Real-Time Water Quality 2012 Annual Report

Lower Churchill River Network

June 29 to November 7, 2012

Newfoundland Labrador

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

CONTENTS

Acknowledgements

The Real-Time Water Quality Monitoring (RTWQM) 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 2012, 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 is acknowledged for her efforts during deployment and removal procedures in 2012.

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 and Steve Pellerin– 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 2012, there was continued communication in the form of small meetings and email correspondence between ENVC and Nalcor. Topics addressed during a September 7, 2012 meeting in St. John's included progress updates as well as invoicing and data transfer agreements. 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(M)	Real-time Water Quality (Monitoring)
SC	Specific Conductivity
WRMD	Water Resources Management Division
%Sat	Percent Saturation

Introduction

- The RTWQM 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 quality data (stage level and flow rate) 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 and flow rate data 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 2010, 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 summer 2012 following a number of setbacks delaying the first deployment. The instruments were undergoing annual maintenance and repair in St. John's during winter 2012. Replacement parts for the instruments were backordered preventing essential repairs from being completed until early June. Once the instruments were fixed and returned to the WRMD office in Goose Bay around mid-June, ENVC staff could not secure a helicopter due to the imminent threat of multiple forest fires burning in the region. All helicopters at both agencies operating from Goose Bay were being used for forest fire fighting operations. Finally, a helicopter was made available on June 29 and instruments were deployed at all stations.
- This annual deployment report illustrates, discusses and summarizes water quality related events from June 29 to November 7, 2012. During this time, five visits were made to each of the five RTWQM sites. Instruments were deployed for four, month-long intervals referred to as deployment periods.

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 2012 deployment season are summarized in Table 1.

Table 1: Installation and removal dates for 2012 deployment periods

Installation	Removal	Deployment
June 29	July 24/25	26/27 days
July 24/25	August 21/22	29/30 days
August 21/22	September 25/26	35/36 days
September 25/26	October 31, November 1 & 7	37/44 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 along side 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 (oC)	<=+/-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 dependant, 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 June 29 to November 7, 2012, are summarized in Table 3.

Lower Churchill River, Newfoundland and Labrador

- 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, June 29 – November 7, 2012

Station	Date	Action	Instrument #	Temperature	pH	Specific Conductivity	Dissolved Oxygen	Turbidity
Below Metchin River	29/Jun/12	Deployment	45707	n/a	n/a	n/a	n/a	n/a
	24/Jul/12	Removal	45707	Good	Marginal	Good	Excellent	Excellent
	24/Jul/12	Deployment	45701	Excellent	Poor	Excellent	Excellent	Excellent
	21/Aug/12	Removal	45701	Excellent	Excellent	Excellent	Excellent	Excellent
	21/Aug/12	Deployment	45707	Good	Excellent	Excellent	Excellent	Excellent
	25/Sep/12	Removal	45707	Good	Good	Excellent	n/a	Excellent
	25/Sep/12	Deployment	45701	Excellent	Excellent	Excellent	n/a	Excellent
	31/Oct/12	Removal	45701	Excellent	Marginal	Excellent	Good	Excellent
Below Grizzle Rapids	29/Jun/12	Deployment	45699	n/a	n/a	n/a	n/a	n/a
	24/Jul/12	Removal	45699	Excellent	Excellent	Good	Excellent	Excellent
	24/Jul/12	Deployment	45042	Excellent	Excellent	Good	Excellent	Excellent
	21/Aug/12	Removal	45042	Excellent	Poor	Excellent	Excellent	Excellent
	21/Aug/12	Deployment	45709	Good	Good	Excellent	Excellent	Excellent
	25/Sep/12	Removal	45709	Excellent	Excellent	Excellent	n/a	Excellent
	25/Sep/12	Deployment	45699	Excellent	Excellent	Excellent	n/a	Excellent
	7/Nov/12	Removal	45699	Excellent	Marginal	Excellent	Excellent	Excellent
Above Muskrat Falls	29/Jun/12	Deployment	45708	Excellent	Good	Excellent	Excellent	Good
	24/Jul/12	Removal	45708	Excellent	Fair	Good	Excellent	Excellent
	24/Jul/12	Deployment	47589	Excellent	Good	Excellent	Excellent	Excellent
	21/Aug/12	Removal	47589	Excellent	Excellent	Excellent	Excellent	Excellent
	21/Aug/12	Deployment	45708	Excellent	Excellent	Good	Excellent	Good
	25/Sep/12	Removal	45708	Excellent	Excellent	Excellent	n/a	Excellent
	25/Sep/12	Deployment	47590	Excellent	Excellent	Excellent	n/a	Good
	1/Nov/12	Removal	47590	Excellent	Marginal	Good	Excellent	Good
Below Muskrat Falls	29/Jun/12	Deployment	45700	Excellent	Excellent	Excellent	Excellent	Excellent
	24/Jul/12	Removal	45700	Good	Marginal	Good	Excellent	Poor
	24/Jul/12	Deployment	47590	Excellent	Poor	Excellent	Excellent	Poor
	22/Aug/12	Removal	47590	Excellent	Good	Excellent	n/a	Poor
	22/Aug/12	Deployment	45700	Good	Good	Good	n/a	Good
	25/Sep/12	Removal	45700	Good	Excellent	Good	n/a	Good
	26/Sep/12	Deployment	45708	Excellent	Excellent	Excellent	Excellent	Excellent
	1/Nov/12	Removal	45708	Good	Poor	Excellent	Excellent	Good
At English Point	29/Jun/12	Deployment	45709	Excellent	Good	Good	Excellent	Marginal
	25/Jul/12	Removal	45709	Excellent	Good	Good	Excellent	Marginal
	25/Jul/12	Deployment	45699	Excellent	Good	Good	Excellent	Good
	22/Aug/12	Removal	45699	Excellent	Good	Good	n/a	n/a
	22/Aug/12	Deployment	45042	Good	Good	Excellent	n/a	n/a
	26/Sep/12	Removal	45042	Excellent	n/a	n/a	n/a	n/a
	26/Sep/12	Deployment	45709	Excellent	Fair	Good	Excellent	Fair
	1/Nov/12	Removal	45709	Excellent	Good	Fair	Good	Poor

Data Interpretation and Review

- The following graphs and discussion illustrate significant water quality-related trends from June 29 to November 7 in the Lower Churchill River Network. In this summary of the deployment periods for 2012, 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, 2010 and 2011 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.

Churchill River below Metchin River

- Water temperature ranged from 1.6°C to 18.8°C during the 2012 deployment season, with a median value of 16.0°C (Figure 1).
- Water temperatures are warmer in 2012 when compared to 2011 and 2010 for the same time period (June 29 to October 31).

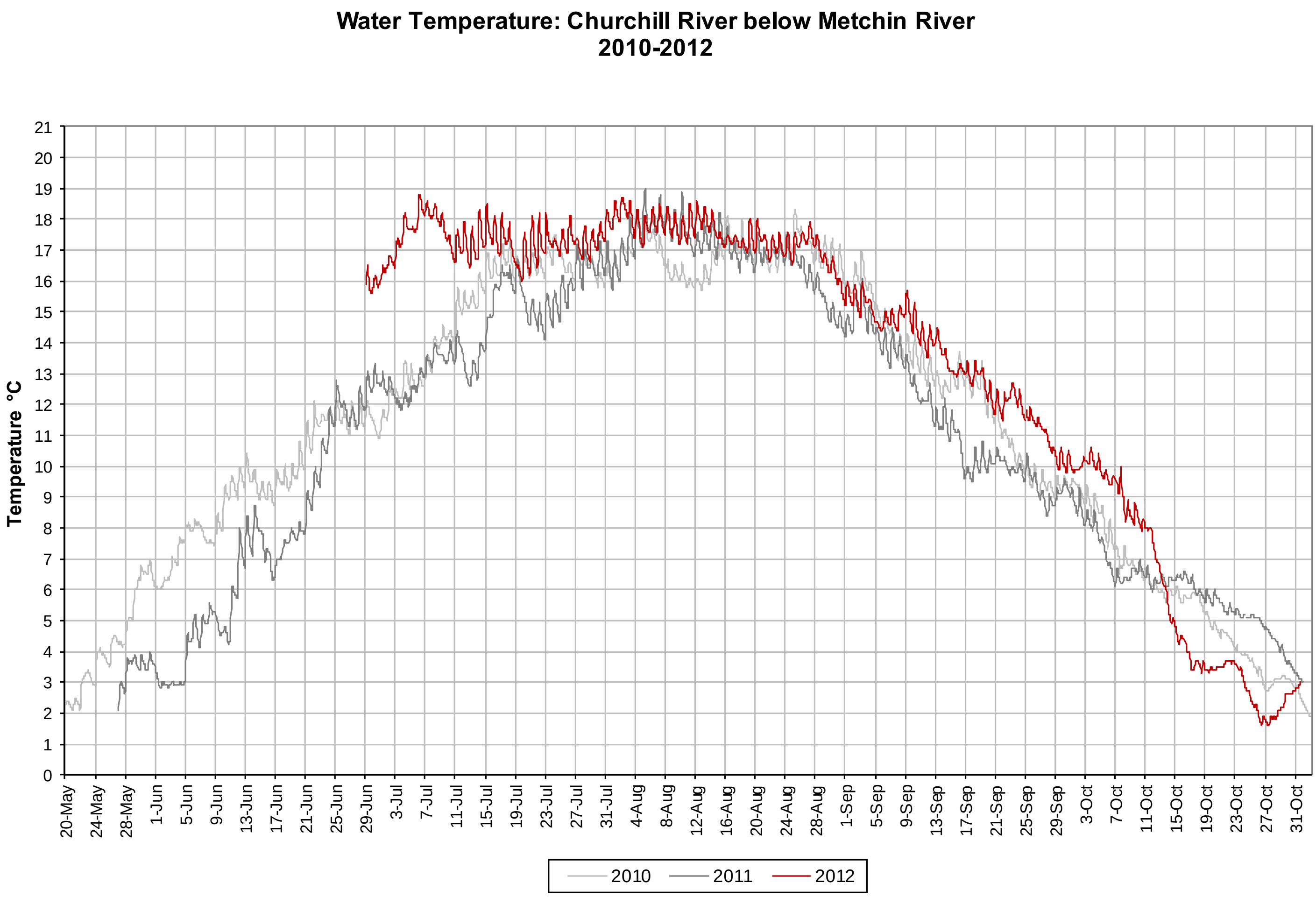


Figure 1: Water temperature at Churchill River below Metchin River

Temperature	2012	2011	2010
Median	16.0	13.3	13.9
Max	18.8	19.0	18.3
Min	1.6	3.1	2.5

- Water temperature values show a typical seasonal trend (Figure 2). Because of the late deployment start in the end of June, water temperatures are at or near seasonal highs shortly after the first deployment. Water and air temperatures are warm until they begin to decrease in early September. Average air and water temperatures decrease throughout the fall season until the instrument is removed for the winter season on October 31.

