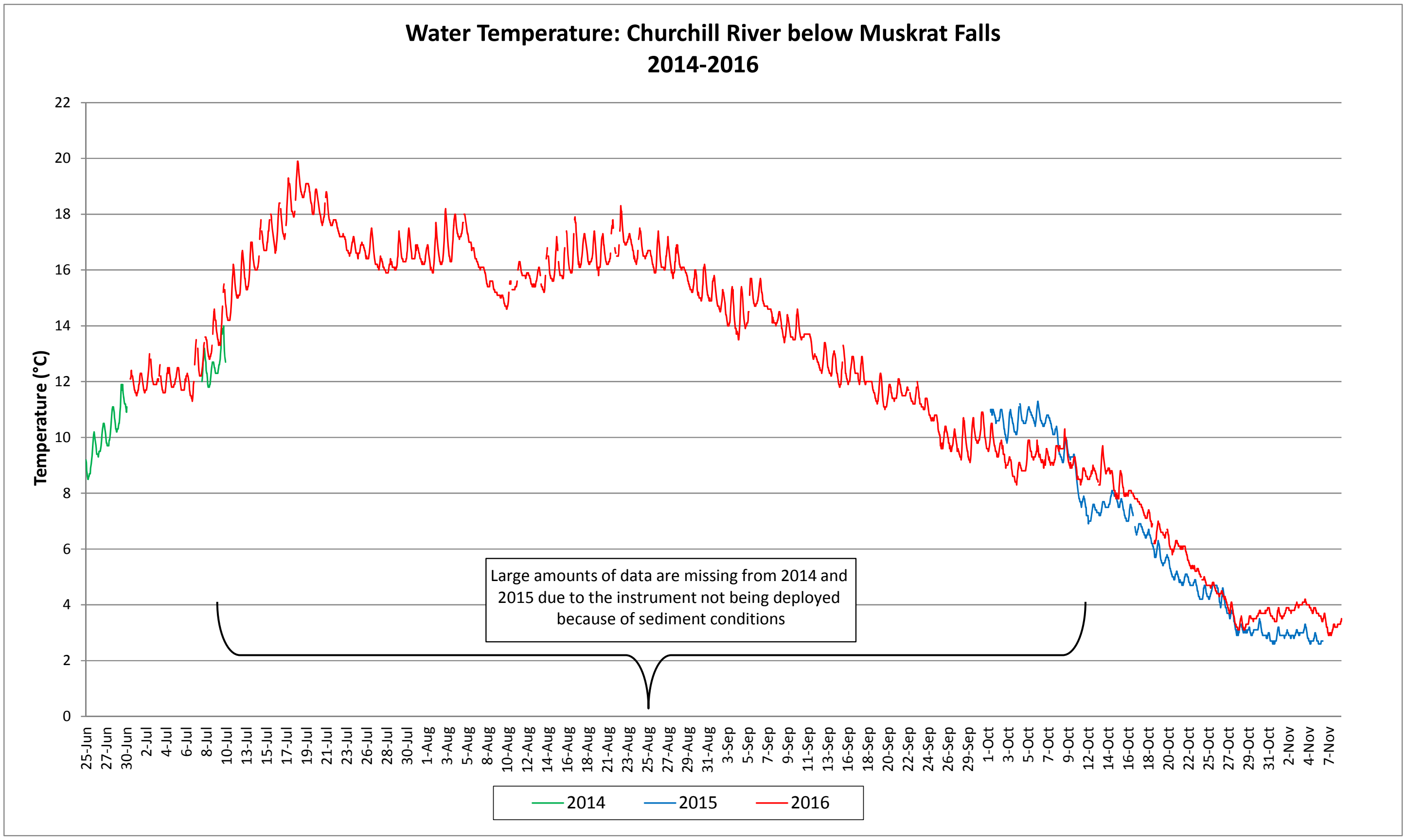


Figure 23: Water temperature at Churchill River below Muskrat Falls

Temperature	2016	*2015	*2014
Min	2.9	2.6	8.5
Max	19.9	16.4	14
Median	13.1	10.4	10.9

***data set not complete cannot be compared to previous years**

- Water temperature values show a typical seasonal trend (Figure 24). Average water and air temperatures are increasing into the summer before gradually declining again into the fall season.

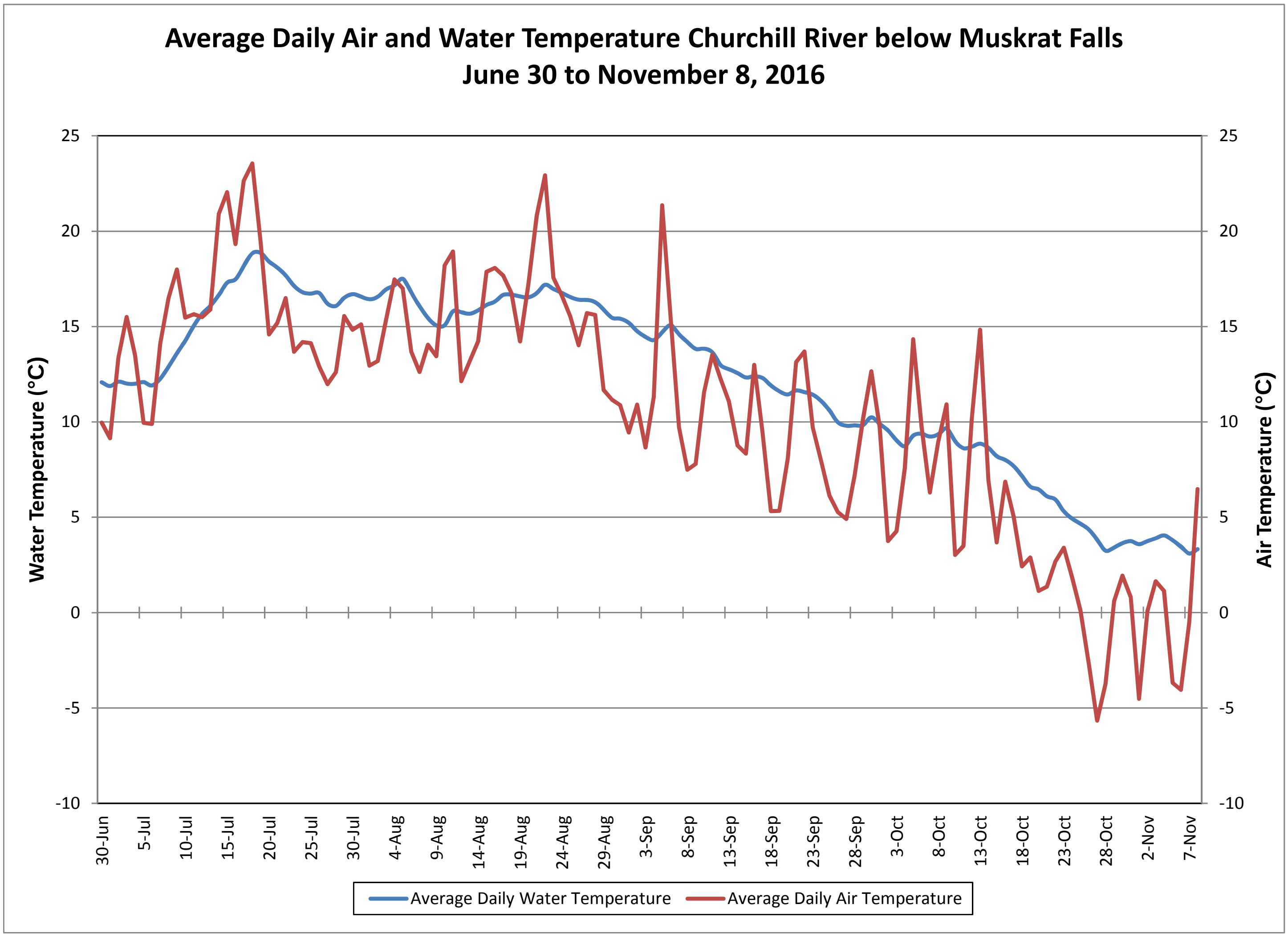


Figure 24: Average daily air and water temperatures at Churchill River below Muskrat Falls (weather data recorded at Muskrat Falls)

- pH ranges between 5.08 and 7.26 pH units during the 2016 deployment season, with a median value of 6.54 pH units (Figure 25). These values are noticeably lower than for each of the previous two years, though this data is limited.
- There are notable drops in pH, generally occurring after large precipitation events. pH was gradually increasing into July, before starting a downward trend July 31. Significant precipitation August 6/7 lowered pH for a brief period of time. Several downtrends at the end of deployment periods may be due to sensor drift.
- Significant amounts of data are missing from the 2014 and 2015 season due to sediment conditions at the station below Muskrat Falls (Figure 25).
- With a median value of 6.54 pH units, about half of the values recorded during the 2016 deployment season are within the CCME Guidelines for the Protection of Aquatic Life (>6.5 and <9.0 pH units). The other half of the data drops below the minimum pH guideline, likely due to influence from precipitation and sensor drift after large precipitation events.

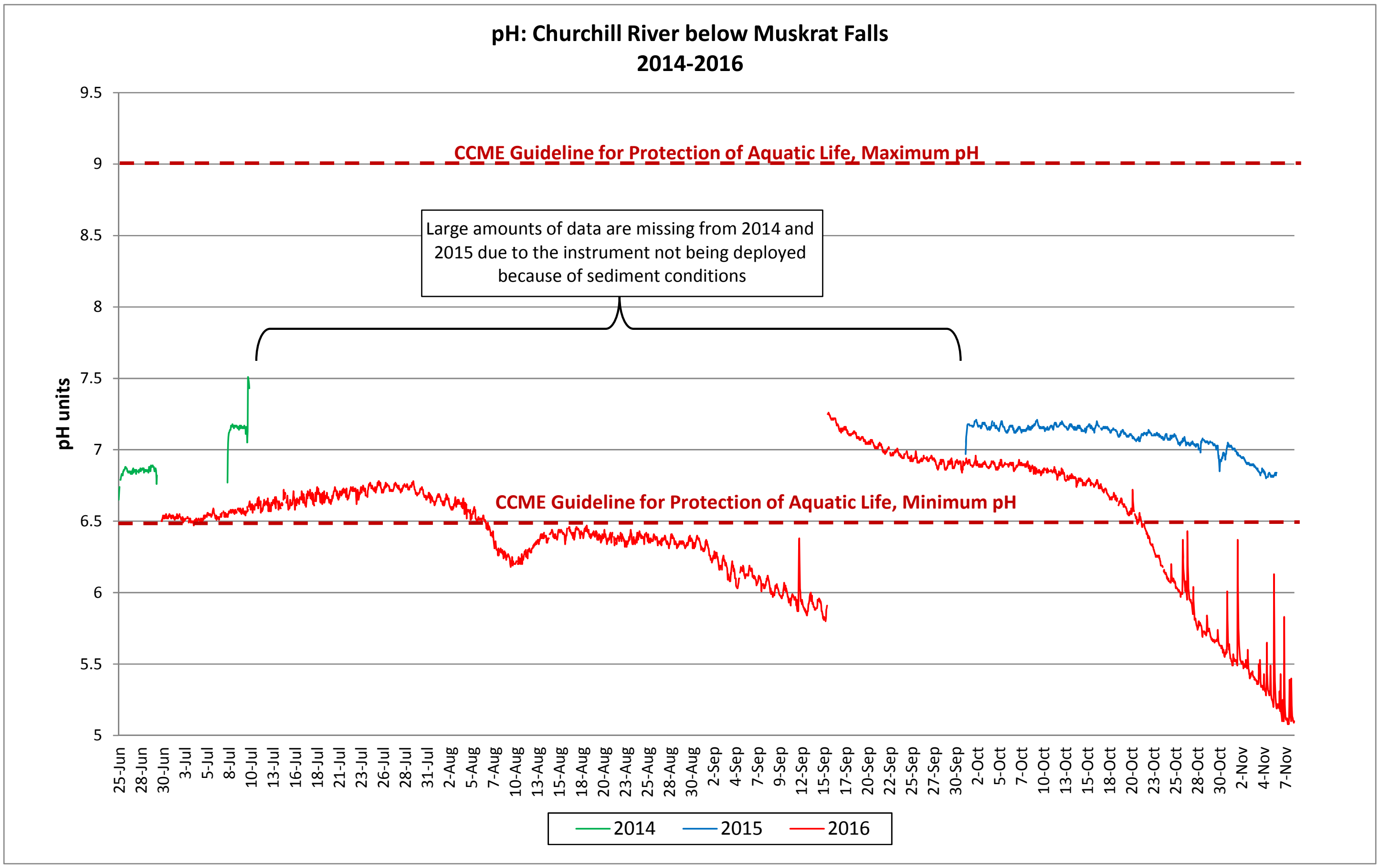


Figure 25: pH at Churchill River below Muskrat Falls

pH (units)	2016	*2015	*2014
Min	5.08	6.80	6.65
Max	7.26	7.29	7.51
Median	6.54	7.13	6.87

***data set not complete cannot be compared to previous years**

- Specific conductivity ranges from 14.0µS/cm to 20.7µS/cm during the 2016 deployment season, with a median value of 17.3µS/cm (Figure 26).
- Specific conductivity is gradually increasing throughout the spring and most of the summer during 2016. Generally, specific conductivity does not vary greatly in the Lower Churchill River. The low variance in values in indicative of this.
- Increases and decreases in specific conductivity are generally related to fluctuations in stage. As stage decreases, specific conductivity usually increases as the concentration of dissolved solids increases. Inversely, when stage increases, specific conductivity decreases due to the dilution of dissolved solids in the water column. A notable event of 89.4mm in early August is evident in 2016 as a rapid decline in conductivity.
- The limited data available from 2014-2015 is similar in trend to the 2016 data.

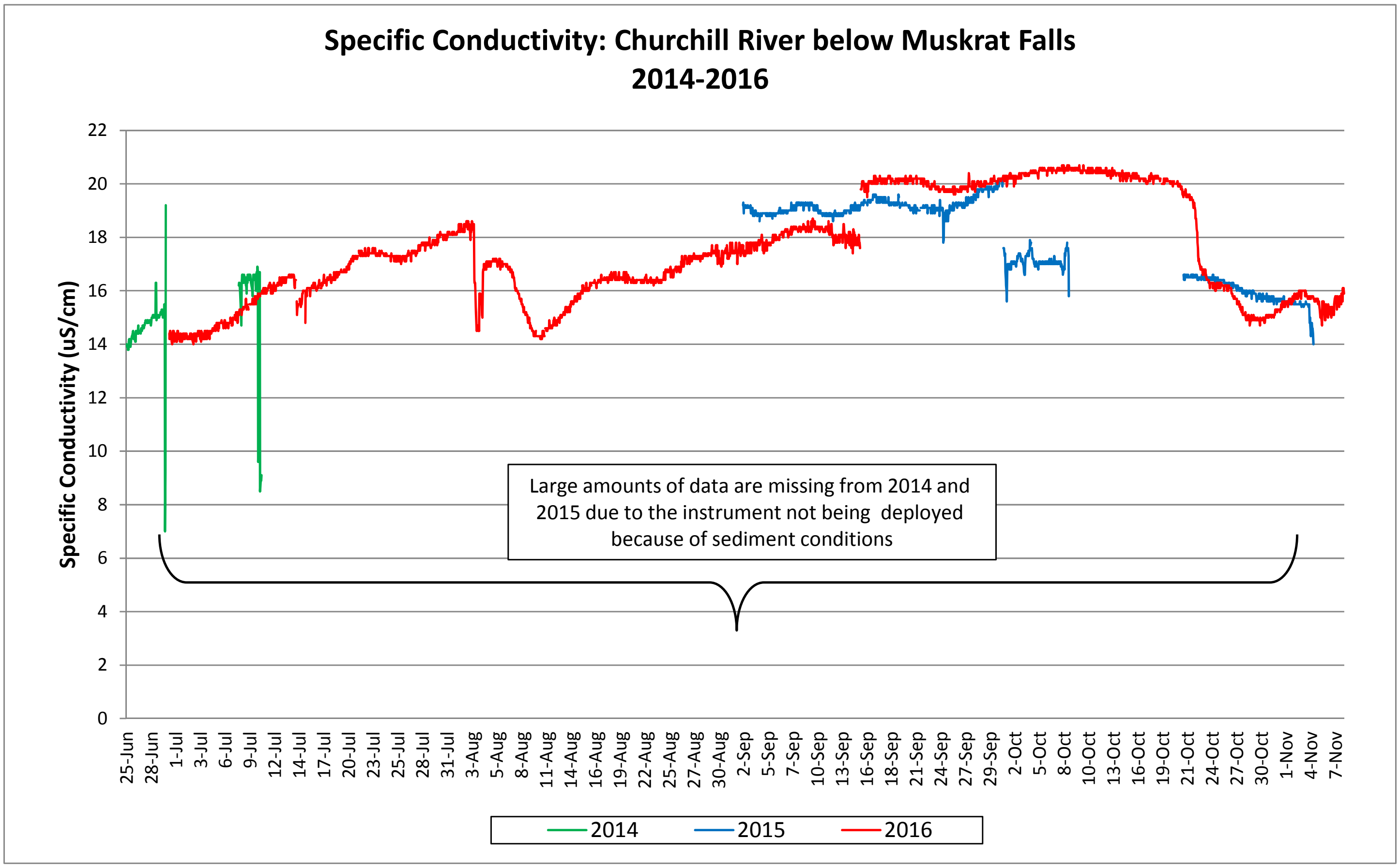


Figure 26: Specific conductivity at Churchill River below Muskrat Falls

Specific Conductivity (µS/cm)	2016	*2015	*2014
Min	14	14	7
Max	20.7	20.1	19.2
Median	17.3	18.9	15

***data set not complete cannot be compared to previous years**

- Throughout the 2016 deployment season, dissolved oxygen ranges from 9.78mg/l to 14.99mg/l, with a median value of 11.85mg/L, while percent saturation ranges from 101.2% to 123.3%, with a median value of 112.3% (Figure 27).
- Significant amounts of data are missing from the 2014 and 2015 season due to sediment conditions at the station below Muskrat Falls (Figure 27).
- Dissolved oxygen content shows a typical seasonal fluctuation in 2016 and is similar to the limited data collected in 2014-2015. Dissolved oxygen content fluctuates regularly on a daily basis and is lower during the summer (July-August). This corresponds to warmer temperatures during this time period, which decreases the amount of oxygen present in the water. Percent saturation is consistent throughout the season.
- There were noticeable drops in dissolved oxygen on August 6th, September 12th and October 23rd.
- All values were above the minimum CCME Guideline for the Protection of Cold Water Biota at Early and Other Life Stages as indicated in red on Figure 27.

