Real-Time Water Quality 2013 Annual Report

Lower Churchill River Network

May 23 to November 8, 2013

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

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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 Conservation (ENVC) as well as Environment Canada (EC) to ensure the protection of ambient water resources in the Lower Churchill River.

ENVC employees have been integral in ensuring the smooth operation of such a technologically advanced network. In 2013, ENVC Environmental Scientist, Grace de Beer, was responsible for deployment and removal of instruments including cleaning, calibration, maintenance and preparation of monthly deployment reports. Maria Murphy and Katherine Blake are acknowledged for their efforts during deployment and removal procedures in 2013.

EC staff, with the Water Survey of Canada (Brent Ruth, Perry Pretty, Roger Ellsworth, Dwayne Akerman and Mike Ludwicki) 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 (Marion Organ – Nalcor; Renee Paterson - ENVC; Howie Wills – EC) 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 2013, there was continued communication in the form of small meetings and email correspondence between ENVC and Nalcor. This network is continually successful due the participation and collaboration of all three agencies.

Abbreviations

EC	Environment Canada
ENVC	Department of Environment and Conservation
CRaboveMF	Station at Churchill River above Muskrat Falls
CRbelowGR	Station at Churchill River below Grizzle Rapids
CRbelowMF	Station at Churchill River below Muskrat Falls
CRbelowMR	Station at Churchill River below Metchin River
CRatEP	Station at Churchill River below English Point
DO	Dissolved Oxygen
NL	Newfoundland and Labrador
QAQC	Quality Assurance and Quality Control
RTWQ	Real-Time Water Quality
SC	Specific Conductivity
WRMD	Water Resources Management Division
%Sat	Percent Saturation

Introduction

- The RTWQ monitoring network on the Lower Churchill River was successfully established by ENVC and EC 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 currently 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, consists 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. These stations measure water quality parameters including water temperature, pH, specific conductivity, dissolved oxygen, and turbidity. Two additional parameters, total dissolved solids and percent saturation are calculated from measured parameters. Water quantity data (stage level and flow rate where applicable) are measured by EC.
- In addition to the four water quality/quantity monitoring stations, there are two water quantity monitoring stations on the Churchill River below the Tailrace and above Grizzle Rapids, which strictly record stage level continuously. These parameters are the responsibility of EC, however, if needed, ENVC staff reporting on water quality will have access to water quantity information to better understand and explain water quality fluctuations.
- In 2011, ENVC in cooperation with EC 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.
- Continuous monitoring at the five water quality/quantity monitoring stations in the Lower Churchill River Network recommenced in spring 2013. This annual deployment report illustrates, discusses and summarizes water quality related events from May 23 to November 8, 2013. During this time, six visits were made to each of the five RTWQ sites. Instruments were deployed for five, month-long intervals referred to as deployment periods.
- Construction at the Muskrat Falls Hydroelectric Generation site began in 2013. Construction mainly took place on the south side of the river adjacent to the upper and lower falls. A road was constructed to the site along the south side of the river from Caroline Brook Access road to the main site (~17km). A significant area was unearthed for construction of the powerhouse and construction on cofferdams and the spillway started late in the season. Site water controls at Muskrat Falls were completed mid-summer and direct run off flows to one of two discharge points either above or below the lower falls. There has been a significant amount of forestry activity in the lower Churchill watershed in preparation for filling the reservoir. Construction is scheduled to continue until 2017.

Maintenance and Calibration

- It is recommended that regular maintenance and calibration of the instruments take place on a monthly basis to ensure accurate data collection. This procedure is the responsibility of the ENVC staff and is performed preferably every 30 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, ENVC staff carefully calibrates each sensor attachment for pH, specific conductivity, dissolved oxygen and turbidity.
- An extended deployment period (>30 days) can result in instrument sensor drift which may result in skewed data. The instrument sensors will still work to capture any water quality event even though the exact data values collected may be inaccurate. Installation and removal dates for each station in the 2013 deployment season are summarized in Table 1.

Table 1: Installation and removal dates for 2013 deployment periods

Installation	Removal	Deployment
May 23/24	June 26/27	34 days
June 26/27	Aug 8/9/13	43-47 days
Aug 8/9/13	Sep 12/14	30-37 days
Sep 12/14	Oct 10/11	26-29 days
Oct 10/11	Nov 6/8	26-28 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.
  - ► 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 23 to November 8, 2013, 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 23 – November 8, 2013

Station	Date	Action	Instrument #	Temperature	pH	Specific Conductivity	Dissolved Oxygen	Turbidity
Below Metchin River	May 23	Deployment	45707	Good	Good	Excellent	n/a	Excellent
	Jun 26	Removal		Instrument out of the water upon retrieval				
	Jun 26	Deployment	45701	Good	Good	Excellent	Good	Excellent
	Aug 8	Removal		Excellent	Excellent	Excellent	Excellent	Excellent
	Aug 8	Deployment	45707	Good	Good	Excellent	Excellent	Excellent
	Sep 14	Removal		Good	Excellent	Excellent	Excellent	Excellent
	Sep 14	Deployment	45701	Excellent	Good	Excellent	Excellent	Excellent
	Oct 10	Removal		Good	n/a	Excellent	Excellent	Excellent
	Oct 10	Deployment	45707	Good	n/a	Excellent	Excellent	Excellent
	Nov 6	Removal		Marginal	n/a	Excellent	Fair	Excellent
Below Grizzle Rapids	May 23	Deployment	45699	Excellent	Excellent	Excellent	Excellent	Excellent
	Jun 26	Removal		Excellent	Poor	Excellent	Excellent	Excellent
	Jun 26	Deployment	45709	Good	Poor	Good	Excellent	Excellent
	Aug 8	Removal		Excellent	Good	Excellent	Excellent	Excellent
	Aug 8	Deployment	45699	Excellent	Good	Excellent	Excellent	Excellent
	Sep 14	Removal		Excellent	n/a	Excellent	Excellent	Excellent
	Sep 14	Deployment	47590	Excellent	n/a	Excellent	Excellent	Excellent
	Oct 10	Removal		Excellent	n/a	Excellent	Excellent	Excellent
	Oct 10	Deployment	45700	Good	n/a	Excellent	Good	Excellent
	Nov 6	Removal		Fair	n/a	Excellent	Excellent	Excellent
Above Muskrat Falls	May 24	Deployment	47590	Excellent	Good	Excellent	Excellent	Excellent
	Jun 27	Removal		Instrument out of the water upon retrieval				
	Jun 27	Deployment	47589	Excellent	Marginal	Excellent	Poor	Excellent
	Aug 8	Removal		Excellent	Good	Excellent	n/a	Good
	Aug 8	Deployment	47590	Excellent	Good	Excellent	n/a	n/a
	Sep12	Removal		Excellent	Good	Excellent	Excellent	n/a
	Sep 12	Deployment	47589	Excellent	Fair	Excellent	Excellent	Good
	Oct 11	Removal		Excellent	n/a	Excellent	Excellent	Excellent
	Oct 11	Deployment	47590	Excellent	n/a	Excellent	Excellent	Excellent
	Nov6	Removal		Excellent	n/a	Excellent	Poor	Excellent
Below Muskrat Falls	May 24	Deployment	45700	Good	Poor	Excellent	Excellent	Excellent
	Jun 27	Removal		Instrument out of the water upon retrieval				
	Jun 27	Deployment	45708	Good	Marginal	Excellent	Excellent	Good
	Aug 9	Removal		Good	Good	Excellent	Excellent	Poor
	Aug 9	Deployment	45700	Good	Excellent	Excellent	n/a	n/a
	Sep 12	Removal		Good	Excellent	Excellent	Excellent	Good
	Sep 12	Deployment	45708	Good	Marginal	Excellent	Excellent	Excellent
	Oct 11	Removal		Good	n/a	Excellent	Good	Fair
	Oct 11	Deployment	45701	Good	n/a	Excellent	Excellent	Good
	Nov 8	Removal		Good	n/a	Excellent	n/a	Good
At English Point	May 24	Deployment	45042	Good	Good	Excellent	Excellent	Excellent
	Jun 27	Removal		Good	Marginal	Excellent	Excellent	Good
	Jun 27	Deployment	47588	Excellent	Fair	Excellent	Excellent	Good
	Aug 13	Removal		Excellent	Good	Excellent	n/a	Good
	Aug 13	Deployment	45042	Good	Fair	Excellent	n/a†	n/a
	Sep 12	Removal		Good	Excellent	Excellent	Excellent	Excellent

	Sep 12	Deployment	45709	Excellent	Fair	Excellent	Excellent	Good
	Oct 11	Removal		Excellent	n/a	Excellent	Excellent	Poor
	Oct 11	Deployment	45042	Good	n/a	Excellent	Excellent	Excellent
	Nov 8	Removal		Good	n/a	Excellent	n/a	Excellent

Data Interpretation and Review

- The following graphs and discussion illustrate significant water quality-related trends from May 23 to November 8 in the Lower Churchill River Network. In this summary of the deployment periods for 2013, 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 is responsible for QAQC of water quantity data. Corrected data can be obtained upon request.
- For a general comparison, 2011 and 2012 data has 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 2013 deployments season was 169 days long while the 2012 and 2011 seasons used for comparison purposes in this report are 131 and 160 days each, respectively.

Churchill River below Metchin River

- Water temperature ranges from 0.3°C to 17.9°C during the 2013 deployment season, with a median value of 11.7°C (Figure 1).
- Water temperatures appear slightly cooler in 2013, especially in the fall season when compared to data collected in previous years.

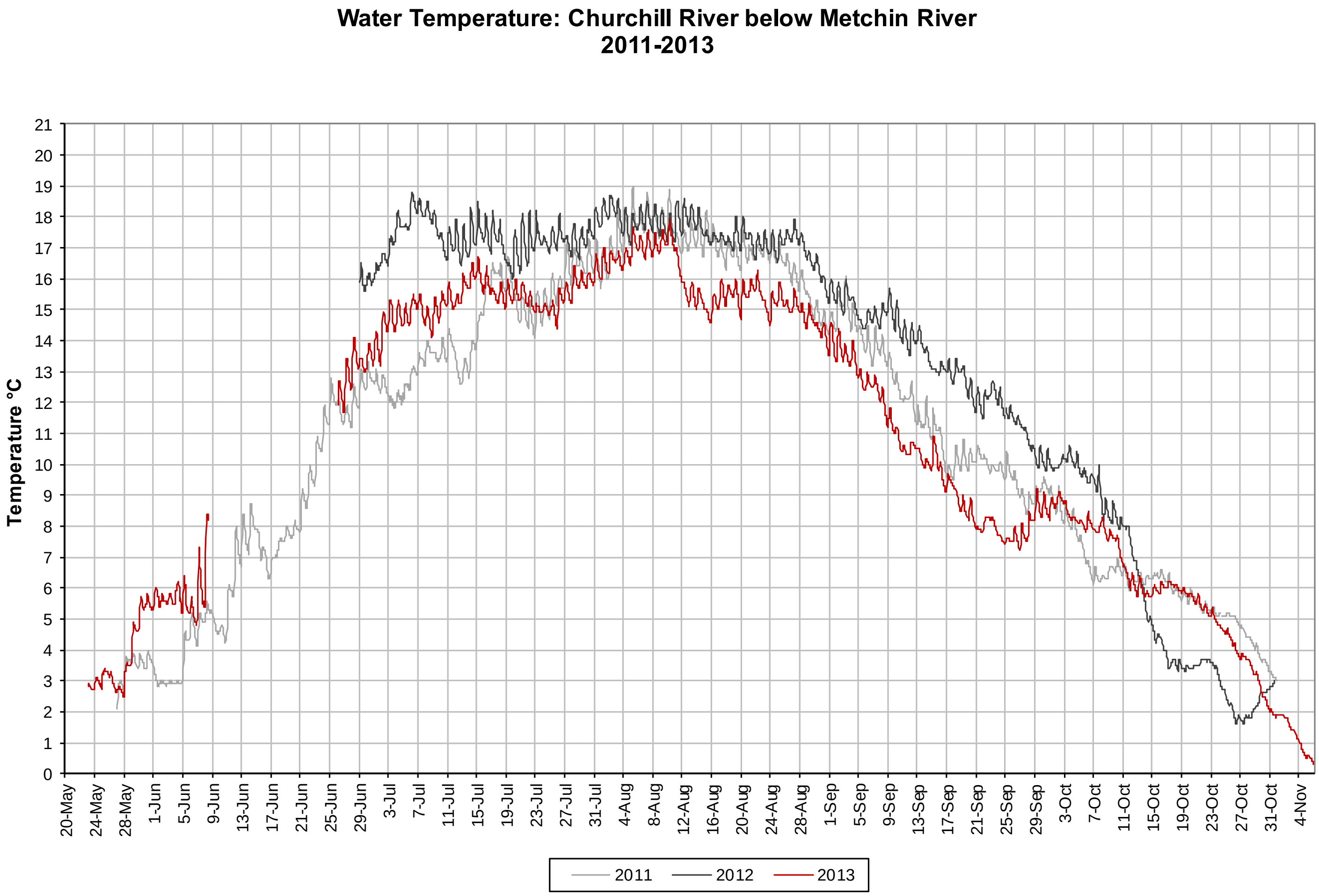


Figure 1: Water temperature at Churchill River below Metchin River

Temperature	2013	2012	2011
Median	11.7	16.0	11.7
Max	17.9	18.8	19.0
Min	0.3	1.6	2.1

- Water temperature values show a typical seasonal trend (Figure 2). Water and air temperatures increasing throughout the spring and early summer with water temperatures peaking in early August. Average air and water temperatures decrease throughout the late summer and fall.

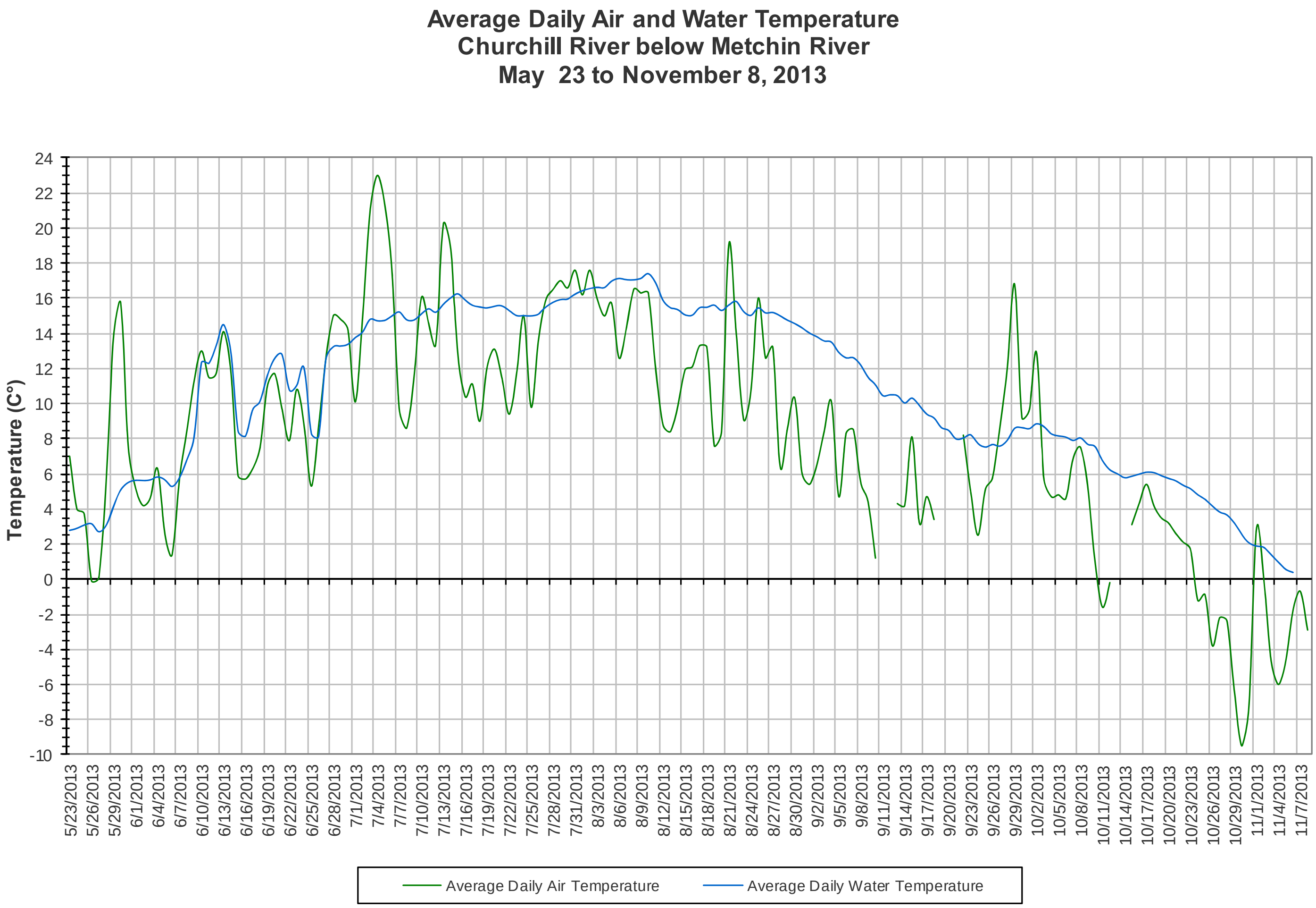


Figure 2: Average daily air and water temperatures at Churchill River below Metchin River

(weather data recorded at Churchill Falls)

- pH ranges between 6.79 and 7.48 pH units during the 2013 deployment season, with a median value of 7.27 pH units (Figure 3).
- pH values are relatively consistent throughout the deployment period. There is an increase in pH in mid-September lasting for about 1 week. This event is highlighted in red on Figure 3.
- All values during the 2013 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 blue on Figure 3.
- pH values appear to be slightly higher in the 2013 season when compared to data from 2011 and 2012.

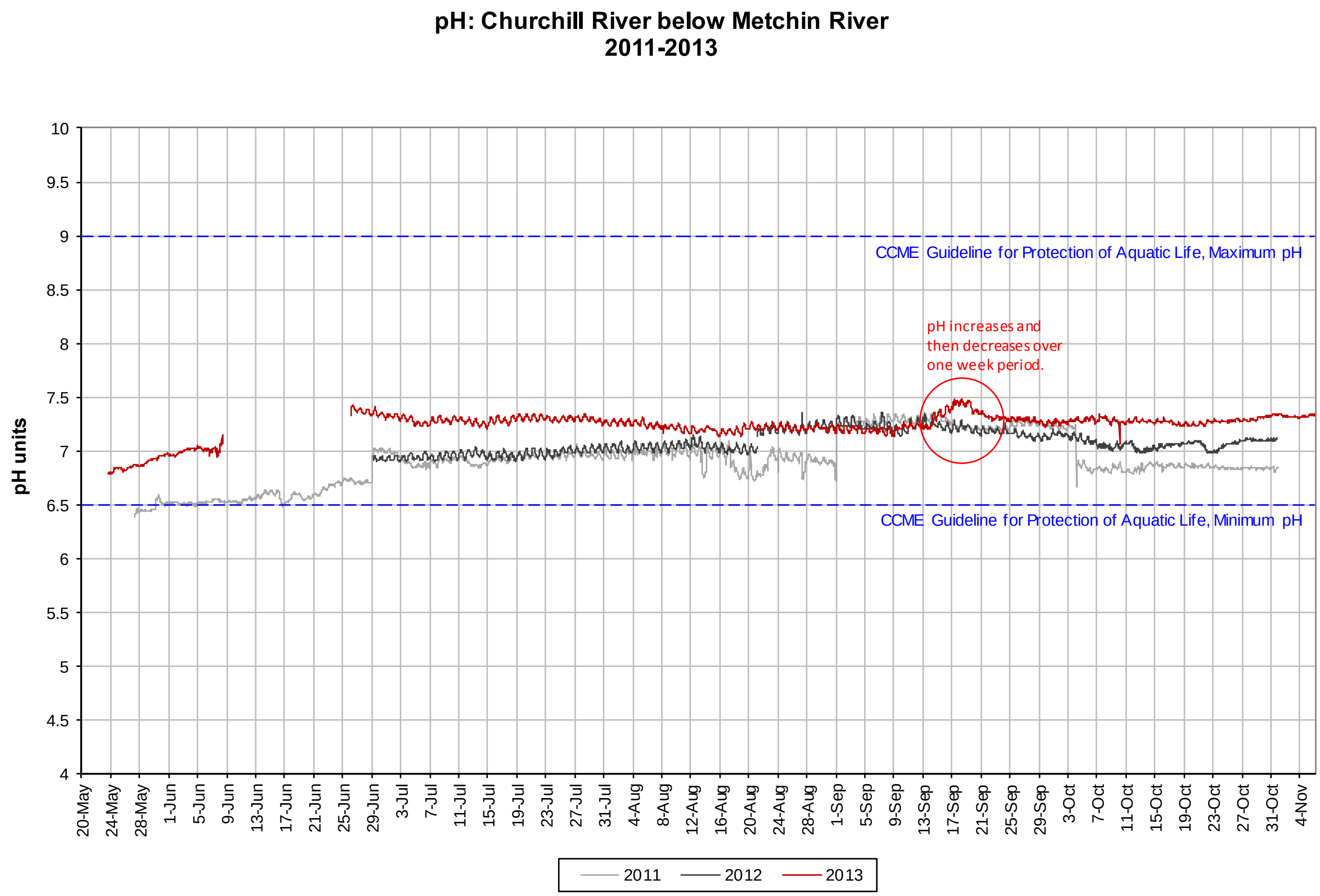


Figure 3: pH at Churchill River below Metchin River

pH (units)	2013	2012	2011
Median	7.27	7.06	6.91
Max	7.48	7.36	7.36
Min	6.79	6.90	6.39

- Specific conductivity ranges from 14.9µS/cm to 23.1µS/cm during the 2013 deployment season, with a median value of 20.6µS/cm (Figure 4).
- Specific conductance increase throughout the spring and early summer before levelling off and decreasing slightly later in the deployment season.
- Increases and decreases in specific conductivity are most times clearly 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 generally decreases due to the dilution of dissolved solids in the water column.
- Specific conductivity is similar in value and trend when compared to data collected in 2011 and 2012.

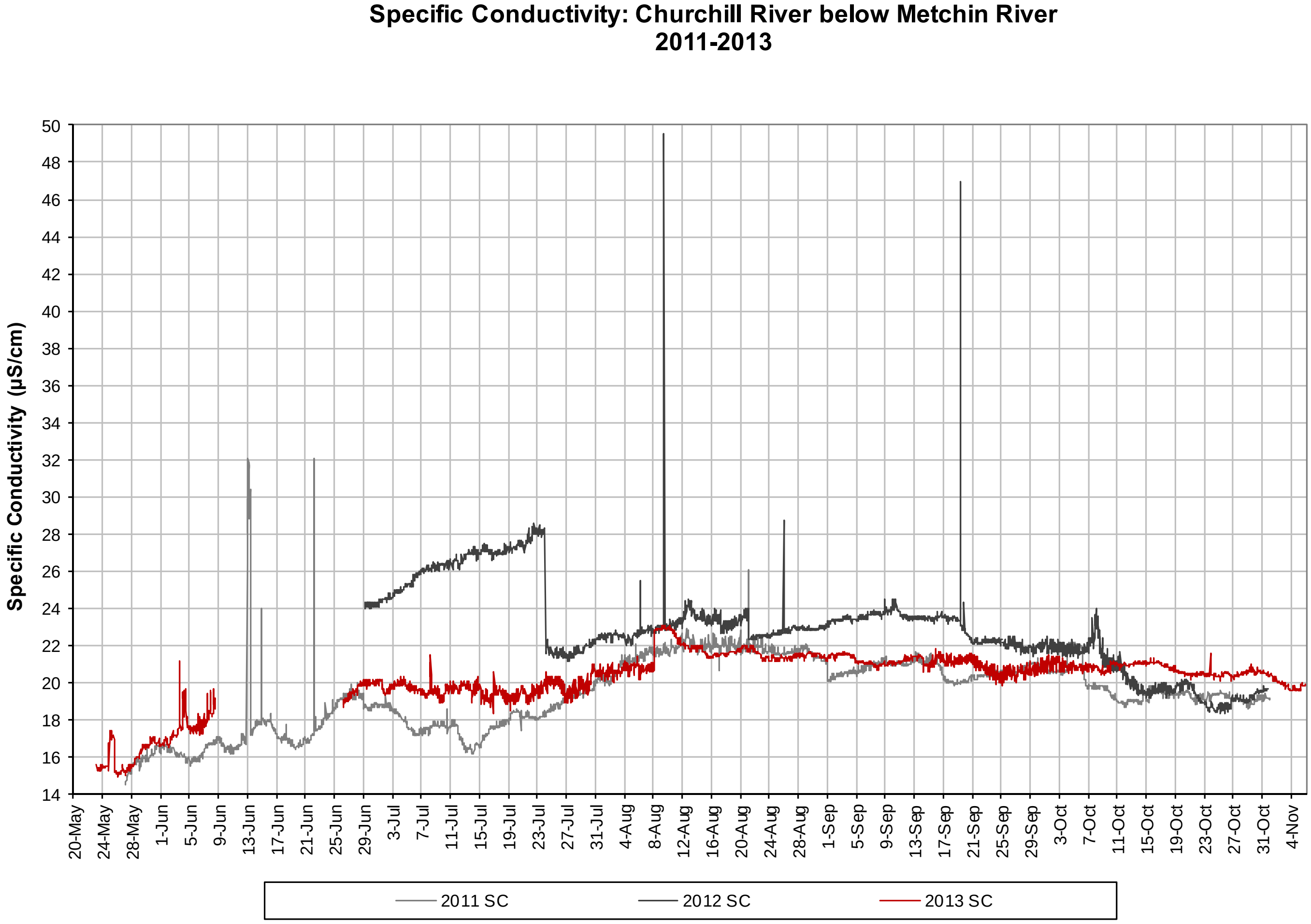


Figure 4: Specific conductivity at Churchill River below Metchin River

Specific Conductivity (µS/cm)	2013	2012	2011
Median	20.6	22.8	19.4
Max	23.1	49.5	32.1
Min	14.9	18.3	14.5

- Throughout the 2013 deployment season, dissolved oxygen ranges from 8.88mg/l to 13.17mg/l, with a median value of 10.28mg/l, while percent saturation ranges from 89.3% to 102.7%, with a median value of 93.6% (Figure 5).
- Dissolved oxygen content shows a typical seasonal fluctuation in 2013. Dissolved oxygen content fluctuates regularly on a daily basis. Percent saturation remains stable throughout the entire deployment season, fluctuating on a daily basis.
- All values were above the minimum CCME Guideline for the Protection of Aquatic Life at Other Life Stages (6.5 mg/l). Between mid-July and early September during the warmest part of the deployment season, dissolved oxygen content is at or just 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 blue on Figure 5.
- Dissolved oxygen and percent saturation values are similar to values collected in 2011 and 2012 (Figure 5).