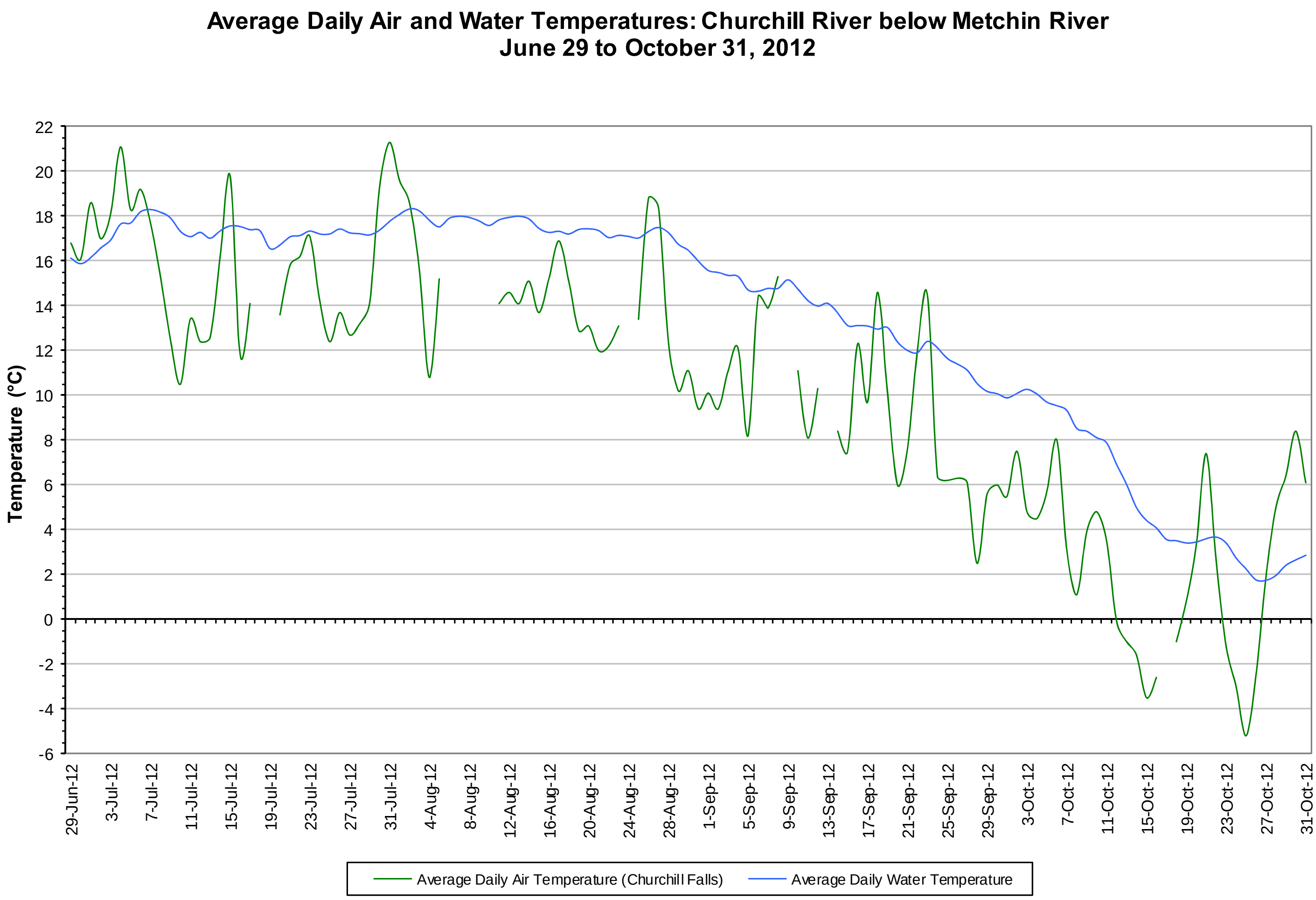


Figure 2: Average daily air and water temperatures at Churchill River below Metchin River

(weather data recorded at Churchill Falls)

- pH ranged between 6.90 and 7.36 pH units during the 2012 deployment season, with a median value of 7.06 pH units (Figure 3).
- pH values are relatively consistent throughout the deployment period, increasing slightly through the late summer weeks.
- All values during the 2012 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 are similar to those values collected in 2010 and 2011 for the same time period (June 29 to October 31).

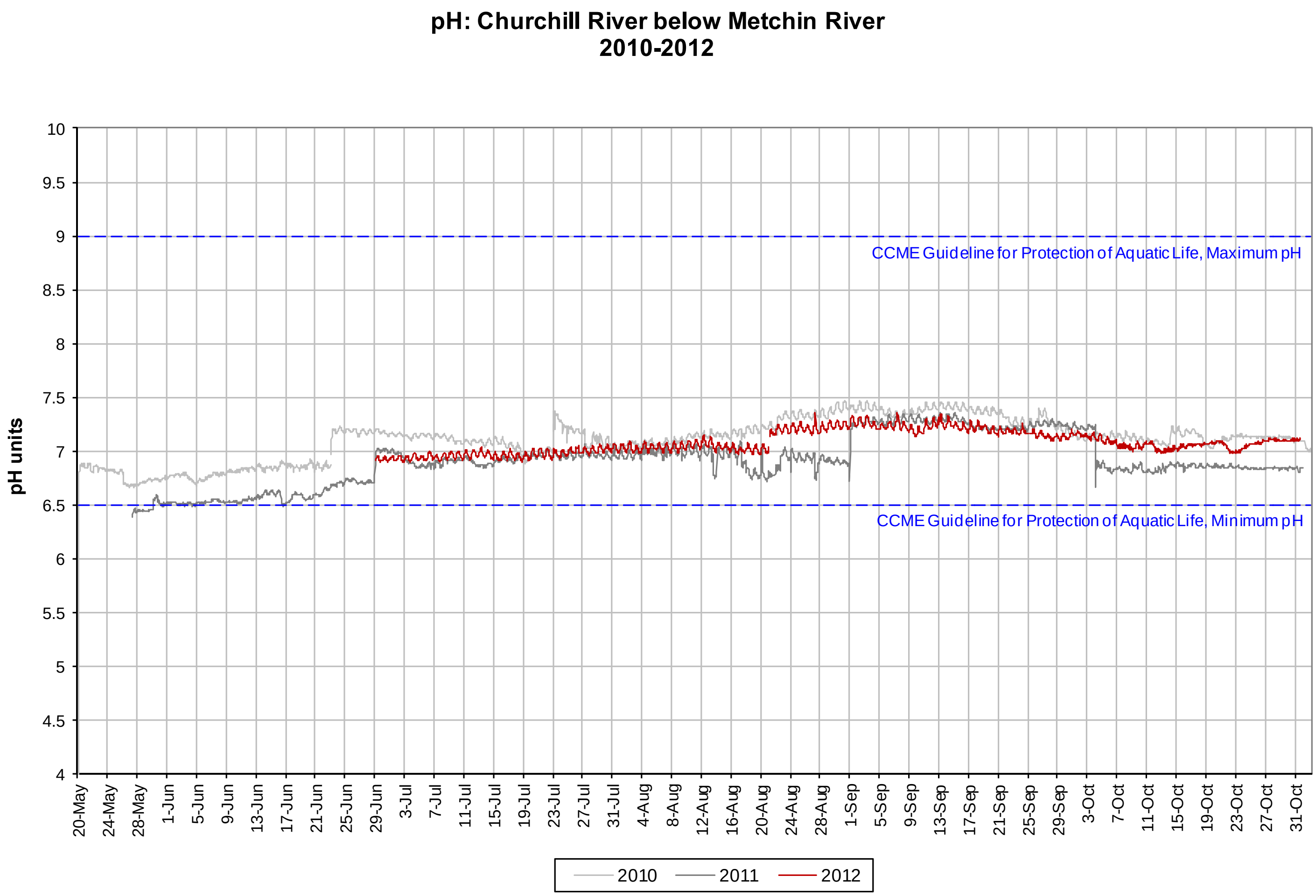


Figure 3: pH at Churchill River below Metchin River

pH (units)	2012	2011	2010
Median	7.06	6.95	7.15
Max	7.36	7.36	7.47
Min	6.90	6.66	6.89

- Specific conductivity ranged from 18.3µS/cm to 49.5µS/cm during the 2012 deployment season, with a median value of 22.8µS/cm (Figure 4).
- Specific conductance values in the first deployment period in 2012 are higher than expected which is indicated by the difference between the end of deployment period 1 and the start of deployment period 2 (July 24). This trend is also noticeable at other stations in the network indicating that a calibration error likely occurred prior to the first deployment.
- Generally, specific conductivity values in 2012 are slightly higher than in previous years for the same time period, with median values of 20.2µS/cm and 20.5 µS/cm in 2011 and 2010 respectively. There are a couple of instances when specific conductivity increases for short periods of time to as high as 49.5µS/cm. It is unknown what causes these increases however it is not unusual to see this type of increase.
- 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.