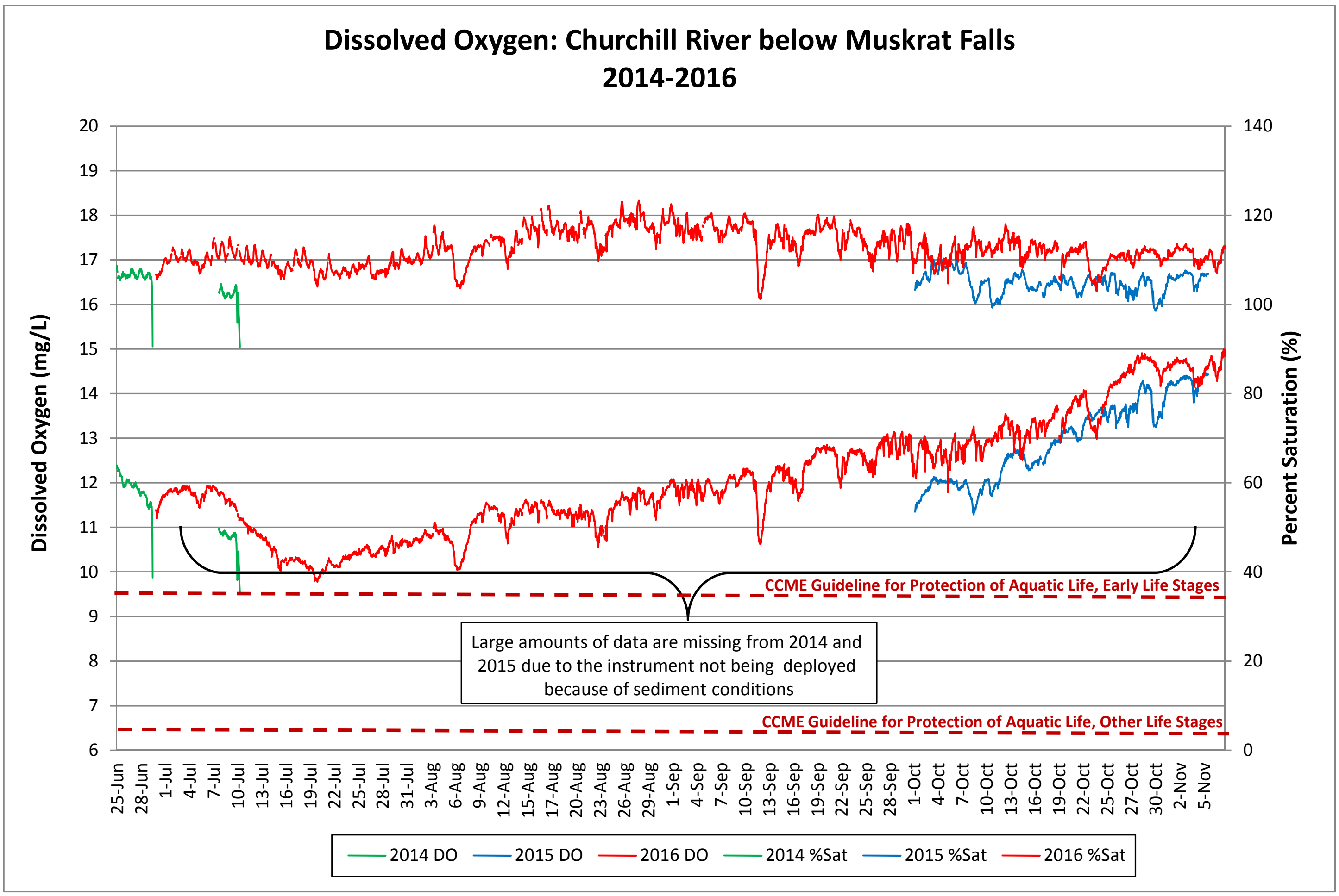


Figure 27: Dissolved oxygen and percent saturation at Churchill River below Grizzle Rapids

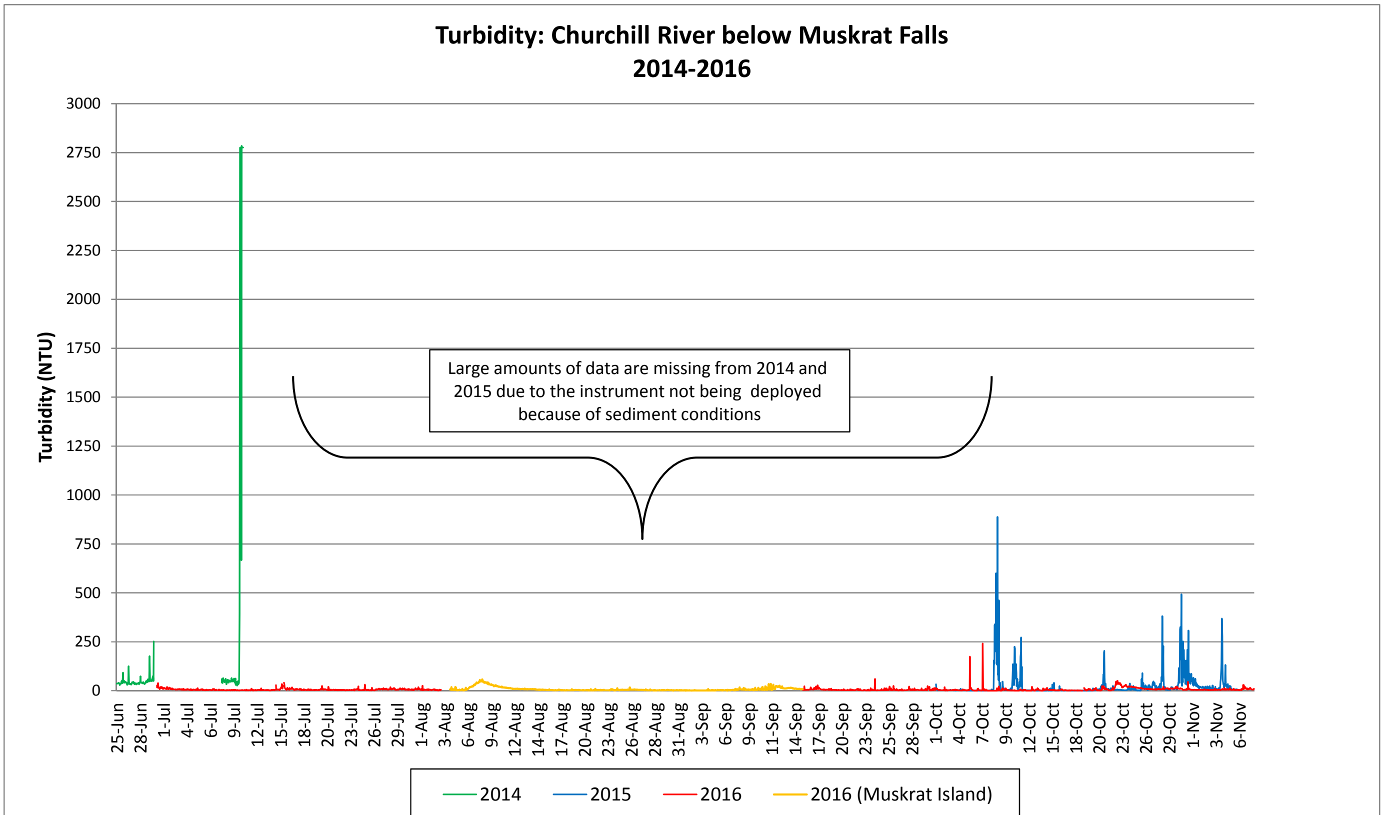
Dissolved Oxygen (mg/L)	2016	*2015	*2014		Percent Saturation	2016	*2015	*2014
Min	9.78	10.21	9.51		Min	101.2	98.6	90.5
Max	14.99	14.46	12.39		Max	123.3	113.2	108.7
Median	11.85	11.92	11.71		Median	112.3	106.4	106

***data set not complete cannot be compared to previous years**

- Significant amounts of data are missing from the 2014 and 2015 season due to sediment conditions at the station below Muskrat Falls (Figure 28). Due to sensor failure during the August to September deployment, data from the instrument at Muskrat Island has been used to supplement the below Lower Muskrat turbidity data for 2016.
- The moving sand conditions may impact the turbidity sensor thus causing variability in the data.
- The majority of turbidity values (95%) were <20.8NTU during the 2016 deployment season (Figure 28 a & b). A median value of 4.3NTU indicates there is a consistent natural background turbidity value at this station. Turbidity values from 2014 to 2016 are depicted in Figures 28 a & b.
- Figure 28a shows data on a scale up to 3000NTU. On a number of occasions in 2016, turbidity increased above median background levels for short periods of time throughout the deployment season, to as high as 241.7NTU. 2016 values are notably lower than those from the previous two years. This is expected as sand was an issue in the area for 2014-2015 and may have contributed to high values during these years.
- Figure 28b shows data at a smaller scale, focusing on the regular consistent background levels, below 100NTU. In the 2016 season, the median value was calculated to be 4.3NTU and the 95th percentile value was 20.8NTU. When data from all years is combined (2014 to 2016), the median value is almost identical at 4.5NTU but the 95th percentile is 43.0NTU.

Turbidity (NTU)	**2016**	***2015**	***2014**	**2014-16**
Min	0	0	27	0
Max	241.7	492	2784	2784
Median	4.3	4.9	43.4	4.5
95%	20.8	66.99	2470.6	43.0
75%	7.7	9.1	50.1	9.4

***data set not complete cannot be compared to previous years**



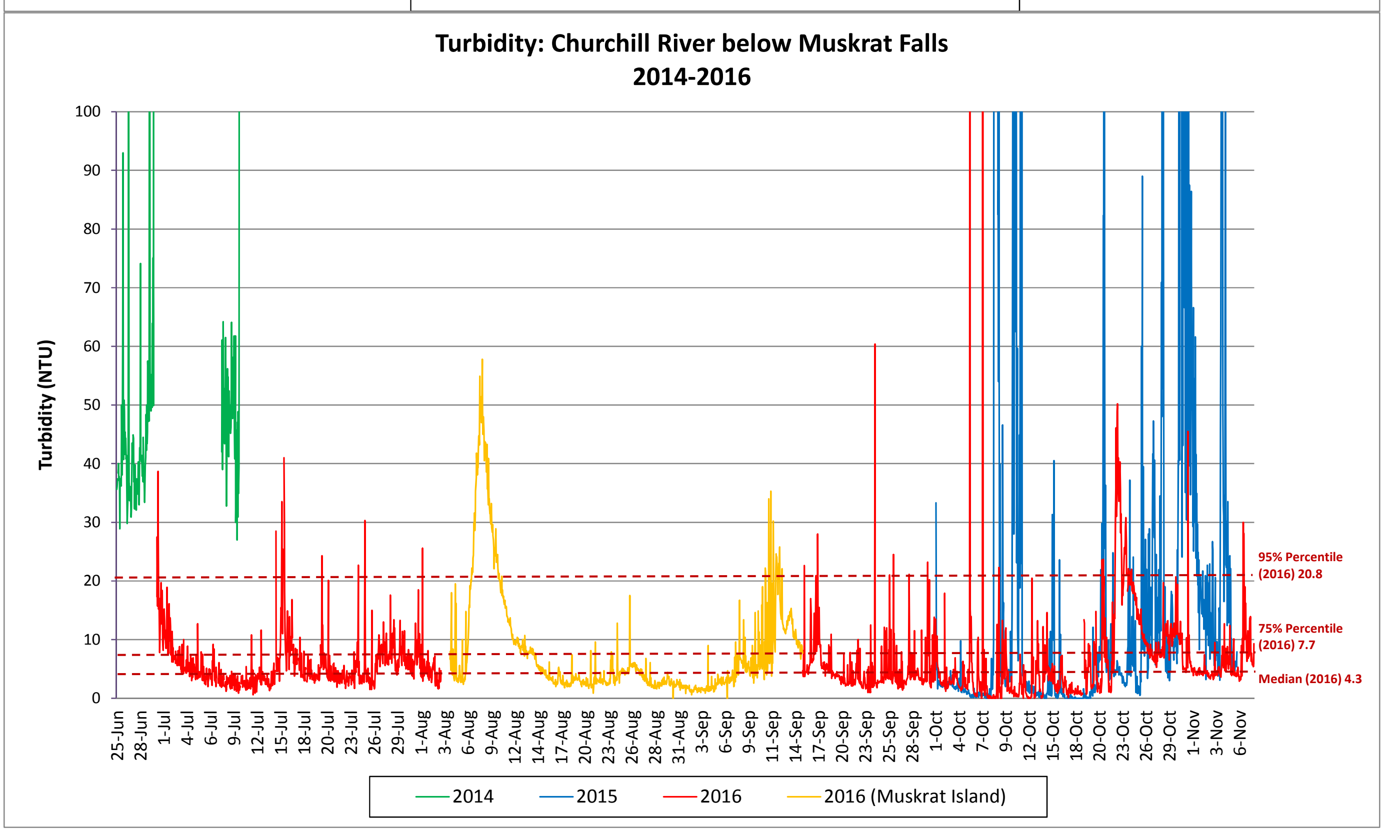


Figure 28a (top): Turbidity to 3000NTU at Churchill River below Muskrat Falls
Figure 28b (bottom): Turbidity to 100NTU at Churchill River below Muskrat Falls

- Stage levels from 2014-2016 are graphed below to show how stage levels vary throughout the season and from year to year (Figure 29). The seasonal low was reached earlier in the season in 2016 when compared to 2014 and 2015. Stage ranges between 1.447 m and 2.415 m each year.
- Water Survey of Canada (ECCC) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