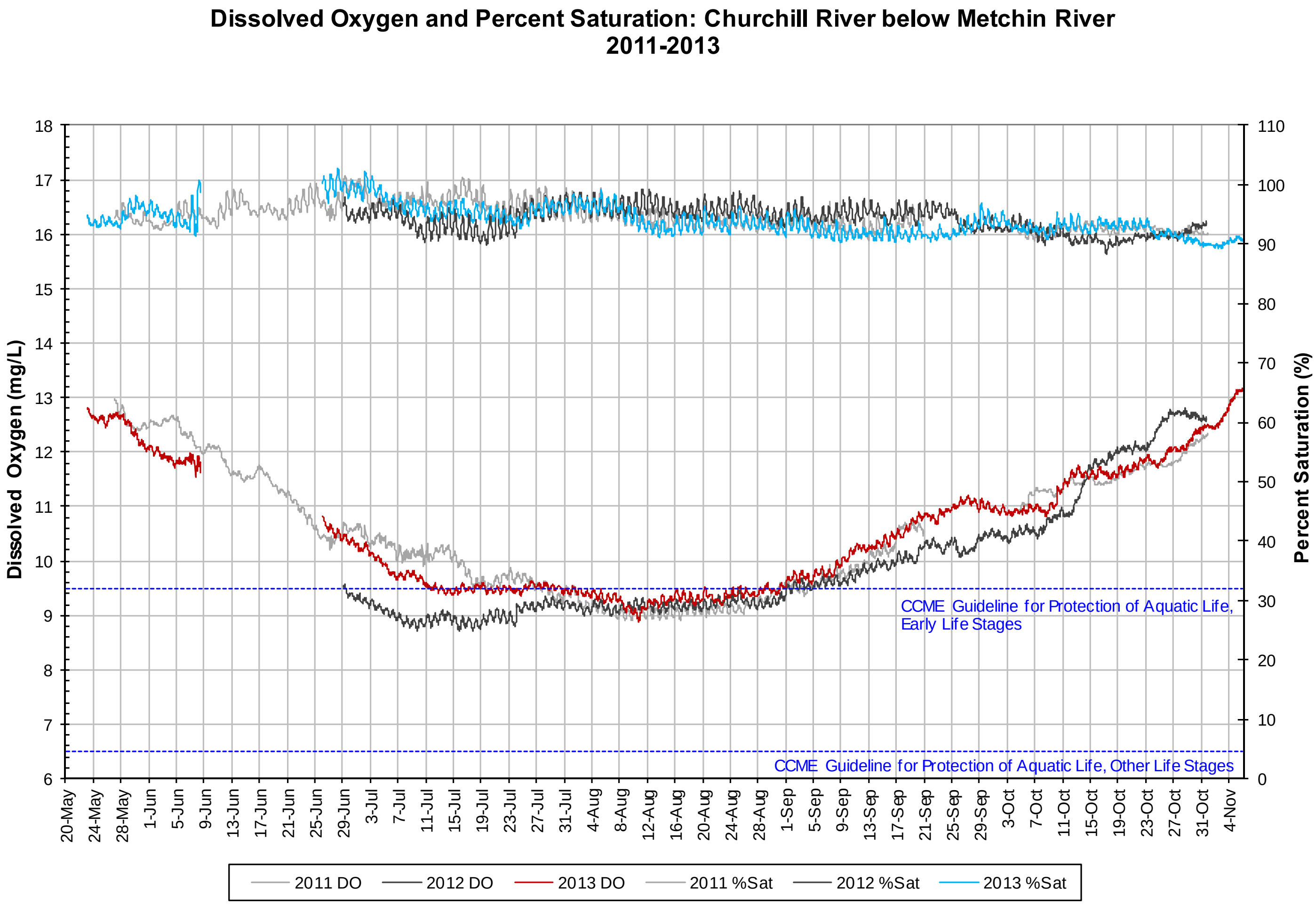


Figure 5: Dissolved oxygen and percent saturation at Churchill River below Metchin River

Dissolved Oxygen (mg/L)	2013	2012	2011		Percent Saturation (%)	2013	2012	2011
Median	10.28	9.38	10.28		Median	93.6	94.5	94.5
Max	13.17	12.8	12.99		Max	102.7	99.3	101.5
Min	8.88	8.72	8.91		Min	89.3	88.4	90.7

- Turbidity generally remains at 0NTU for the majority of the deployment season (Figure 6). A median value of 0NTU from 2011-13 indicates there is no natural background turbidity value at this station.
- There are a couple of instances where turbidity increases (to as high as 55.5NTU) for very short periods of time (1-3 hours). These are not considered water quality events as they are isolated and infrequent occurrences. In the beginning of June there are a number of turbidity increases that occur as the water levels were dropping rapidly. This decreases in stage left the instrument exposed to air on the river edge from June 8 – 26.
- When 2013 values are compared to 2011 and 2012 values for the same time period, a similar trend is observed with background levels at 0NTU. Numerous short lived increases occurring throughout the season.

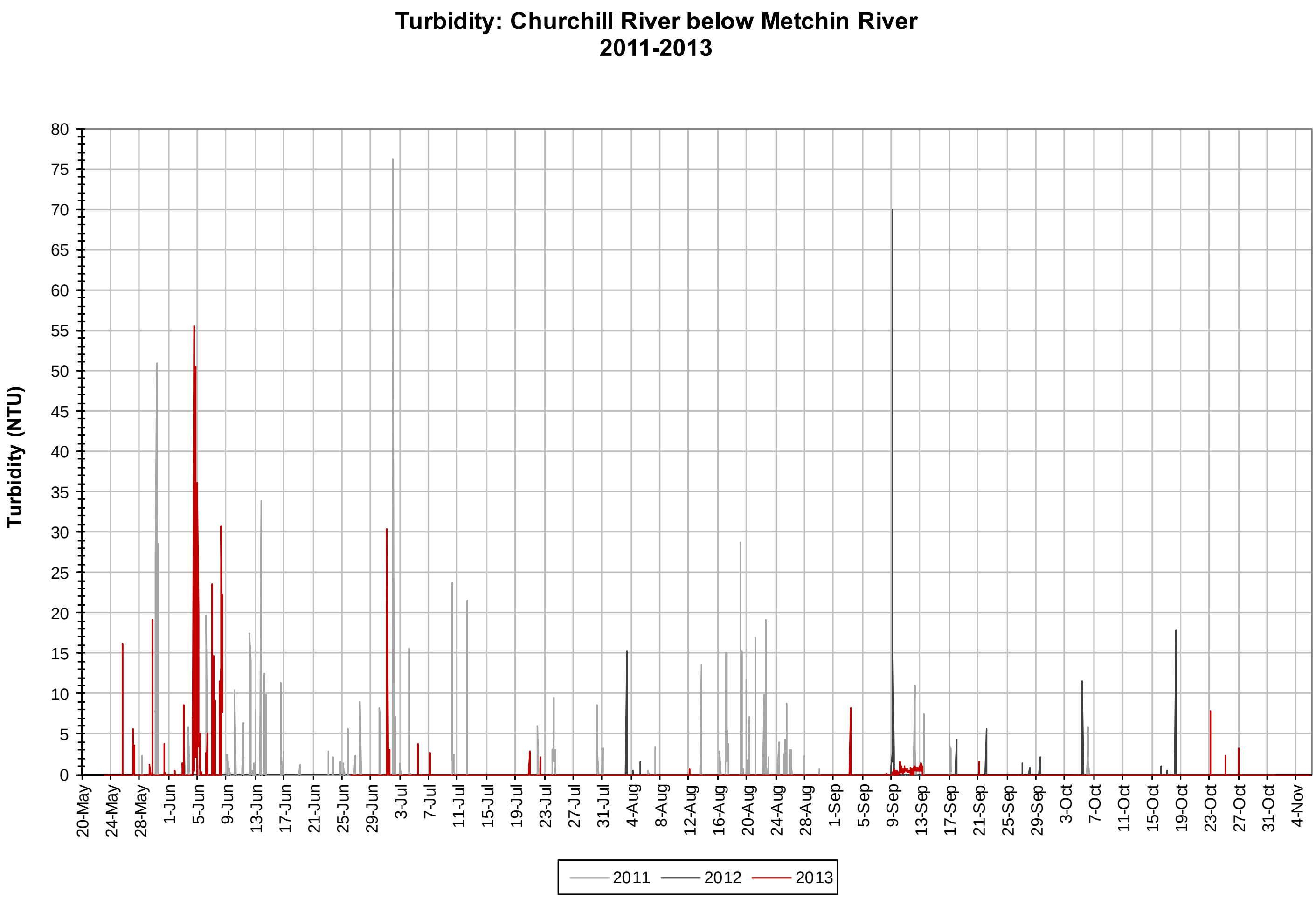


Figure 6: Turbidity at Churchill River below Metchin River

Turbidity (NTU)	2013	2012	2011
Median	0	0	0
Max	55.5	69.9	76.2
Min	0	0	0

- Stage levels in 2013 tend to decrease in the spring and summer months reaching a seasonal low in early July (Figure 7).
- Stage levels from 2011-2013 are graphed below to show how stage levels vary throughout the season and from year to year. The seasonal low was reached much earlier in the season in 2013 when compared to 2011 and 2012. Stage ranges between 1.53m and 2.51m each year.

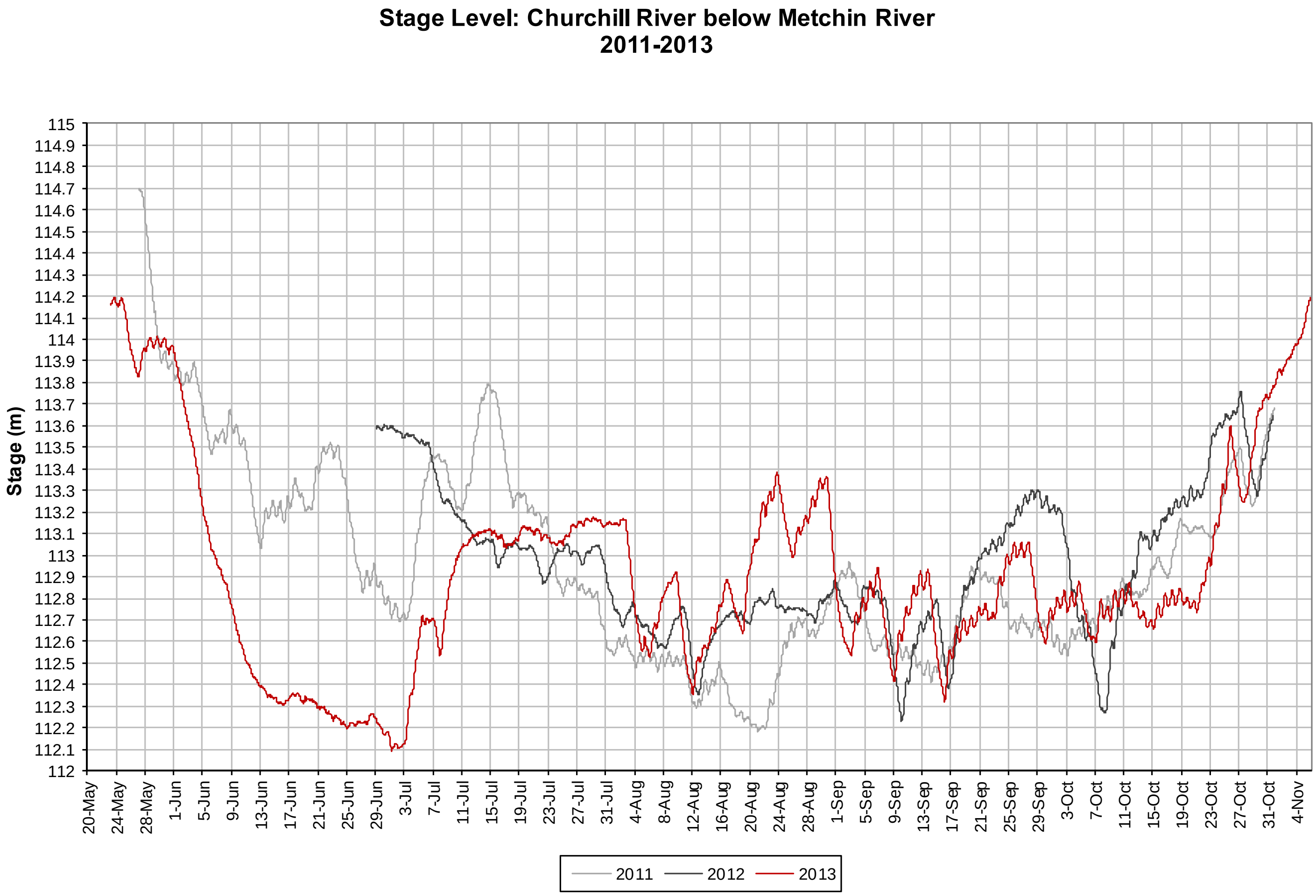


Figure 7: Stage level at Churchill River below Metchin River

Stage (m)	2013	2012	2011
Median	112.832	112.932	112.866
Max	114.197	113.758	114.696
Min	112.093	112.232	112.184
Range	2.104	1.526	2.512

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 8).
- Stage is decreasing rapidly in the first month of the deployment season. Stage increases in early July and fluctuates throughout most of the summer and early fall seasons. Stage increases rapidly near the end of October.
- Precipitation events are frequent and range from low to high in magnitude.

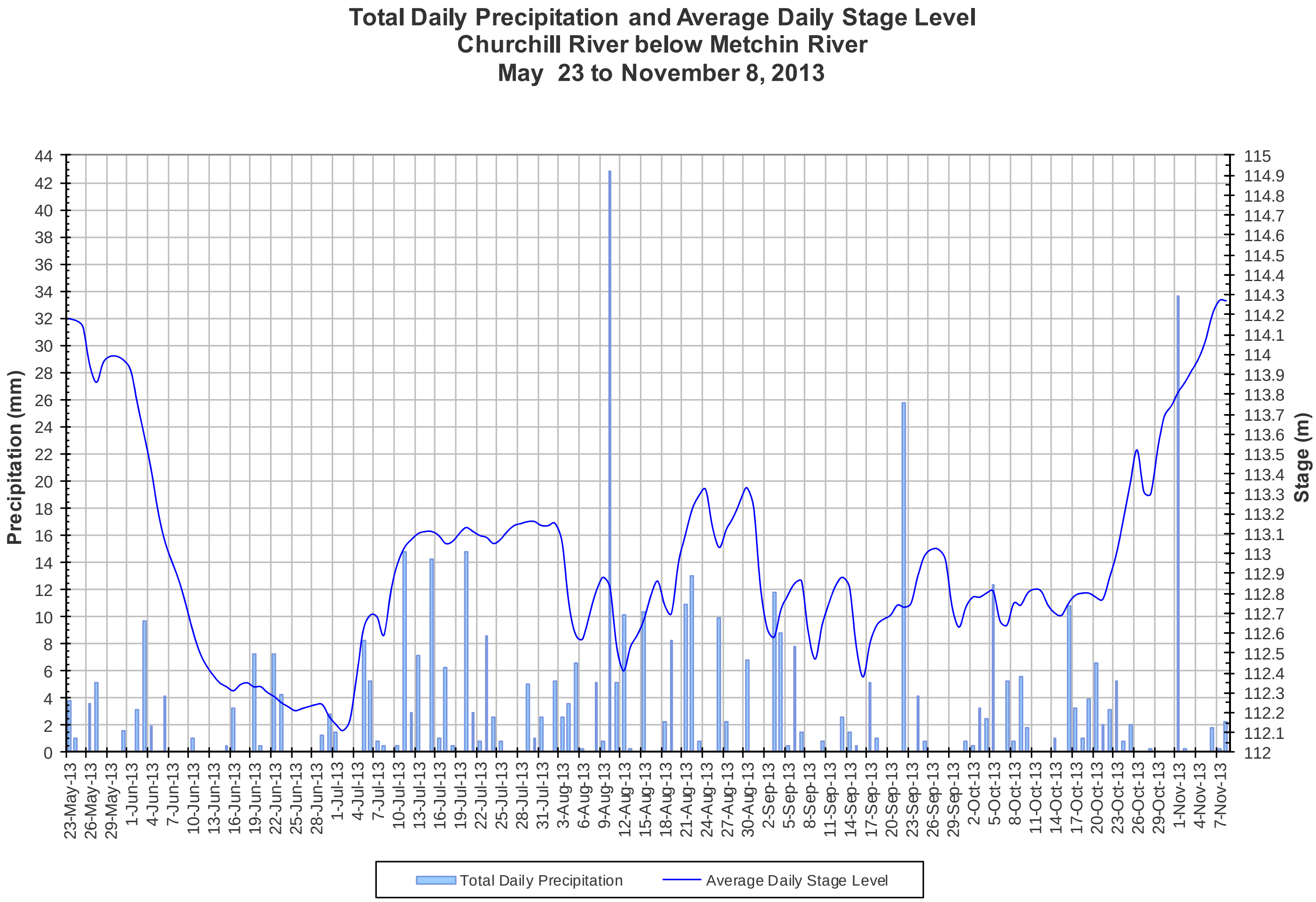


Figure 8: Daily precipitation and average daily stage level at Churchill River below Metchin River

(weather data recorded at Churchill Falls)

Churchill River below Grizzle Rapids

- Water temperature ranges from 2.2°C to 18.4°C during the 2013 deployment season, with a median value of 11.6°C (Figure 9).
- Water temperatures appear slightly cooler in 2013 than in previous years.

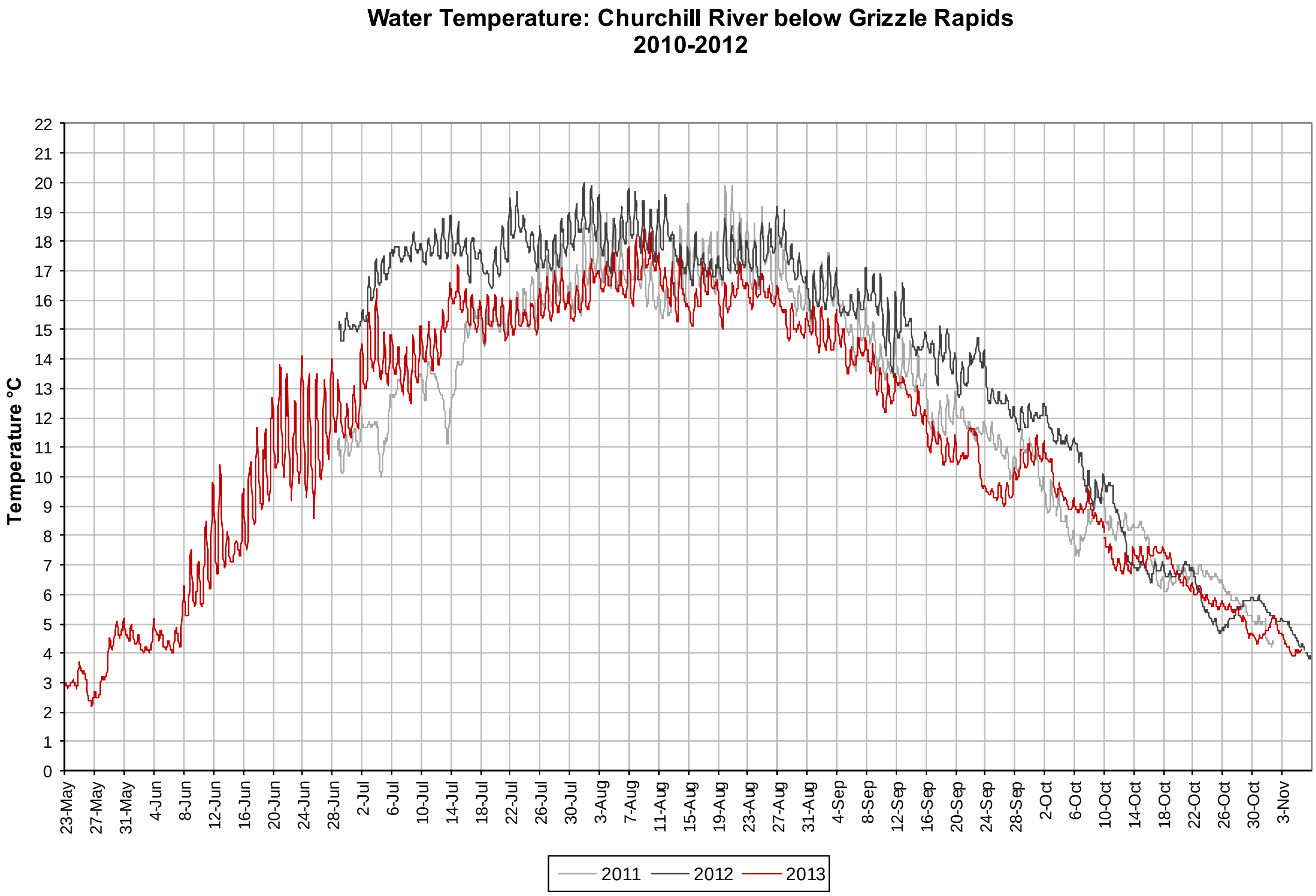


Figure 9: Water temperature at Churchill River below Grizzle Rapids

Temperature	2013	2012	2011
Median	11.6	15.9	13.5
Max	18.4	20.0	19.9
Min	2.2	3.8	5.0

- Water temperature values show a typical seasonal trend (Figure 10). Water and air temperatures increasing throughout the spring and early summer with water temperatures peaking in early August. Average air and water temperatures decrease throughout the late summer and fall.

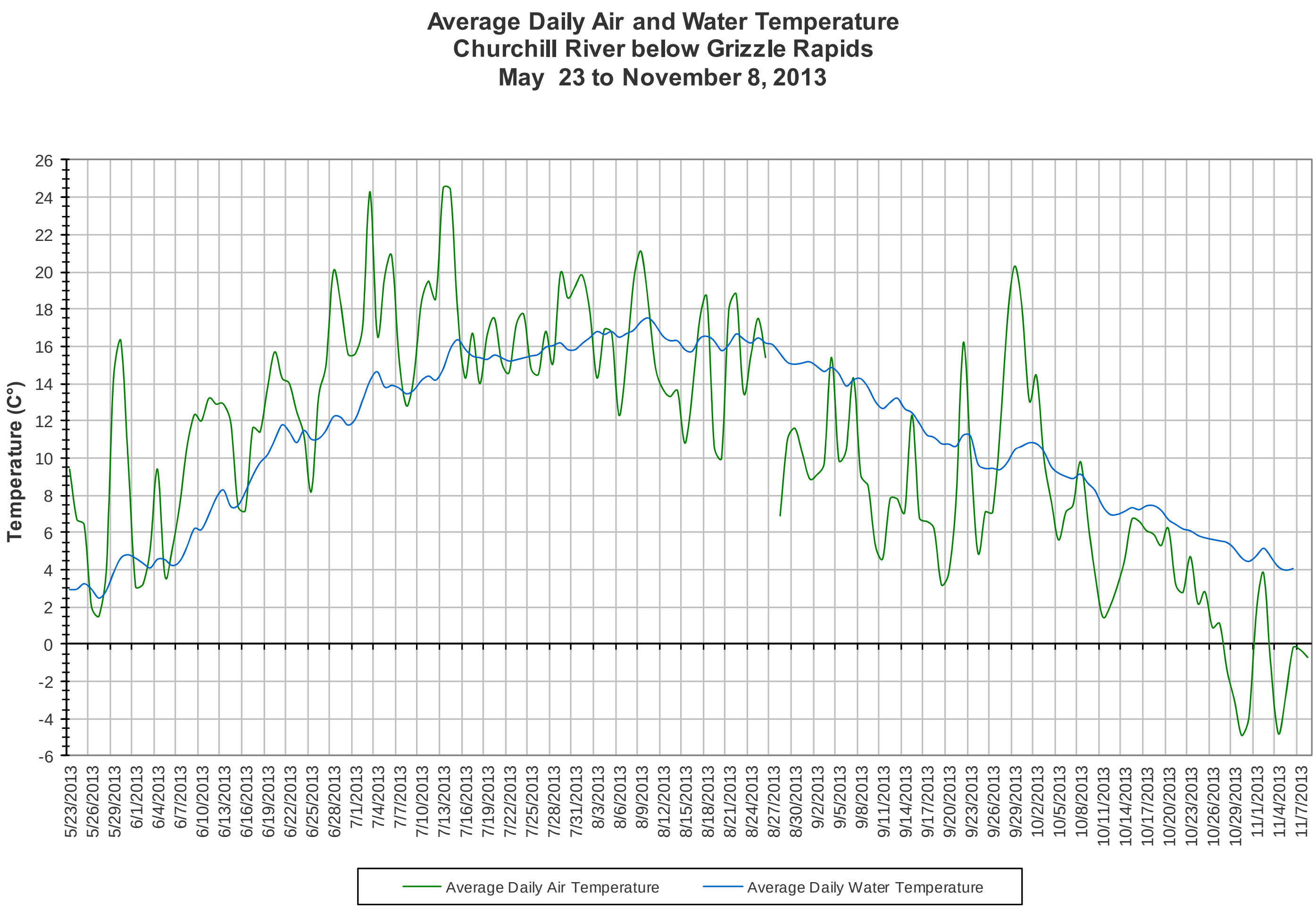


Figure 10: Average daily air and water temperatures at Churchill River below Grizzle Rapids

(weather data recorded at Goose Bay)

- pH ranges between 6.72 and 7.39 pH units during the 2013 deployment season, with a median value of 7.05 pH units (Figure 11).
- pH values are consistent throughout the deployment season with a clear diurnal fluctuation.
- All values during the 2013 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 blue on Figure 3.
- pH values in 2013 are very similar to data collected in 2011 and 2012.

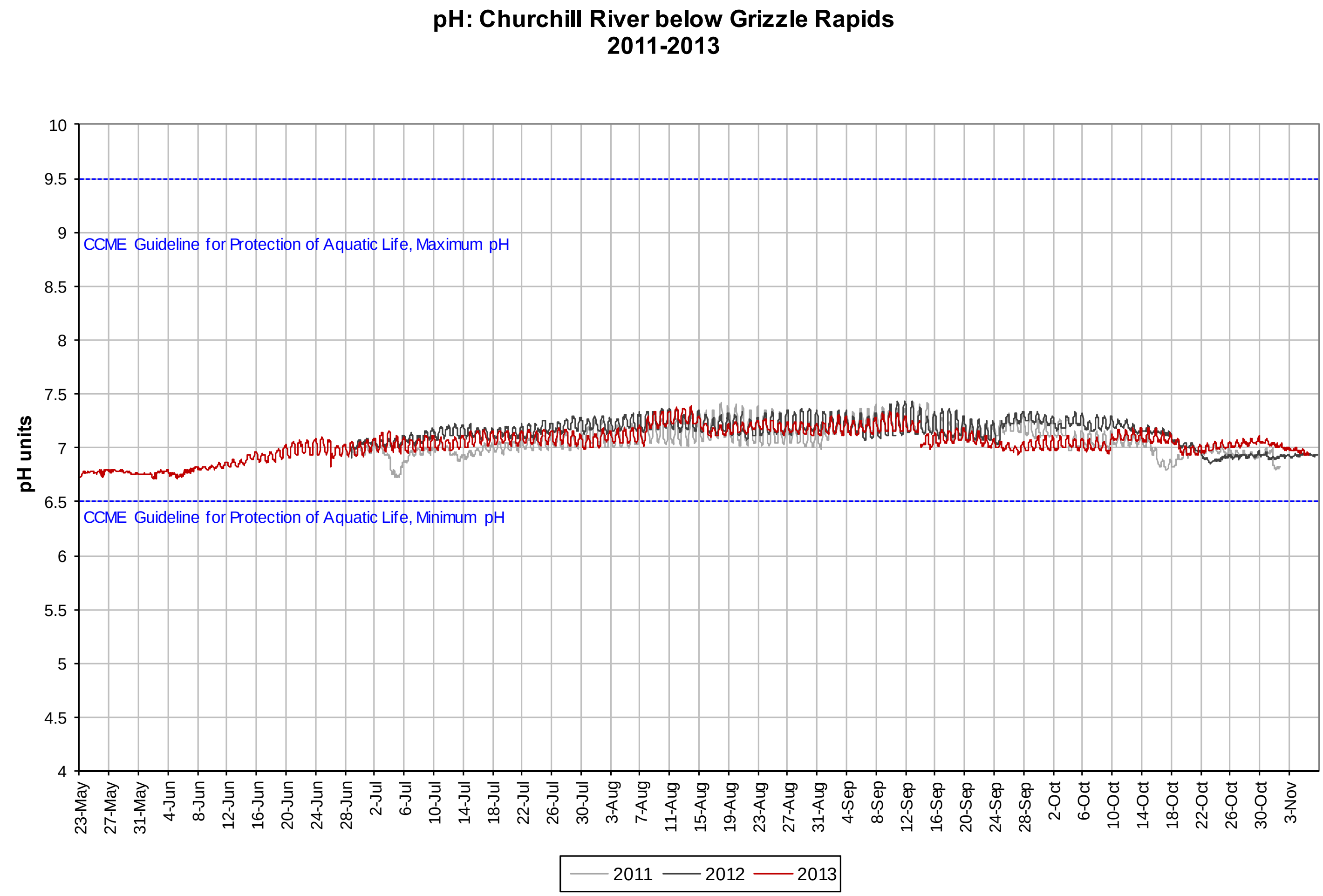


Figure 11: pH at Churchill River below Grizzle Rapids

pH (units)	2013	2012	2011
Median	7.05	7.17	7.07
Max	7.39	7.44	7.44
Min	6.72	6.85	6.73

- Specific conductivity ranges from 13.7µS/cm to 22.5µS/cm during the 2013 deployment season, with a median value of 18.9µS/cm (Figure 12).
- Specific conductivity is increasing in the spring and early summer, peaking in early August. Specific conductivity then begins to decrease slowly throughout the remainder of the deployment season in November.
- Increases and decreases in specific conductivity are most times clearly 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 generally decreases due to the dilution of dissolved solids in the water column.
- Specific conductivity trends in 2011 and 2012 are somewhat similar, increasing throughout the summer when stage is typically decreasing and decreasing again in the fall season when stage is typically increases.