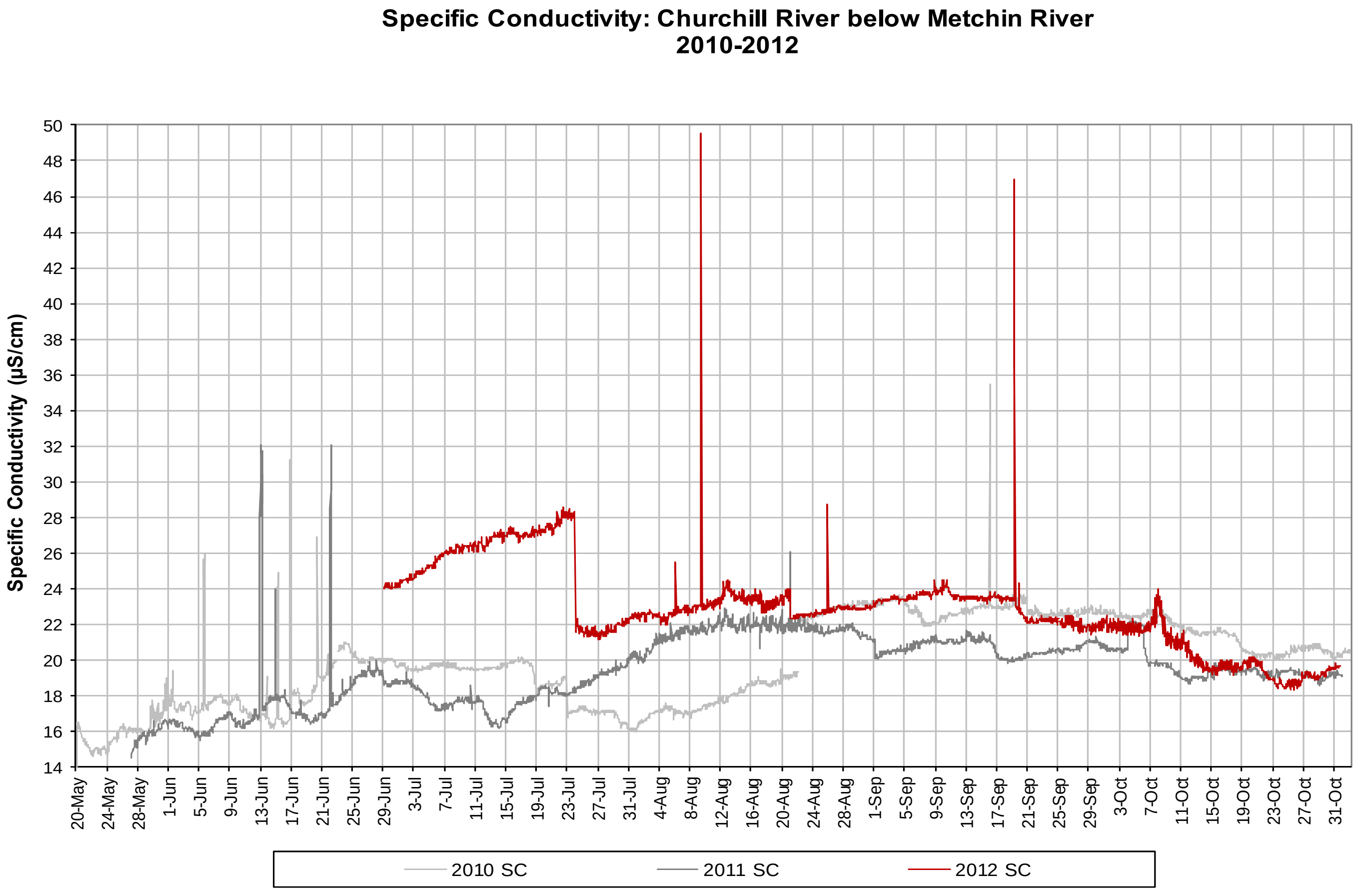


Figure 4: Specific conductivity at Churchill River below Metchin River

Specific Conductivity (µS/cm)	2012	2011	2010
Median	22.8	20.2	20.5
Max	49.5	26.1	35.5
Min	18.3	16.2	16.0

- Throughout the 2012 deployment season, dissolved oxygen ranged from 8.72mg/l to 12.80mg/l, with a median value of 9.38mg/l, while percent saturation ranged from 88.4% to 99.3%, with a median value of 94.5% (Figure 5).
- All values were above the minimum CCME Guideline for the Protection of Aquatic Life at Other Life Stages (6.5 mg/l). For the first two deployment periods, almost all values were 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 5.
- Dissolved oxygen content shows a typical seasonal fluctuation in 2012. Because of the late deployment start in 2012, the decreasing trend normally observed in the spring and early summer season is not captured. Dissolved oxygen values are low and consistent through the warmest part of the season and increase later in the summer and fall season as air and water temperatures cool. Dissolved oxygen content fluctuates regularly on a daily basis.
- For the same time period, dissolved oxygen content is slightly higher in 2010 and 2011 with median values of 9.85mg/l and 9.86mg/L. This trend is expected given the warmer temperatures recorded in 2012 (Figure 1).

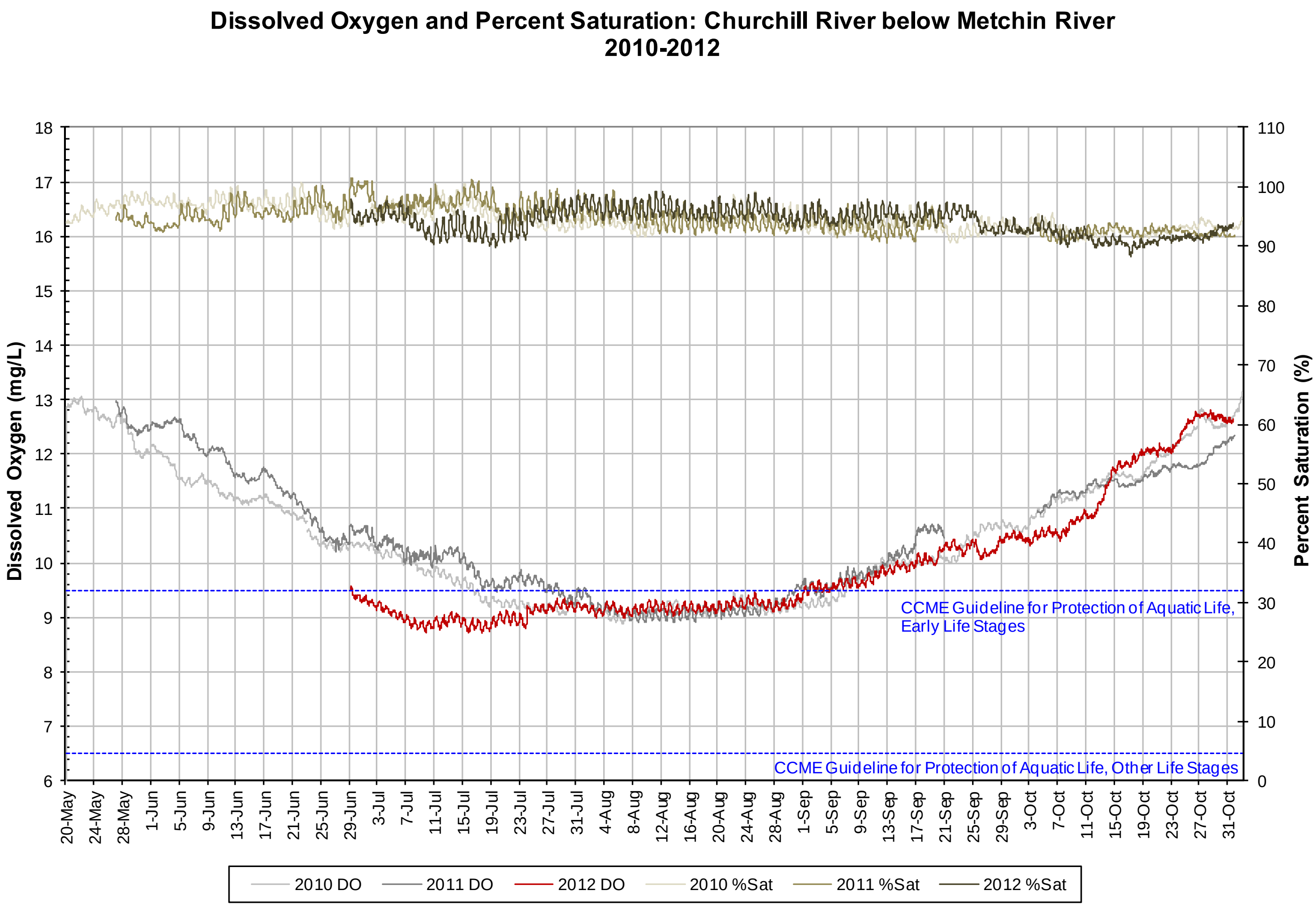


Figure 5: Dissolved oxygen and percent saturation at Churchill River below Metchin River

Dissolved Oxygen (mg/L)	2012	2011	2010		Percent Saturation (%)	2012	2011	2010
Median	9.38	9.86	9.85		Median	94.5	94.0	93.7
Max	12.8	12.3	12.85		Max	99.3	101.5	100.4
Min	8.72	8.91	8.88		Min	88.4	90.7	90.5

- Turbidity generally remains at 0NTU for the majority of the deployment season (Figure 6). A median value of 0 NTU from 2010-12 indicates there is no natural background turbidity value at this station.
- Turbidity data collected during the first deployment period was deemed inaccurate due to sensor failure and has been removed from the data set.
- There are a couple of instances where turbidity increases (to as high as 69.9NTU) for very short periods of time (1-3 hours). These are not considered water quality events as they are isolated and infrequent occurrences.
- When 2012 values are compared to 2010 and 2011 values for the same time period, a similar trend is observed with background levels at 0NTU. Numerous short lived increases occurring throughout each year.