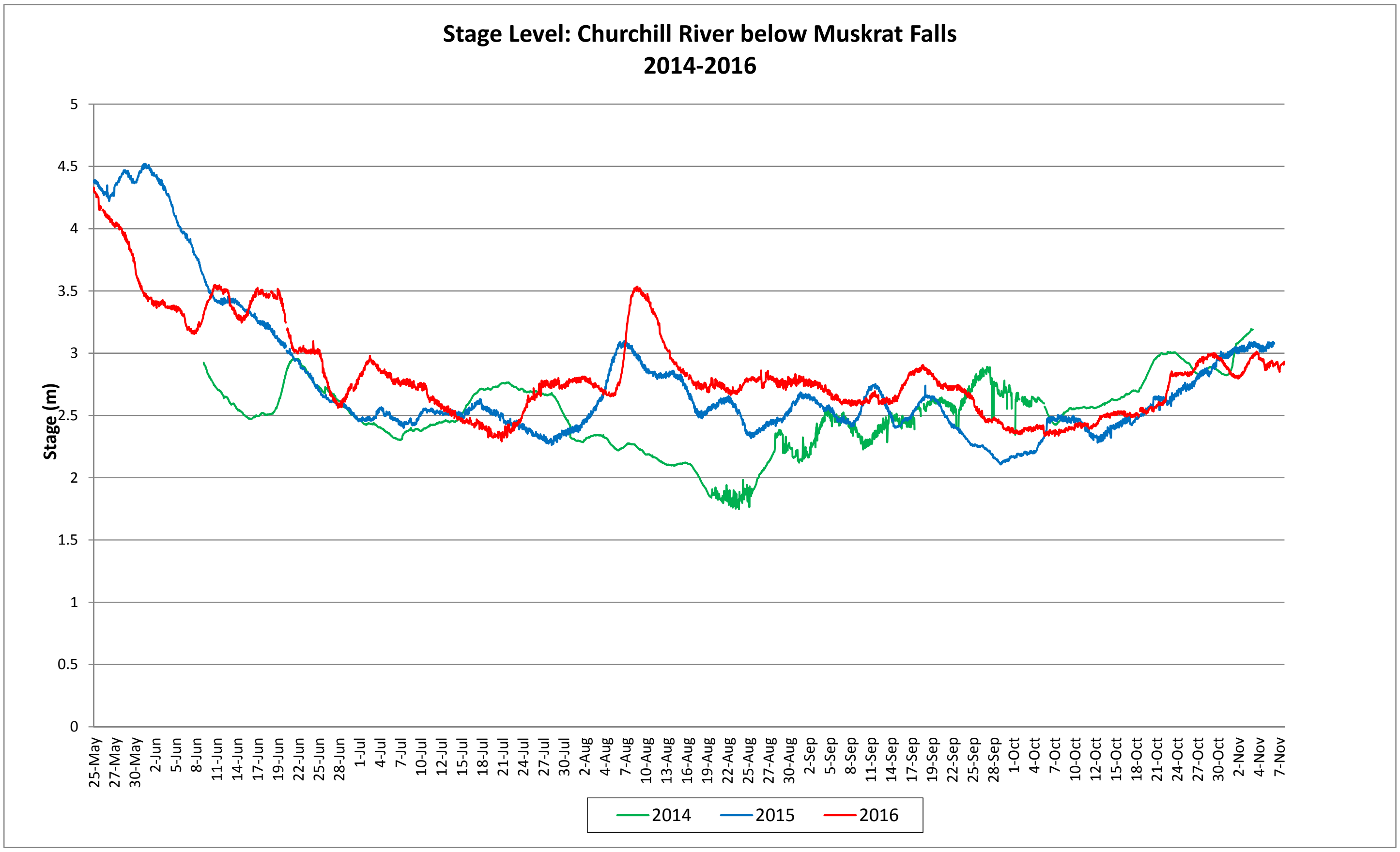


Figure 29: Stage level at Churchill River below Muskrat Falls

Stage (m)	**2016**	**2015**	**2014**
Min	2.291	2.106	1.746
Max	4.331	4.521	3.193
Median	2.762	2.566	2.528
Range	2.040	2.415	1.447

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 30).
- Stage is generally decreasing into July, reaching a seasonal low July 20th, before rising again into August after precipitation events. Stage begins to decrease again in late September before rising gradually into October after precipitation events. Fluctuations in stage levels are associated with precipitation events.
- Precipitation events are frequent and range from low to high in magnitude.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

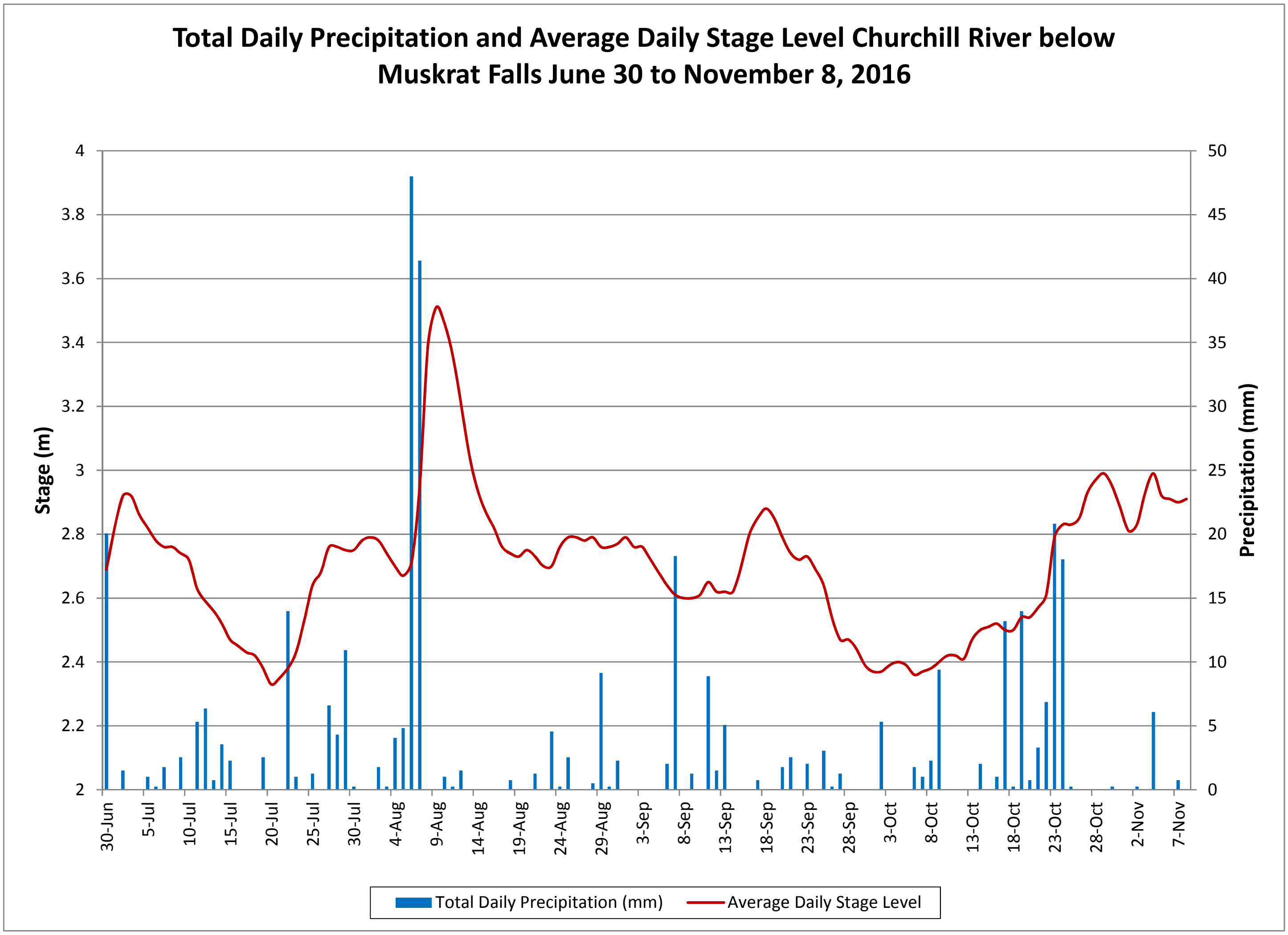


Figure 30: Daily precipitation and average daily stage level at Churchill River below Muskrat Falls (weather data recorded at Muskrat Falls)

Churchill River at English Point

- Water temperature ranges from 1.60°C to 21.70°C during the 2016 deployment season, with a median value of 12.10°C (Figure 31).
- There are greater daily fluctuations at this station due to the influence of the tides in the Atlantic Ocean and Lake Melville. In 2016, the warmest temperature was reached earlier in the season than in the previous two years.

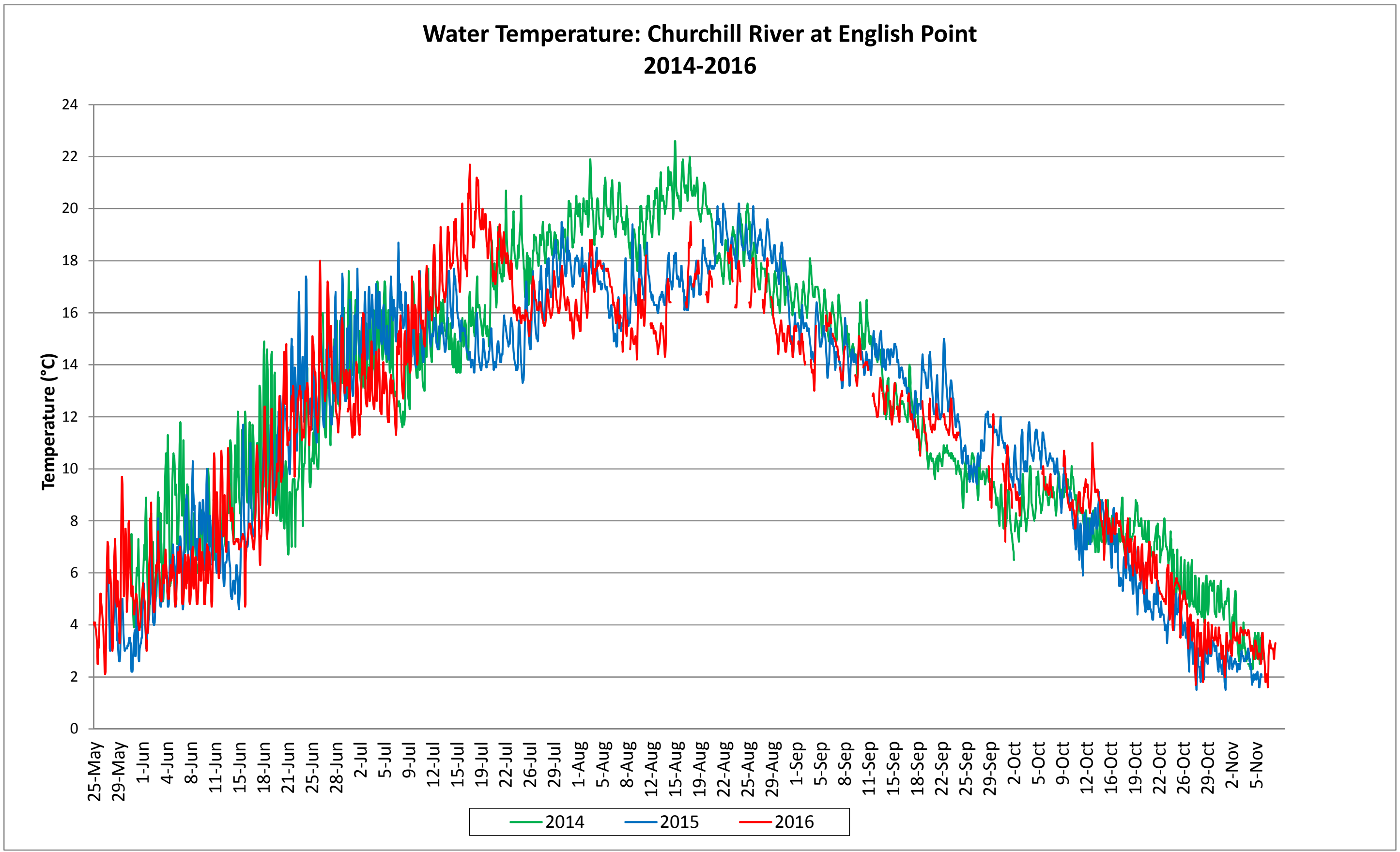


Figure 31: Water temperature at Churchill River at English Point

Temperature	2016	2015	2014
Min	1.60	1.50	2.30
Max	21.70	20.20	22.60
Median	12.10	13.60	12.60

- Water temperature values show a typical seasonal trend (Figure 32). Water and air temperatures are increasing throughout the spring and early summer with water temperatures peaking in mid-July. Average air and water temperatures decrease throughout the late summer and into fall.

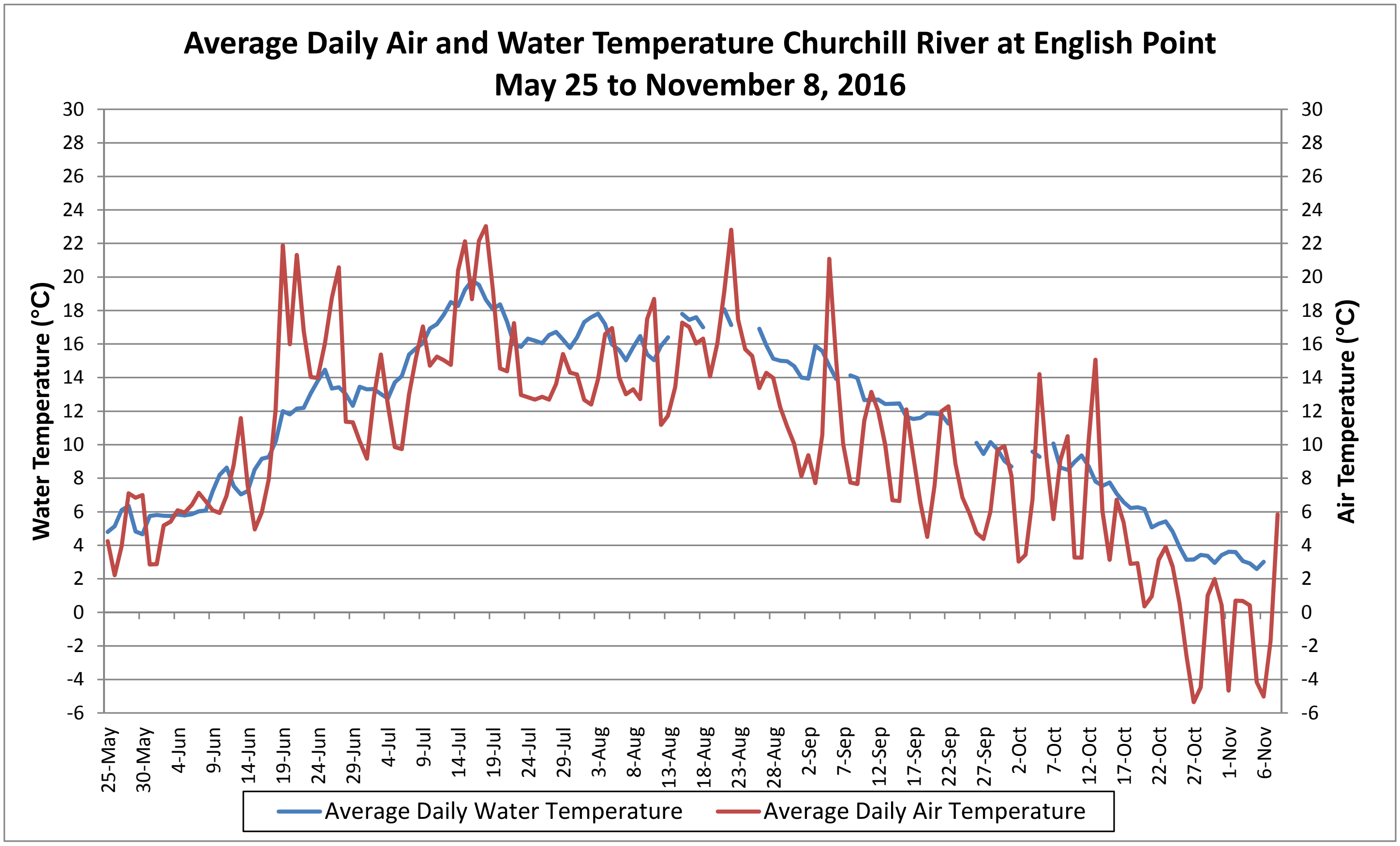


Figure 32: Average daily air and water temperatures at Churchill River at English Point (weather data recorded at Mud Lake)

- pH ranges between 6.20 and 7.32 pH units during the 2016 deployment season, with a median value of 6.69 pH units (Figure 33). The 2016 data is lower than during the previous two years.
- Most pH values during the 2016 deployment season are within the CCME Guidelines for the Protection of Aquatic Life (>6.5 and <9.0 pH units). pH values drop below this guideline for a period of time in June, July, August and October after precipitation events. Guidelines are indicated in red on Figure 33.