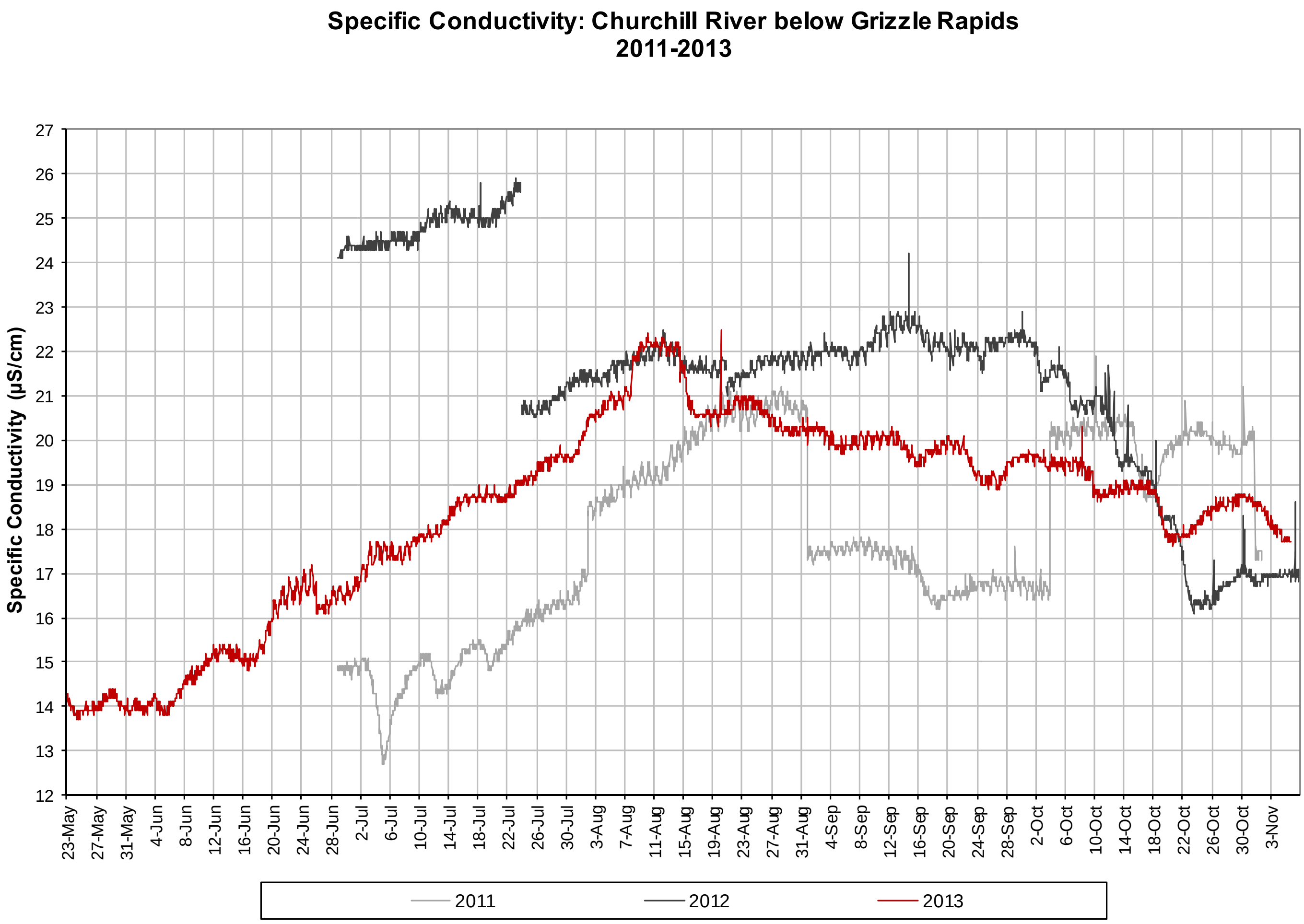


Figure 12: Specific conductivity at Churchill River below Grizzle Rapids

Specific Conductivity (µS/cm)	2013	2012	2011
Median	18.9	21.8	17.6
Max	22.5	25.9	21.9
Min	13.7	16.1	12.7

- During the 2013 deployment season, dissolved oxygen ranges from 9.04mg/l and 12.95mg/l, with a median value of 10.63mg/l, while percent saturation ranges from 91.4% to 105.2%, with a median value of 96.3% (Figure 13).
- Dissolved oxygen content shows a typical seasonal fluctuation in 2013. 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 the month of August, dissolved oxygen values were just below the minimum CCME Guideline for the Protection of Aquatic life at Early Life Stages (9.5mg/l). In late August and early September as air and water temperatures cool, the dissolved oxygen content increases above 9.5mg/l. The guidelines are indicated in blue on Figure 13.
- Dissolved oxygen and percent saturation values are very comparable to the data collected in 2011 and 2012.

Dissolved Oxygen and Percent Saturation: Churchill River below Grizzle Rapids 2011-2013

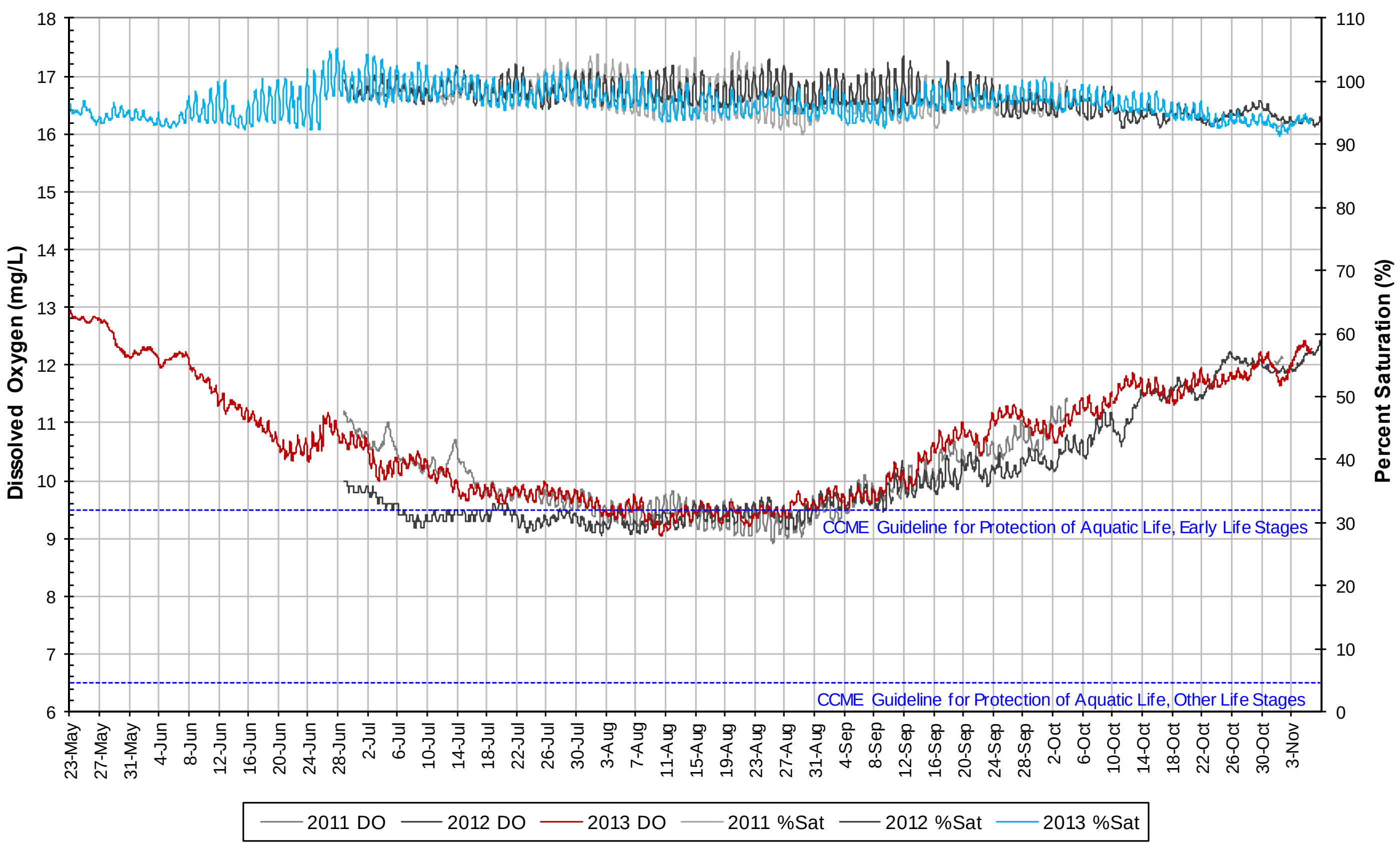


Figure 13: Dissolved oxygen and percent saturation at Churchill River below Grizzle Rapids

Dissolved Oxygen (mg/L)	2013	2012	2011		Percent Saturation	2013	2012	2011
Median	10.63	9.72	9.80		Median	96.3	97.2	97.4
Max	12.95	12.41	11.42		Max	105.2	103.9	104.7
Min	9.04	9.06	8.90		Min	91.4	92.6	91.5

- Turbidity generally remains at 0NTU for the majority of the 2013 deployment season (Figure 14). A median value of 0 NTU from 2011 to 2013 indicates there is no natural background turbidity value at this station.
- There are a couple of instances where turbidity increases minimally to as high as 259.4NTU for very short periods of time (1-5 hours). These are not considered water quality events as they are isolated and infrequent occurrences.
- Similar trends have been identified in the 2011 and 2012 datasets for this station.

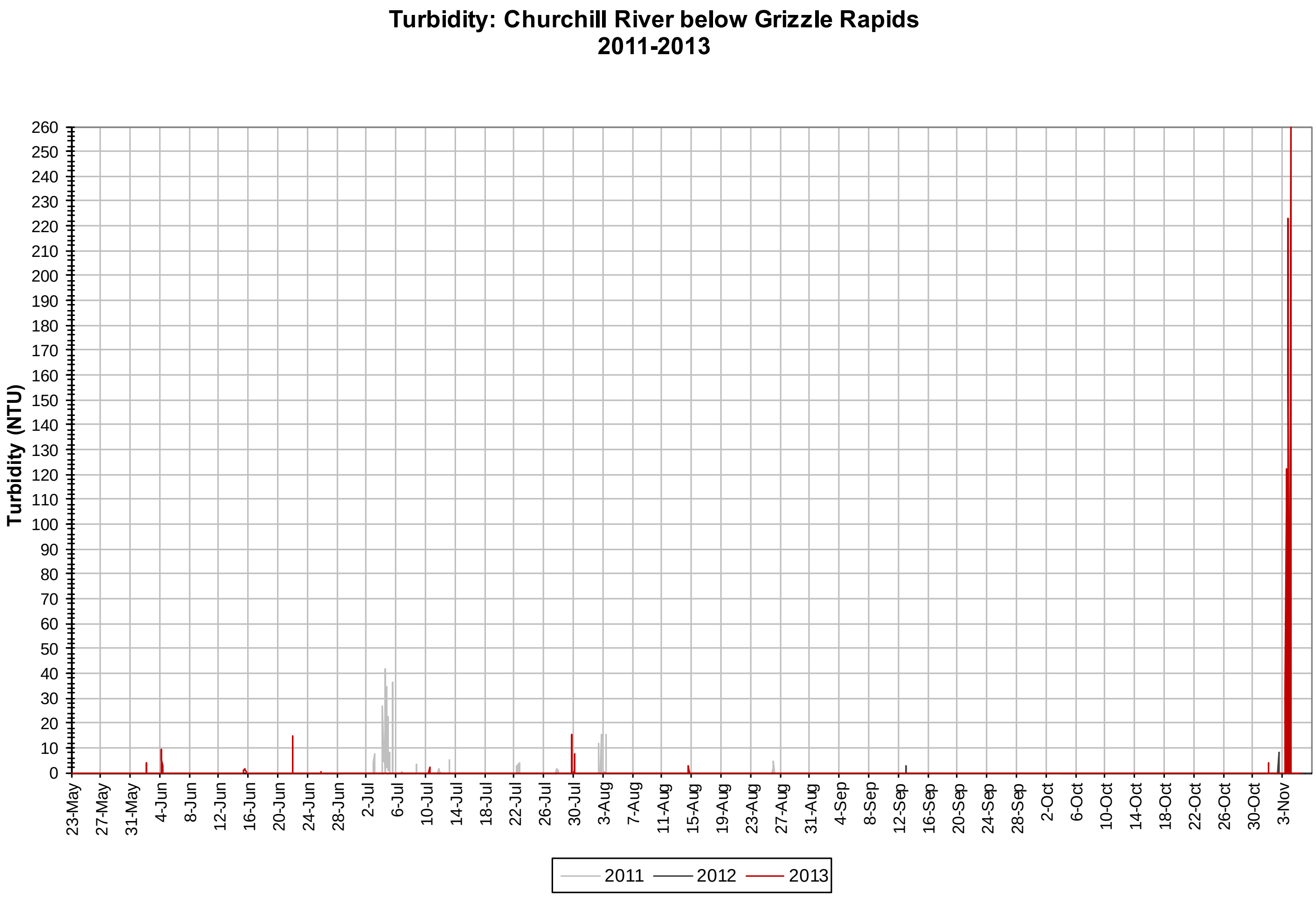


Figure 14: Turbidity at Churchill River below Grizzle Rapids

Turbidity (NTU)	2013	2012	2011
Median	0	0	0
Max	259.4	8.3	41.7
Min	0	0	0

- Stage levels in 2013 tend to decrease in the spring and summer months reaching a seasonal low in early July (Figure 15).
- Stage levels from 2011-2013 are graphed below to show how stage levels vary throughout the season and from year to year. The seasonal low was reached much earlier in the season in 2013 when compared to 2011 and 2012. Stage ranges between 0.74m and 1.00m each year.

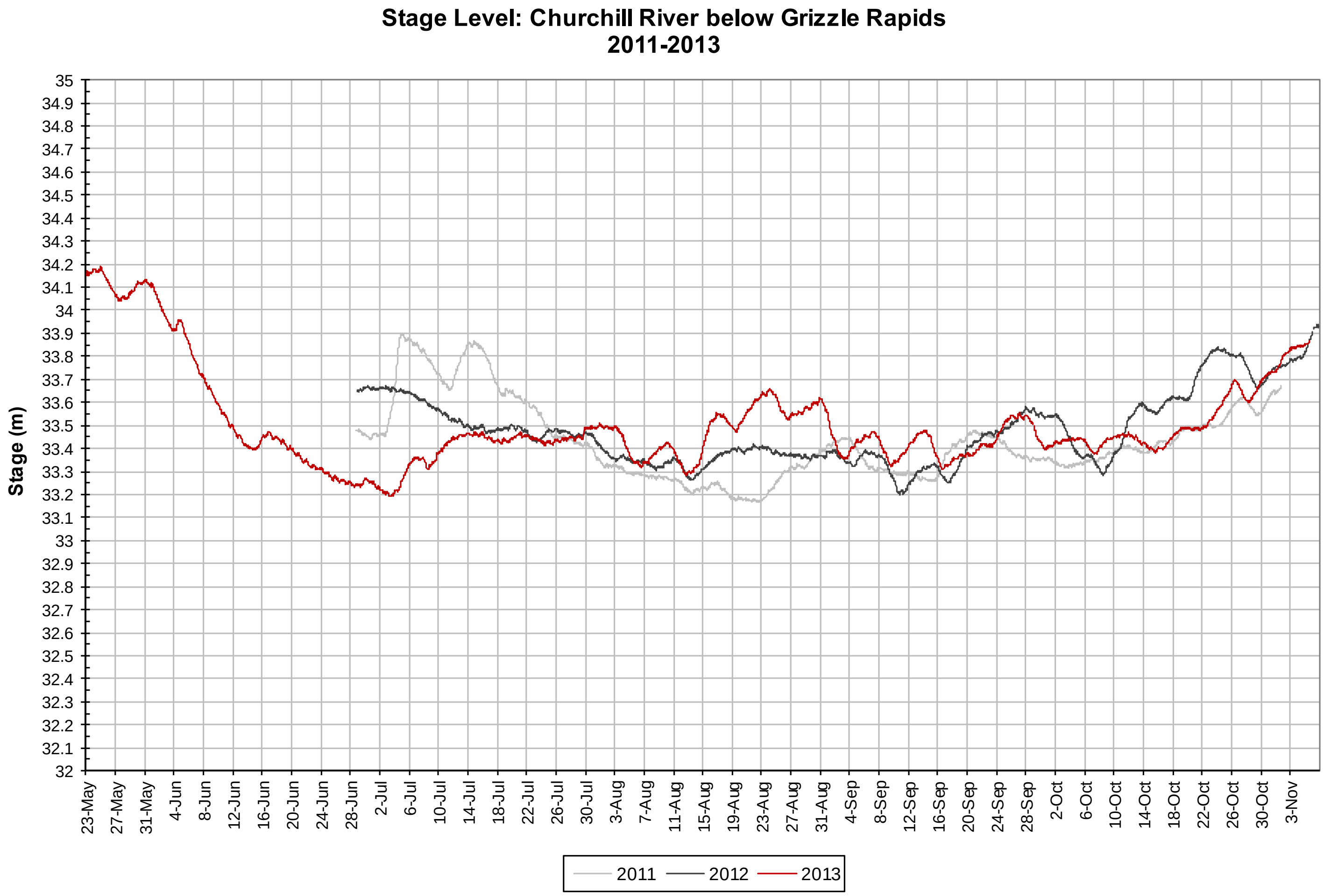


Figure 15: Stage level at Churchill River below Grizzle Rapids

Stage (m)	2013	2012	2011
Median	33.448	33.461	33.400
Max	34.189	33.941	33.901
Min	33.190	33.201	33.165
Range	0.999	0.740	0.736

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 16).
- Stage is decreasing in the first month of the deployment season. Stage increases in early July and fluctuates throughout most of the summer and early fall seasons. Stage increases near the end of October. Water levels at this station to not fluctuate as greatly when compared to other stations in the network.
- Precipitation events are frequent and range from low to high in magnitude.

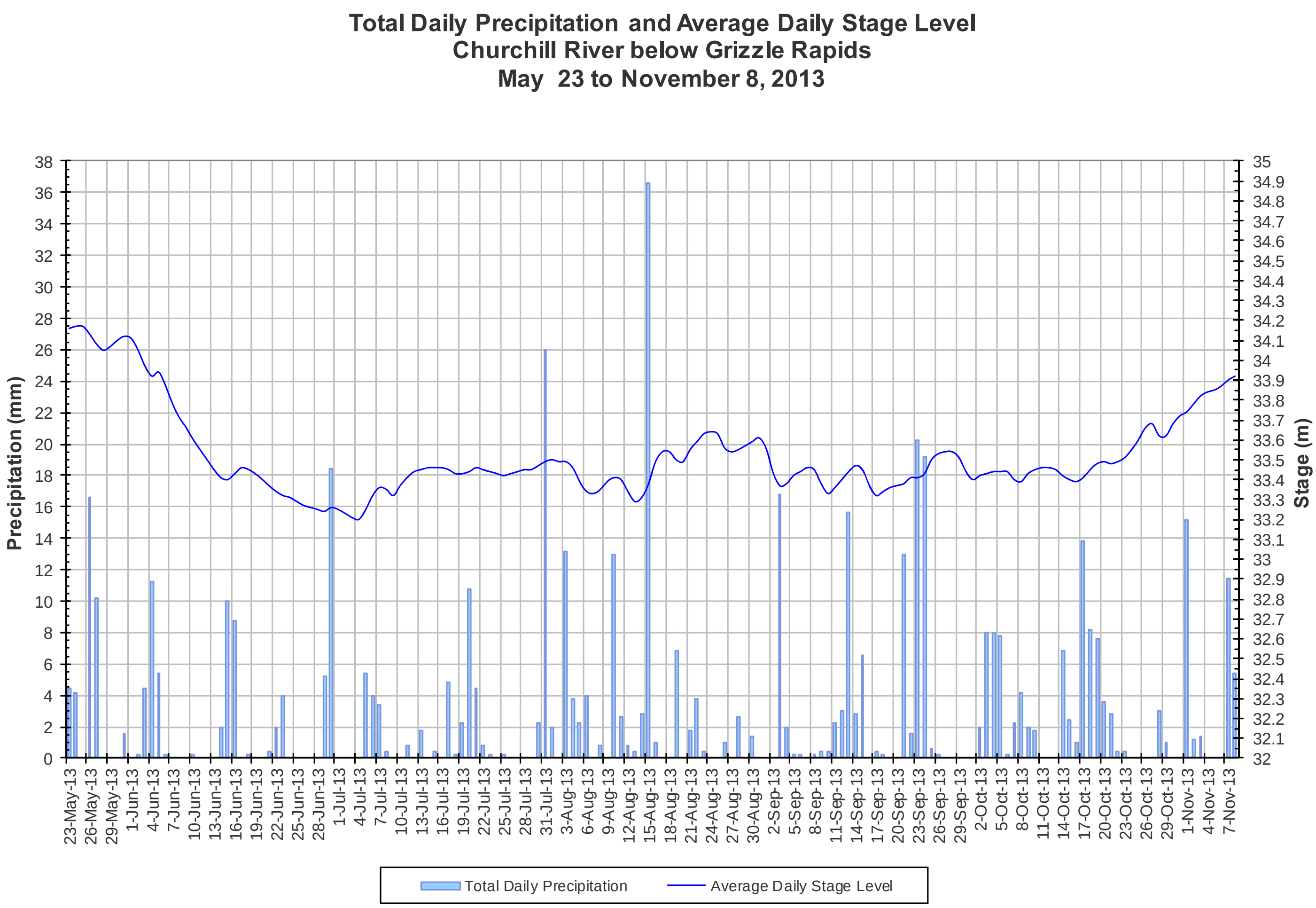


Figure 16: Daily precipitation and average daily stage level at Churchill River below Grizzle Rapids (weather data recorded at Goose Bay)

Churchill River above Muskrat Falls

- Water temperature ranges from 2.6°C to 18.3°C during the 2013 deployment season, with a median value of 12.5°C (Figure 17).
- Water temperatures appear to be slightly cooler in 2013 when compared to previous years, particularly in the late summer and fall seasons when water temperatures are decreasing.

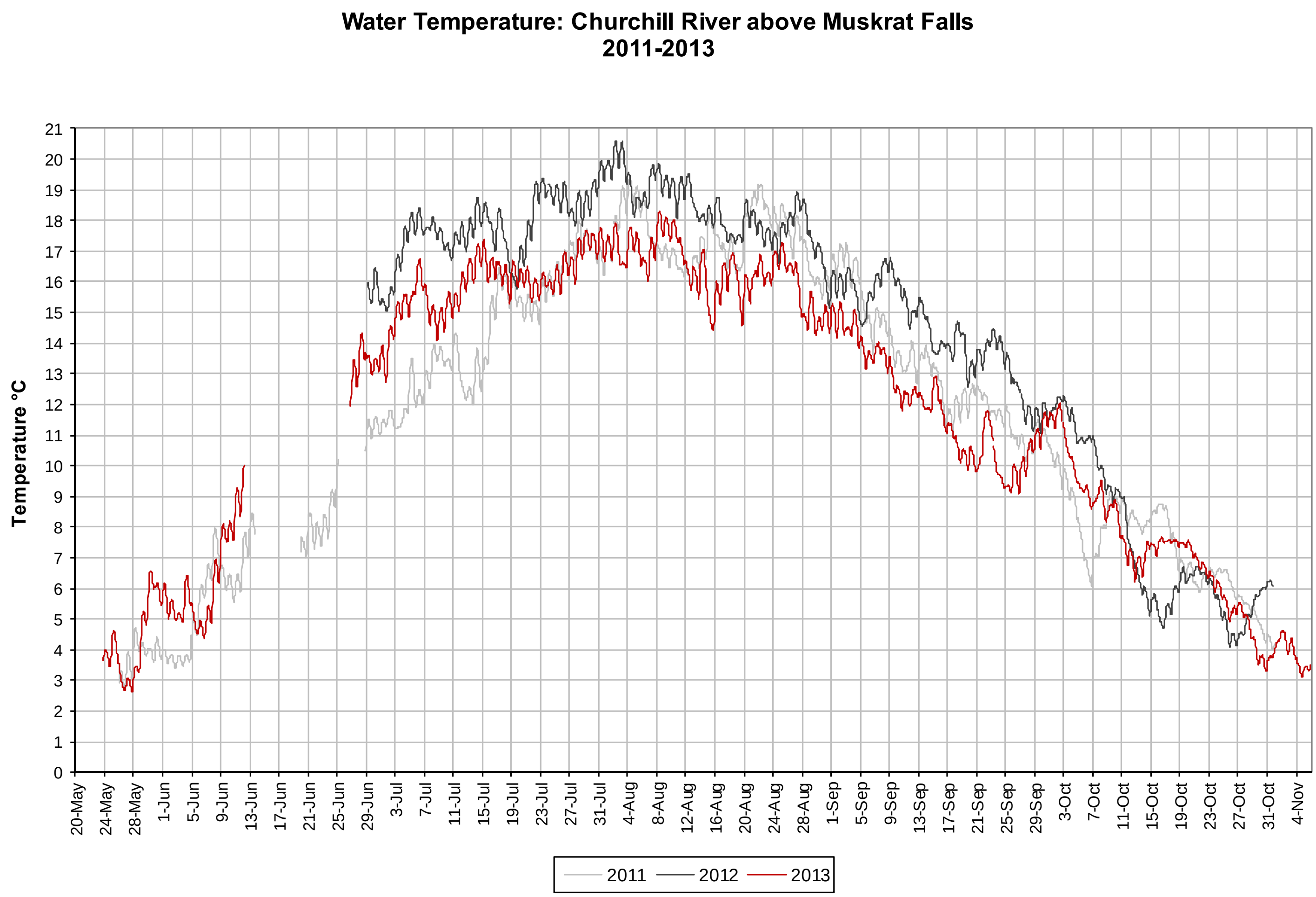


Figure 17: Water temperature at Churchill River above Muskrat Falls

Temperature	2013	2012	2011
Median	12.5	16.2	12.3
Max	18.3	20.6	19.3
Min	2.6	4.1	2.7

- Water temperature values show a typical seasonal trend (Figure 18). Water and air temperatures are increasing throughout the spring and early summer with water temperatures peaking in early August. Average air and water temperatures decrease throughout the late summer and fall.

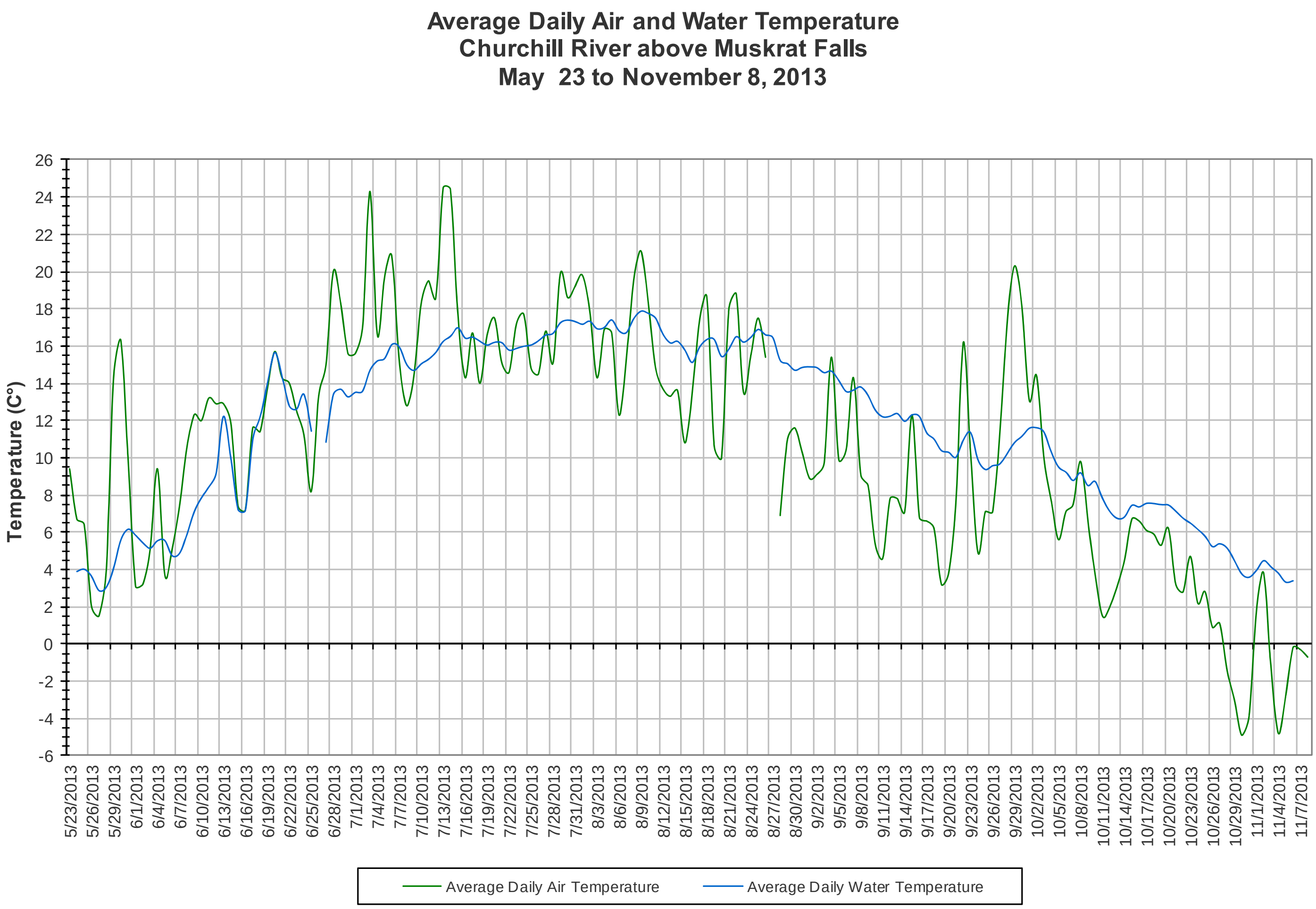


Figure 18: Average daily air and water temperatures at Churchill River above Muskrat Falls

(weather data recorded at Goose Bay)

- pH ranges between 6.48 and 7.30 pH units during the 2013 deployment season, with a median value of 6.94 pH units (Figure 19).
- pH values are increasing throughout the spring and early summer months. pH values then level off and decrease slightly in the fall months. It appears as though the pH values collected in the fourth deployment period between September 12 and October 10 are slightly lower than would be expected. This trend is only noticed for the time period specified and is highlighted in red on Figure 19. .
- Most values during the 2013 deployment season are within the CCME Guidelines for the Protection of Aquatic Life (>6.5 and <9.0 pH units). In the first deployment period, pH values are just slightly below or at the minimum guideline. Guidelines are indicated in blue on Figure 11
- pH values are comparable to data collected in years previous.