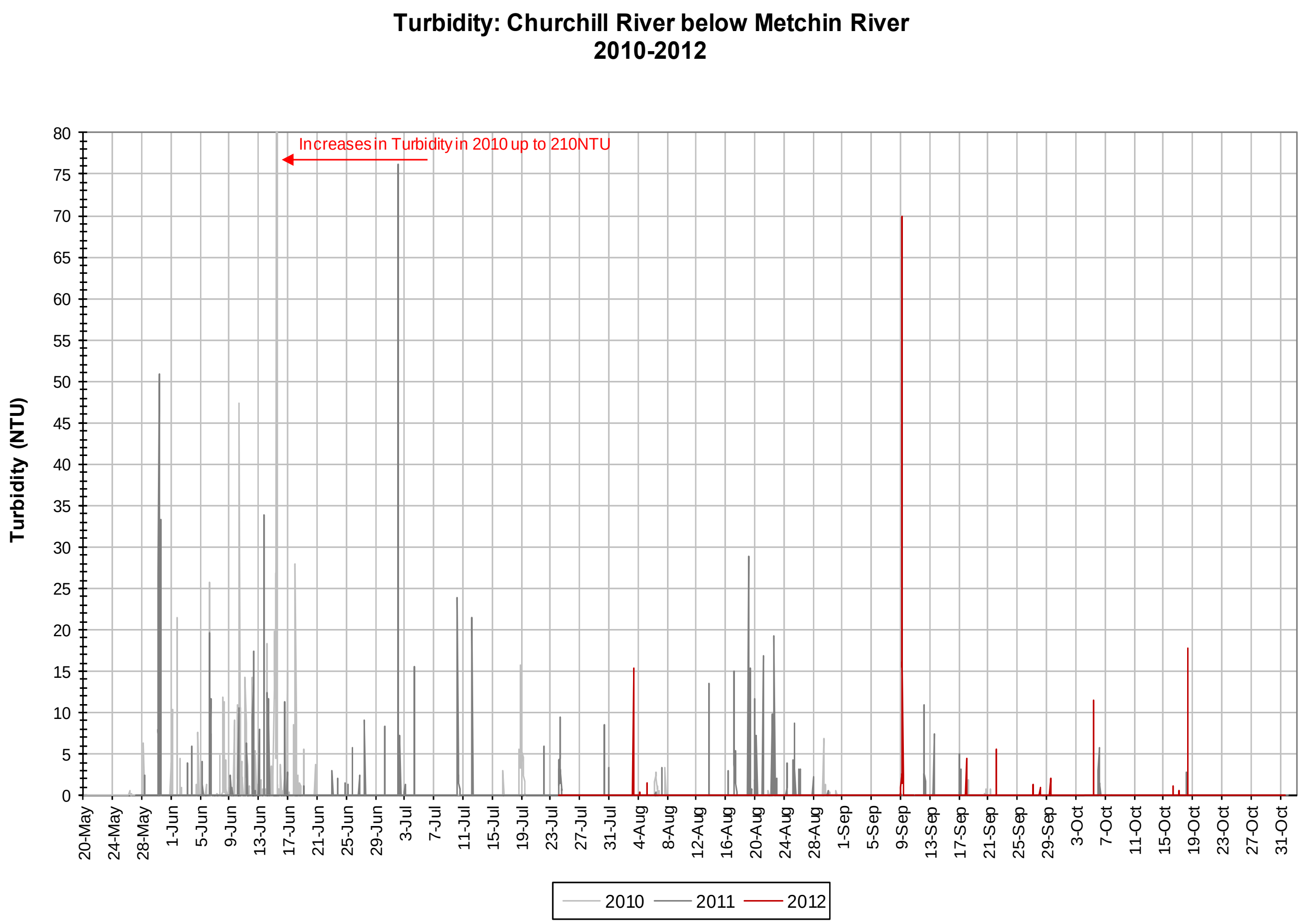


Figure 6: Turbidity at Churchill River below Metchin River

Turbidity (NTU)	2012	2011	2010
Median	0	0	0
Max	69.9	76.2	15.8
Min	0	0	0

- Stage levels in 2012 tend to decrease in the spring and summer months reaching a seasonal low in early September (Figure 7).
- Stage levels from 2010-2012 are graphed below to show how stage levels vary throughout the season and from year to year. Stage levels throughout the season were comparable throughout the three years. Stage levels are slightly lower in 2011 when compared to the 2010 and 2012 data for the same time period. Stage ranged between 1.31m and 1.62m each year.

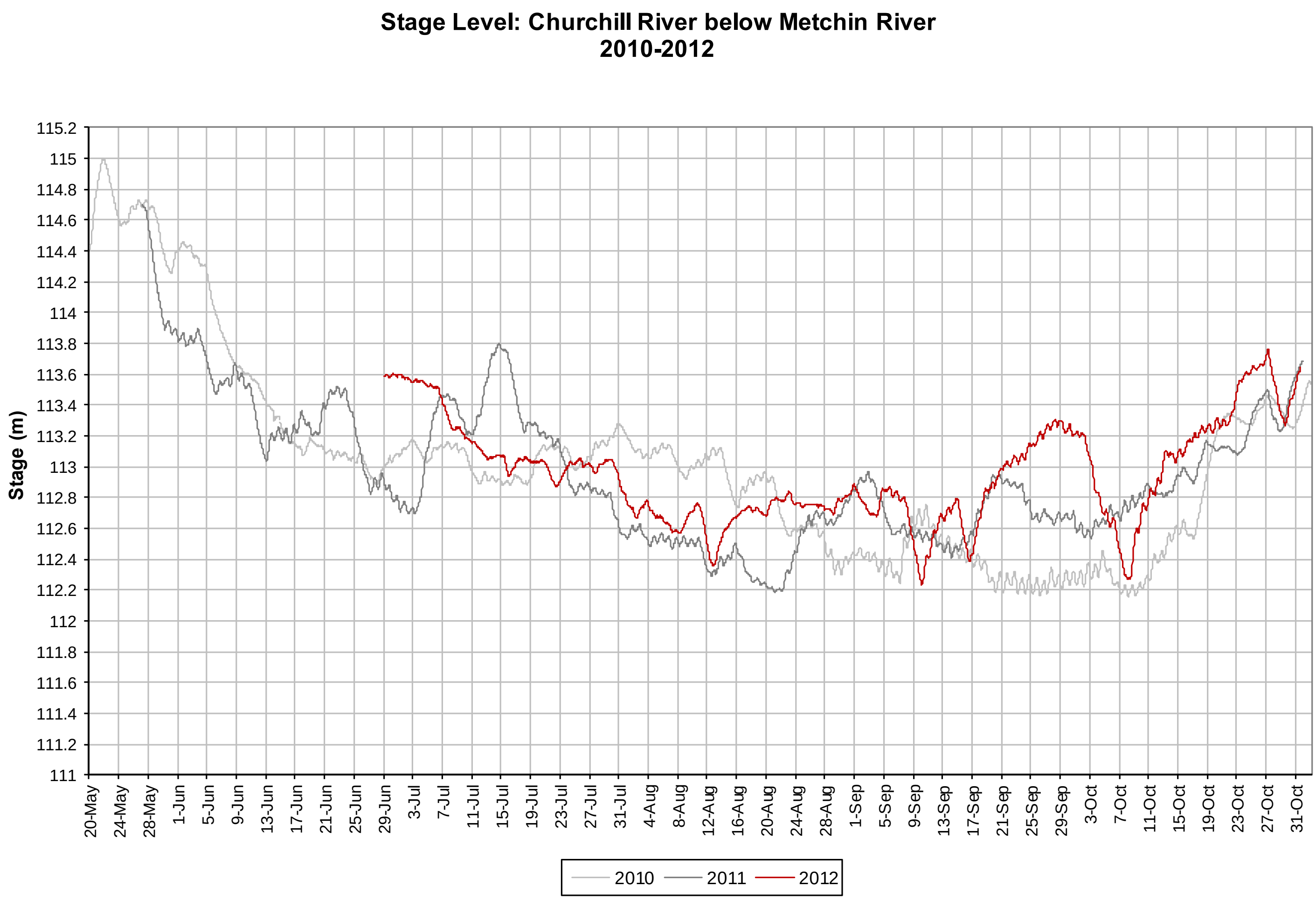


Figure 7: Stage level at Churchill River below Metchin River

Stage (m)	2012	2011	2010
Median	112.93	112.77	112.88
Max	113.76	113.80	113.47
Min	112.23	112.18	112.16
Range	1.53	1.62	1.31

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 8).
- Stage is decreasing for much of the first half of the deployment season. Stage begins to increase again in early to mid-September. A significant decrease occurs in the end of September but this trend is quickly reverse and water levels increase rapidly in the month of October.