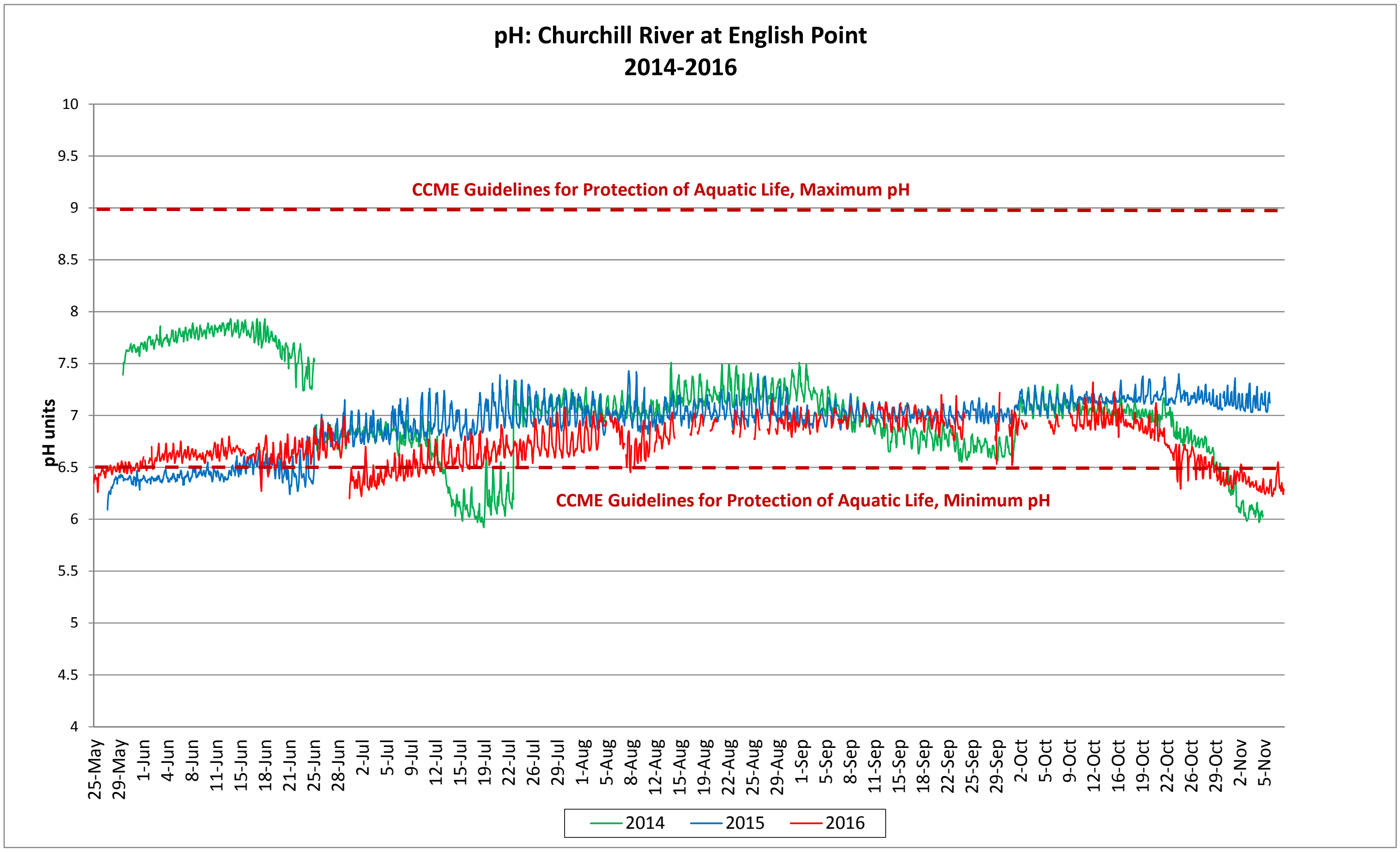


Figure 33: pH at Churchill River at English Point

pH (units)	2016	2015	2014
Min	6.20	6.09	5.92
Max	7.32	7.43	7.93
Median	6.69	7.00	7.04

- Specific conductance ranges between 12.2µS/cm and 72.0µS/cm, with a median value of 30.1µS/cm during the 2016 deployment season (Figure 34).
- Specific conductance is highly variable at this station, fluctuating significantly each day. The consistent fluctuations at this location are due to the tidal influences of the Atlantic Ocean. As the tide comes in, the specific conductivity increases as the dissolved solids and salinity increase, and vice versa as the tide goes out. This increase and decrease in specific conductivity and stage occurs twice daily.
- Trends and values from 2014 and 2015 are similar for the same time period, with median values for all three years almost identical.

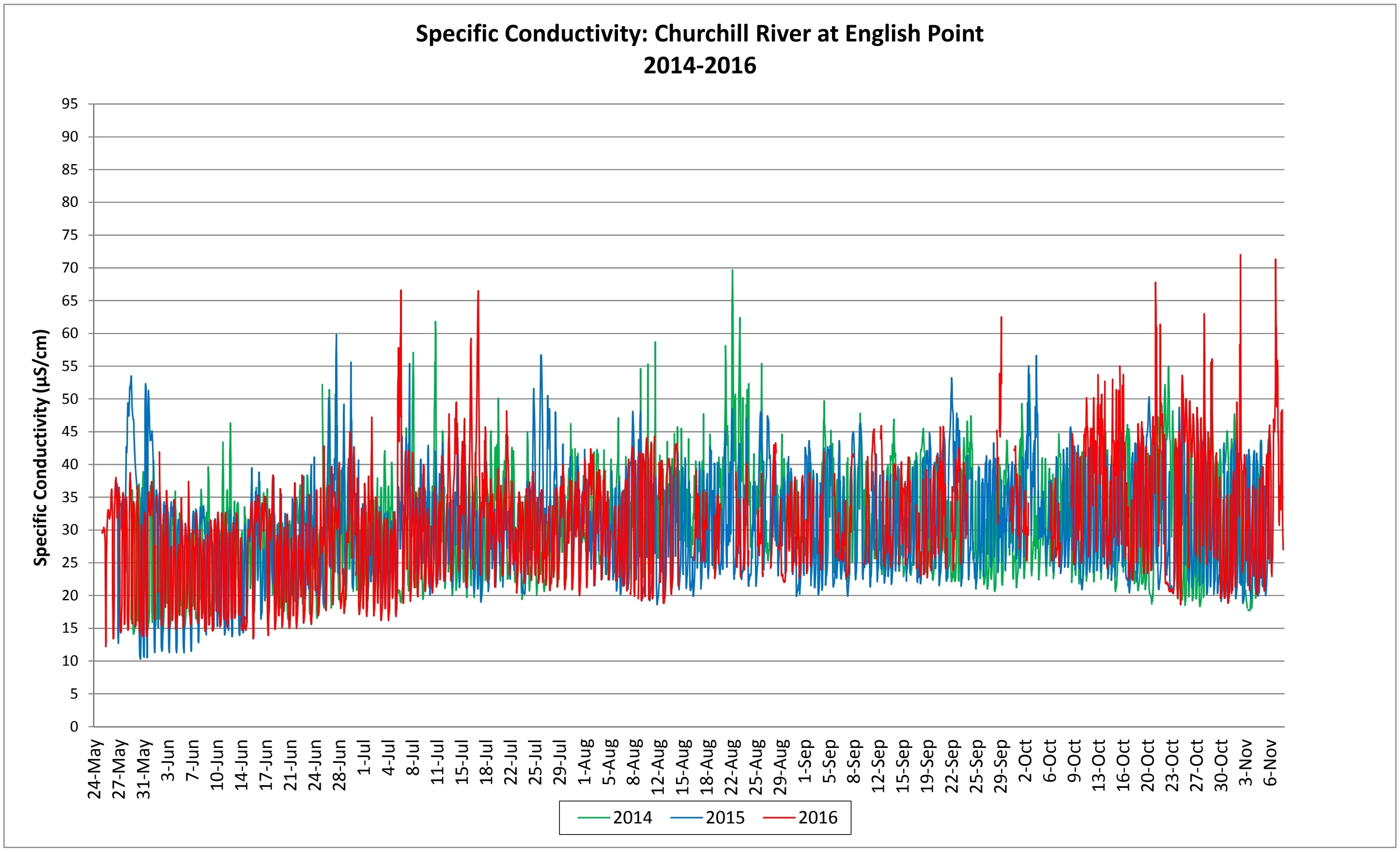


Figure 34: Specific Conductivity at Churchill River at English Point

Specific Conductivity (µS/cm)	2016	2015	2014
Min	12.2	10.3	14.1
Max	72.0	59.8	69.7
Median	30.1	29.9	30.6

- Throughout the 2016 deployment season, dissolved oxygen ranges from 9.04mg/l and 14.14mg/l, with a median value of 10.94mg/l, while percent saturation ranges from 86.3% to 115.2%, with a median value of 100.7% (Figure 35).
- Dissolved oxygen content shows a typical seasonal fluctuation in 2016. Dissolved oxygen content fluctuates considerably on a regular daily basis. Percent saturation is generally consistent throughout the deployment season.
- All values were above the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages (6.5 mg/l). Between mid-July and early September, dissolved oxygen content occasionally fluctuated above and below the minimum CCME Guideline for the Protection of Aquatic life at Early Life Stages (9.5mg/l). In September, as air and water temperatures cool, the dissolved oxygen content increases above 9.5mg/l. The guidelines are indicated in red on Figure 35.
- Dissolved oxygen and percent saturation values were higher than the data collected in 2014 and 2015.

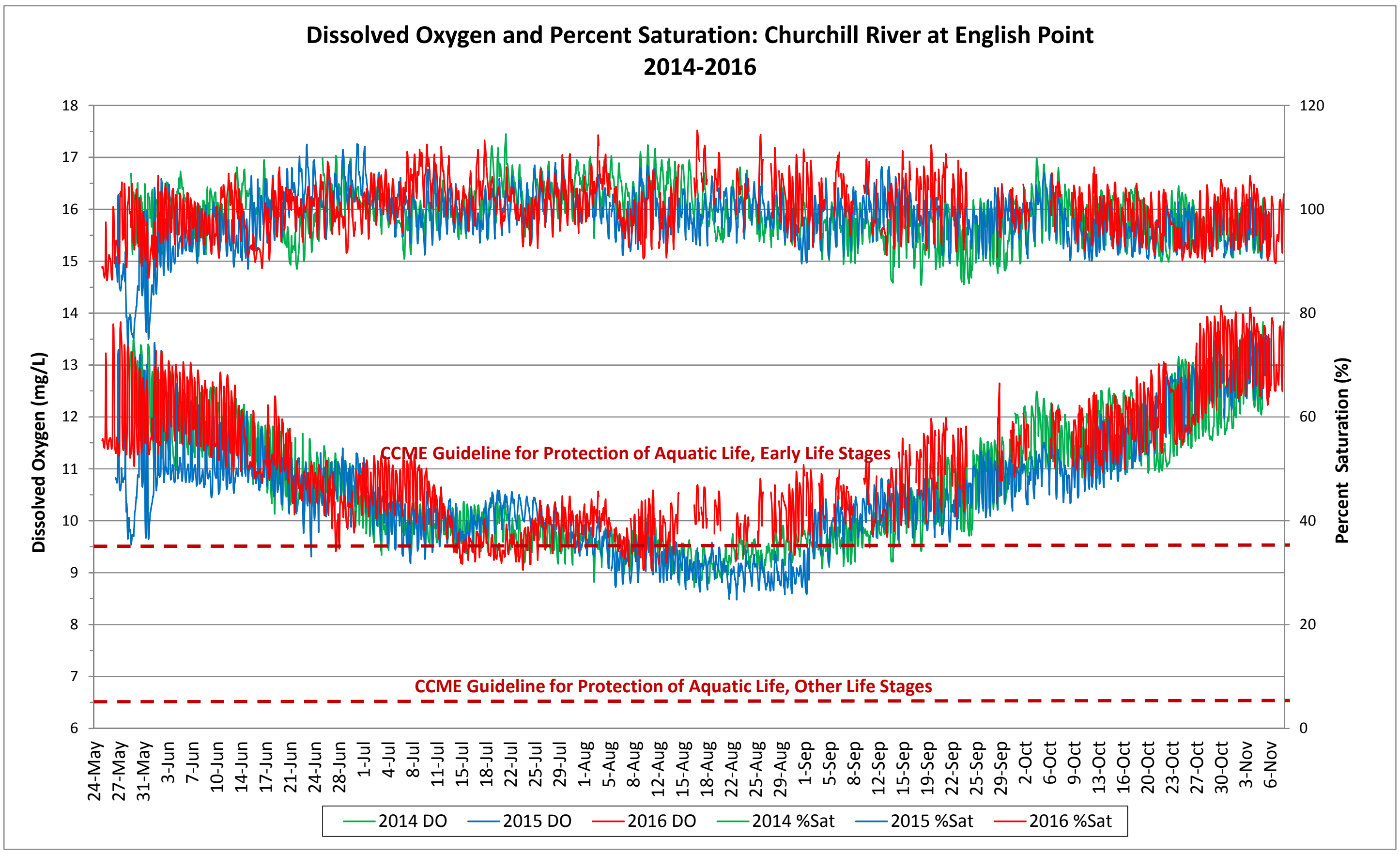
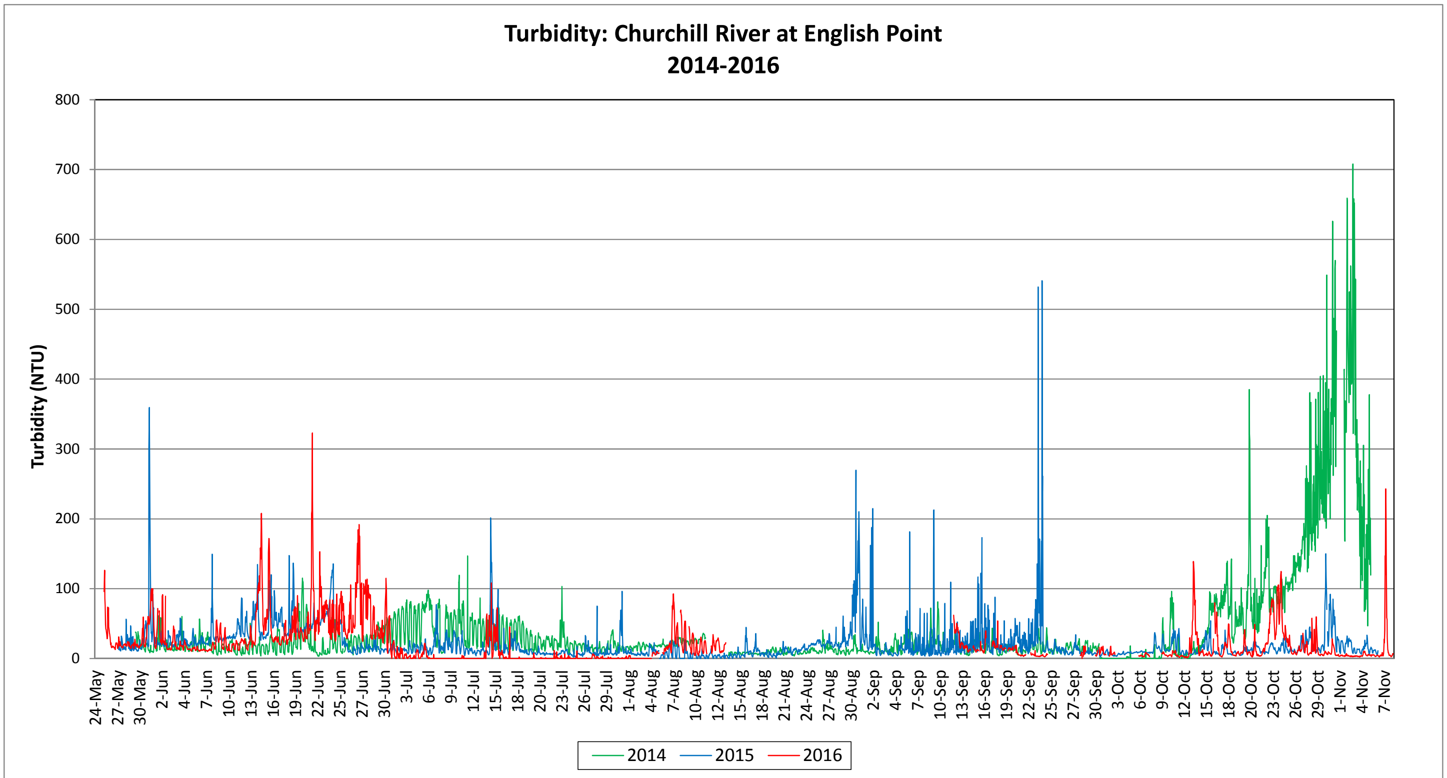


Figure 35: Dissolved oxygen and percent saturation at Churchill River at English Point

Dissolved Oxygen (mg/L)	2016	2015	2014		Percent Saturation	2016	2015	2014
Min	9.04	8.48	8.72		Min	86.3	73.80	85.40
Max	14.14	13.66	13.83		Max	115.2	112.60	114.50
Median	10.94	10.42	10.34		Median	100.7	99.00	99.60

- The majority of turbidity values (95%) were <78.4NTU during the 2016 deployment season (Figure 36 a & b). A median value of 10.5NTU indicates there is a consistent natural background turbidity value at this station. Turbidity values from 2014 to 2016 are depicted in Figures 36 a & b.
- Figure 36a shows data on a scale up to 800NTU. On a number of occasions in 2016, turbidity increased above median background levels for short periods of time throughout the deployment season, to as high as 322.9NTU. 2016 values are on par with 2014 and 2015, with a slightly lower median value than in the previous two years. Precipitation, tidal action and mixing sediment due to low water levels may have contributed to spikes in turbidity throughout the deployments.
- Figure 36b shows data at a smaller scale, focusing on the regular consistent background levels, below 100NTU. In the 2016 season, the median value was calculated to be 10.5NTU and the 95th percentile value was 78.4NTU. When data from all years is combined (2014 to 2016), the median value increases to 14.4NTU and the 95th percentile is 89.3NTU. Data from all years is similar and comparable in trend.