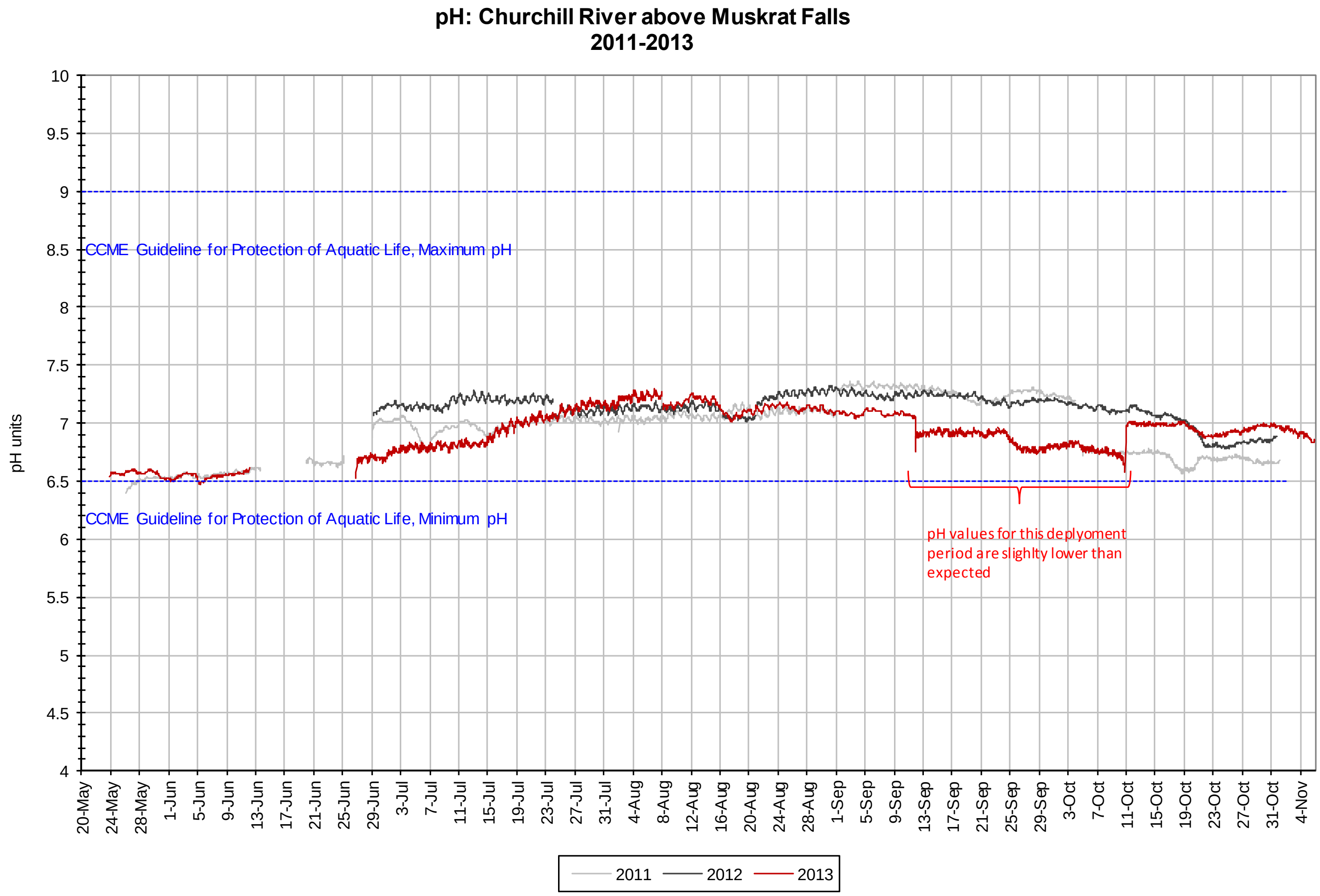


Figure 19: pH at Churchill River above Muskrat Falls

pH (units)	2013	2012	2011
Median	6.94	7.16	7.04
Max	7.30	7.33	7.36
Min	6.48	6.78	6.40

- Specific conductivity ranges from 10.7µS/cm to 23.1µS/cm during the 2013 deployment season, with a median value of 20.1µS/cm (Figure 20).
- Specific conductivity is increasing throughout the spring and most of the summer before decreasing in mid–August. Generally, specific conductivity does not vary greatly in the Lower Churchill River.
- Increases and decreases in specific conductivity are most times clearly 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 generally decreases due to the dilution of dissolved solids in the water column.
- Data collected in 2011-2012 is similar in trend and value.

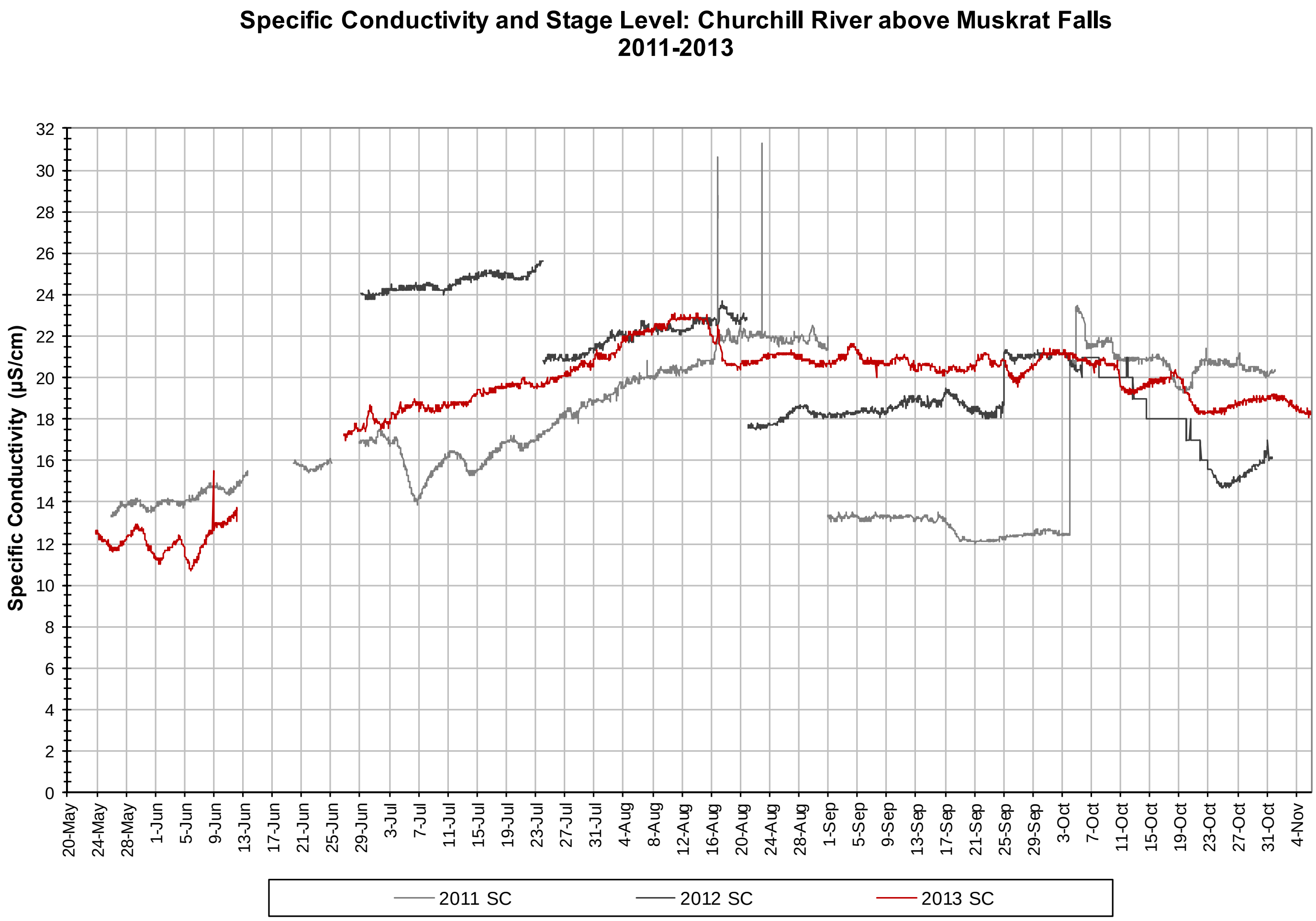


Figure 20: Specific conductivity at Churchill River above Muskrat Falls

Specific Conductivity (µS/cm)	2013	2012	2011
Median	20.1	20.9	16.9
Max	23.1	25.6	31.3
Min	10.7	14.7	12.0

- Throughout the 2013 deployment season, dissolved oxygen ranges from 9.06mg/l and 13.16mg/l, with a median value of 10.30mg/L, while percent saturation ranges from 90.0% to 103.4%, with a median value of 96.6% (Figure 21).
- Dissolved oxygen content shows a typical seasonal fluctuation in 2013 and is similar to data collected in previous years. Dissolved oxygen content fluctuates regularly on a daily basis. 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 month of August, dissolved oxygen values were at or just below 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 blue on Figure 21.
- Dissolved oxygen and percent saturation values are similar to data collected in 2011 and 2012.

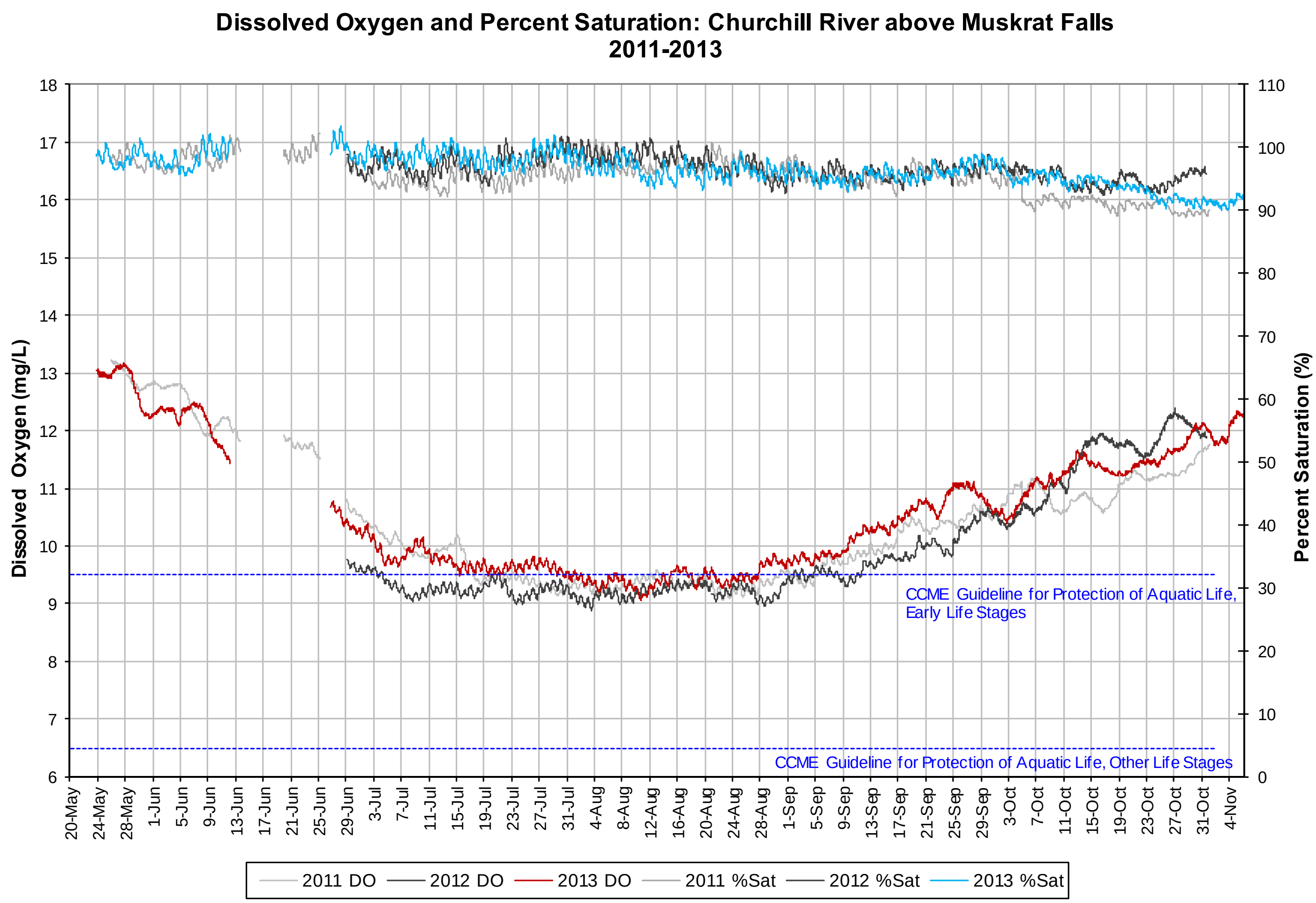
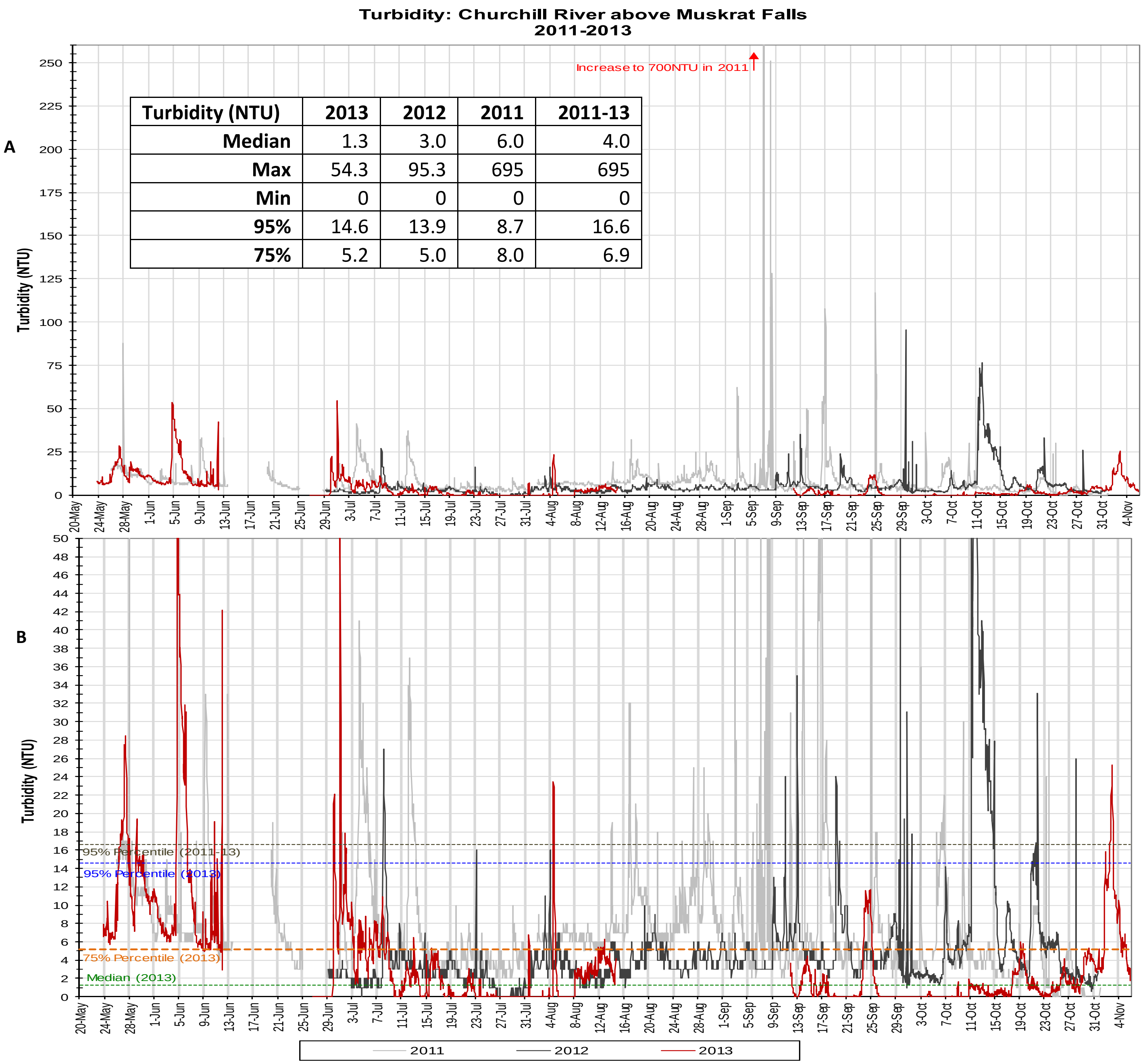


Figure 21: Dissolved oxygen and percent saturation at Churchill River above Muskrat Falls

Dissolved Oxygen (mg/L)	2013	2012	2011		Percent Saturation	2013	2012	2011
Median	10.30	9.47	10.22		Median	96.6	96.5	95.9
Max	13.16	12.38	13.22		Max	103.4	101.8	102.3
Min	9.06	8.87	9.06		Min	90.0	92.4	88.9

- The majority of turbidity values (95%) were <14.6NTU during the 2013 deployment season (Figure 22 a & b). A median value of 1.3NTU indicates there is a consistent natural background turbidity value at this station. Turbidity values from 2011 to 2013 are depicted in Figures 22 a & b.
- Figure 22a shows data on a scale up to 260NTU. On a number of occasions in 2013, turbidity increased above median background levels for short periods of time throughout the deployment season, to as high as 54.3NTU.
- Figure 22b shows data at a smaller scale, focusing on the regular consistent background levels, below 50NTU. In the 2013 season, median value was calculated to be 1.3NTU and the 95th percentile value was 14.6NTU. When data from all years is combined (2011 to 2013), the median value increases slightly to 4.0NTU and the 95th percentile is 16.6NTU. Data from all years is similar and comparable in trend. In 2013, there appear to be more ‘0NTU’ readings which contribute to the lower median value.



Turbidity (NTU)	2013	2012	2011	2011-13
Median	1.3	3.0	6.0	4.0
Max	54.3	95.3	695	695
Min	0	0	0	0
95%	14.6	13.9	8.7	16.6
75%	5.2	5.0	8.0	6.9

Figure 22a (top): Turbidity to 260NTU at Churchill River above Muskrat Falls

Figure 22b (bottom): Turbidity to 50NTU at Churchill River above Muskrat Falls

- Stage levels in 2013 tend to decrease in the spring and summer months reaching a seasonal low in early July (Figure 23).
- Stage levels from 2011-2013 are graphed below to show how stage levels vary throughout the season and from year to year. The seasonal low was reached much earlier in the season in 2013 when compared to 2011 and 2012. Stage ranges between 1.75m and 3.13m each year.

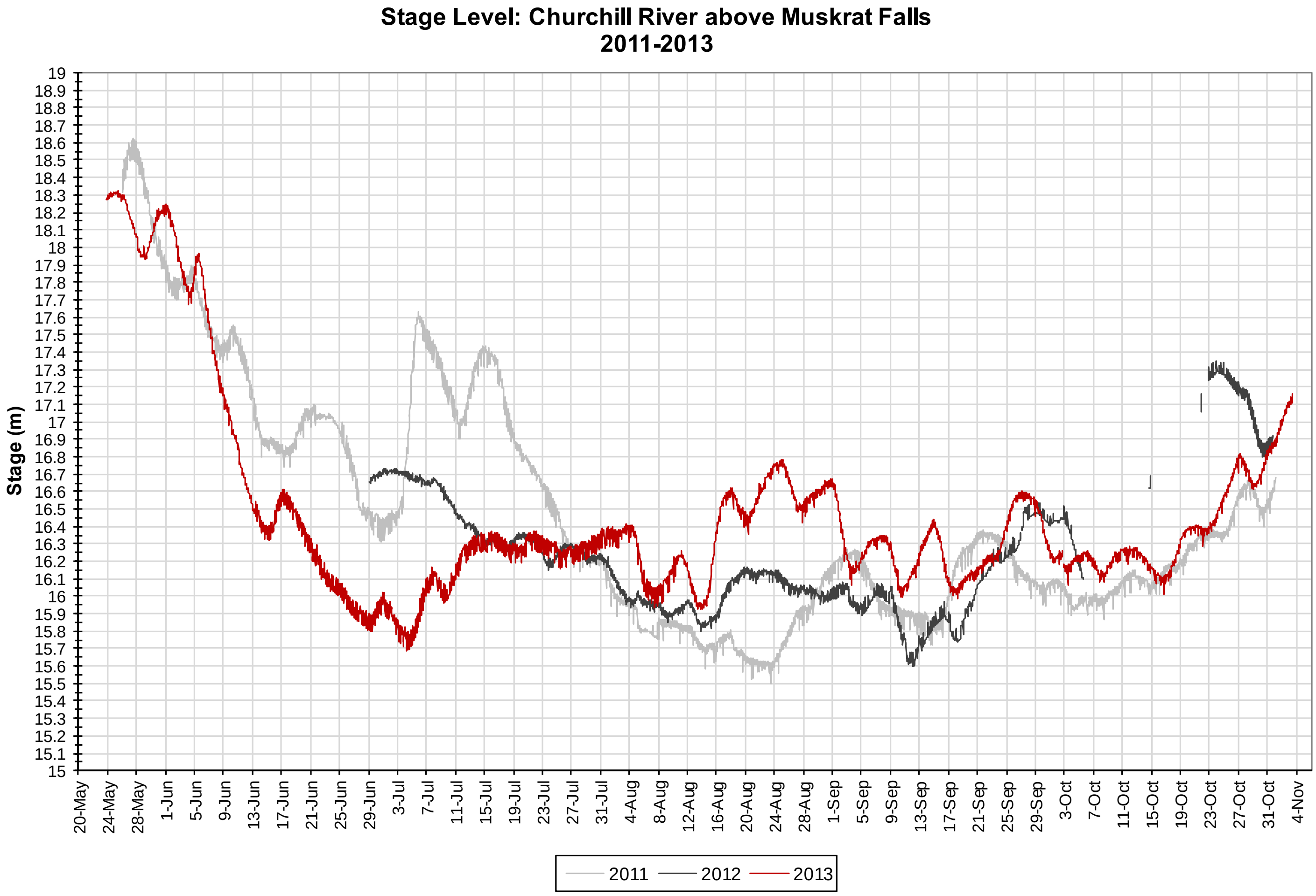


Figure 23: Daily stage level at Churchill River above Muskrat Falls

Stage (m)	2013	2012	2011
Median	16.314	16.177	16.278
Max	18.323	17.348	18.626
Min	15.690	15.599	15.495
Range	2.633	1.749	3.131

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 24).
- Stage is decreasing in the first month of the deployment season. Stage increases in early July and fluctuates throughout most of the summer and early fall seasons. Stage increases near the end of October.
- Precipitation events are frequent and range from low to high in magnitude.

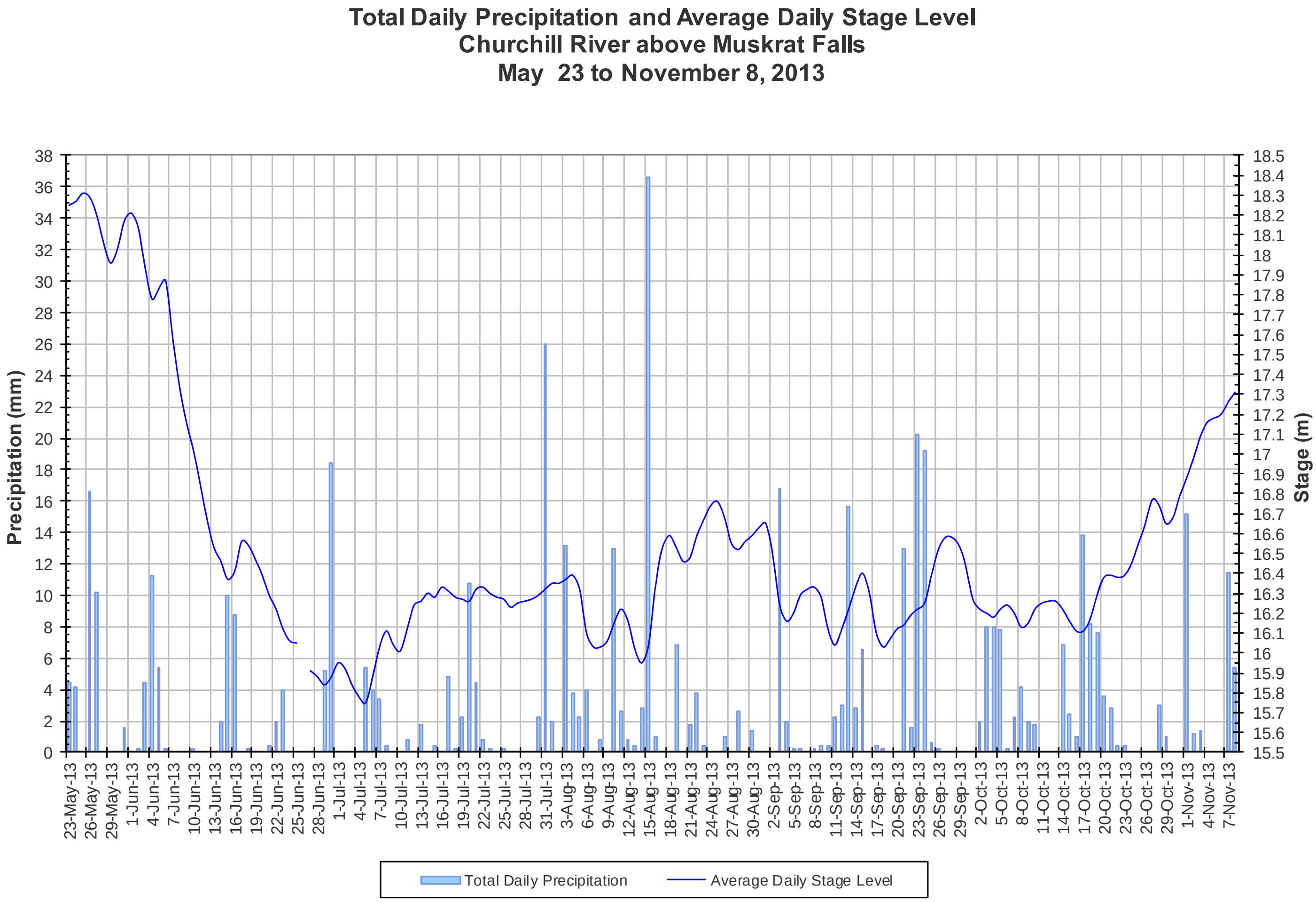


Figure 24: Daily precipitation and average daily stage level at Churchill River above Muskrat Falls

(weather data recorded at Goose Bay)

Churchill River below Muskrat Falls

- Water temperature ranges from 1.9C to 18.0°C during the 2013 deployment season, with a median value of 12.0°C (Figure 25).
- Water temperatures appear to be cooler in 2013 when compared to 2011 and 2012, especially in the fall season when water temperatures are cooling.