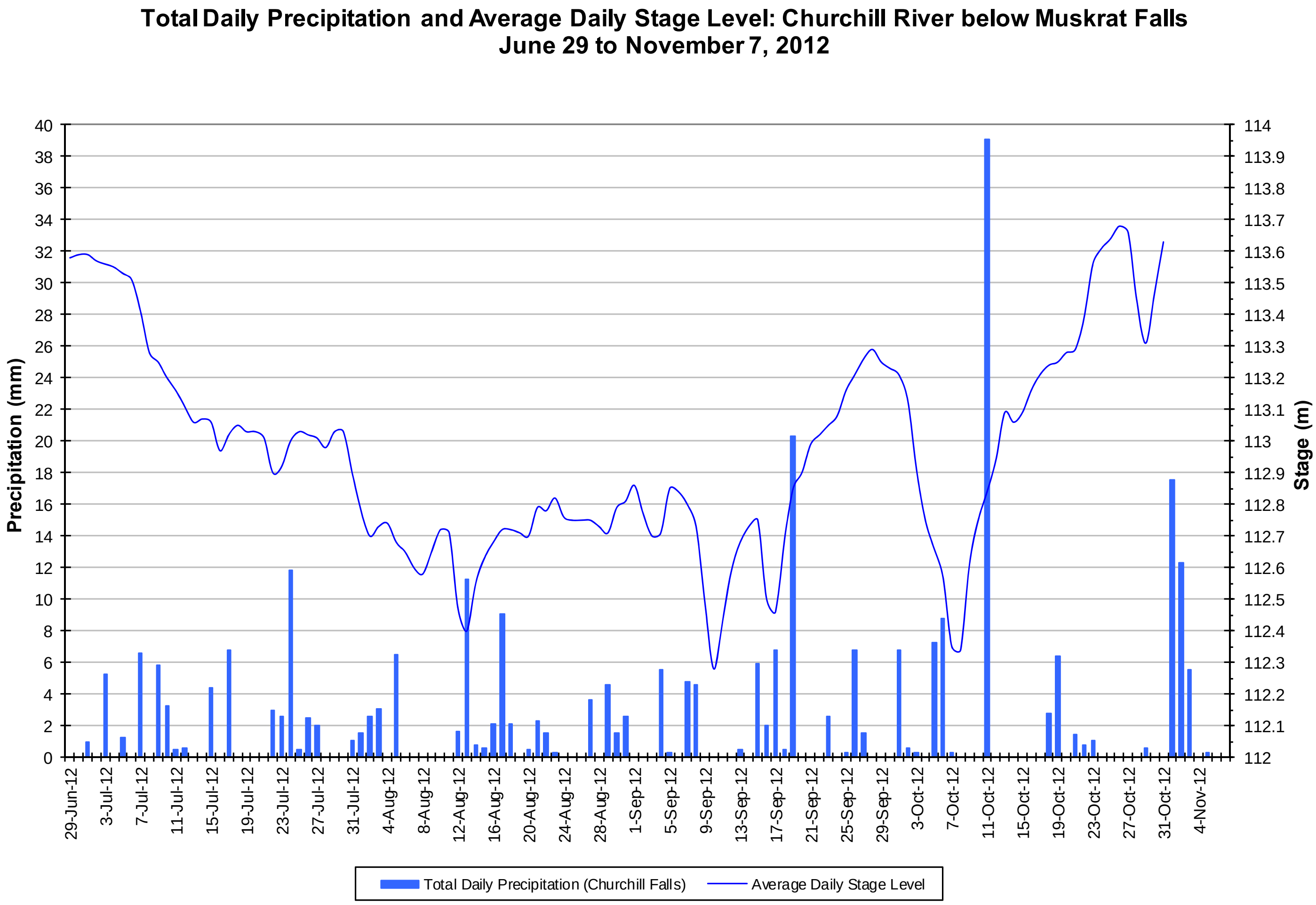


Figure 8: Daily precipitation and average daily stage level at Churchill River below Metchin River

(weather data recorded at Churchill Falls)

Churchill River below Grizzle Rapids

- Water temperature ranged from 4.7°C to 20.0°C during the 2012 deployment season, with a median value of 16.2°C (Figure 9).
- Water temperatures are warmer in 2012 when compared to 2010 and 2011 for the same time period (June 29 to November 7).

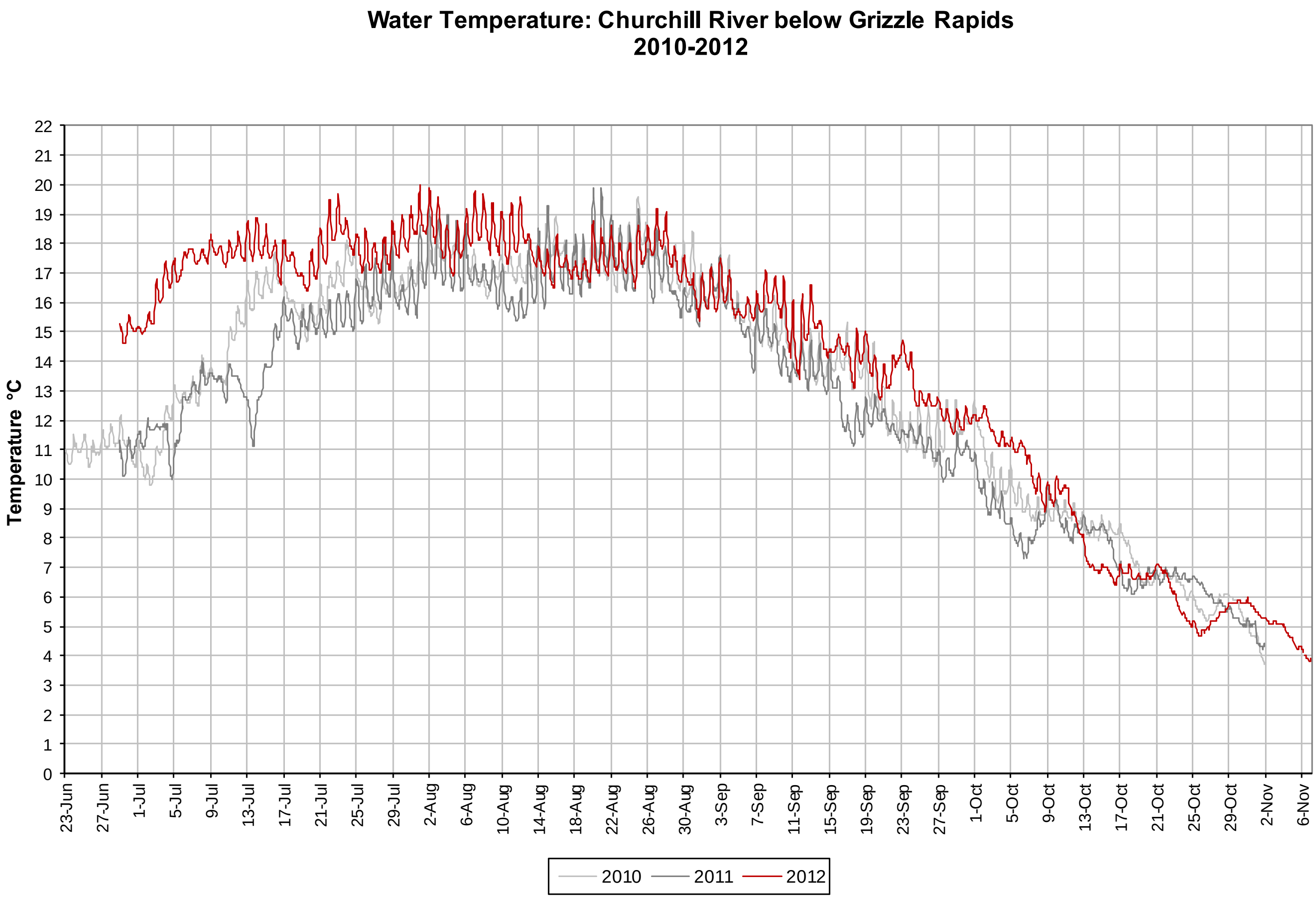


Figure 9: Water temperature at Churchill River below Grizzle Rapids

Temperature	2012	2011	2010
Median	16.2	13.5	14.6
Max	20.0	19.9	19.6
Min	4.7	5.0	4.6

- Water temperature values show a typical seasonal trend (Figure 10). Because of the late deployment start in the end of June, water temperatures are at or near seasonal highs shortly after the first deployment. Water and air temperatures are warm until they begin to decrease in late August. Average air and water temperatures decrease throughout the fall season until the instrument is removed for the winter season on November 7.