Turbidity (NTU)	2016	2015	2014	2014-16
Min	0.0	0.0	0.0	0.0
Max	322.9	541.1	708.0	708.0
Median	10.5	13.3	18.2	14.4
95%	78.4	59.9	58.9	89.3
75%	25.0	24.4	24.7	27.7



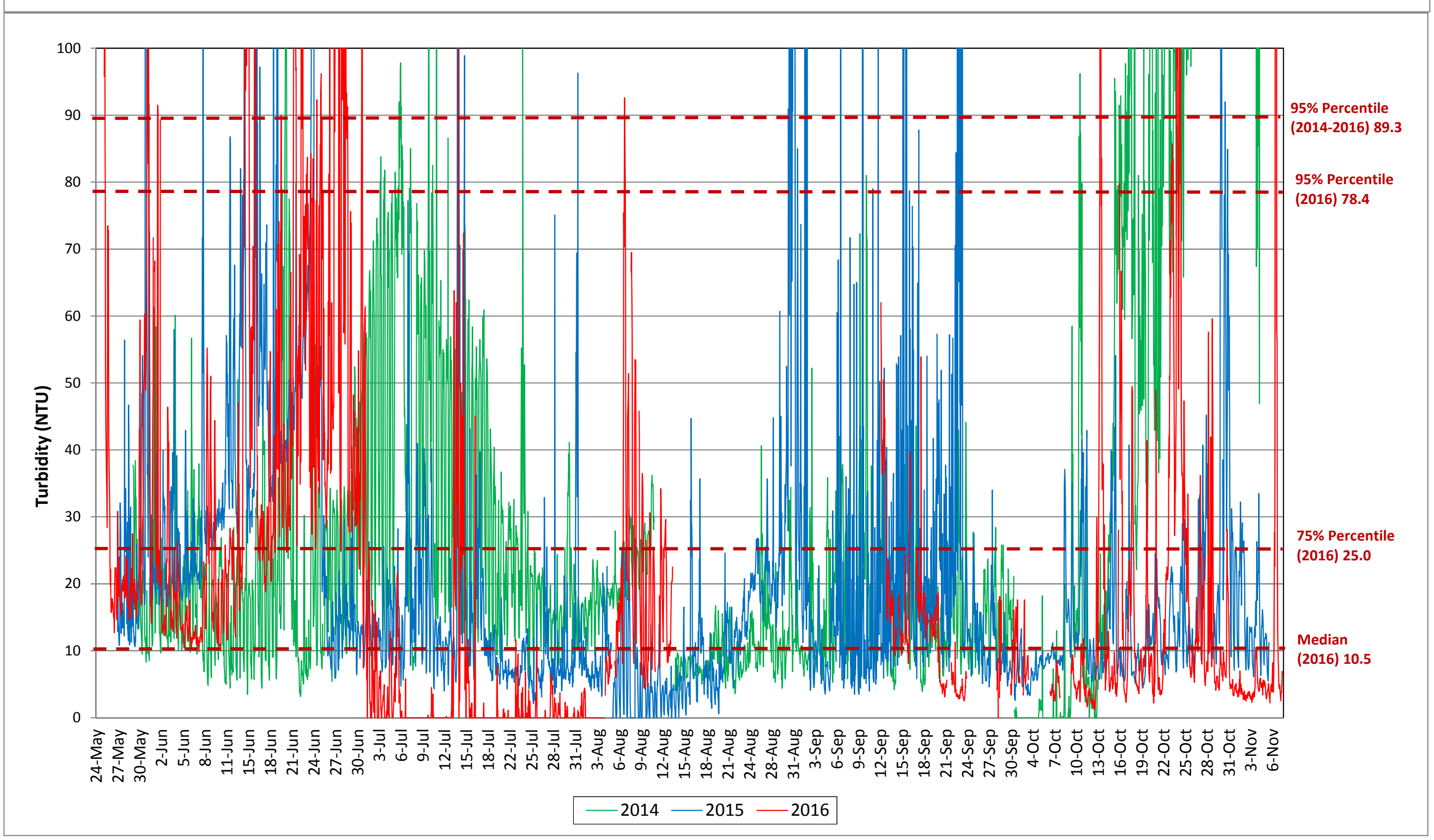


Figure 36a (top): Turbidity to 800NTU at Churchill River at English Point
Figure 36b (bottom): Turbidity to 100NTU at Churchill River at English Point

- Stage levels in 2016 are very consistent and do not fluctuate greatly on a seasonal level (Figure 37). Instead, stage values fluctuate considerably with tidal influences on a daily basis.
- Stage levels from 2014-2016 are graphed below to show how stage levels vary throughout the season and from year to year. Stage levels in previous years were very similar when compared to data collected in 2016. Stage ranges between 1.14m and 1.36m each year.
- Water Survey of Canada (ECCC) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

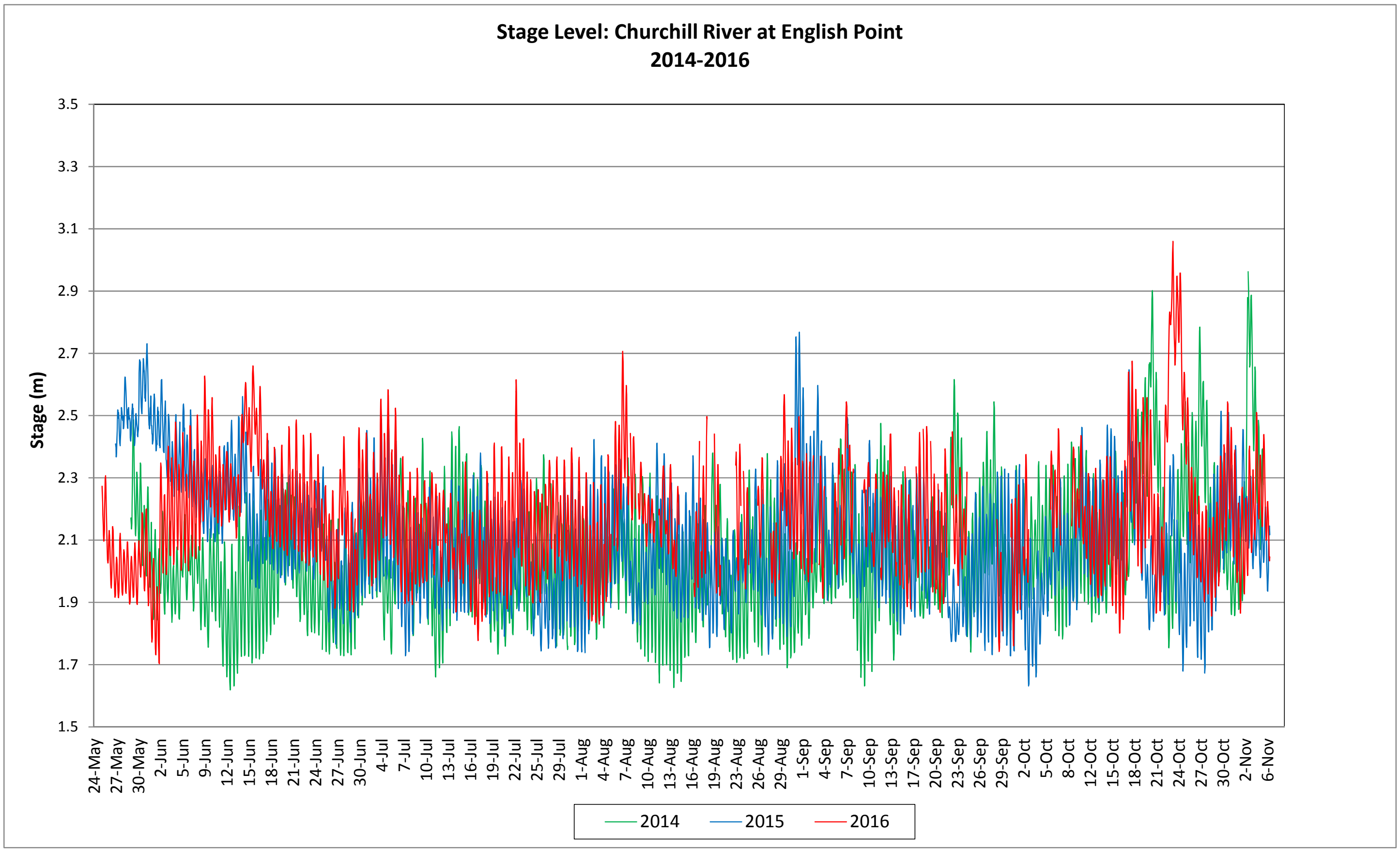


Figure 37: Stage level at Churchill River at English Point

Stage (m)	2016	2015	2014
Min	1.70	1.63	1.62
Max	3.06	2.77	2.96
Median	2.16	2.09	2.04
Range	1.36	1.14	1.34

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 38).
- Stage is relatively consistent throughout the deployment season. This trend is very different from all other network stations due to its location at the mouth of the Lower Churchill River and the tidal influences affecting water level.
- Water Survey of Canada (ECCC) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

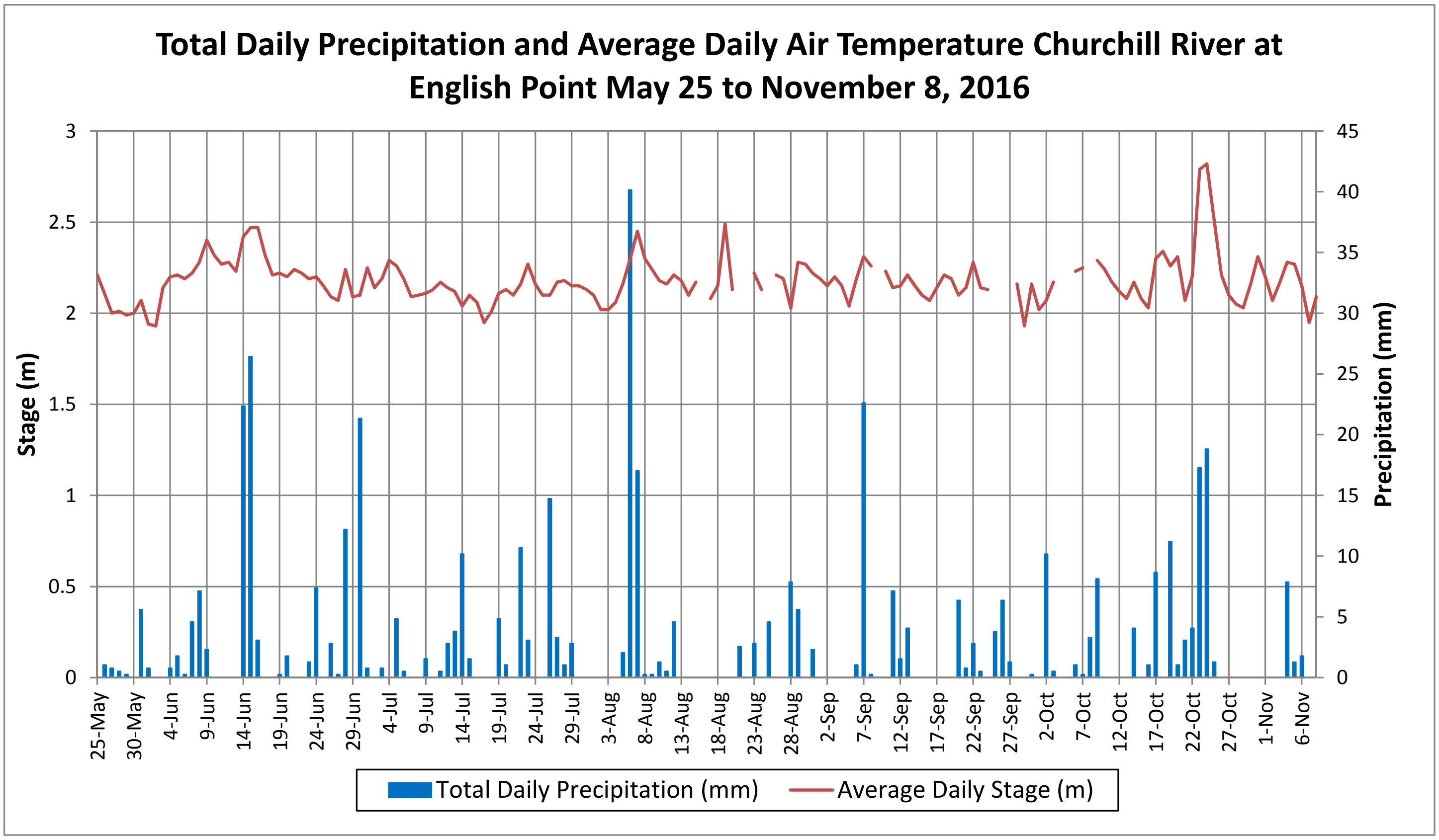


Figure 38: Daily precipitation and average daily stage level at Churchill River at English Point (weather data recorded at Mud Lake)

Station Comparison

- Water temperature at each of the four stations monitored shows a similar trend throughout the 2016 deployment season (Figure 39). Overall, increases and decreases occur at all stations at the same time, though to different degrees.
- For 2016, water temperature is generally warmest at English Point, while this station also has the greatest diurnal fluctuations. In the spring and early summer, English Point recorded the highest and lowest temperatures daily. Into the summer, the coolest water temperatures were recorded at below Grizzle Rapids, while the warmest were recorded at English Point. Median water temperature values decrease moving downward along the Churchill River system, from below Grizzle Rapids to English Point, but it should be noted that these medians are based on different time periods as stations were initially deployed at different times. As water temperatures began to cool mid-August into November, Churchill River at English Point had the lowest water temperatures when compared to other stations in the network.