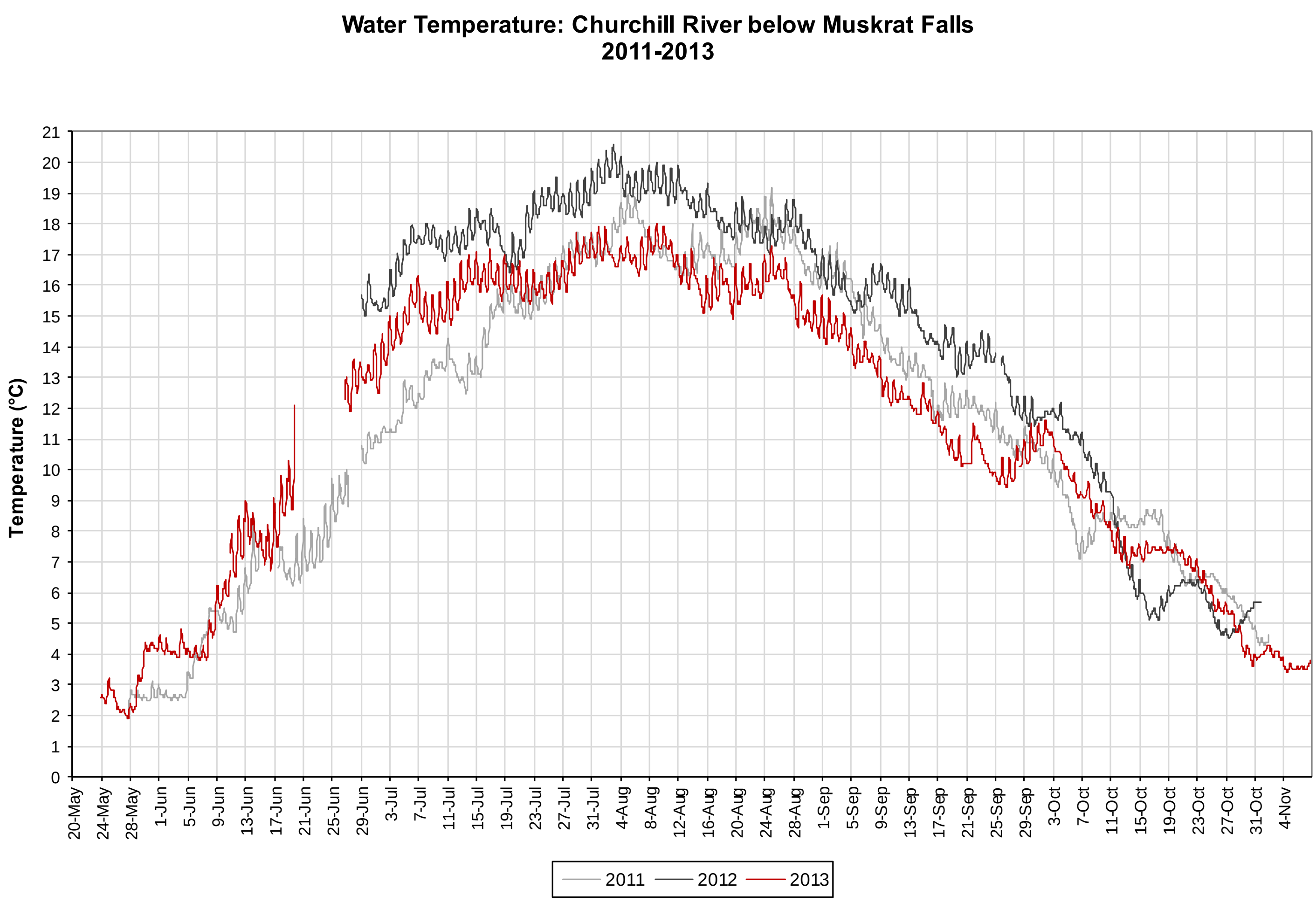


Figure 25: Water temperature at Churchill River below Muskrat Falls

Temperature	2013	2012	2011
Median	12.0	16.2	12
Max	18.0	20.6	19.2
Min	1.9	4.5	1.9

- Water temperature values show a typical seasonal trend (Figure 26). Water and air temperatures are increasing throughout the spring and early summer with water temperatures peaking in early August. Average air and water temperatures decrease throughout the late summer and fall.

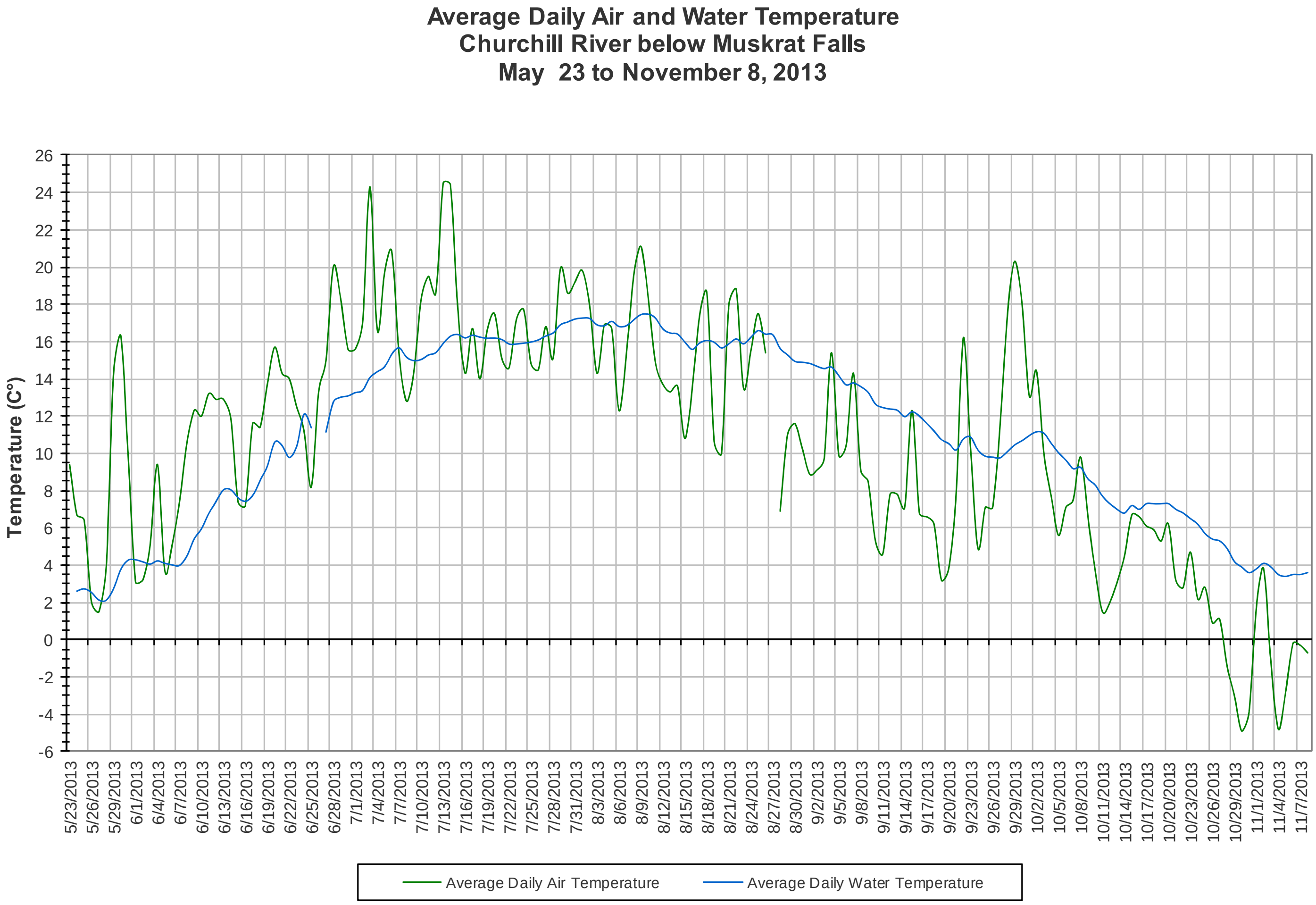


Figure 26: Average daily air and water temperatures at Churchill River below Muskrat Falls

(weather data recorded at Goose Bay)

- pH ranges between 6.25 and 7.51 pH units during the 2013 deployment season, with a median value of 7.01 pH units (Figure 27).
- pH values are relatively stable throughout the deployment period. There is some discrepancy each time a new instrument is deployed. This is likely a result of the insufficient sensor stabilization time during calibration. In the third deployment period, from August 9 to September 12, pH values are slightly higher than would be expected. While in the fourth deployment, between September 12 and October 11, pH values are slightly lower than would be expected. The instrument may also be experiencing a certain amount of drift as values steadily decrease throughout the deployment period. These events are highlighted in red on Figure 27.
- Most values during the 2013 deployment season are within the CCME Guidelines for the Protection of Aquatic Life (>6.5 and <9.0 pH units). In June, the pH values drop to just below the minimum guideline on a couple of occasions to as low as 6.25 pH units. Guidelines are indicated in blue on Figure 27.
- pH trends and values are relatively similar throughout the three years of data graphed below for the same time period.

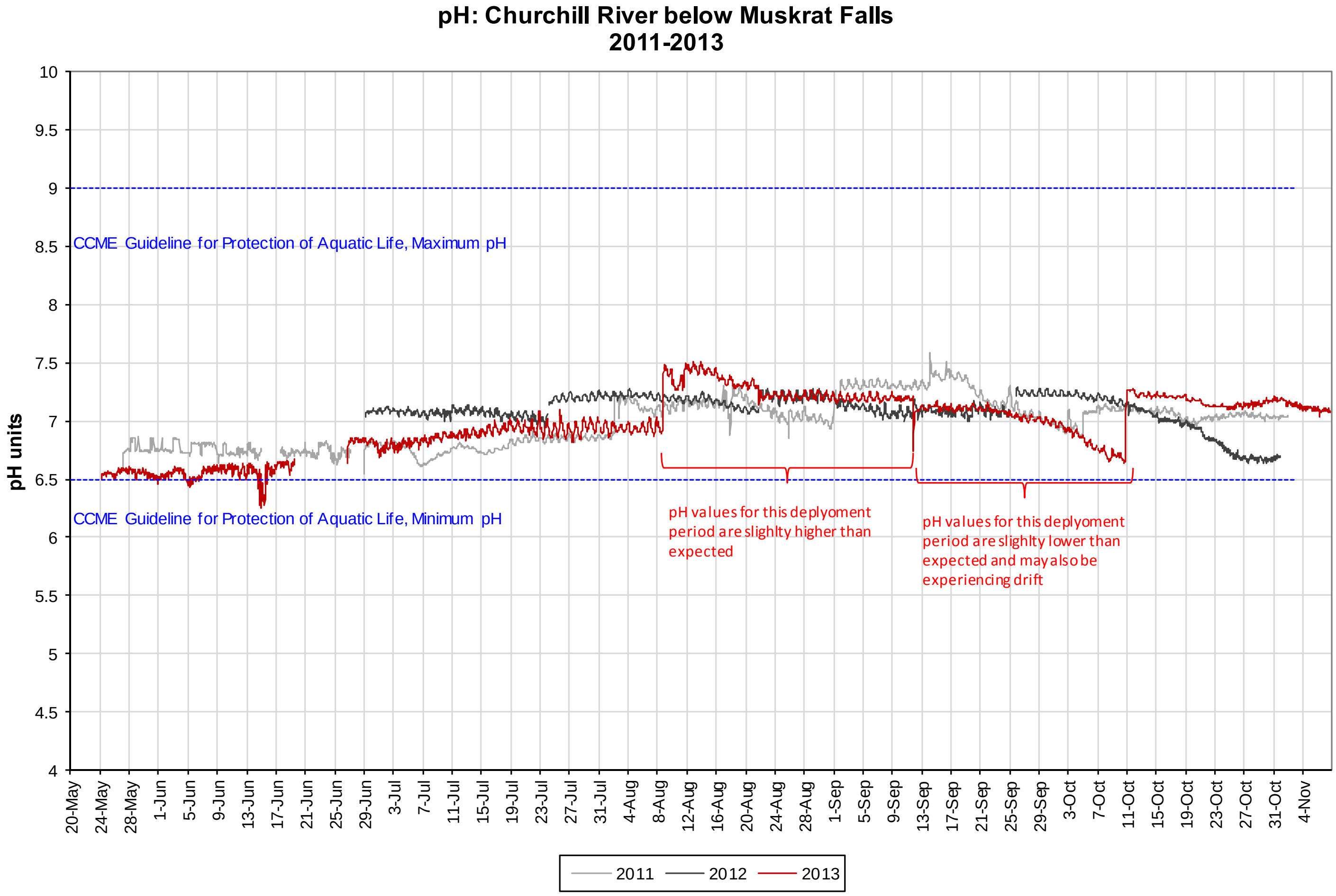


Figure 27: pH at Churchill River below Muskrat Falls

pH (units)	2013	2012	2011
Median	7.01	7.11	7.02
Max	7.51	7.29	7.58
Min	6.25	6.63	6.55

- Specific conductance ranges between 11.6µS/cm and 22.1µS/cm, with a median value of 18.6µS/cm during the 2013 deployment season (Figure 28).
- Specific conductance values are increasing steadily throughout the first half of the deployment season before reaching a seasonal high in mid-August. Specific conductivity then decreases slowly for the remainder of the deployment season.
- Increases and decreases in specific conductivity are most times 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 generally decreases due to the dilution of dissolved solids in the water column.
- In previous years, data collected is rather erratic and not consistent. Trends however are similar as each year, specific conductivity increases in the spring and summer months and then slowly levels out and decreases slightly in the late summer and fall season.

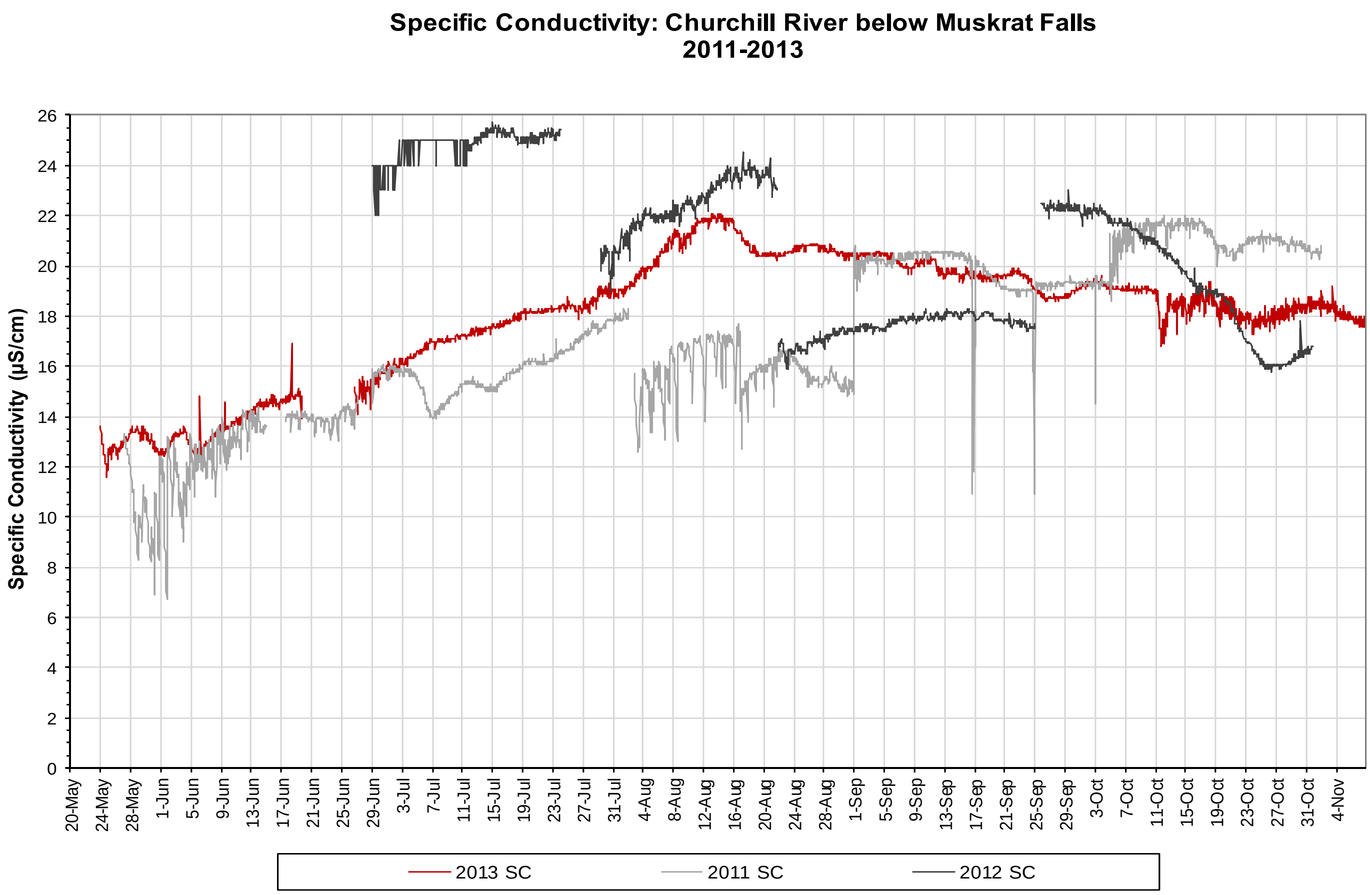


Figure 28: Specific conductivity at Churchill River below Muskrat Falls

Specific Conductivity (µS/cm)	2013	2012	2011
Median	18.6	21.1	16.6
Max	22.1	25.7	22.0
Min	11.6	15.8	6.7

- Throughout the 2013 deployment season, dissolved oxygen ranges from 9.90mg/l and 14.90mg/l, with a median value of 11.28mg/l, while percent saturation ranges from 99.1% to 114.6%, with a median value of 106.8% (Figure 29).
- Dissolved oxygen content shows a typical seasonal fluctuation in 2013. Dissolved oxygen is typically higher at this station compared to the other stations further upstream due to the addition of oxygen to the water at Muskrat Falls.
- All values were above both the minimum CCME Guidelines for the Protection of Cold Water Biota at Other Life Stages of 6.5 mg/l and at Early Life Stages of 9.5mg/l. The guidelines are indicated in blue on Figure 29.
- Dissolved oxygen content is comparable to data collected in 2011 and 2012 (Figure 25).

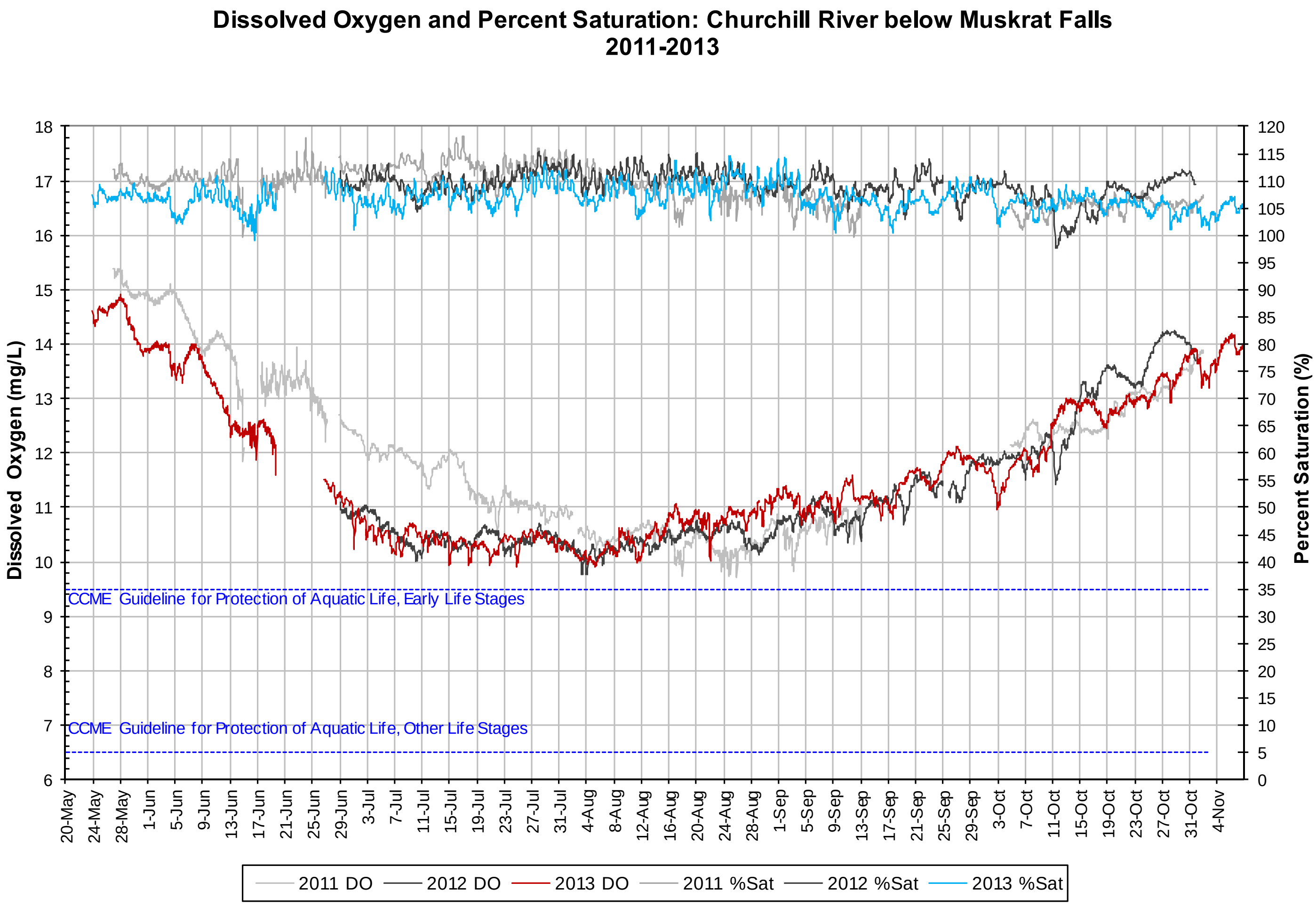
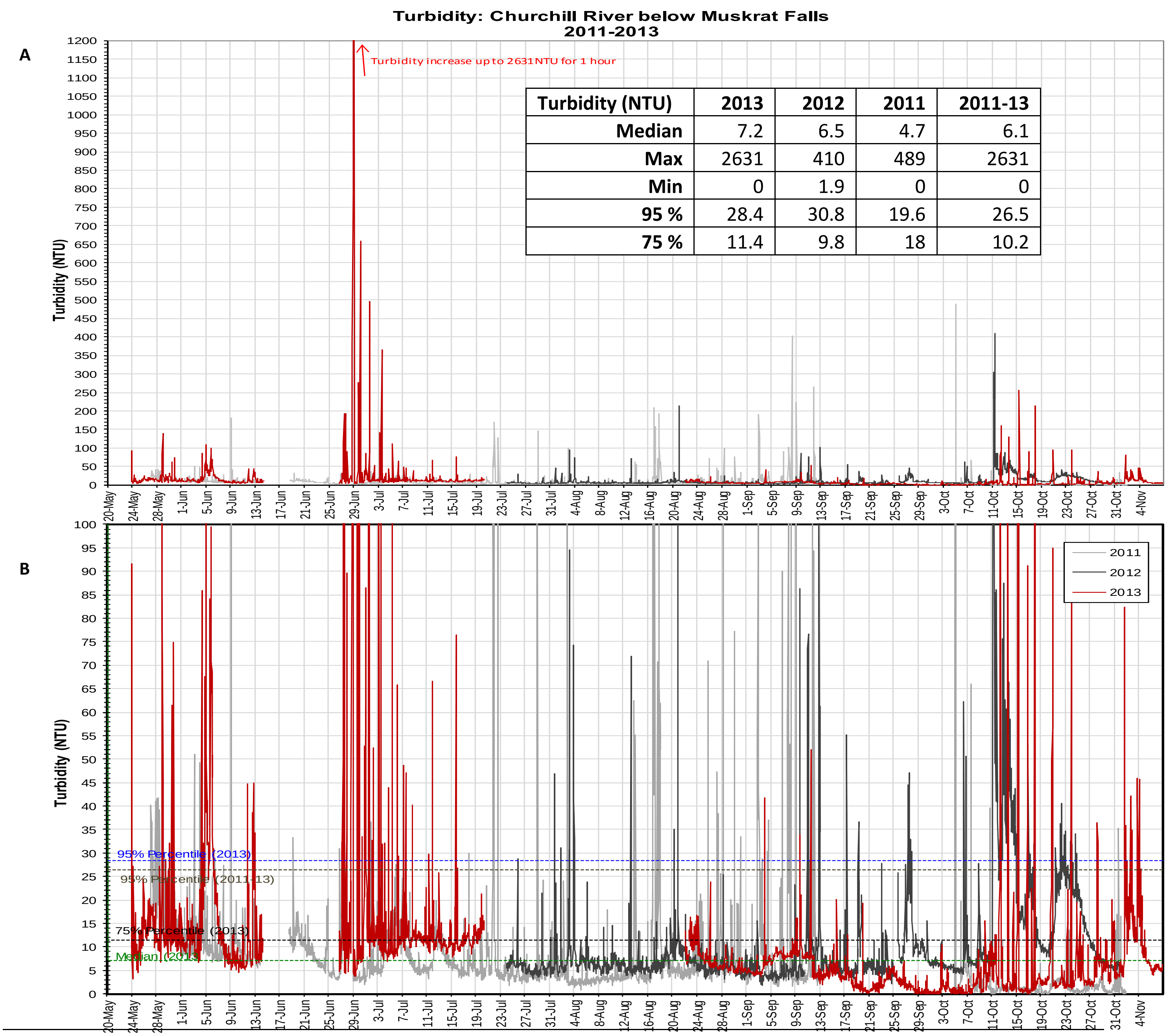


Figure 29: Dissolved oxygen and percent saturation at Churchill River below Muskrat Falls

Dissolved Oxygen (mg/L)	2013	2012	2011		Percent Saturation	2013	2012	2011
Median	11.28	10.73	11.97		Median	106.8	109.4	109.3
Max	14.90	14.26	15.39		Max	114.6	115.5	118.2
Min	9.90	9.76	9.71		Min	99.1	97.7	99.7

- The majority of turbidity values (95%) were <28.4NTU during the 2013 deployment season (Figure 30 a & b). A median value of 7.2NTU indicates there is a consistent natural background turbidity value at this station. Turbidity values from 2011 to 2013 are depicted in Figures 30 a & b.
- Figure 30a shows data on a scale up to 1200NTU. On a number of occasions in 2013, turbidity increased above median background levels for short periods of time throughout the deployment season, to as high as 2631NTU. When compared to the station above Muskrat Falls, turbidity values are greater and show more variability at the station below Muskrat Falls. This is particularly evident during the second deployment period from June 27 to August 9.
- Figure 30b shows data at a smaller scale, focusing on the regular consistent background levels, below 100NTU. In the 2013 season, median value was calculated to be 7.2NTU and the 95th percentile value was 28.4NTU. When data from all years is combined (2011 to 2013), the median value decreases slightly to 6.1NTU and the 95th percentile is 26.5NTU.



Turbidity (NTU)	2013	2012	2011	2011-13
Median	7.2	6.5	4.7	6.1
Max	2631	410	489	2631
Min	0	1.9	0	0
95 %	28.4	30.8	19.6	26.5
75 %	11.4	9.8	18	10.2

Figure 30a (top): Turbidity to 1200NTU at Churchill River below Muskrat Falls

Figure 30b (bottom): Turbidity to 100NTU at Churchill River below Muskrat Falls

- **Stage levels in 2013 tend to decrease in the spring and summer months reaching a seasonal low in early July (Figure 31).**

- Stage levels from 2011-2013 are graphed below to show how stage levels vary throughout the season and from year to year. The seasonal low was reached much earlier in the season in 2013 when compared to 2011 and 2012. Stage ranges between 0.98m and 1.97m each year.