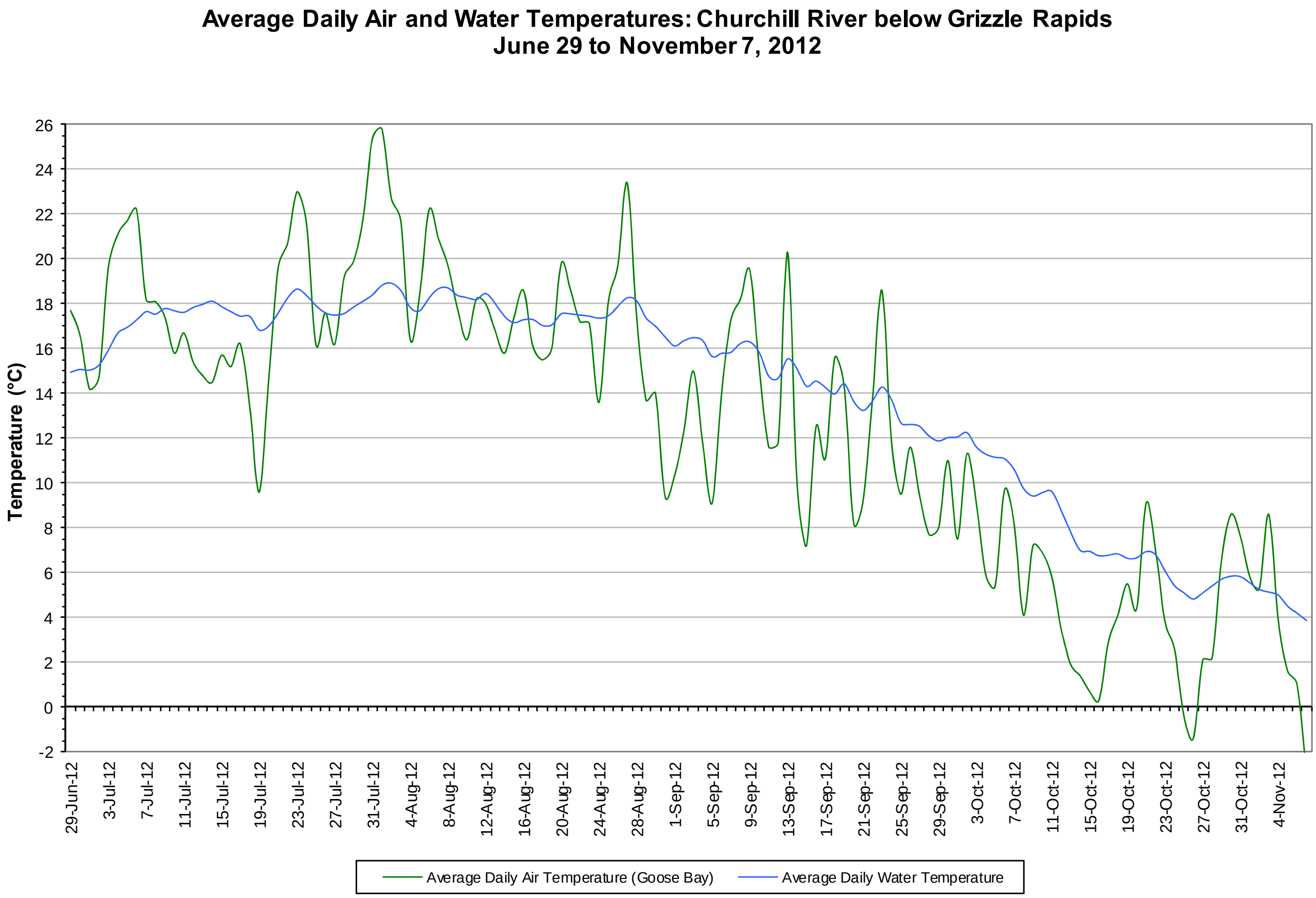


Figure 10: Average daily air and water temperatures at Churchill River below Grizzle Rapids

(weather data recorded at Goose Bay)

- pH ranges between 6.85 and 7.44 pH units during the 2012 deployment season, with a median value of 7.17 pH units (Figure 11).
- pH values are consistent throughout the deployment season with a clear diurnal fluctuation.
- All values during the 2012 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 2012 are slightly higher than in 2011 and 2010 for this station for the same time period.

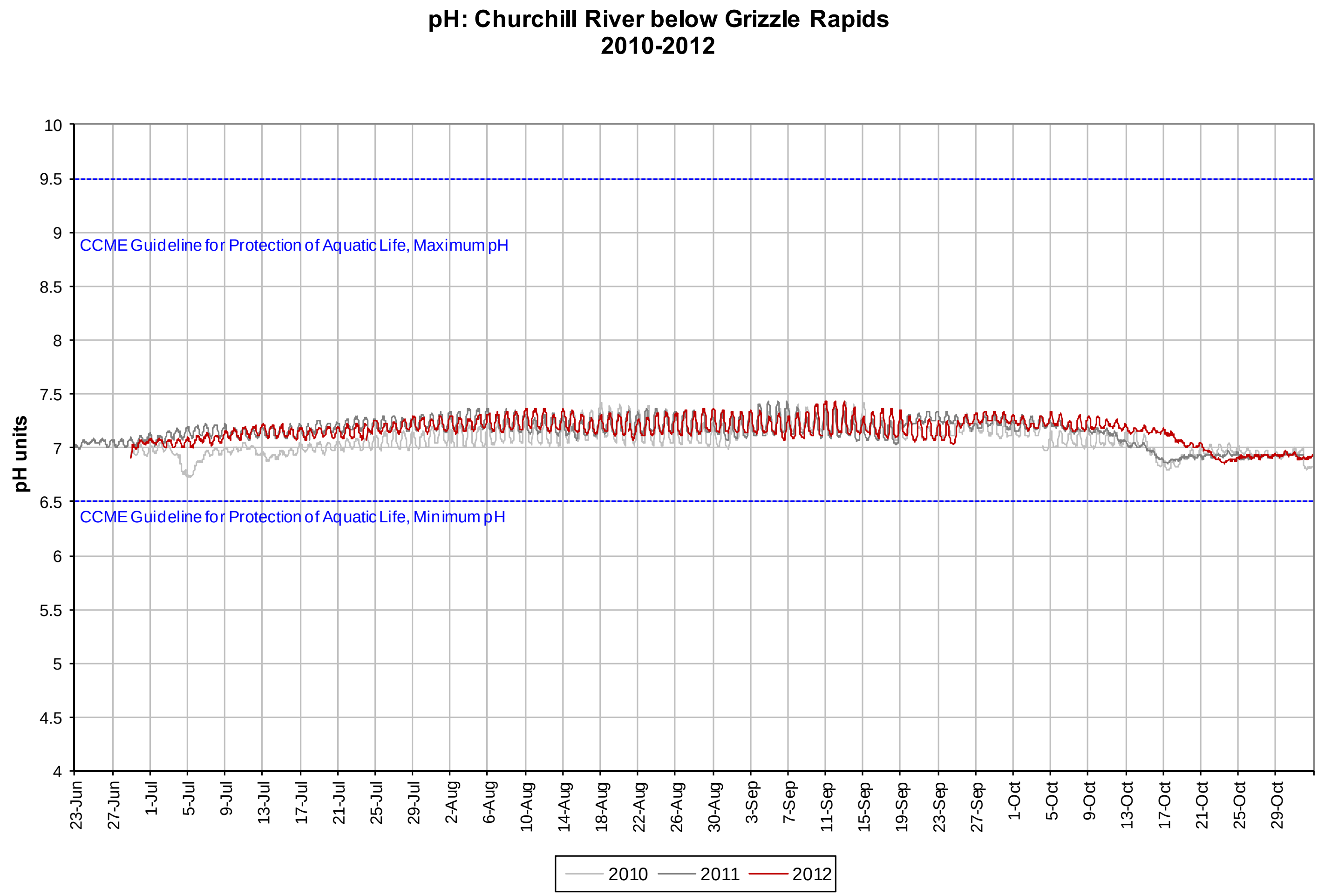


Figure 11: pH at Churchill River below Grizzle Rapids

pH (units)	2012	2011	2010
Median	7.17	7.07	7.08
Max	7.44	7.44	7.50
Min	6.85	6.73	6.68

- Specific conductivity ranges from 16.1µS/cm to 25.9µS/cm during the 2012 deployment season, with a median value of 21.9µS/cm (Figure 12).
- Specific conductance values in the first deployment period in 2012 are higher than expected which is indicated by the difference between the end of deployment period 1 and the start of deployment period 2 (July 24). This trend is also noticeable at other stations in the network indicating that a calibration error likely occurred prior to the first deployment.
- 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 2010 and 2012 are similar for the same time period, increasing throughout the summer when stage is typically decreasing and decreasing again in the fall season when stage is typically increases. In 2011, specific conductivity is unusually low for the deployment period in September.

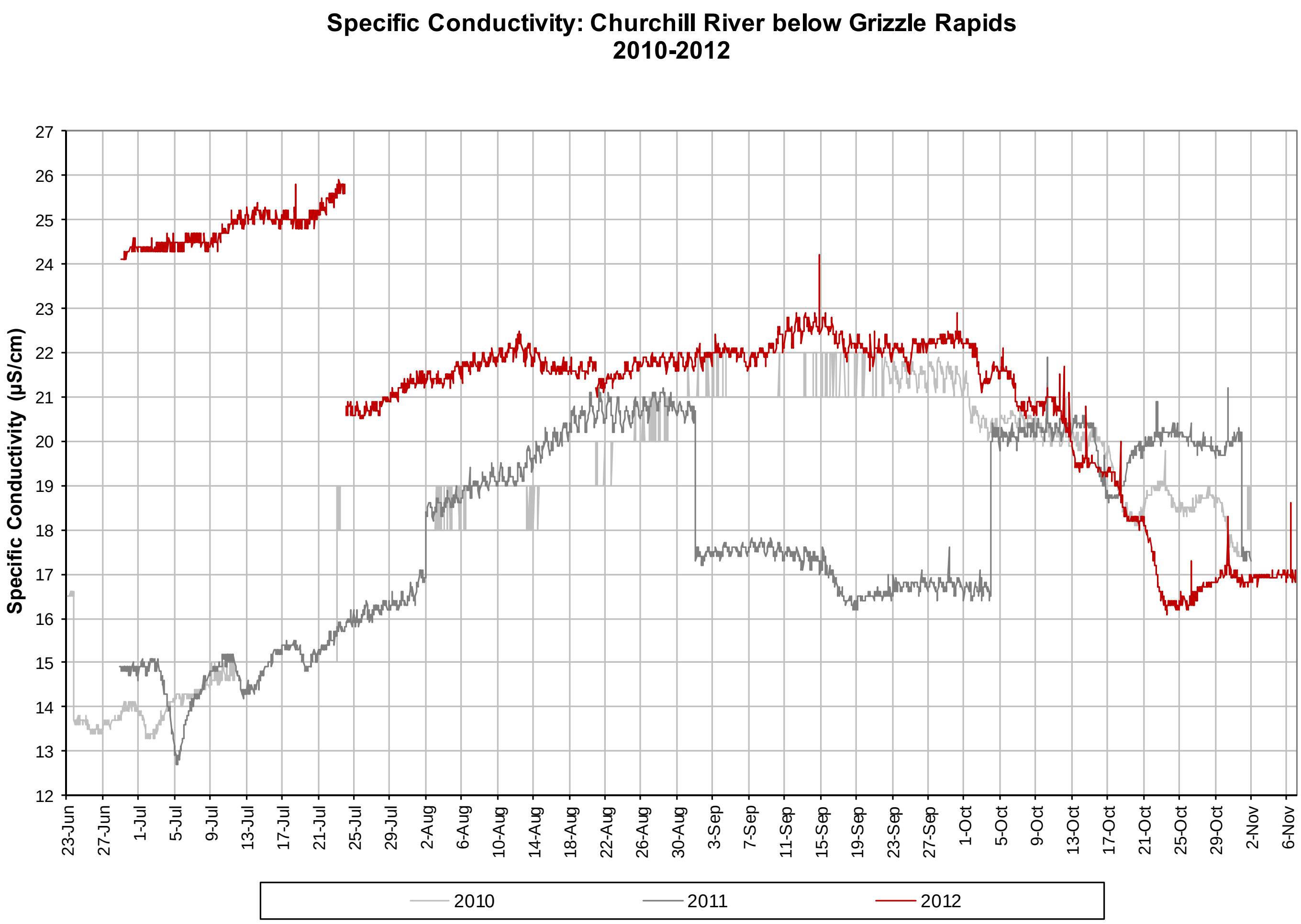


Figure 12: Specific conductivity at Churchill River below Grizzle Rapids

Specific Conductivity (µS/cm)	2012	2011	2010
Median	21.9	17.6	19.0
Max	25.9	21.9	22
Min	16.1	12.7	13.3