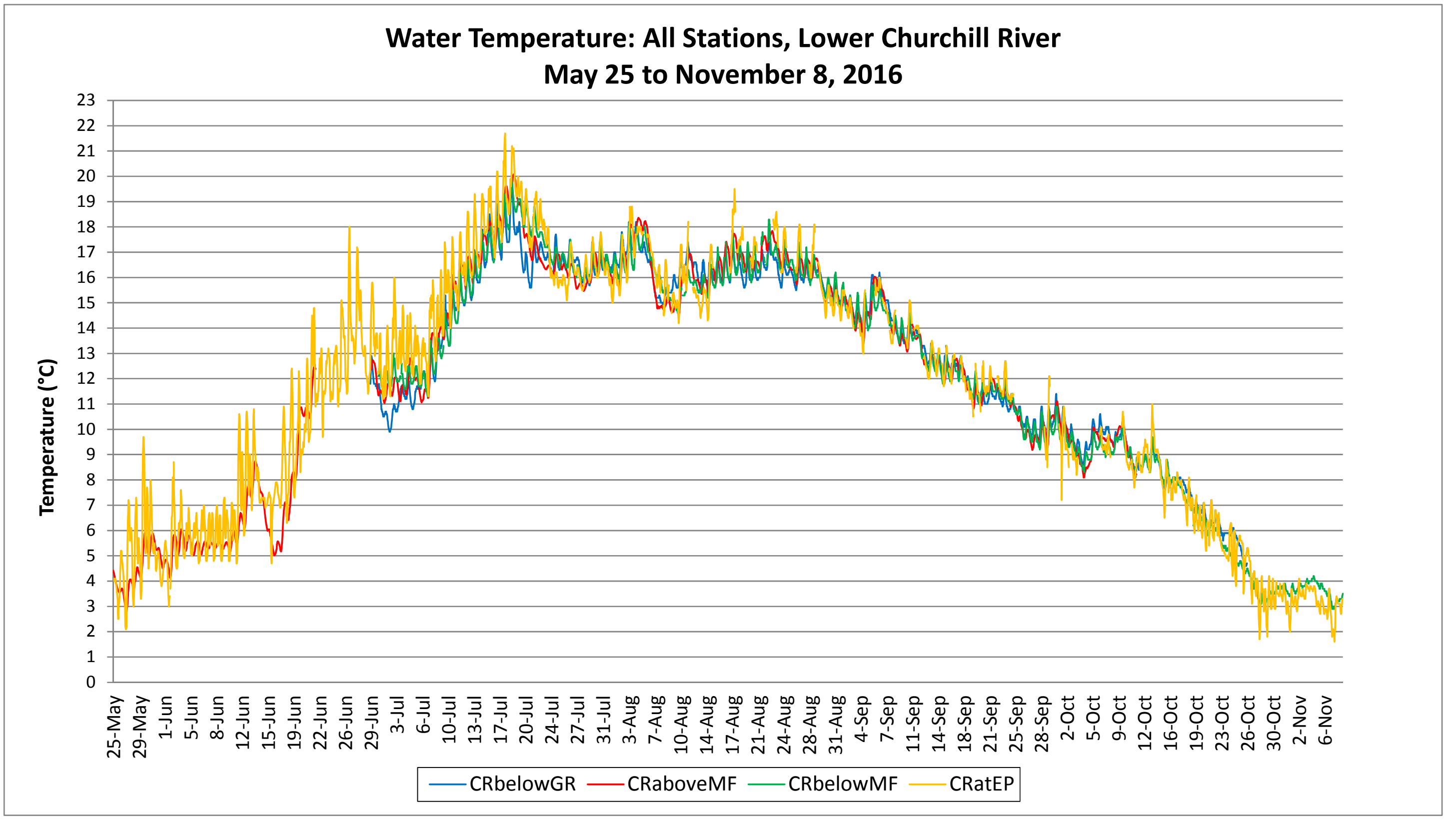


Figure 39: Temperature at all stations in 2016, Lower Churchill River

Temperature	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Min	4.6	2.79	2.9	1.6
Max	20.0	20.08	19.9	21.7
Median	14.4	13.35	13.1	12.1

- Water temperatures at all four stations display clear seasonal trends in response to changes in air temperatures throughout the deployment season (Figure 40).
- Average Daily water temperatures peak at all stations in mid-July, a day after the highest air temperature was reached.

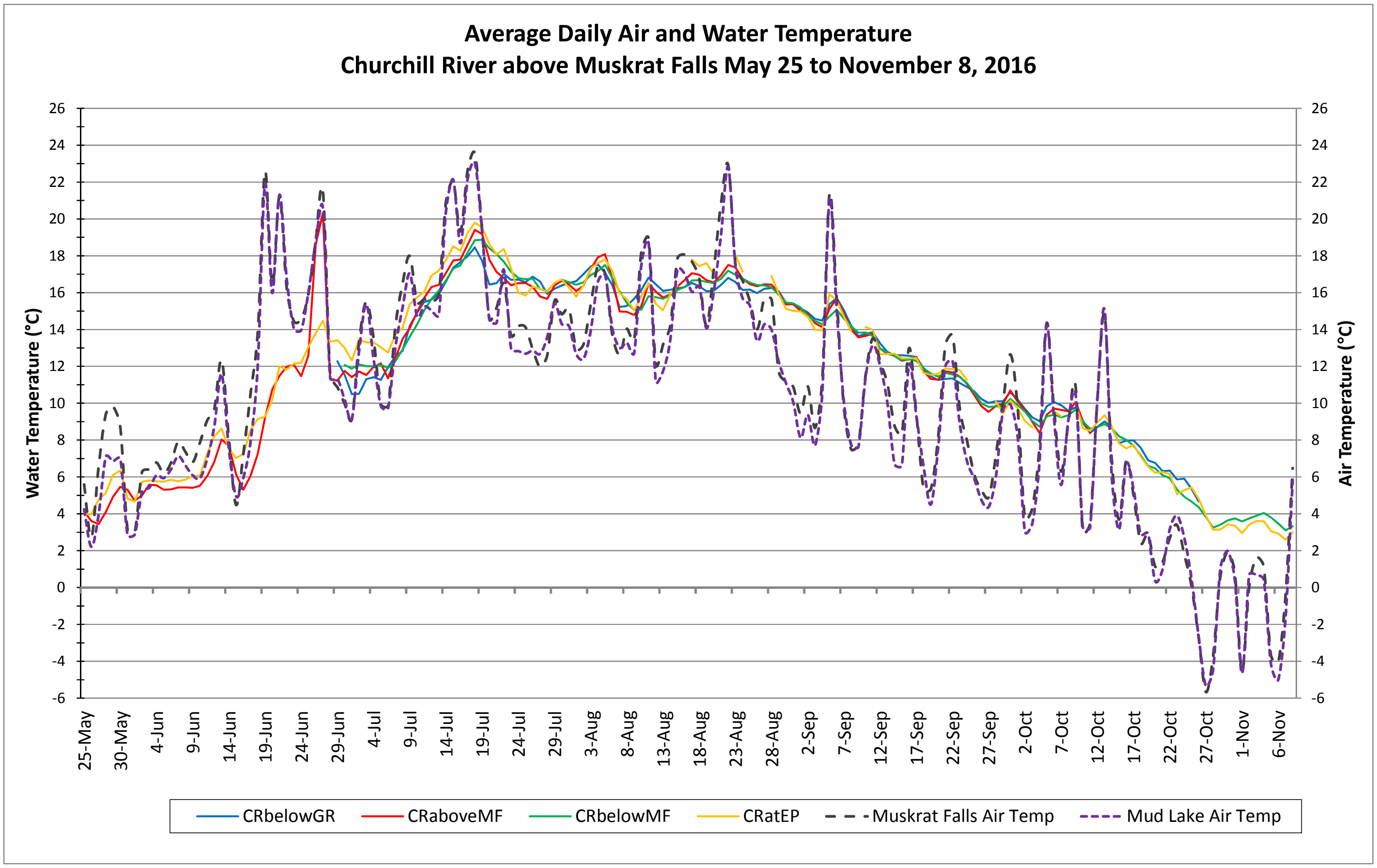


Figure 40: Average daily air and water temperatures at all stations in 2016, Lower Churchill River

- pH values are similar at the four monitoring sites throughout the 2016 deployment season (Figure 41), with the exception of below Lower Muskrat Falls, which displayed a lower pH than the other stations for portions of the year.
- A notable drop in pH at all stations occurred in early August after 89.4mm of rainfall over a two day period (August 6th/7th).
- The median values for above Muskrat Falls and at English Point were very similar, while the median value for below Grizzle Rapids was higher at 7.00. Values at the station at English Point are the most variable day to day throughout the deployment season due to the position of the station at the mouth of the Lower Churchill River and the tidal impact on the station water level and water quality.

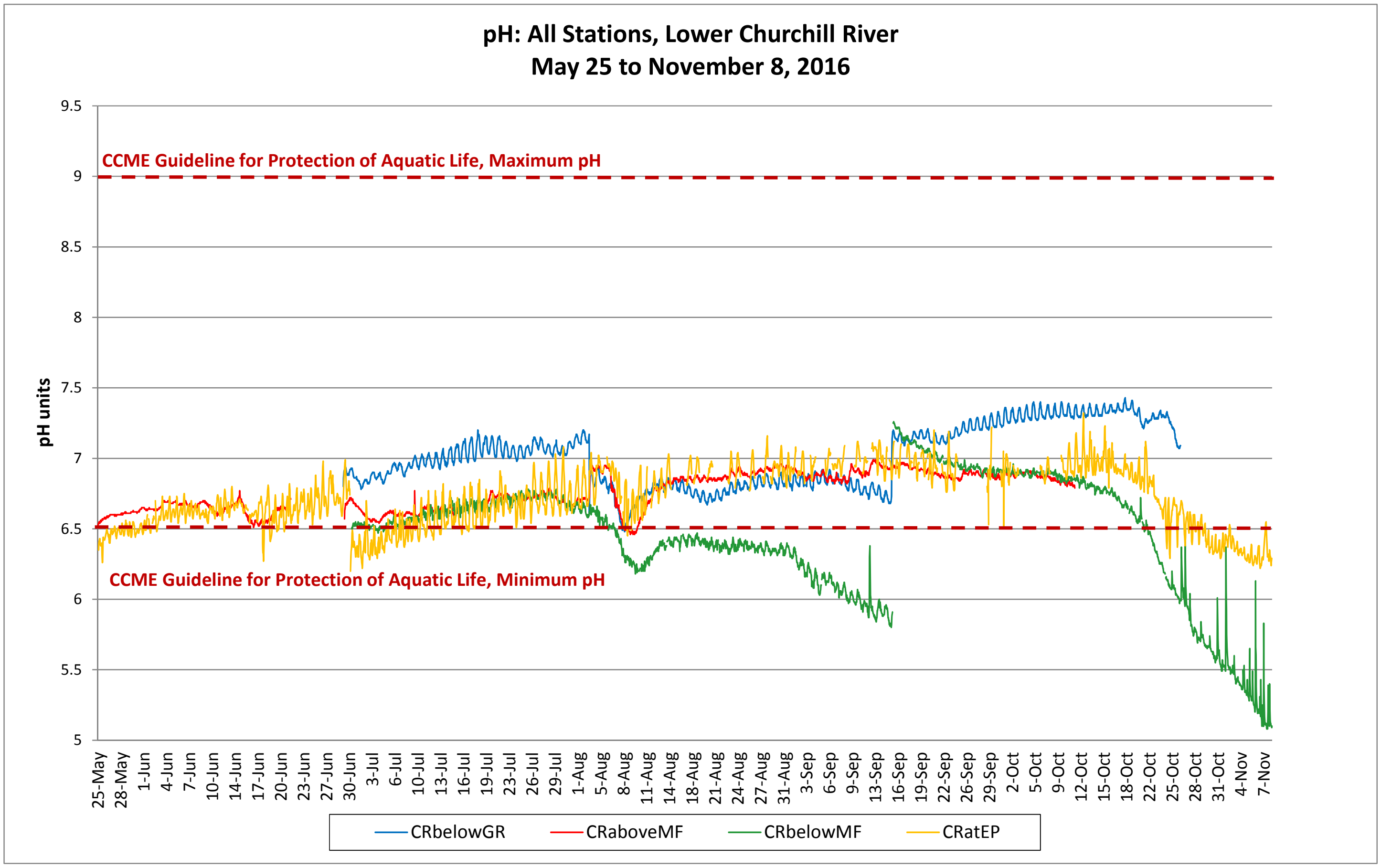


Figure 41: pH at all stations in 2016, Lower Churchill River

pH	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Min	6.50	6.46	5.08	6.20
Max	7.40	6.99	7.26	7.32
Median	7.00	6.75	6.54	6.69

- Specific conductivity trends are similar along the Lower Churchill River except at English Point (Figure 42).
- Specific conductivity is generally very stable on the Lower Churchill River (above English Point), fluctuating only a few micro Siemens during a deployment period. At the station at English Point, specific conductance is highly variable, fluctuating significantly twice each day due to the tidal influences of the Atlantic Ocean.
- Seasonal trends are notable at these stations and show specific conductivity increasing from the time of deployment in May to mid-August. Specific conductivity then decreases into the fall.

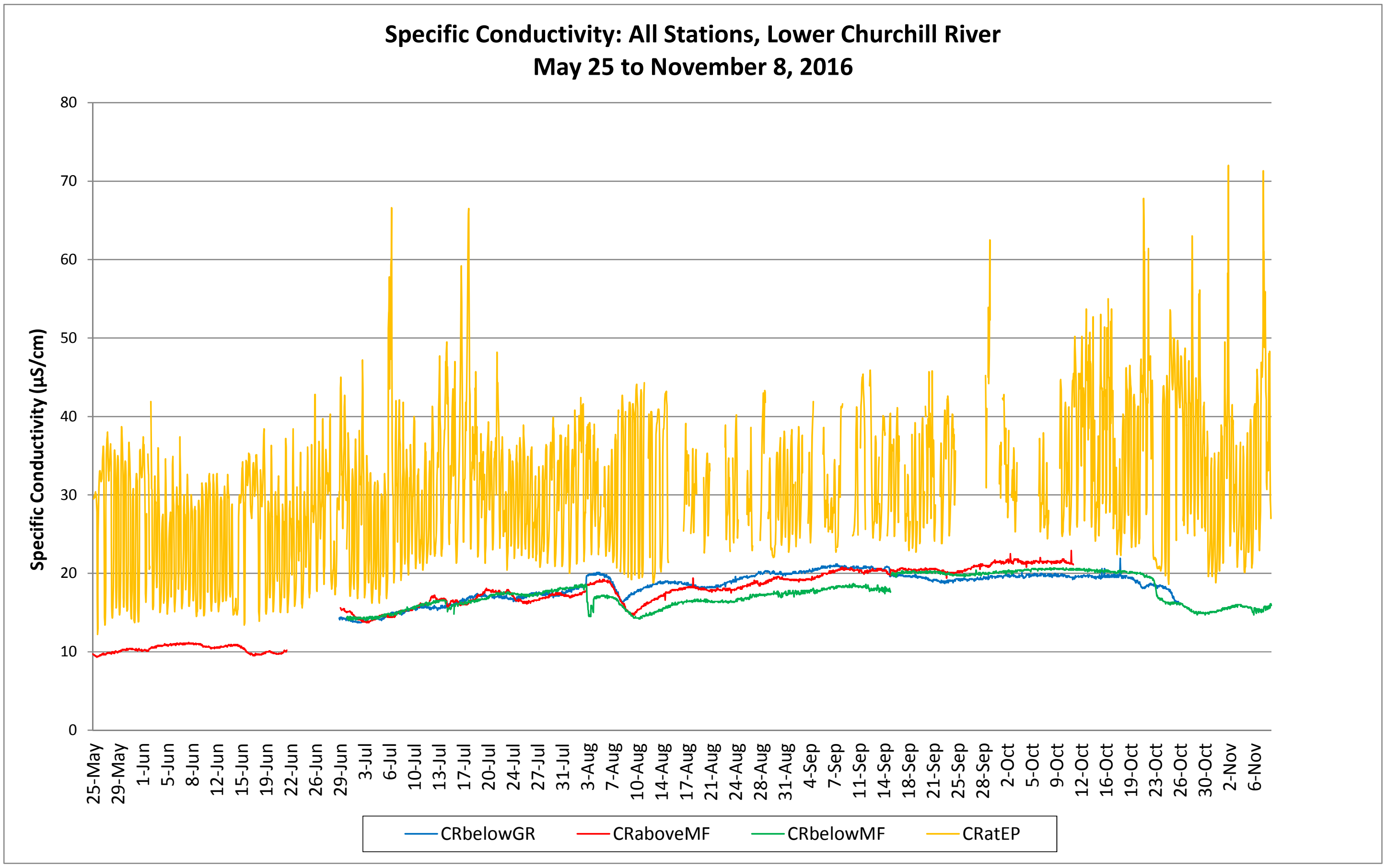


Figure 42: Specific conductivity at all stations in 2016, Lower Churchill River

Specific Conductivity (µS/cm)	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Min	13.7	9.3	14.0	12.2
Max	21.9	22.9	20.7	72.0
Median	19.0	17.5	17.3	30.1

- Dissolved oxygen content and percent saturation values are very similar throughout the network with median values from 9.77mg/l (below Grizzle Rapids) to 11.85mg/l (at below Muskrat Falls) and 95.9% (below Grizzle Rapids) to 112.3% (below Muskrat Falls) (Figure 43).
- Dissolved oxygen content shows a very clear inverse relationship to water temperature and has a distinct seasonal trend decreasing in the early summer, and increasing into the late summer and fall.
- Generally, dissolved oxygen content at the below Muskrat Falls station is higher than all other stations throughout the deployment season due to its location downstream from Muskrat Falls. All stations (except below Muskrat Falls) recorded values below the minimum CCME Guideline for the Protection of Early Life Stage Cold Water Biota value at 9.5 mg/l during the summer months. Guidelines are indicated in red on Figure 43.