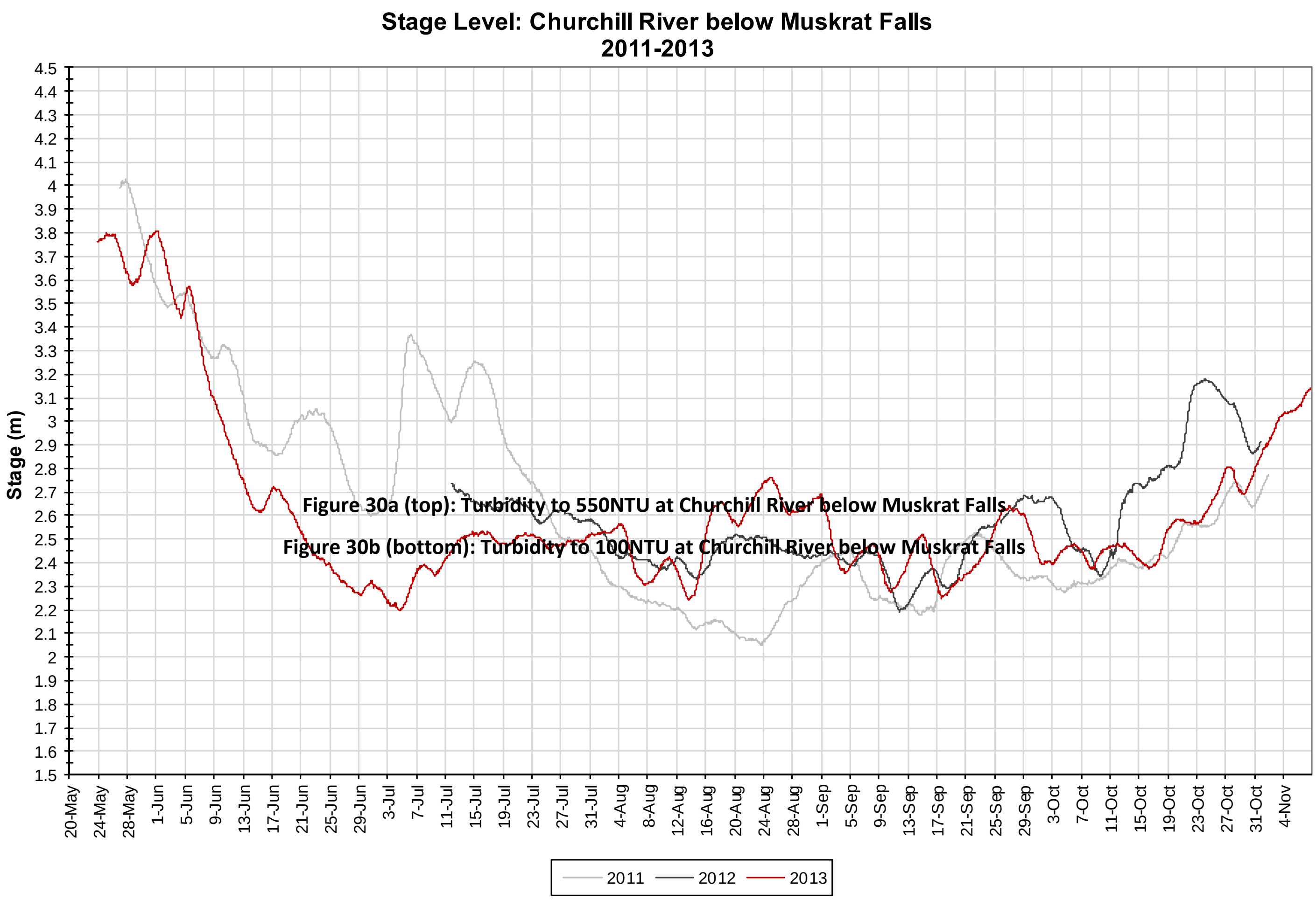


Figure 31: Stage level at Churchill River below Muskrat Falls

Stage (m)	2013	2012	2011
Median	2.510	2.510	2.484
Max	3.809	3.177	4.026
Min	2.198	2.193	2.053
Range	1.611	0.984	1.973

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 32).
- Stage is decreasing in the first month of the deployment season. Stage increases in early July and fluctuates throughout most of the summer and early fall seasons. Stage increases near the end of October.
- Precipitation events are frequent and range from low to high in magnitude.

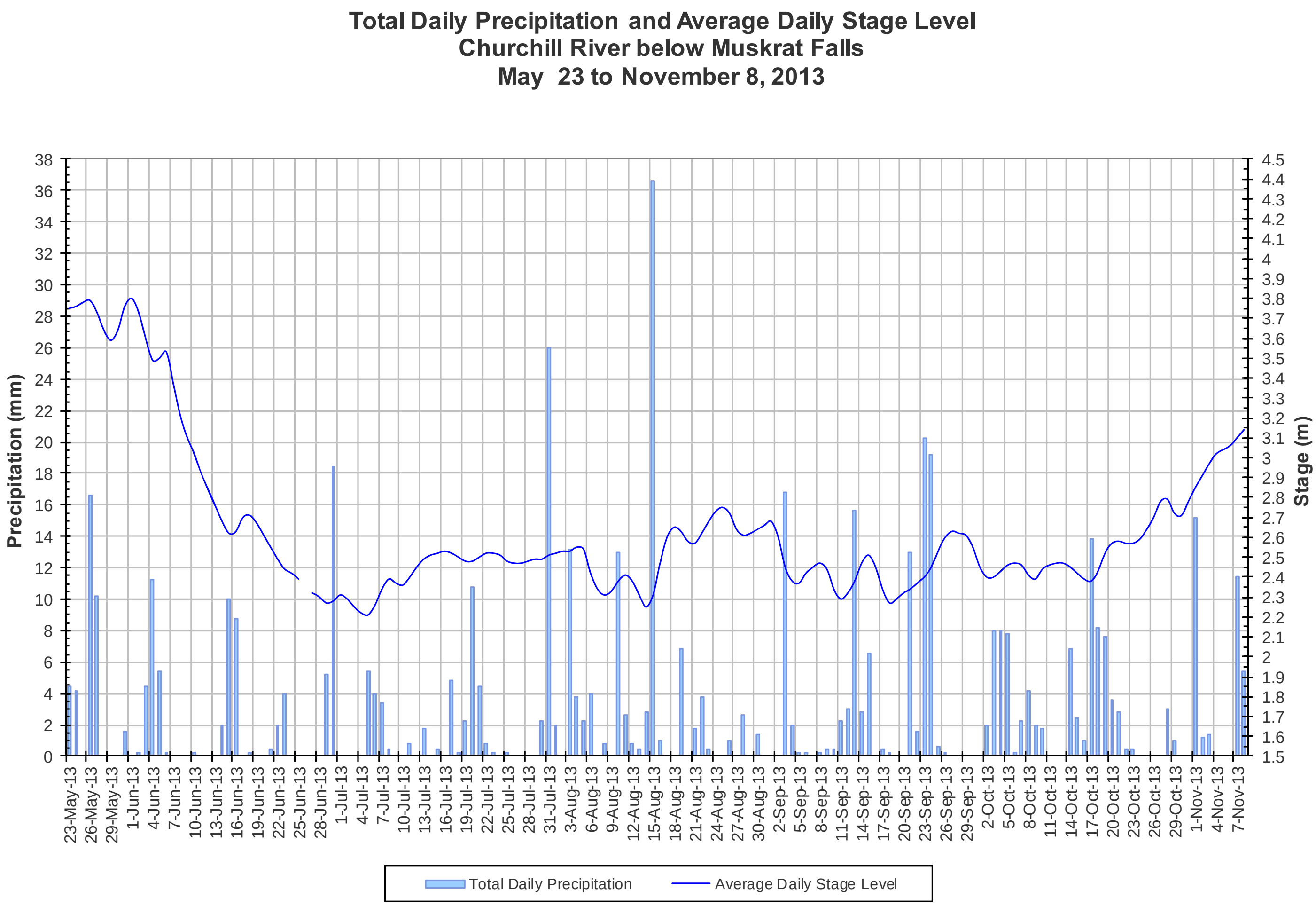


Figure 32: Daily precipitation and average daily stage level at Churchill River below Muskrat Falls (weather data recorded at Goose Bay)

Churchill River at English Point

- Water temperature ranges from 1.7°C to 20.6°C during the 2013 deployment season, with a median value of 12.4°C (Figure 33).
- There are greater daily fluctuations at this station due to the influence of the tides in the Atlantic Ocean and Lake Melville.
- Water temperatures are slightly cooler when compared to 2011 and 2012, especially in the fall season when water temperatures are decreasing.

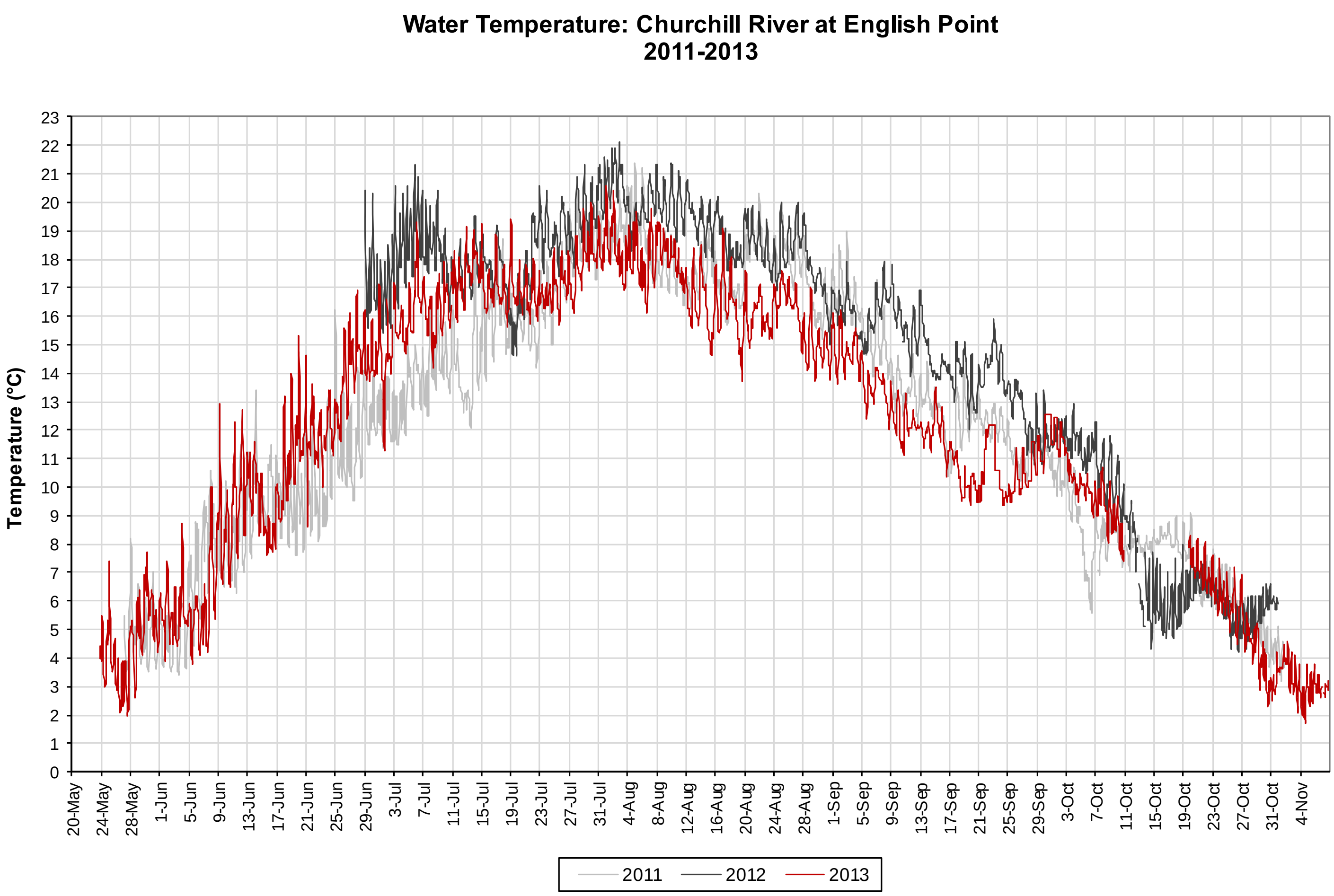


Figure 33: Water temperature at Churchill River at English Point

Temperature	2013	2012	2011
Median	12.4	16.5	12.6
Max	20.6	22.1	21.4
Min	1.7	4.2	3.2

- Water temperature values show a typical seasonal trend (Figure 34). Water and air temperatures are increasing throughout the spring and early summer with water temperatures peaking in early August. Average air and water temperatures decrease throughout the late summer and fall.

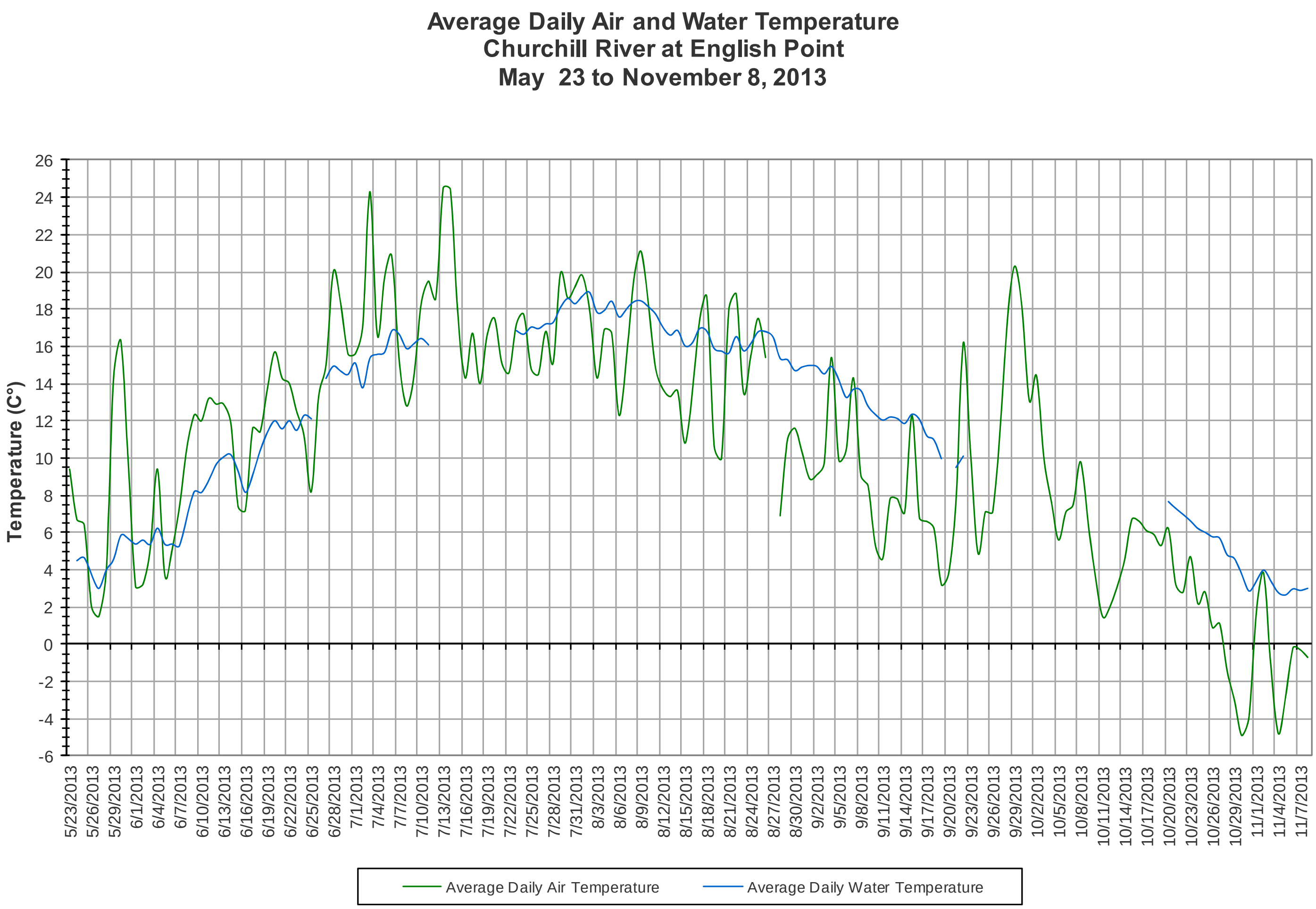


Figure 34: Average daily air and water temperatures at Churchill River at English Point

(weather data recorded at Goose Bay)

- pH ranges between 6.34 and 7.56 pH units during the 2013 deployment season, with a median value of 7.03 pH units (Figure 35).
- pH values are increasing near the end of the first deployment period. There is some fluctuation in pH during the second deployment period between June 27 and August 13. pH values are relatively consistent throughout the rest of the deployment season. These events are highlighted on Figure 35.
- Most pH values during the 2013 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 short period of time in early June, late July and again in mid-August. Each of these events is short lived (<6 hour). Guidelines are indicated in blue on Figure 35.
- pH trends and values are similar for data collected in previous years.

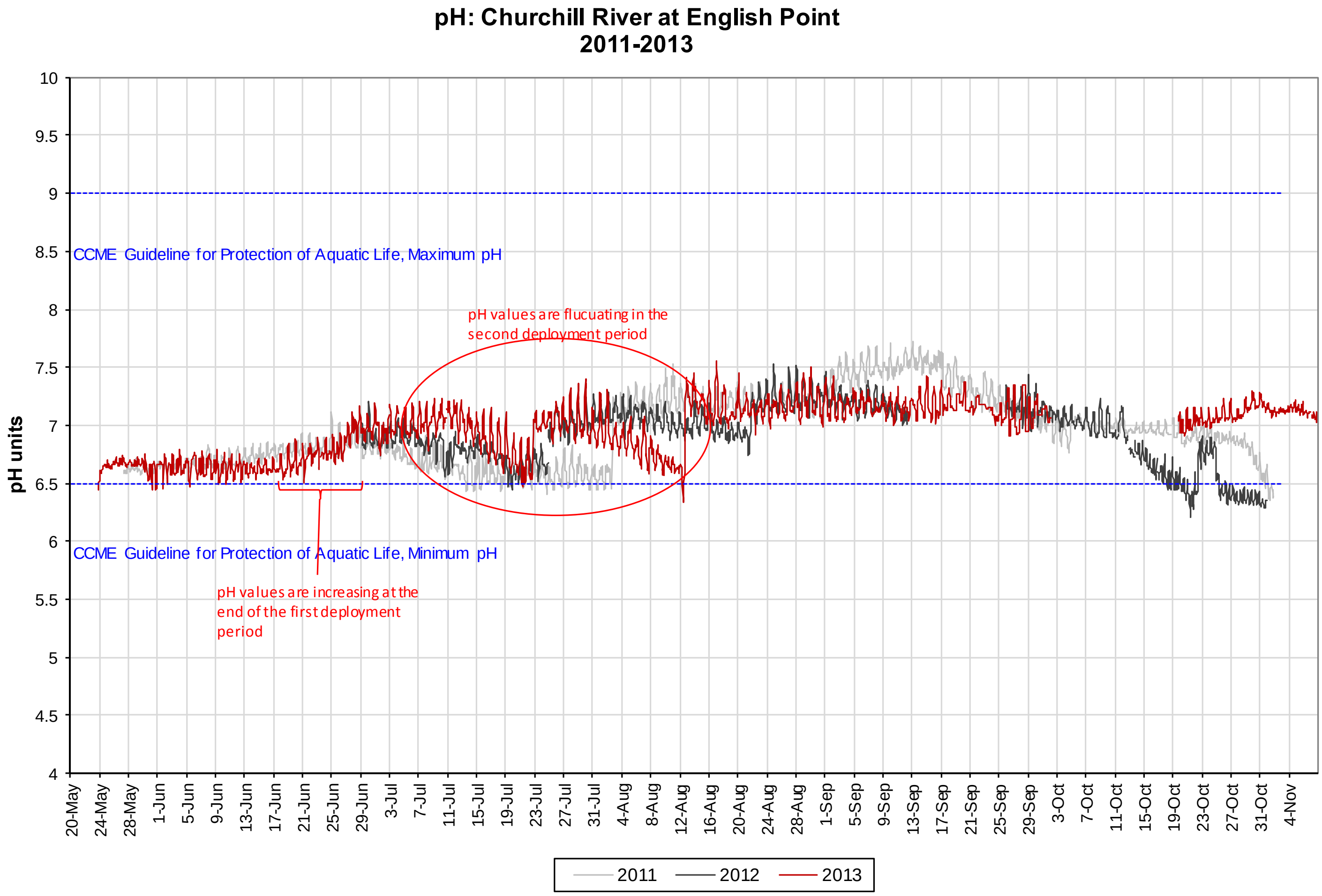


Figure 35: pH at Churchill River at English Point

pH (units)	2013	2012	2011
Median	7.03	6.97	6.93
Max	7.56	7.53	7.72
Min	6.34	6.21	6.36

- Specific conductance ranges between 11.2µS/cm and 91.4µS/cm, with a median value of 29.0µS/cm during the 2013 deployment season (Figure 36).
- 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 2012 and 2013 are similar for the same time period.

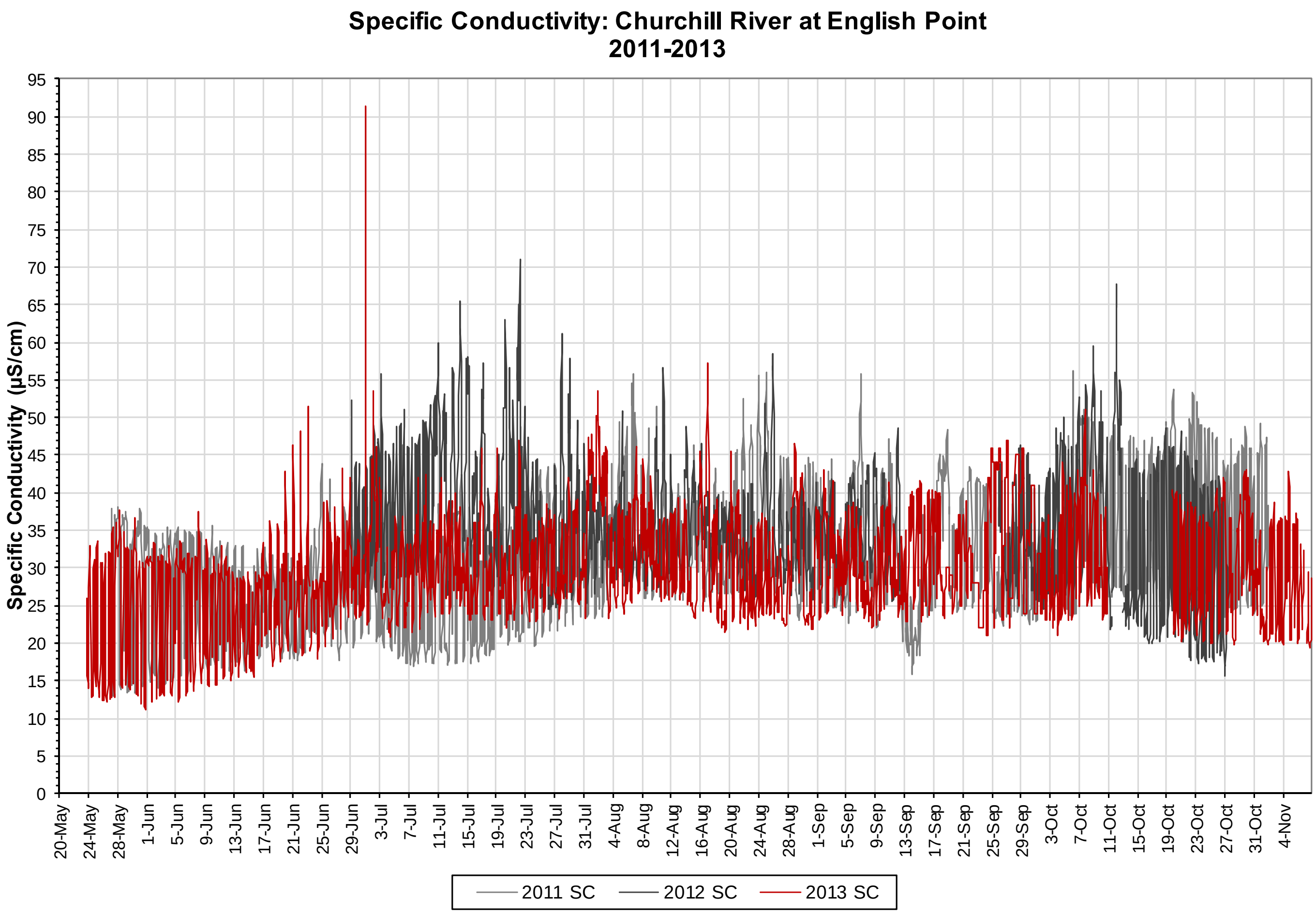


Figure 29: Specific Conductivity at Churchill River at English Point

Specific Conductivity (µS/cm)	2013	2012	2011
Median	29	34.2	30.4
Max	91.4	71.1	30.4
Min	11.2	15.6	12.9

- Throughout the 2013 deployment season, dissolved oxygen ranges from 8.42mg/l and 14.17mg/l, with a median value of 10.55mg/l, while percent saturation ranges from 85.5% to 111.9%, with a median value of 99.4% (Figure 37).
- Dissolved oxygen content shows a typical seasonal fluctuation in 2013. 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 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 blue on Figure 37.
- Dissolved oxygen and percent saturation values were very similar to the data collected in 2011 and 2013.