- During the 2012 deployment season, dissolved oxygen ranged from 9.06mg/l and 12.24mg/l, with a median value of 9.65mg/l, while percent saturation ranged from 92.6% to 103.9%, with a median value of 97.3% (Figure 13).
- 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 first two deployment periods, most values were 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 13.
- Dissolved oxygen content shows a typical seasonal fluctuation in 2012. Because of the late deployment start in 2012, the decreasing trend normally observed in the spring and early summer season is not captured. Dissolved oxygen values are low and consistent through the warmest part of the season and increase later in the summer and fall season as air and water temperatures cool. Dissolved oxygen content fluctuates regularly on a daily basis.
- For the same time period, dissolved oxygen content are comparable in both 2010 and 2011 with median values of 9.84mg/l and 9.80mg/l respectively.

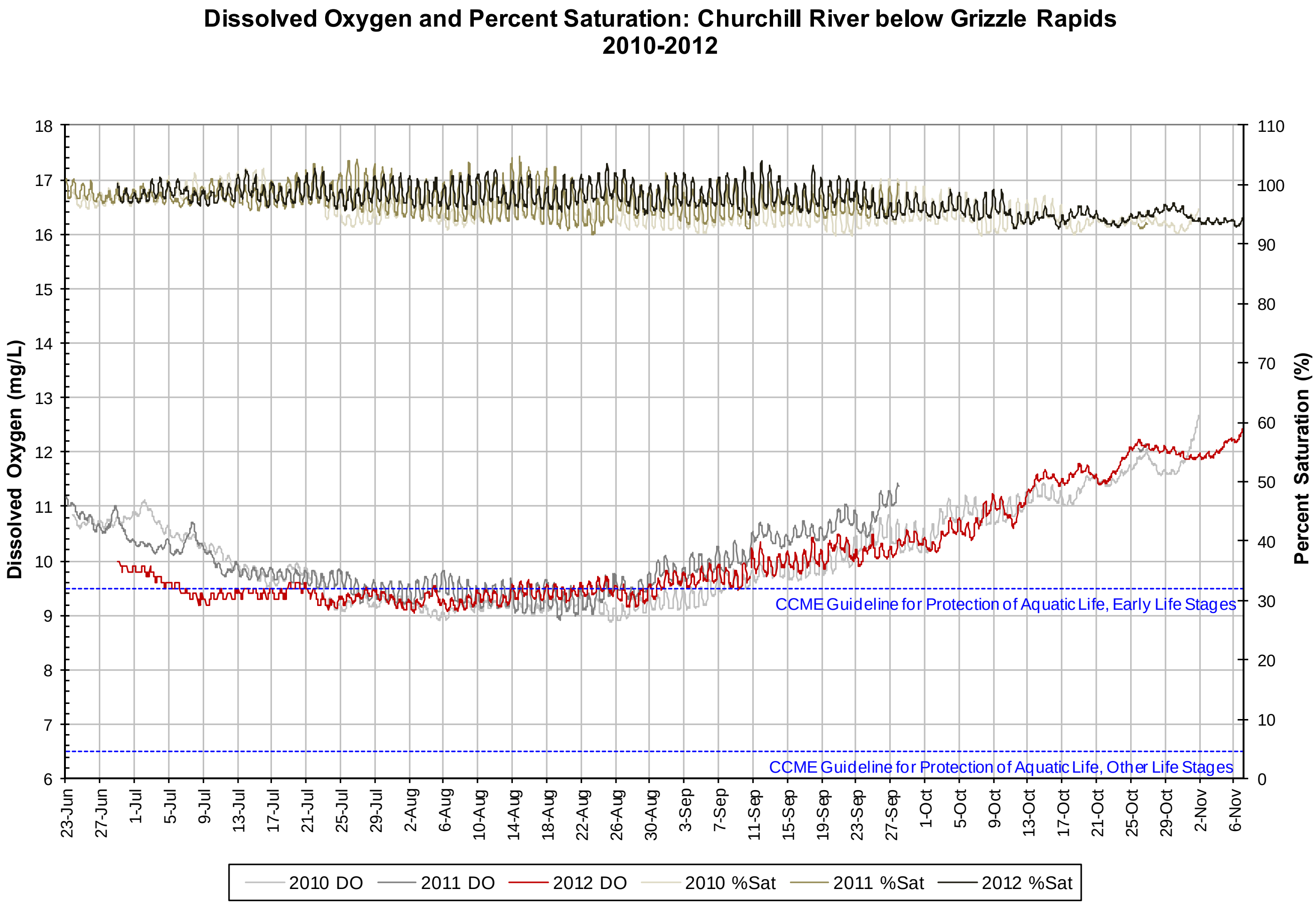


Figure 13: Dissolved oxygen and percent saturation at Churchill River below Grizzle Rapids

Dissolved Oxygen (mg/L)	2012	2011	2010		Percent Saturation	2012	2011	2010
Median	9.65	9.80	9.84		Median	97.3	97.4	95.2
Max	12.24	11.42	12.10		Max	103.9	104.7	102.7
Min	9.06	8.90	8.89		Min	92.6	91.5	91.4

- Turbidity generally remains at 0NTU for the majority of the 2012 deployment season (Figure 14). A median value of 0 NTU from 2010 to 2012 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 3.0NTU for very short periods of time (1-3 hours). These are not considered water quality events as they are isolated and infrequent occurrences.
- Similar trends have been identified in the 2010 and 2011 datasets for this station for the same time period.

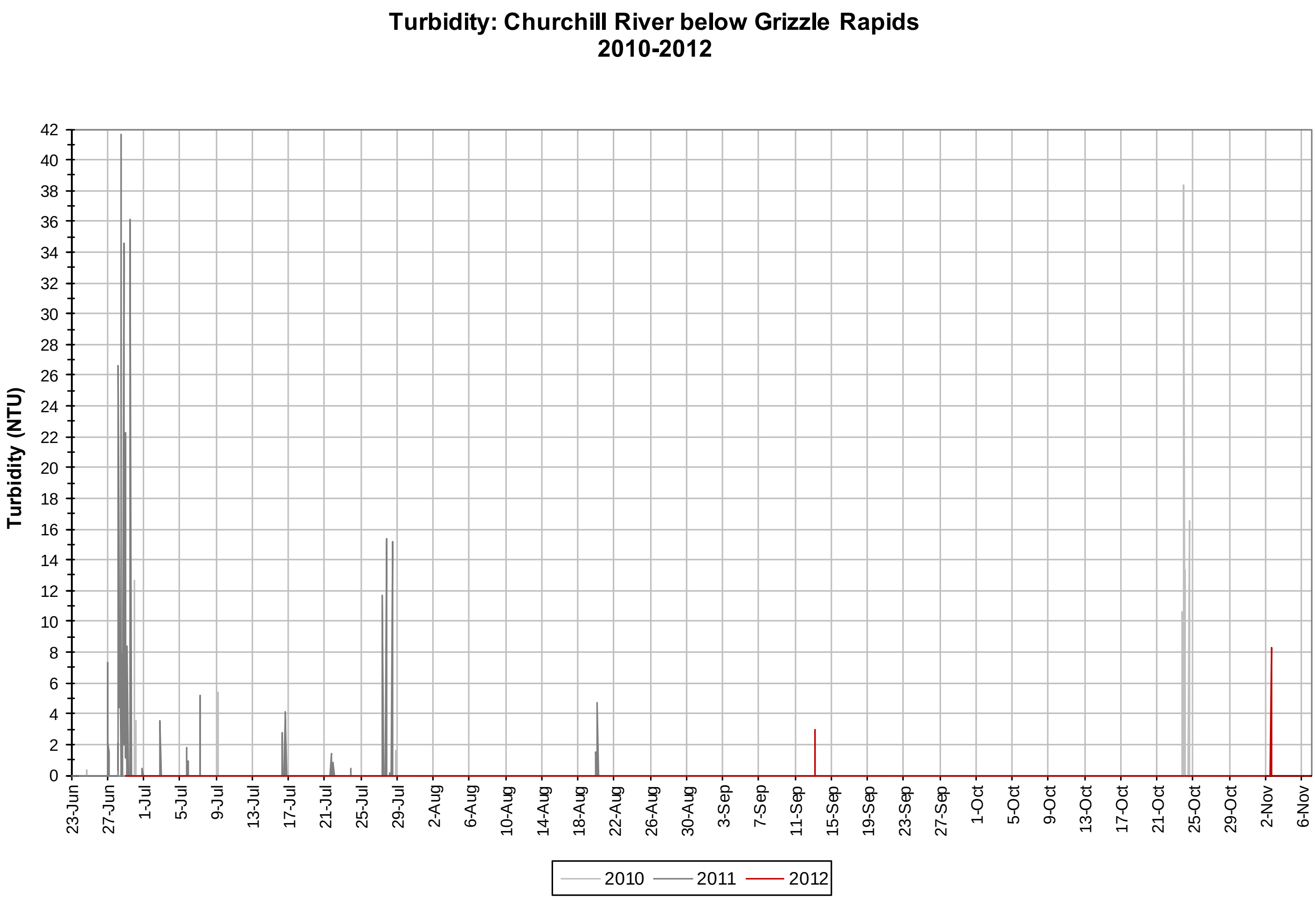


Figure 14: Turbidity at Churchill River below Grizzle Rapids

Turbidity (NTU)	2012	2011	2010
Median	0	0	0
Max	3.0	41.7	38.4
Min	0	0	0

- Stage levels in 2012 tend to decrease in the spring and summer months reaching a seasonal low in early September (Figure 15).
- Stage levels from 2010-2012 are graphed below to show how stage levels vary throughout the season and from year to year. Much of the stage data for the 2010 season is missing however stage levels in 2011 and 2012 are comparable for the same time period. Stage ranges between 0.56m and 0.73m each year.