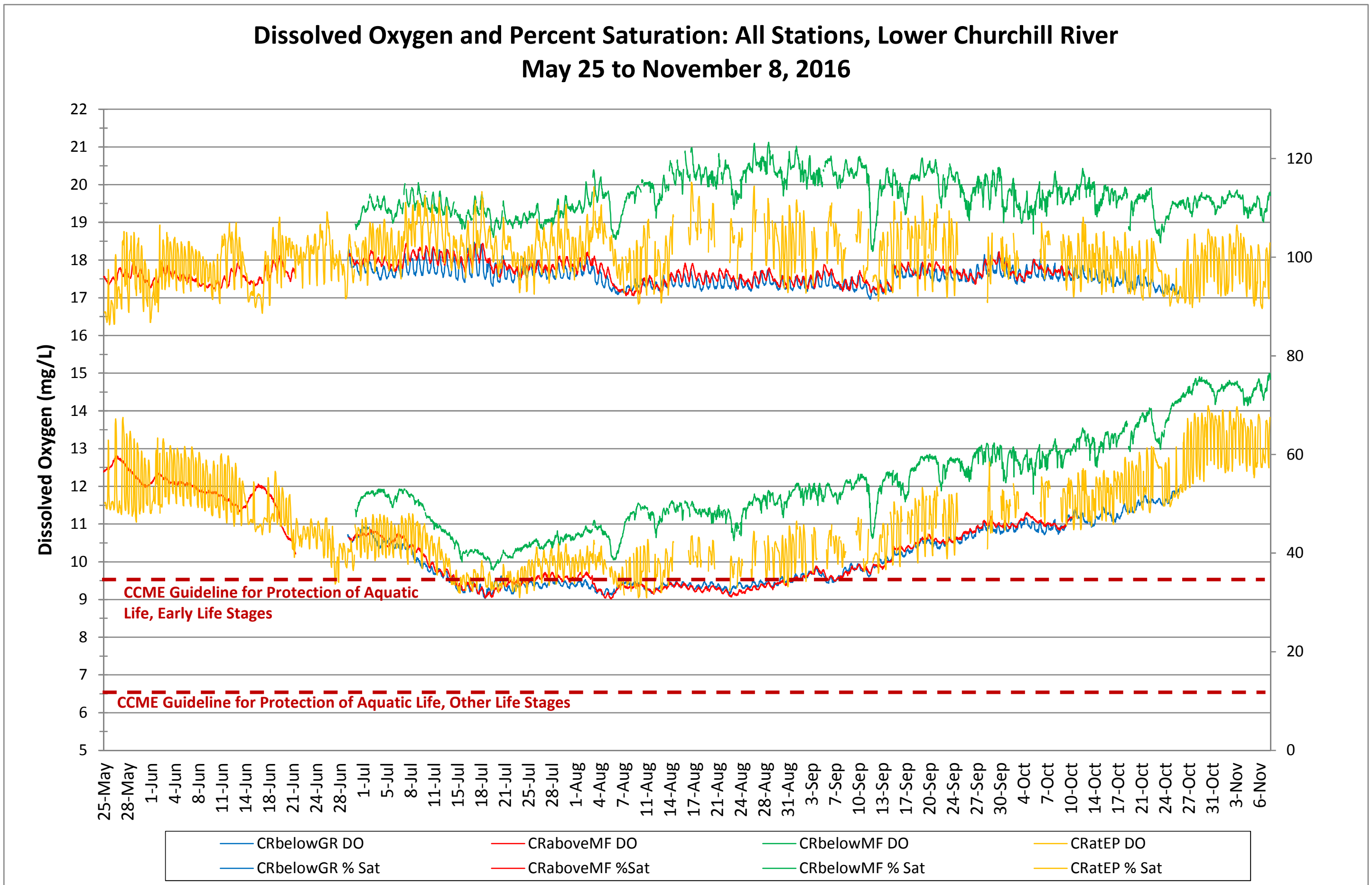
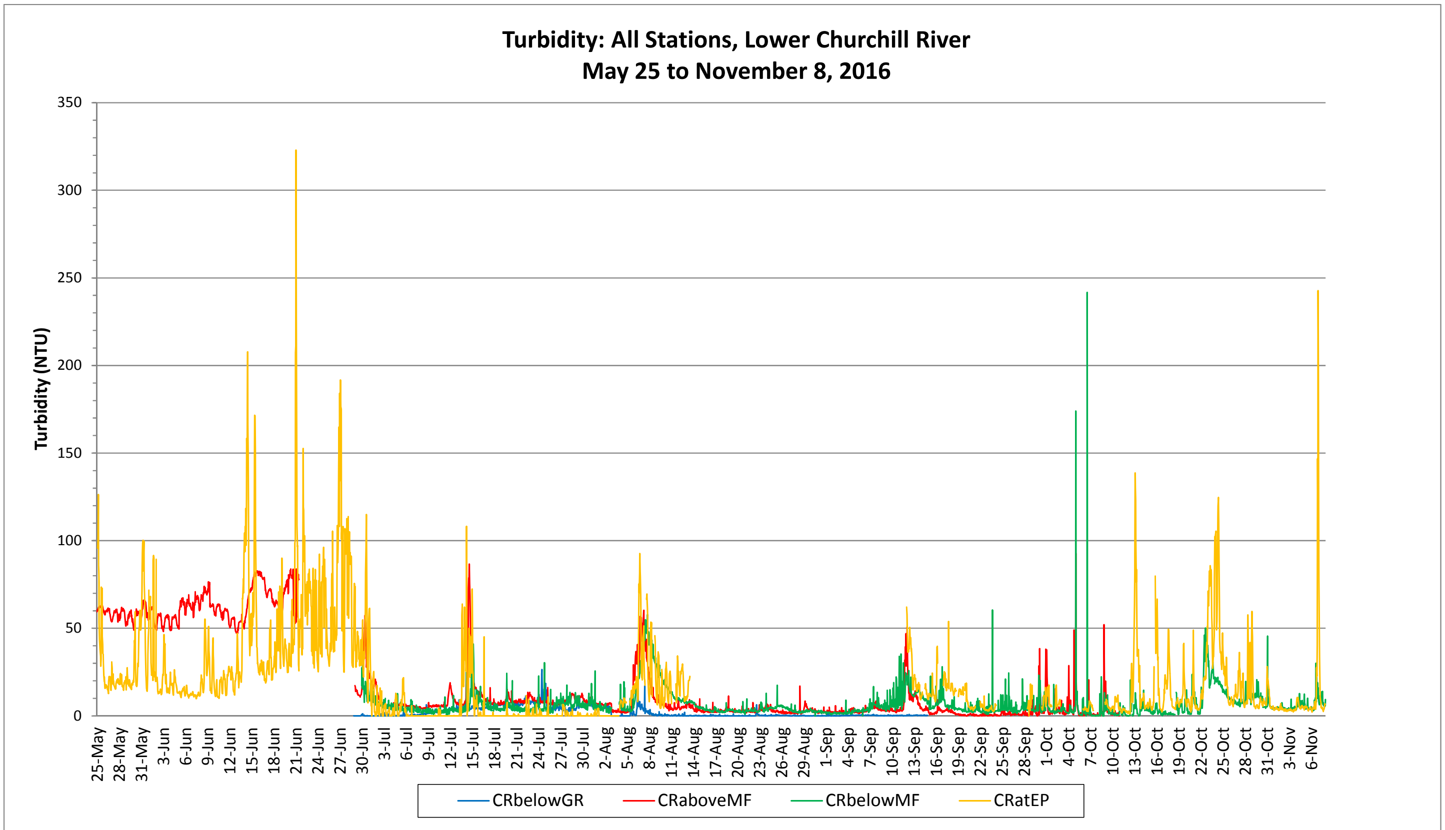


Figure 43: Dissolved oxygen and percent saturation at all stations in 2016, Lower Churchill River

	Dissolved Oxygen (mg/l)					Percent Saturation (%)			
	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP		CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Min	9.03	9.01	9.78	9.04		91.5	92.2	101.2	86.3
Max	11.94	12.80	14.99	14.14		103.0	102.8	123.3	115.2
Median	9.77	9.99	11.85	10.94		95.9	96.8	112.3	100.7

- Turbidity values at below Grizzle Rapids are generally low (0.3NTU) with minimal, short lived turbidity events (Figure 44 a & b). In the lower reaches of the Lower Churchill River, the stations above Muskrat Falls and at English Point have consistent natural background turbidity values of 5.9NTU and 10.5NTU, respectively. English Point has a higher range of values and more frequent increases, likely due to the tidal influence at this location as sediment is washed back and forth by wave action.

Turbidity (NTU)	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Min	0	0	0	0
Max	26.5	92.8	241.7	322.9
Median	0.3	5.9	4.3	10.5
95^{th} Percentile	7.4	67.1	20.8	78.4



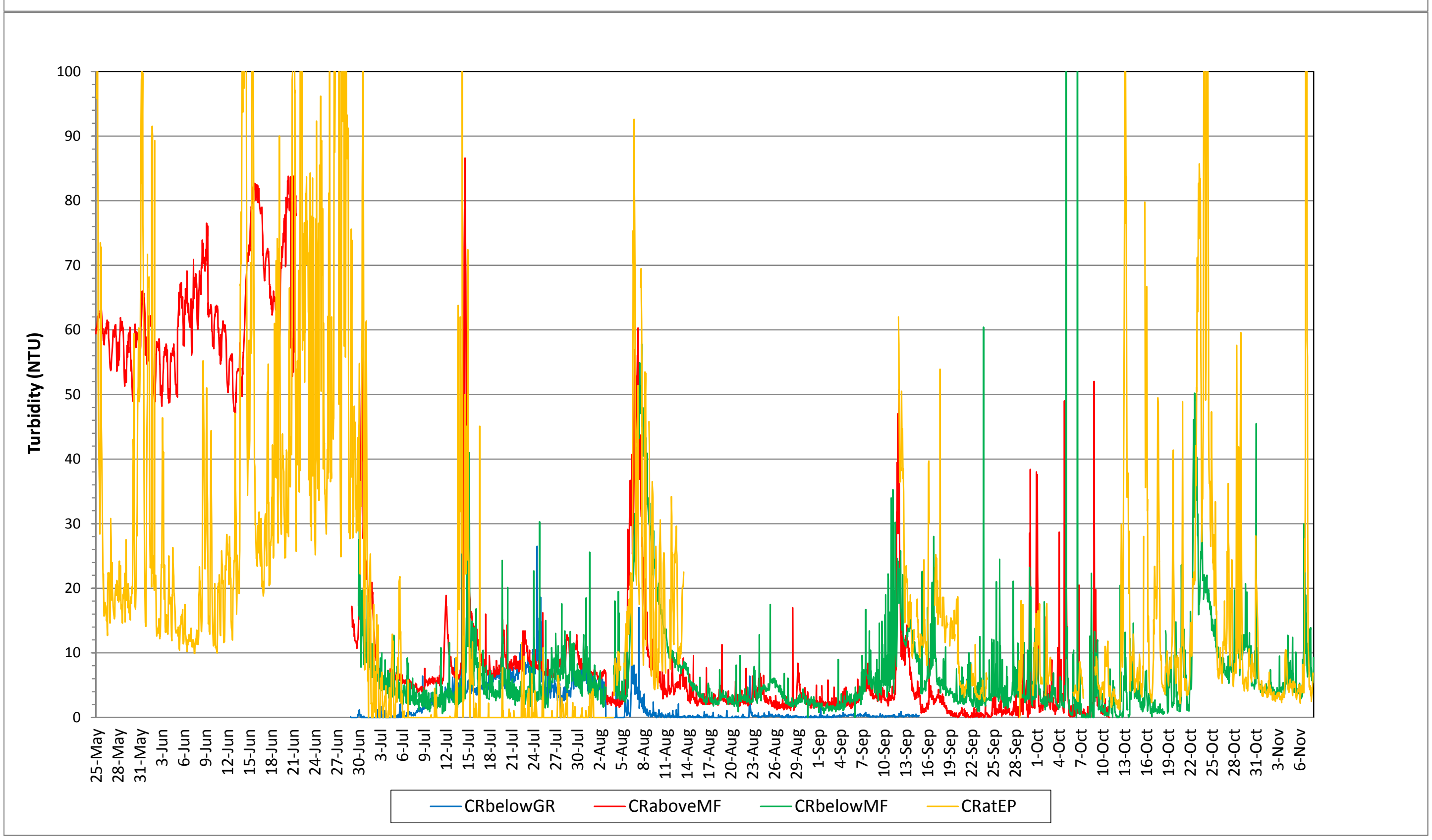


Figure 44a (top): Turbidity to 350NTU at all stations in 2016, Churchill River
Figure 44b (bottom): Turbidity to 100NTU at all stations in 2016, Churchill River

- Stage levels are similar across the network throughout the 2016 deployment season (Figure 45). Stage is generally decreasing at all stations from May into July. Stage levels reach a seasonal low at all stations above English Point in late July, then rise to a summer peak in early August. Stage levels were relatively stable in August and September before decreasing and rising again into October.
- Stage ranges between 0.721m and 2.995m depending on the station. Most increases and decreases captured are noticeable at all stations in the network. The stage level at English Point is greatly affected by the tidal influence of the Atlantic Ocean and varies widely on a daily basis compared to the other stations in the network.
- There is a noticeable upward trend at the above Upper Muskrat falls station during the last few days of the season. This coincides with reservoir impoundment on the Churchill River which began November 5th. This was the only station inside the reservoir.
- Water Survey of Canada (ECCC) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

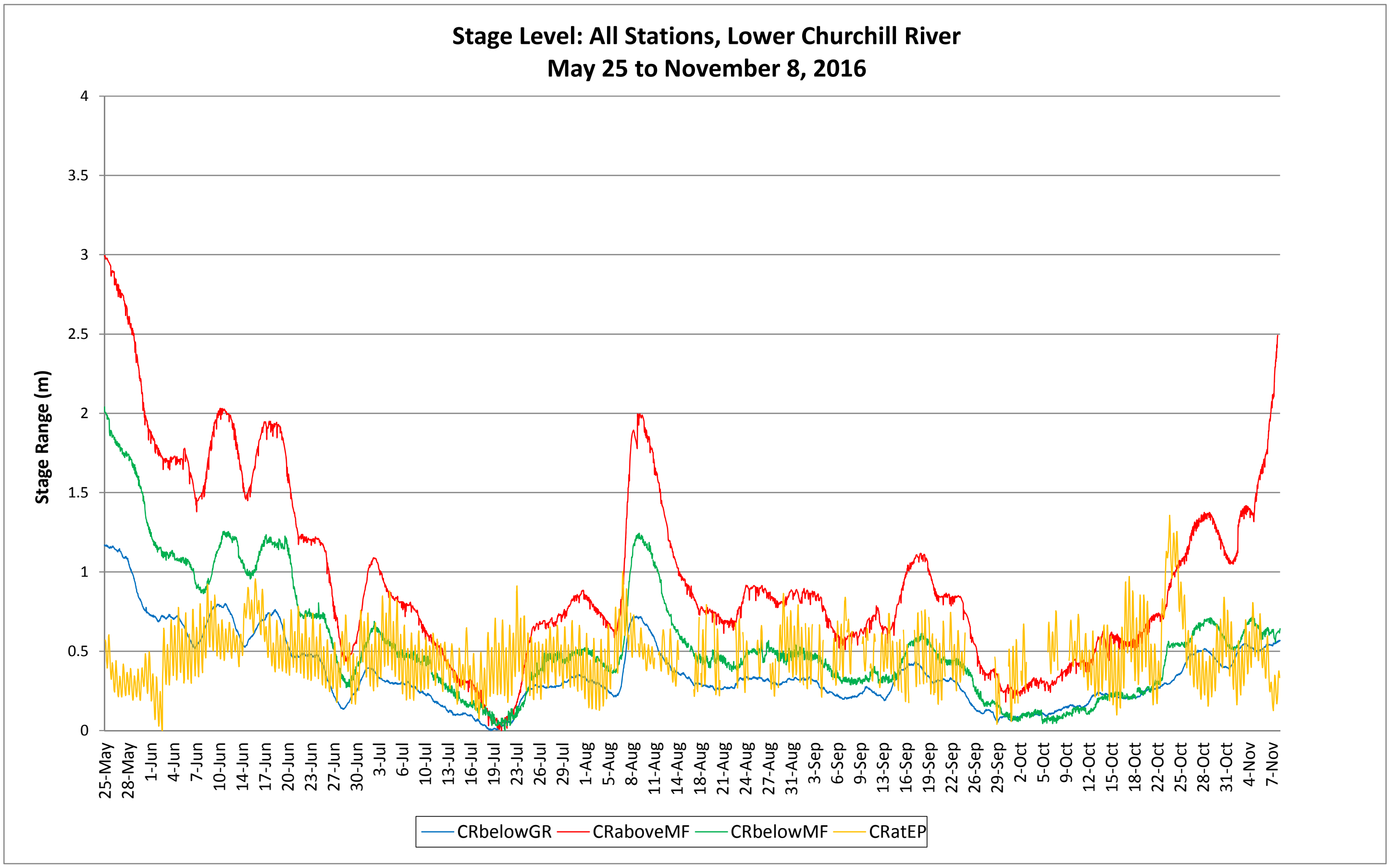


Figure 45: Stage Range at all stations in 2016, Lower Churchill River

	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Stage Range (m)	0.721	2.995	1.24	1.36