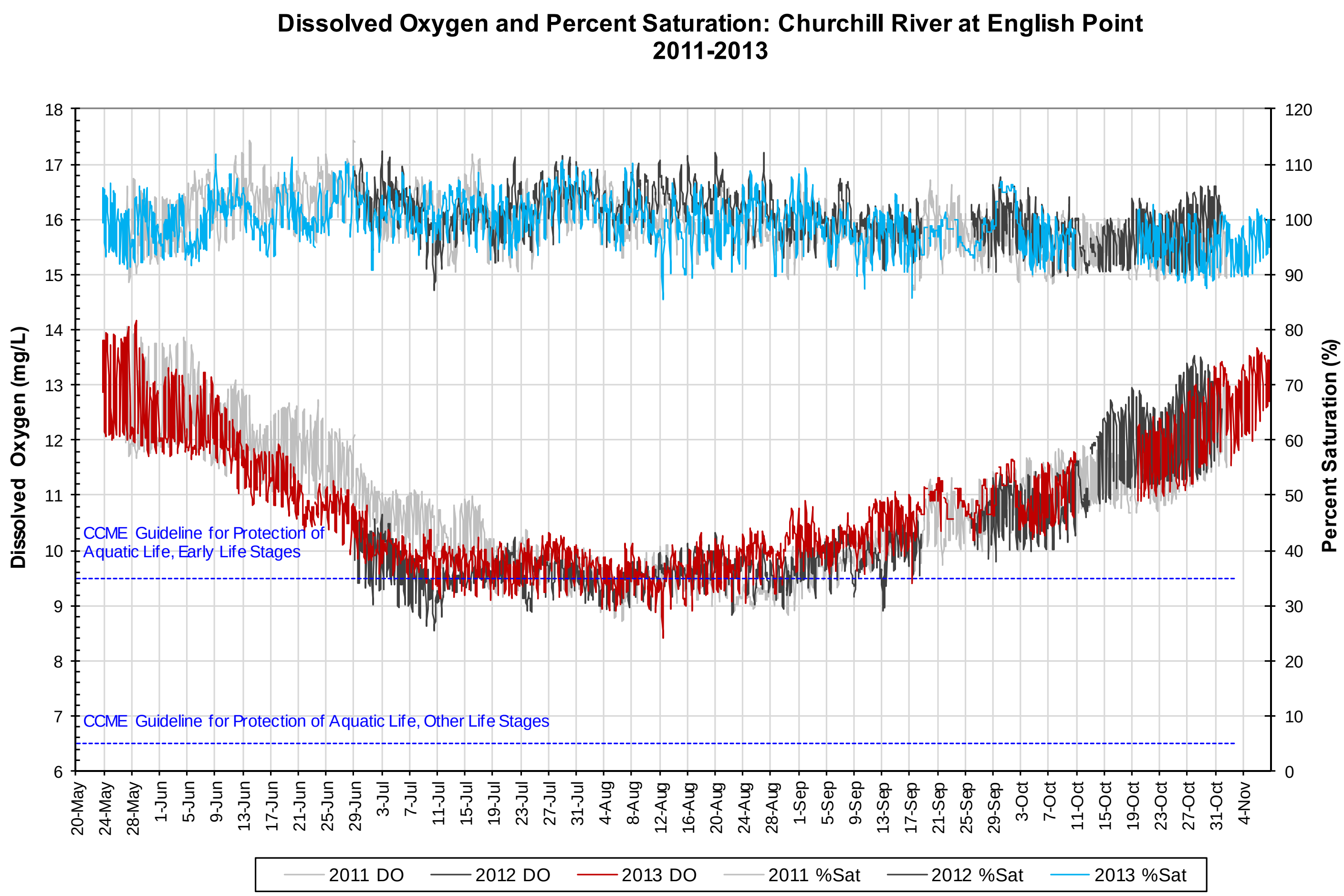
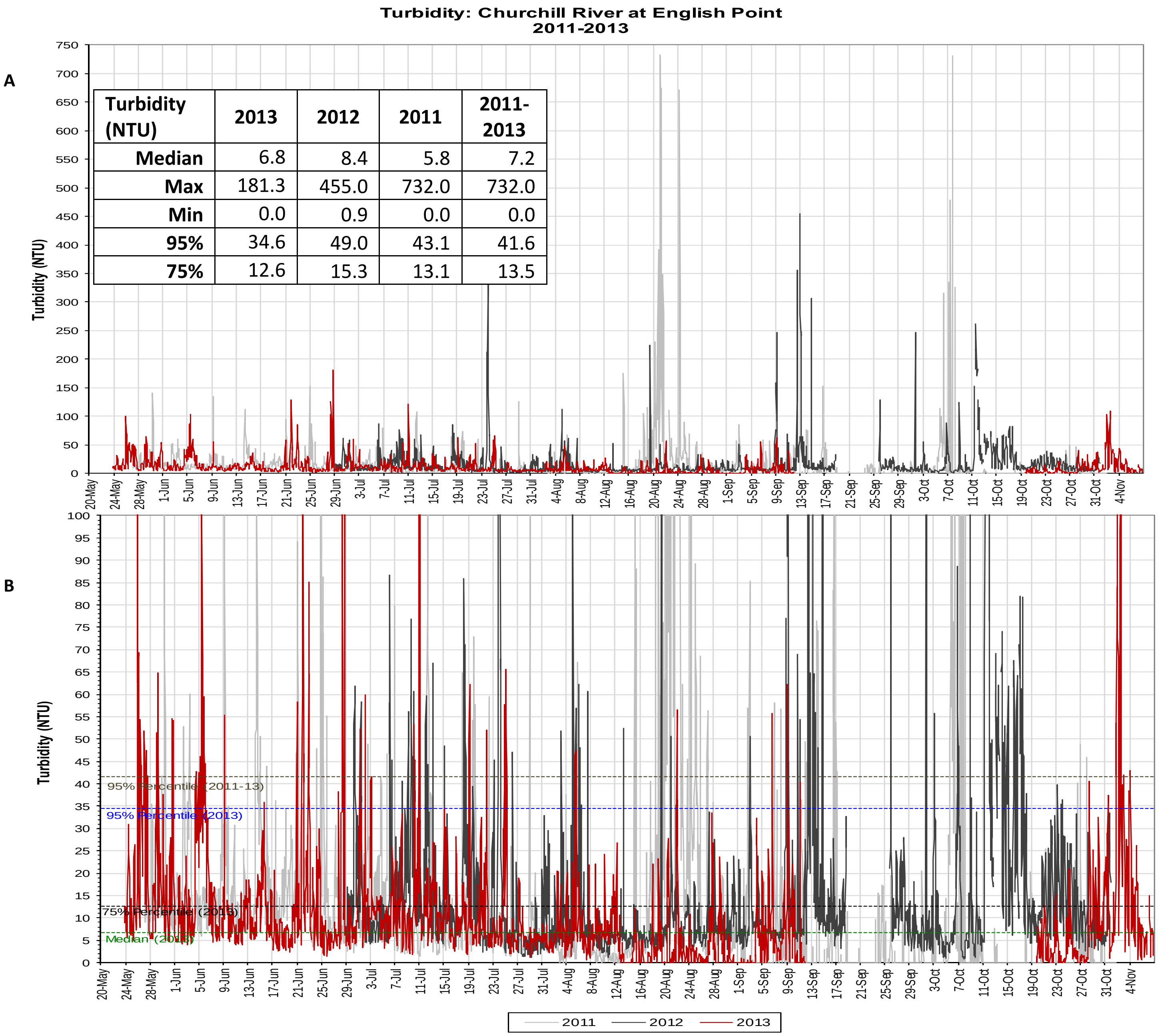


Figure 37: Dissolved oxygen and percent saturation at Churchill River at English Point

Dissolved Oxygen (mg/L)	2013	2012	2011		Percent Saturation	2013	2012	2011
Median	10.55	9.84	10.60		Median	99.4	100.8	99.2
Max	14.17	13.52	14.05		Max	111.9	112.3	114.3
Min	8.42	8.56	8.72		Min	85.5	87.1	87.1

- The majority of turbidity values (95%) were <34.6NTU during the 2013 deployment season (Figure 38 a & b). A median value of 6.8NTU indicates there is a consistent natural background turbidity value at this station. Turbidity values from 2011 to 2013 are depicted in Figures 38 a & b.
- Figure 38a shows data on a scale up to 750NTU. On a number of occasions in 2013, turbidity increased above median background levels for short periods of time throughout the deployment season, to as high as 181.3NTU. There appear to be more ‘0NTU’ values during the third deployment period between August 13 and September 12.
- Figure 38b shows data at a smaller scale, focusing on the regular consistent background levels, below 100NTU. In the 2013 season, median value was calculated to be 6.8NTU and the 95th percentile value was 34.6NTU. When data from 2011 to 2013 is combined, the median value increases slightly to 7.2NTU and the 95th percentile is 41.6. Turbidity values are similar to data collected in 2011 and 2012.



Turbidity (NTU)	2013	2012	2011	2011-2013
Median	6.8	8.4	5.8	7.2
Max	181.3	455.0	732.0	732.0
Min	0.0	0.9	0.0	0.0
95%	34.6	49.0	43.1	41.6
75%	12.6	15.3	13.1	13.5

Figure 38 (a) (top): Turbidity to 750NTU at Churchill River at English Point

Figure 38 (b) (bottom): Turbidity to 100NTU at Churchill River at English Point

- Stage levels in 2013 are very consistent and do not fluctuate greatly on a seasonal level (Figure 39). Instead, stage values fluctuate considerably with tidal influences on a daily basis.
- Stage levels from 2011-2013 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 data collected in 2013. Stage ranges between 0.97m and 1.27m each year.

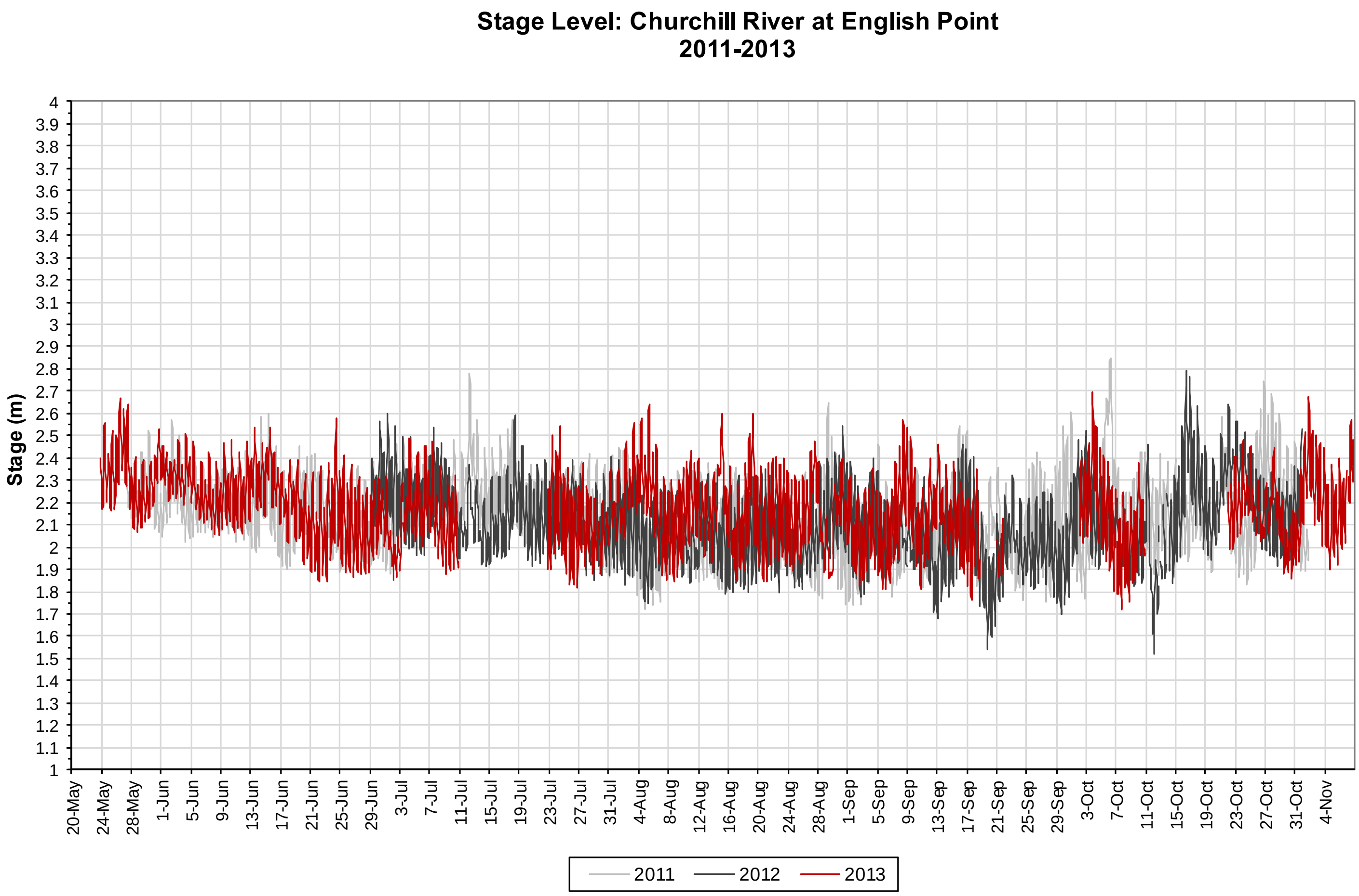


Figure 39: Stage level at Churchill River at English Point

Stage (m)	2013	2012	2011
Median	2.175	2.093	2.139
Max	2.693	2.790	2.845
Min	1.724	1.519	1.724
Range	0.969	1.271	1.121

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 40).
- Stage is 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.

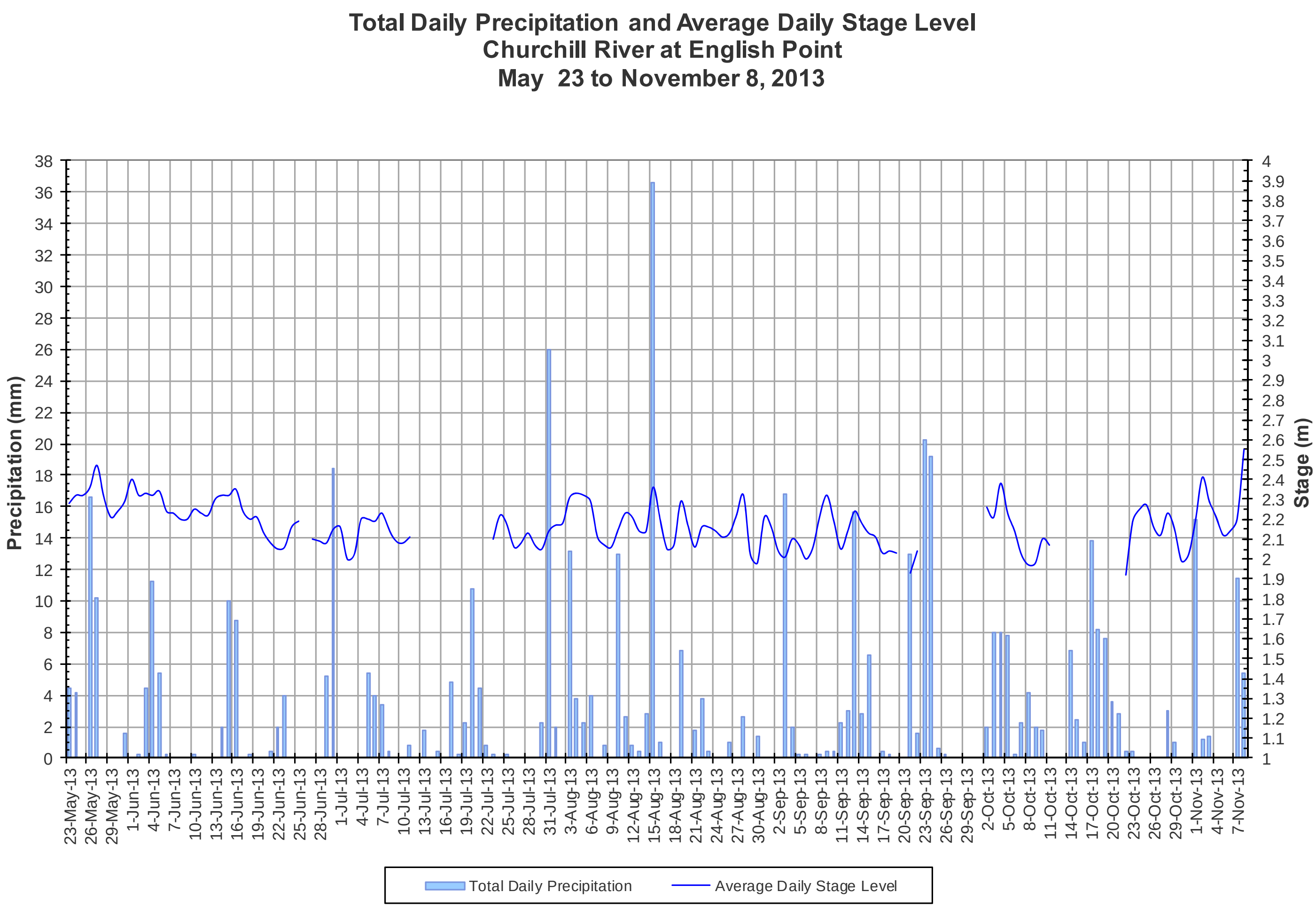


Figure 40: Daily precipitation and average daily stage level at Churchill River at English Point

(weather data recorded at Goose Bay)

Station Comparison

- Water temperature at each of the five stations shows a similar trend throughout the 2013 deployment season (Figure 41).
- Water temperature is warmest at Churchill River at English Point and also has the greatest diurnal fluctuations. The coolest water temperatures in the spring and early summer were found at Churchill River below Grizzle Rapids. When water temperatures began to cool in mid-August, Churchill River below Metchin River had the lowest water temperatures when compared to other stations in the network. Stations above and below Muskrat falls were very similar as is expected with their close proximity to one another (~7km).

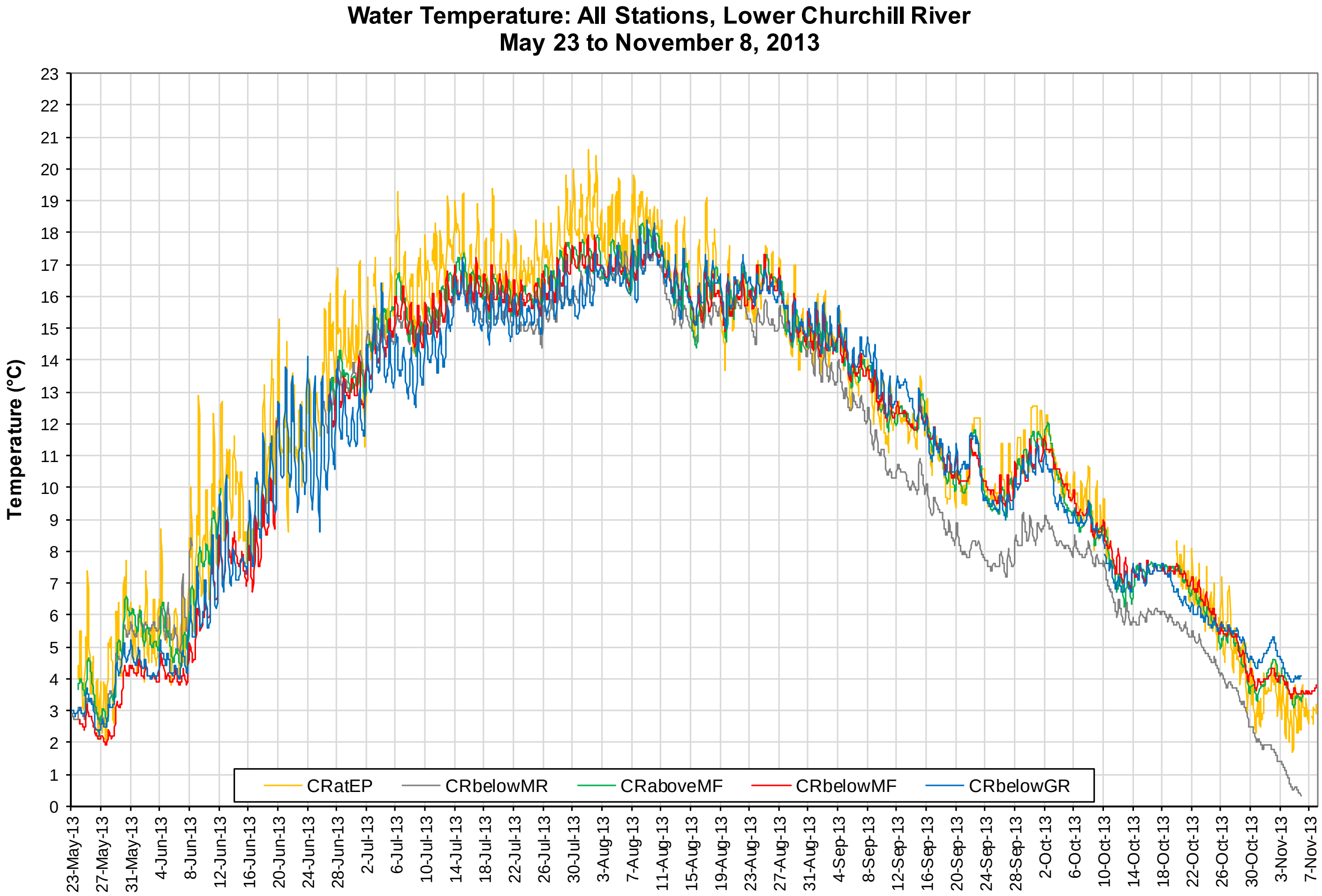


Figure 41: Temperature at all stations in 2013, Lower Churchill River

Temperature	CRbelowMR	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Median	11.7	11.6	12.54	12.00	12.43
Max	17.9	18.4	18.28	18.00	20.6
Min	0.30	2.20	2.63	1.90	1.70

- Water temperatures at all five stations display clear seasonal trends in response to changes in air temperatures throughout the deployment season (Figure 42).
- Water temperatures peak at seasonal highs in late July at English Point and early August at all other station in the network.

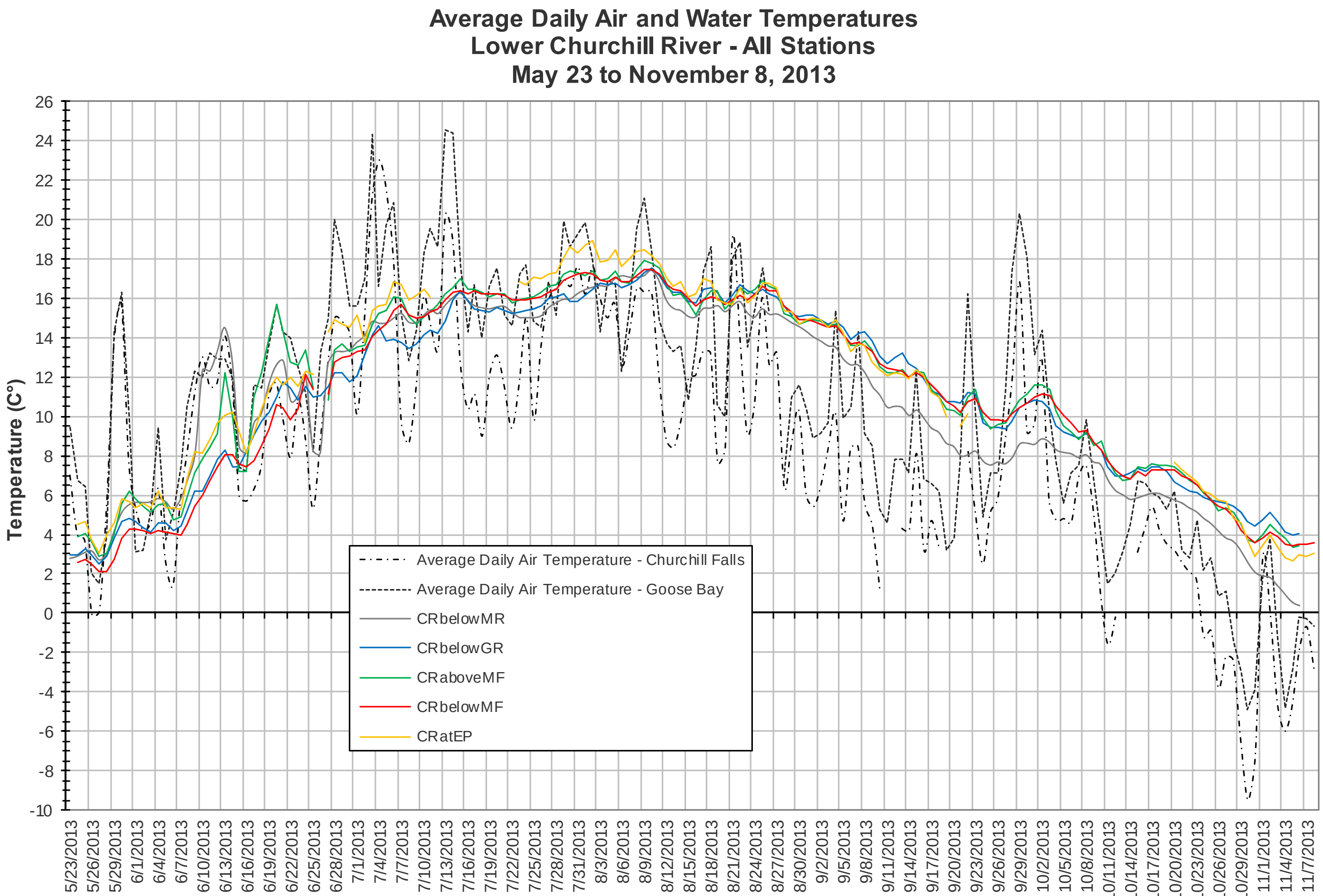


Figure 42: Average daily air and water temperatures at all stations in 2013, Lower Churchill River

- pH values are similar at the five monitoring sites throughout the 2013 deployment season (Figure 43).
- Median values range between 6.94 (Churchill River above Muskrat Falls) and 7.27 (Churchill River below Metchin River). Values at the station at English Point are the most variable day to day throughout the deployment season. This is likely 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.

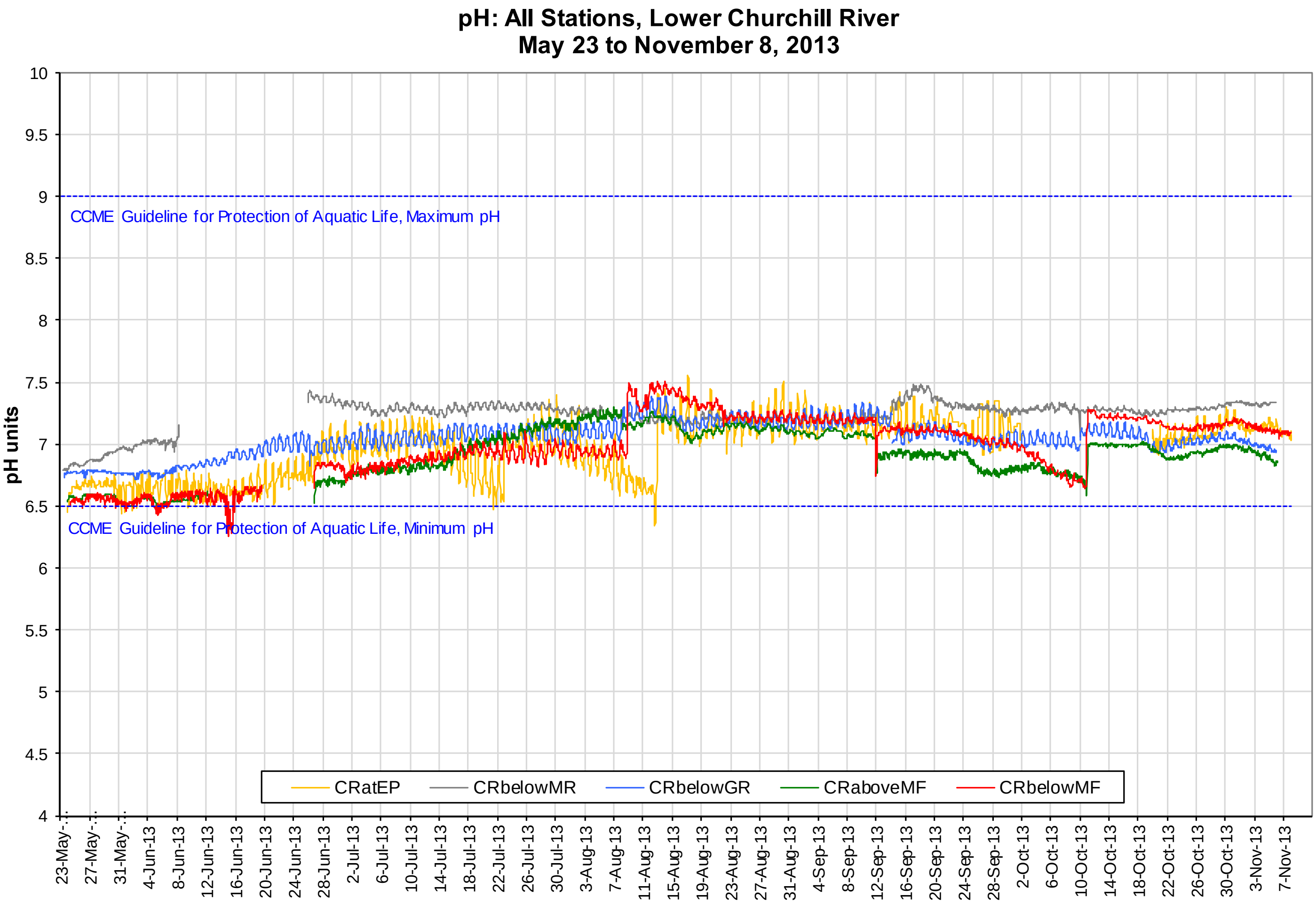


Figure 43: pH at all stations in 2013, Lower Churchill River

pH (units)	CRbelowMR	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Median	7.27	7.05	6.94	7.01	7.03
Max	7.48	7.39	7.30	7.51	7.56
Min	6.79	6.72	6.48	6.25	6.34

- Specific conductivity trends are similar along the Lower Churchill River at the five monitoring stations except for at the station at English Point (Figure 44).
- Specific conductivity is generally very stable on the Lower Churchill River (above English Point), fluctuating only a few micro Siemens during a deployment period.
- Seasonal trends are notable at these stations and show specific conductivity increasing from the time of deployment in May to about mid-August. Specific conductivity then decreases slightly until the instruments are removed in early November.
- At the station at English Point, specific conductance is highly variable 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.

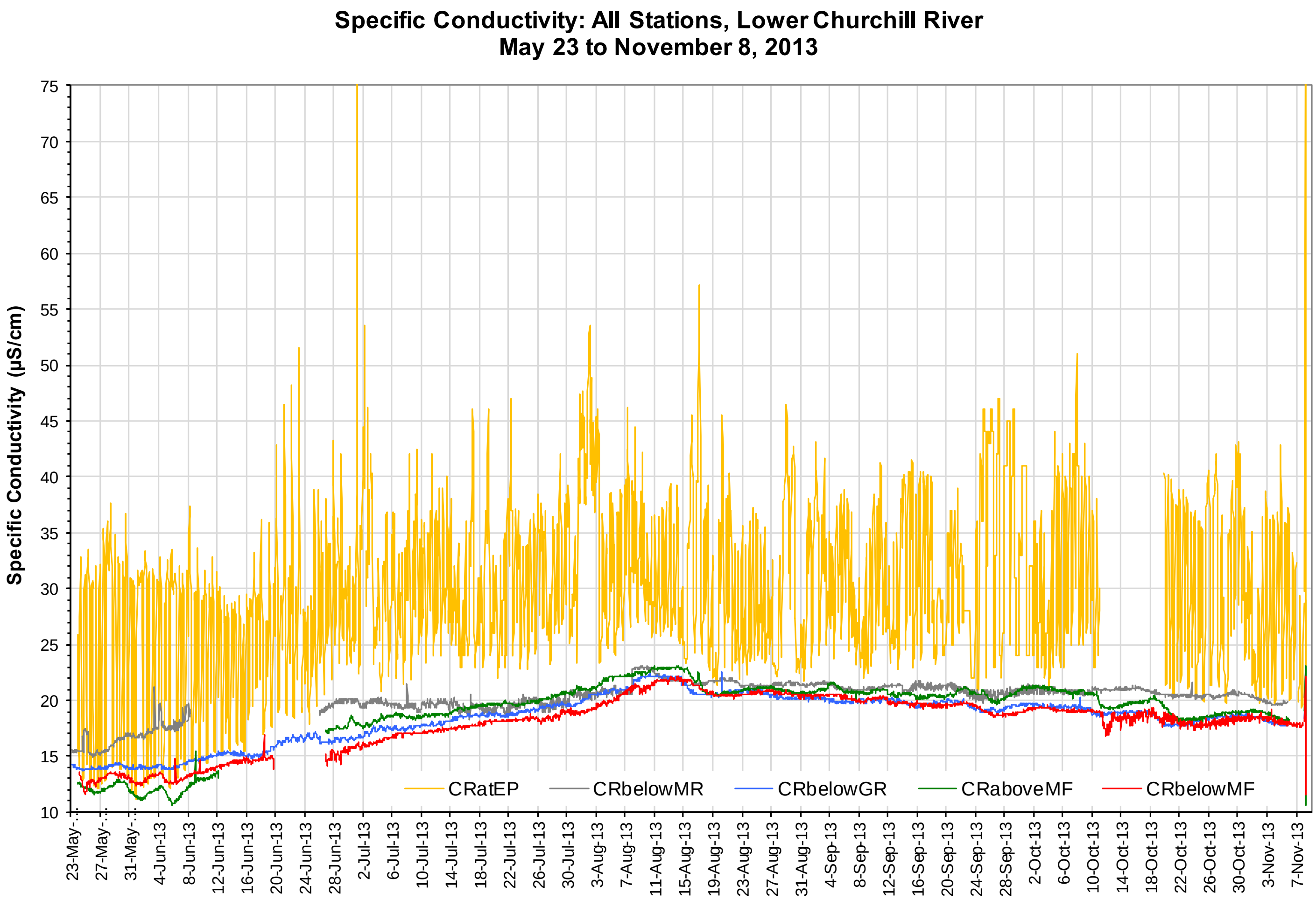


Figure 44: Specific conductivity at all stations in 2013, Lower Churchill River

Specific Conductivity (µS/cm)	CRbelowMR	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Median	20.6	18.9	20.1	18.6	29.0
Max	23.1	22.5	23.1	22.1	91.4
Min	14.9	13.7	10.7	11.6	11.2

- Dissolved oxygen content and percent saturation values are very similar throughout the network with median values from 10.28mg/l (below Metchin River) to 11.28mg/l (below Muskrat Falls) and 93.6% (below Metchin River) to 106.8% (below Muskrat Falls) (Figure 45).
- Dissolved oxygen content shows a very clear inverse relationship to water temperature and has a distinct seasonal trend decreasing in the spring and early summer, and increasing in the late summer and fall.
- Dissolved oxygen content below Muskrat Falls is higher than all other stations throughout the deployment season due to its location downstream from Muskrat Falls. The station below Muskrat Falls is the only station where dissolved oxygen content does not fall below the minimum CCME Guideline for the Protection of Early Life Stage Cold Water Biota value at 9.5 mg/l during any part of the season. Guidelines are indicated in blue on Figure 45.

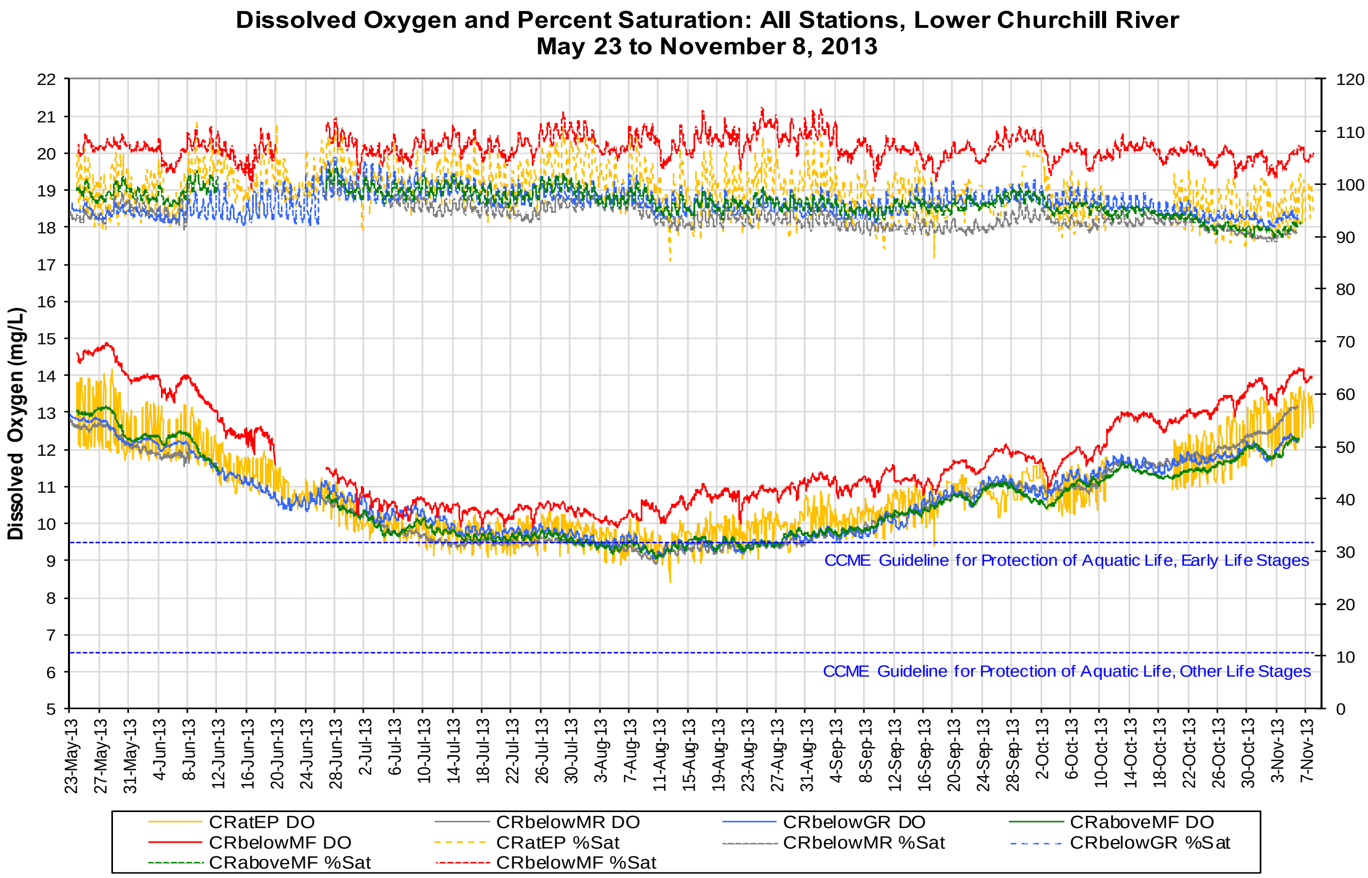


Figure 45: Dissolved oxygen and percent saturation at all stations in 2013, Lower Churchill River

	Dissolved Oxygen (mg/l)				
	CRbelowMR	**CRbelowGR**	**CRaboveMF**	**CRbelowMF**	**CRatEP**
Median	10.28	10.63	10.30	11.28	10.55
Max	13.17	12.95	13.16	14.90	14.17
Min	8.88	9.04	9.06	9.90	8.42
	Percent Saturation (%)				
	CRbelowMR	**CRbelowGR**	**CRaboveMF**	**CRbelowMF**	**CRatEP**
Median	93.6	96.3	96.6	106.8	99.4
Max	102.7	105.2	103.4	114.6	111.9
Min	89.3	91.4	90.0	99.1	85.5

- Turbidity values at stations below Grizzle Rapids and below Metchin River are generally 0NTU with minimal, short lived turbidity events (Figures 6 & 14). In the lower reaches of the Lower Churchill River, at the stations above and below Muskrat Falls and at English Point have consistent natural background turbidity values.
- Background turbidity values are 1.3NTU, 7.2NTU and 6.8NTU for the stations above and below Muskrat Falls and English Point, respectively.

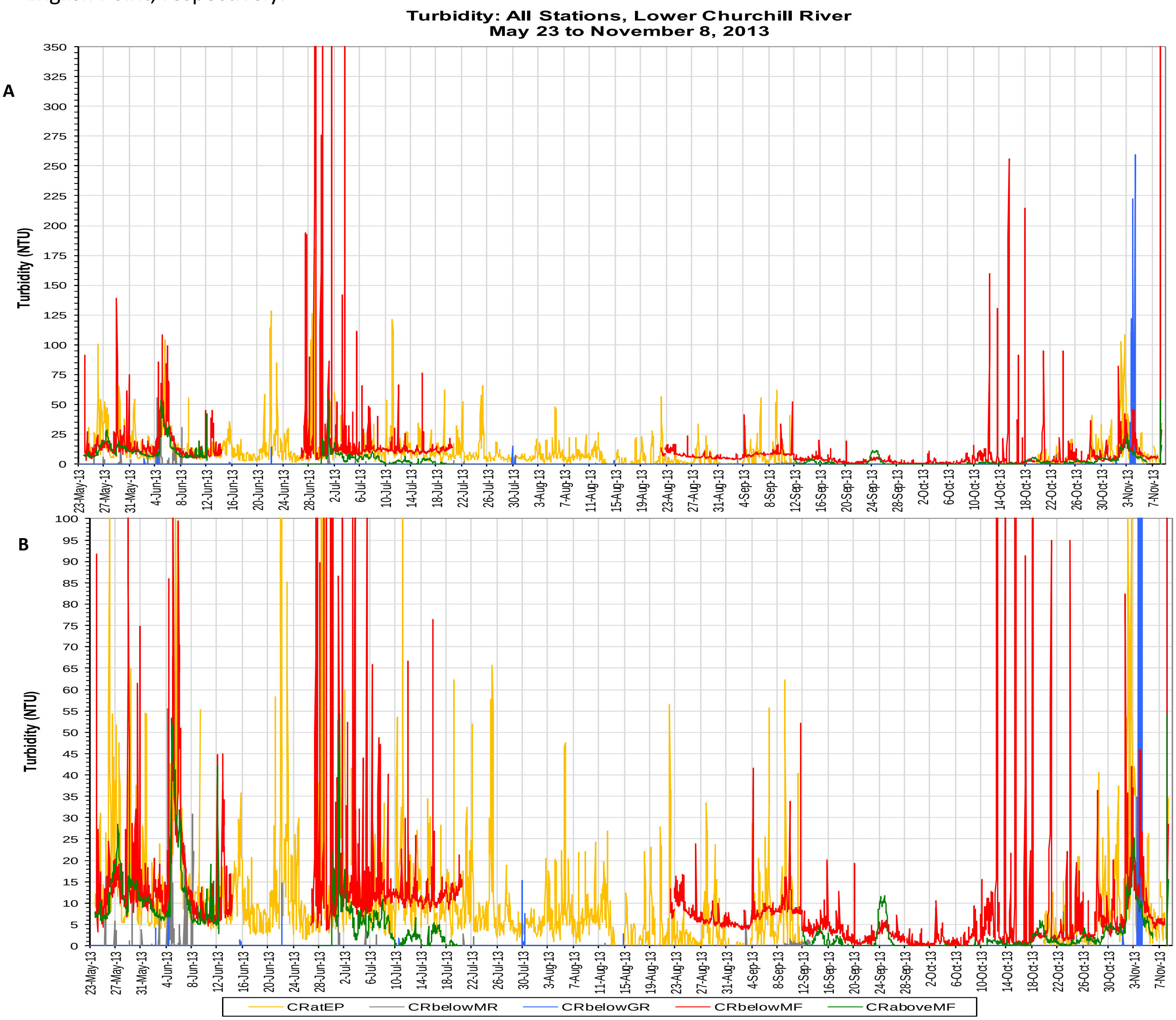


Figure 46a: Turbidity to 350NTU at all stations in 2013; Figure 46b: Turbidity to 100NTU at all stations in 2013

Turbidity (NTU)	CRbelowMR	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Median	0	0	1.3	7.2	6.8
Max	55.5	259.4	54.3	2631	181.3
Min	0	0	0	0	0
95 %	0	0	14.6	28.4	34.6
75 %	0	0	5.23	11.4	12.6

- Stage levels are similar across the network throughout the 2013 deployment season (Figure 47). Stage is decreasing at all stations in the end of May and throughout June. Stage levels reach a seasonal low at all stations above English Point in early July. Stage levels remain low throughout the summer months. Stage level at English Point reaches a seasonal low in early October. Stage levels begin to increase again in mid-October until the end of the deployment season in November.
- Stage ranges between 1.00m and 2.63m 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.

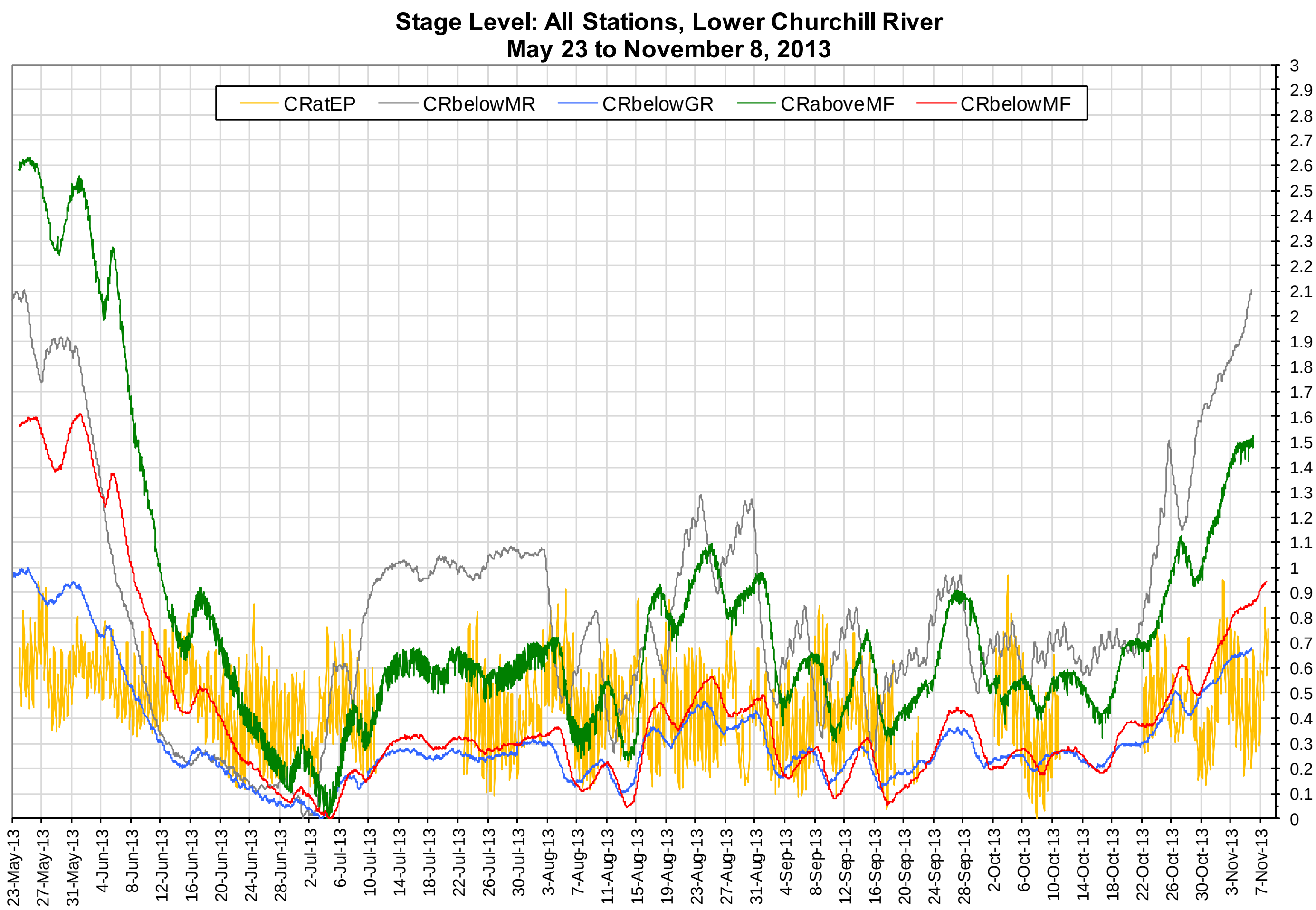


Figure 47: Stage levels at all stations in 2013, Lower Churchill River

	CRbelowMR	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Stage Range (m)	2.104	0.999	2.633	1.611	0.969

Conclusions

- Water quality monitoring instruments were successfully deployed on the Lower Churchill River at stations below Metchin River, below Grizzle Rapids, above and below Muskrat Falls and at English Point from May 23/24 to November 6/8.
- In most cases, weather related events or increase/decreases in water level could be used to explain the fluctuations. The four 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 near 30 day deployment schedule have been adhered to for the most part. 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.
    - Significant water level decreases left instrument exposed to air at the river edge at stations below Metchin River from June 8-26, above Muskrat Falls from June 12-27 and June 20-27 below Muskrat Falls. Data for these time periods has been removed from the data set. Turbidity data has been removed for some stations up to one week prior to the instrument being fully exposed to air due to inaccuracies captured resulting from the instrument being in very shallow water.
    - Turbidity data was compromised during several different deployments at stations above and below Muskrat Falls and English Point. Turbidity data above Muskrat Falls between August 15 and September 12, below Muskrat Falls from July 21 to August 22, and at English Point from September 12 to October 11 has been removed from the data set.
    - Finally, transmission errors were infrequent across the network. The station at English Point however did experience a transmission error from July 11-23 and from September 19 to October 20. Log file data has been used to fill in the gaps where applicable. The station has been serviced and a new field cable will be installed prior to the spring 2014 deployment season.
- Data collected in 2013 is comparable with datasets from previous years in 2011 and 2012. 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 in late July at English Point and in early August at all other stations. Water temperatures had median values between 11.6°C (below Grizzle Rapids) and 12.5°C (above Muskrat Falls).
- All values recorded were within ranges as suggested by the CCME Guidelines for the Protection of Aquatic Life for pH except for short periods of time at the station below Muskrat Falls in during the May-June deployment and at English Point during July-August. Median pH values ranged between 6.94 (above Muskrat Falls) and 7.27 (below Metchin River)
- At stations below Metchin River, below Grizzle Rapids, above Muskrat Falls, and at English Point, dissolved oxygen content did fall below the minimum CCME Guideline for the Protection of Aquatic Life during early life stages (9.5mg/L) during the warmest part of the season (August). All values at all stations remained above the minimum CCME Guideline for the Protection of Aquatic Life during other life stages (6.5mg/L). Median values for dissolved oxygen and percent saturation ranged between 10.28mg/l (93.6%) (below Metchin River) and 11.28 (106.8%) (below Muskrat Falls).
- Background turbidity values at the stations below Metchin River and below Grizzle Rapids were 0NTU and turbidity events were short lived and insignificant. At stations above and below Muskrat Falls and at English Point, median

turbidity values were 1.3NTU, 7.2NTU and 6.8NTU respectively. Turbidity events were frequent, most often corresponding with rain fall 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 2013 deployment season was successful in providing baseline water quality data for the Lower Churchill Project. 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.

- A second deployment at the station below Muskrat Falls was installed on August 22, 2013. An instrument supported in a buoy structure designed for hydrolabs was deployed from shore and set to log internally for a period of 2 weeks. Upon return to the station on September 12, the bottom shaft of the buoy structure had become separated from the main floating portion and the instrument was lost in the Churchill River. No data was received for comparison. Additional plans for a second deployment have not yet been determined and will be discussed before the 2014 season begins.
- The Lake Melville station remains a water quantity station. RTWQ monitoring was stopped in 2012 following continual damage to the deployed instrument. Five grab samples were taken during the 2013 season and results have been made available to Nalcor. ENVC will continue to explore new deployment techniques for this station.
- Chlorophyll sensors were added to instruments #45700 and #45708 (owned by Nalcor) for the station below Muskrat Falls and to instrument #47589 and #47590 (owned by ENVC) for the station above Muskrat Falls in 2013. The sensors have not functioned properly since installation. The four instruments will be sent to Campbell Scientific for evaluation and repair (if necessary in January 2014).
- ENVC has updated the TSS-Turbidity model for the stations above and below Muskrat Falls to include grab sample data from 2013. A meeting with Nalcor and AMEC consulting staff will be set up for January 2014 to discuss the outcome of the model update and continue to coordinate sampling and research projects for the future.
- Research into the use of remote sensing (using satellite imagery) to predict/map water quality parameters (i.e. turbidity and TSS) will continue in 2014. Satellite imagery will be acquired by WRMD to further this area of research.
- Nalcor and ENVC planned to install a weather station at the construction site at Muskrat Falls in fall 2013 however time did not permit before the first major snowfall. The weather station equipment is being stored at ENVC office in Goose Bay and plans to install the station in spring 2014 will be determined.
- ENVC staff will deploy RTWQ instruments in spring 2014 when ice conditions allow and perform regular site visits throughout the 2014 deployment season for calibration and maintenance of the instruments.
- EC 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 ENVC, EC and Nalcor employees involved with the agreement in order to respond to emerging issues on a proactive basis.

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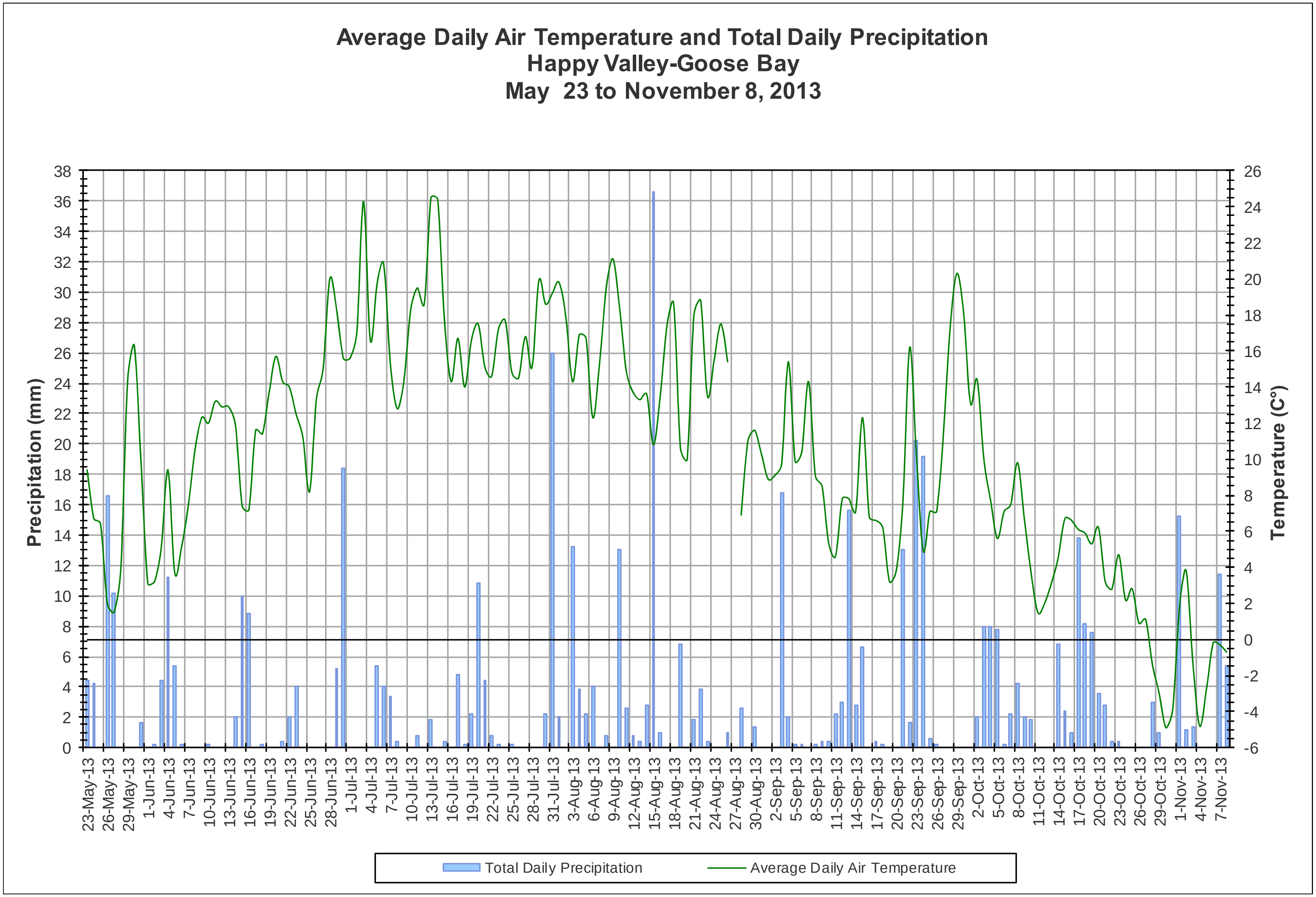
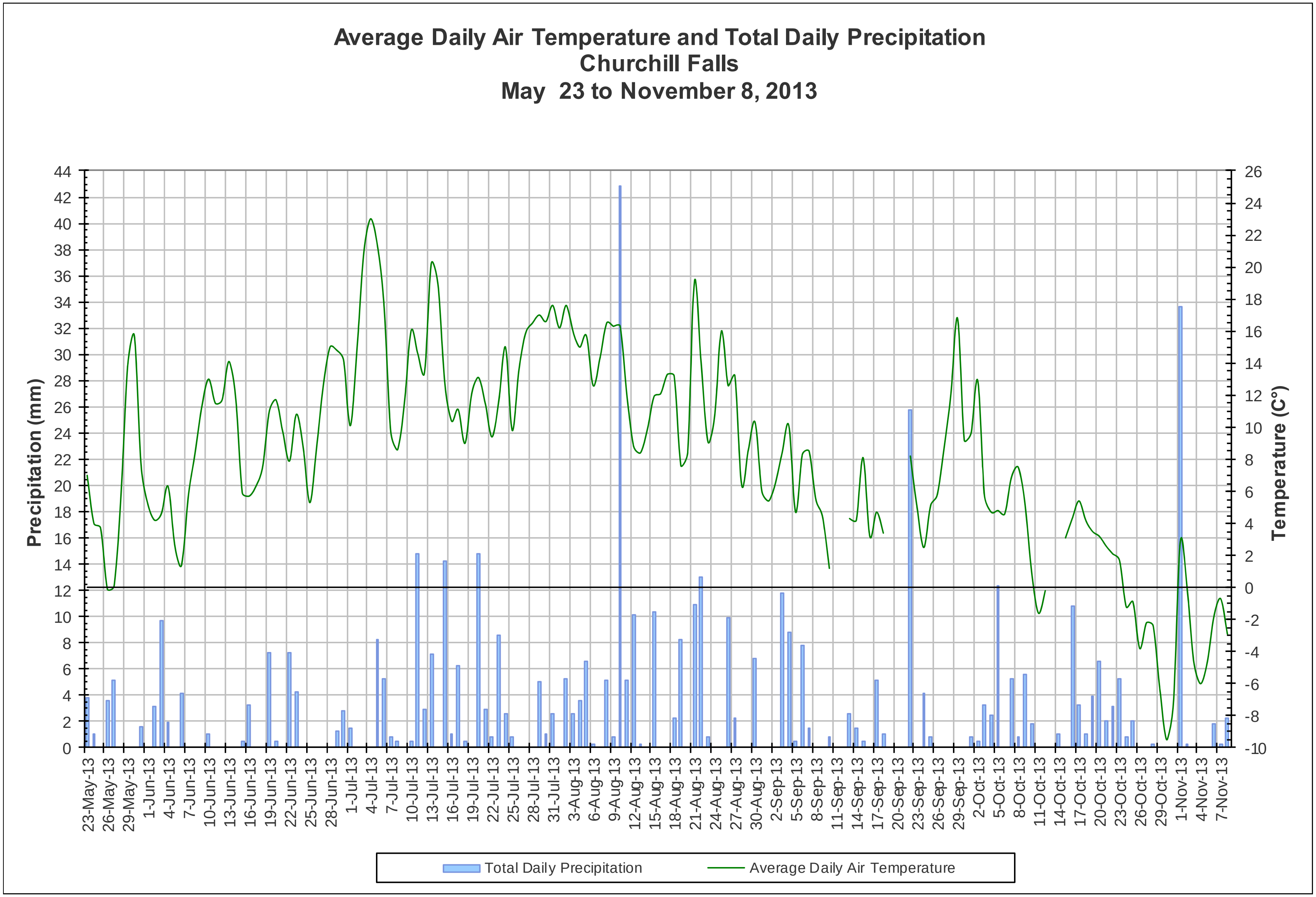
Appendix 1


Average Daily Air Temperature and Total Daily Precipitation
Happy Valley-Goose Bay
May 23 to November 8, 2013
Precipitation (mm)
Temperature (C°)
Total Daily Precipitation
Average Daily Air Temperature


Average Daily Air Temperature and Total Daily Precipitation
Churchill Falls
May 23 to November 8, 2013
Precipitation (mm)
Temperature (C°)
Total Daily Precipitation
Average Daily Air Temperature