Conclusions

- Water quality monitoring instruments were successfully deployed on the Lower Churchill River for different lengths of time during the spring, summer and fall of 2016. The below Grizzle Rapids station was not deployed until June 29 due to the presence of an ice wall blocking accessibility to the site in May. The below Muskrat Falls station was not deployed until June 30 due to the site being inaccessible in May due to ice conditions. A backup sonde was also deployed at Muskrat Island to capture any water quality events should the Lower Muskrat station be deemed inoperable again due to sand interference.
- In most cases, weather related events explain the fluctuations in water levels. In 2016, the four deployed original stations continue to perform well at capturing water quality baseline data along different reaches of the river. The English Point station provides a last measurement of water quality in the lower Churchill River before entering Lake Melville. This station is affected by tidal influences from the Atlantic Ocean.
- Regular visits on a 30-50 day deployment schedule have been adhered to. This has provided good quality data with limited drift. The effects of bio fouling rarely impact the instruments due to the cold pristine nature of the river and the regular maintenance each month.
- The instruments performed well for much of the deployment season with limited disruptions to data collection.
    - Rapid water level decreases left the instrument exposed to air at the river's edge at the above Muskrat Falls from June 21 to 29. Data for this time period has been removed from the data set. Turbidity data has been removed for some stations due to data inaccuracies resulting from the instrument being in very shallow water before running dry.
    - Some data collected from the below Muskrat Falls station was still affected by moving sediment and sand.
    - Finally, transmission errors were infrequent across the network during 2016, with the exception being English Point, which experienced transmission losses between August and October due to an issue with the station's GPS.
- Data collected in 2016 is comparable with datasets from previous years in 2014 and 2015. Water quality parameters do not tend to vary significantly. Stage appears to be one of the greatest variables from year to year.
- Water temperatures were seasonal at all stations in the network peaking at seasonal highs in late July at all stations in the network. Water temperatures had median values between 12.1°C (at English Point) and 14.4°C (below Grizzle Rapids).
- The majority of pH values recorded were within range as suggested by the CCME Guidelines for the Protection of Aquatic Life for pH, except for short periods of time at the station at below Lower Muskrat and English Point. The median pH was 7 at below Grizzle Rapids, while above Muskrat Falls (6.75) and at English Point (6.69) were similar.
- During the warm summer period of mid-July to early September, dissolved oxygen at all stations except below Lower Muskrat Falls fell below the minimum CCME Guideline for the Protection of Aquatic Life during early life stages (9.5mg/L). All values at all stations remained above the minimum CCME Guideline for the Protection of Aquatic Life during other life stages (6.5mg/L) throughout the deployment period. Median values for dissolved oxygen and percent saturation ranged between 9.77mg/l (95.9%) (below Grizzle Rapids) and 11.85 (112.3%) (at below Lower Muskrat).
- Specific conductivity is generally very stable on the Lower Churchill River (above English Point), fluctuating only a few micro Siemens during a deployment period. At the station at English Point, specific conductance is highly variable, fluctuating significantly each day due to the tidal influences of the Atlantic Ocean. As the tide comes in, the

specific conductivity increases as the dissolved solids and salinity increase, and vice versa as the tide goes out. This increase and decrease in specific conductivity and stage occurs twice daily. Median values for specific conductivity ranged between 17.3uS/cm (below Lower Muskrat Falls) and 30.1 uS/cm (at English Point)

- Background turbidity values at the station below Grizzle Rapids were 0.3NTU and turbidity events were short lived and insignificant. At stations above and below Muskrat Falls and at English Point, median turbidity values were 5.9NTU, 4.3NTU and 10.5NTU, respectively. Turbidity events were frequent, most often corresponding with precipitation events and visible at each of these three stations.

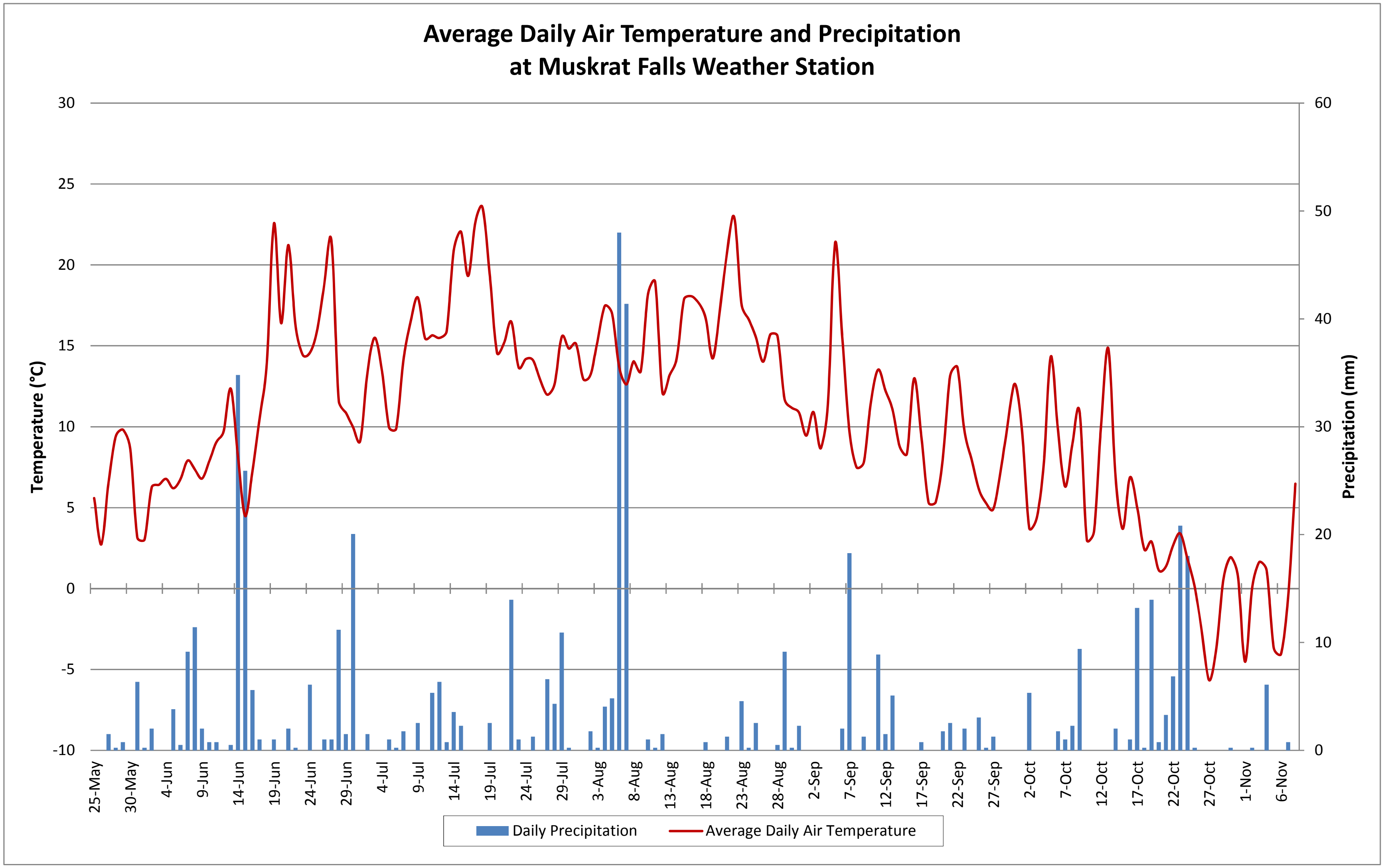
Path Forward

In order for this agreement to be successful, it is essential to continually evaluate and move forward. The 2016 deployment season was successful in providing water quality data for the Lower Churchill Project at all four stations. The following is a list of planned activities to be carried out in the upcoming year. The list also includes some multi-year activities planned in the previous year that are still in progress.

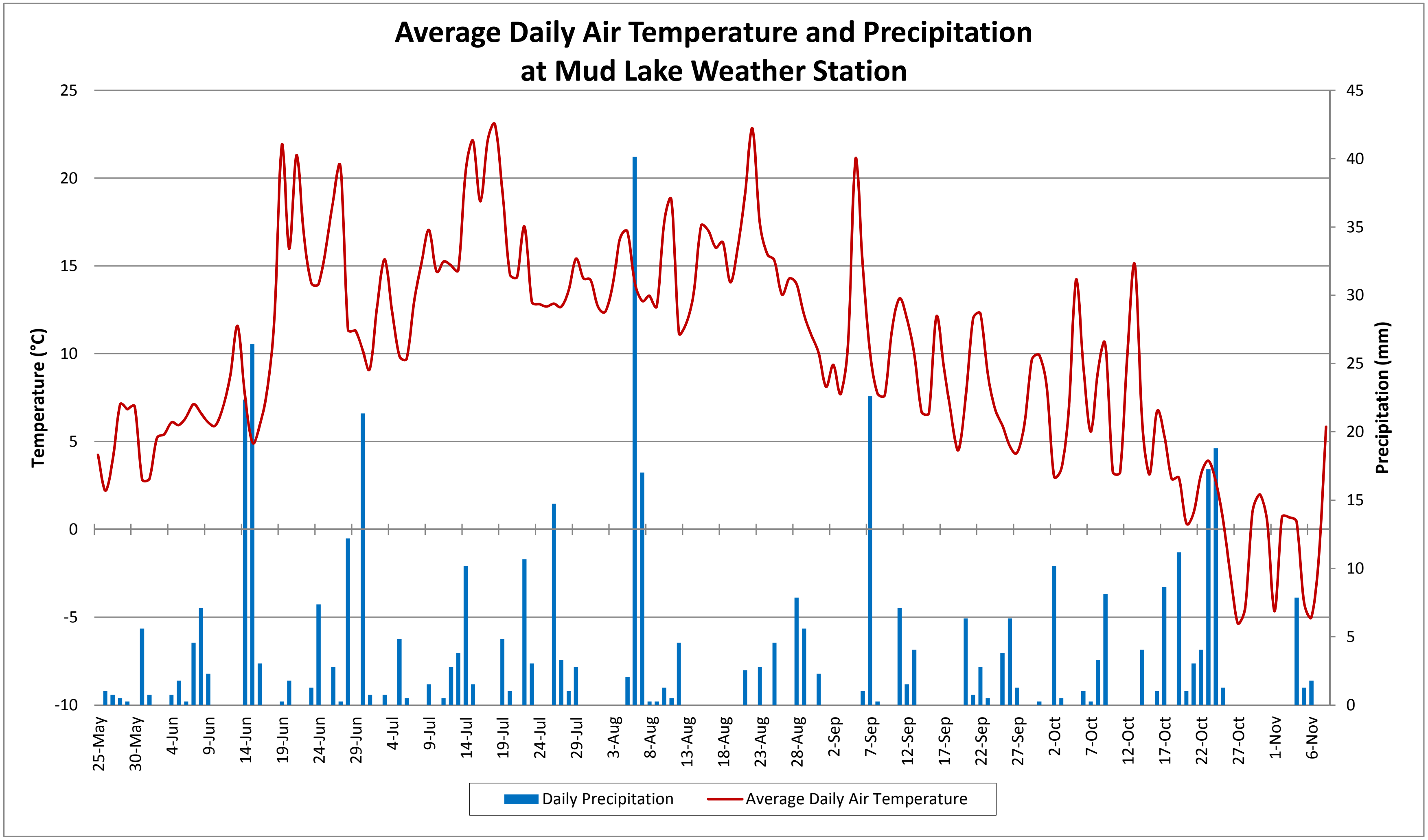
- ECC staff will deploy RTWQ instruments in spring 2017 when ice conditions allow and perform regular site visits throughout the 2017 deployment season for calibration and maintenance of the instruments.
- ECCC staff will perform regular site visits to ensure water quantity instrumentation is correctly calibrated and providing accurate measurements.
- Nalcor will continue to be informed of data trends and any significant water quality events in the form of a monthly deployment report when the deployment season begins. Nalcor will also receive an annual report summarizing the events of the deployment season.
- Nalcor will continue to receive batch datasets of all RTWQ data. Raw data will be provided if requested.
- Open communication lines will continue to be maintained between ECC, ECCC and Nalcor employees involved with the agreement in order to respond to emerging issues on a proactive basis.
- ECC will continuously update the TSS-Turbidity model for the stations above and below Muskrat Falls as new grab sample data becomes available. The model will then be tested and validated in consultation with Nalcor or their consultants as necessary.
- Research into the use of remote sensing (using satellite imagery) to predict/map water quality parameters (i.e. turbidity and TSS) will continue in 2017. Satellite imagery will be acquired by ECC to further this area of research.
- The Lake Melville station remains a water quantity station. RTWQ monitoring was stopped in 2012 following continual damage to the deployed instrument.
- ENVC purchased a NexSens CB-450 data buoy that was deployed in Lake Melville in August 2015. However, due to heavy ice at the end of the season, significant damage was sustained. A buoy was successfully deployed in 2016 from July 7th to September 21st. The buoy will be deployed again in 2017 as Lake Melville is very important to assessing the water quality of the Lower Churchill River ecosystem.

Prepared by:
Kyla Brake – Environmental Scientist
Department of Environment and Climate Change
Water Resources Management Division
Phone: 709.729. 3899
Fax: 709.729.0320

Appendix 1


Average Daily Air Temperature and Precipitation
at Muskrat Falls Weather Station
Temperature (°C)
Precipitation (mm)
30
25
20
15
10
5
0
-5
-10
60
50
40
30
20
10
0
25-May
30-May
4-Jun
9-Jun
14-Jun
19-Jun
24-Jun
29-Jun
4-Jul
9-Jul
14-Jul
19-Jul
24-Jul
29-Jul
3-Aug
8-Aug
13-Aug
18-Aug
23-Aug
28-Aug
2-Sep
7-Sep
12-Sep
17-Sep
22-Sep
27-Sep
2-Oct
7-Oct
12-Oct
17-Oct
22-Oct
27-Oct
1-Nov
6-Nov
Daily Precipitation
Average Daily Air Temperature

Appendix 2


Average Daily Air Temperature and Precipitation
at Mud Lake Weather Station
Temperature (°C)
Precipitation (mm)
25
20
15
10
5
0
-5
-10
45
40
35
30
25
20
15
10
5
0
25-May
30-May
4-Jun
9-Jun
14-Jun
19-Jun
24-Jun
29-Jun
4-Jul
9-Jul
14-Jul
19-Jul
24-Jul
29-Jul
3-Aug
8-Aug
13-Aug
18-Aug
23-Aug
28-Aug
2-Sep
7-Sep
12-Sep
17-Sep
22-Sep
27-Sep
2-Oct
7-Oct
12-Oct
17-Oct
22-Oct
27-Oct
1-Nov
6-Nov
Daily Precipitation
Average Daily Air Temperature