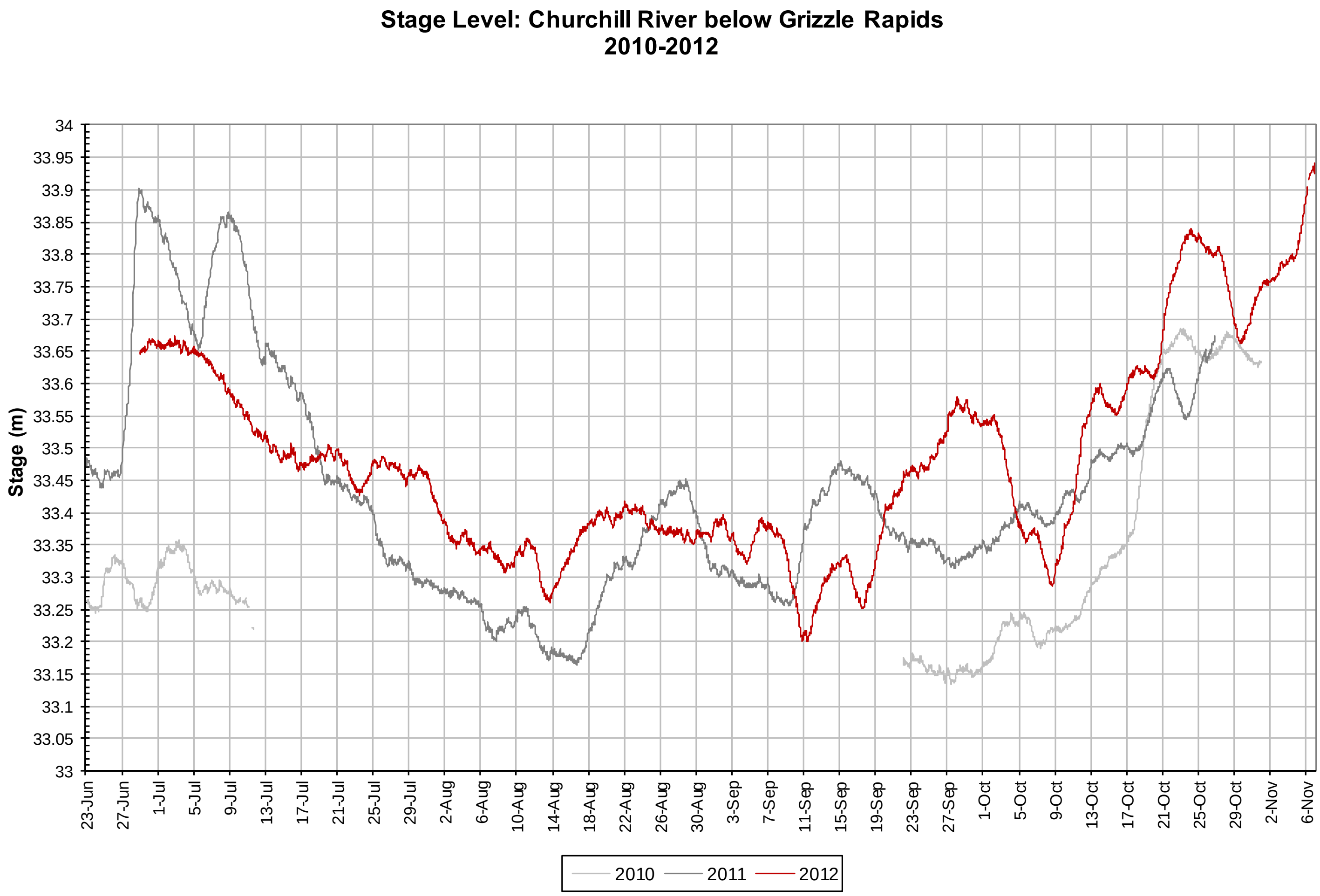


Figure 15: Stage level at Churchill River below Grizzle Rapids

Stage (m)	2012	2011	2010
Median	33.45	33.40	33.28
Max	33.84	33.90	33.69
Min	33.20	33.17	33.13
Range	0.64	0.73	0.56

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 16).
- Stage is decreasing for much of the first half of the deployment season. Stage begins to increase again in early to mid-September. A significant decrease occurs in early October but this trend is quickly reversed and water levels increase rapidly for the remainder of the deployment season.

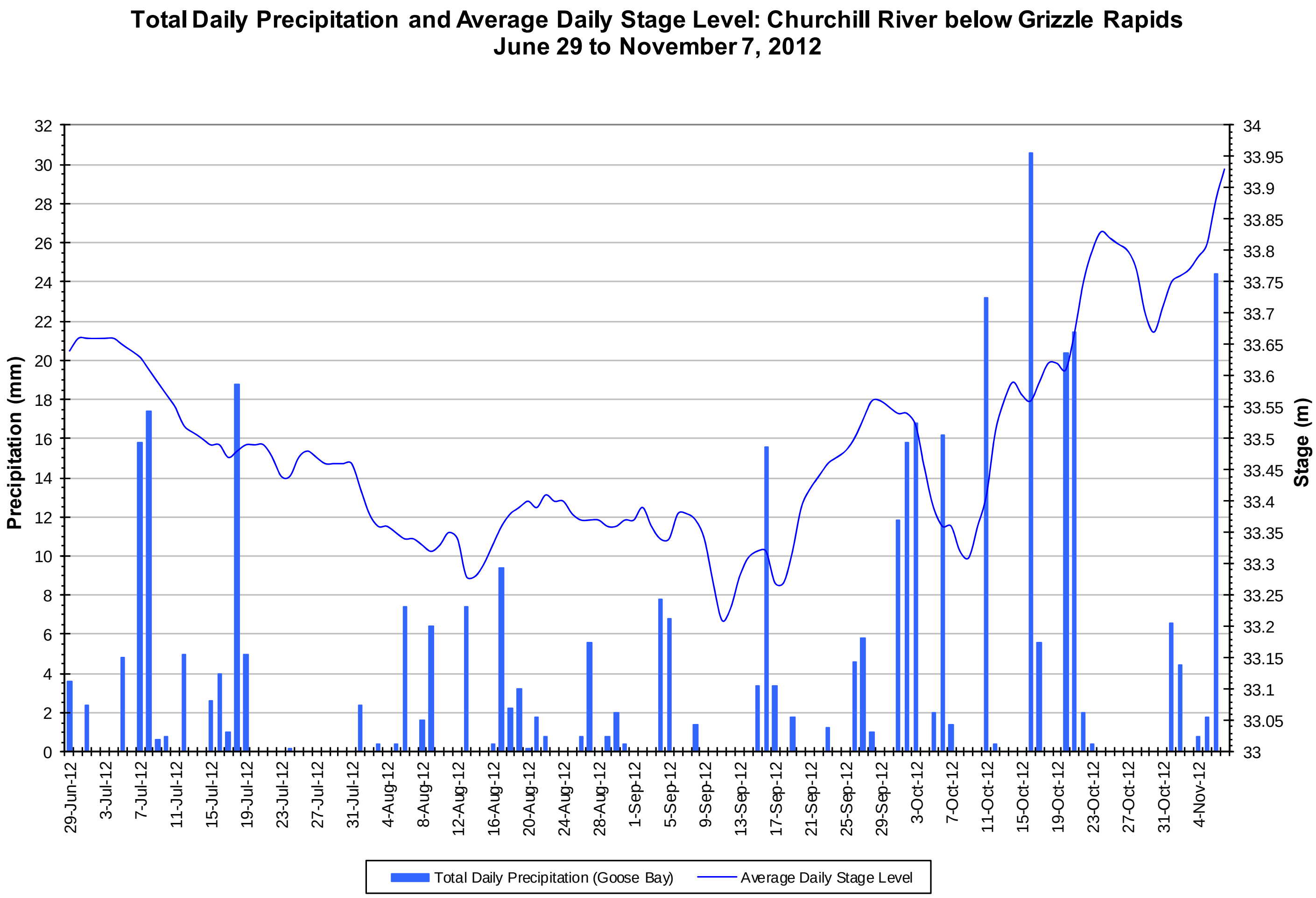


Figure 16: Daily precipitation and average daily stage level at Churchill River below Grizzle Rapids (weather data recorded at Goose Bay)

Churchill River above Muskrat Falls

- Water temperature ranged from 4.1°C to 20.6°C during the 2012 deployment season, with a median value of 16.2°C (Figure 17).
- Water temperatures are warmer in 2012 when compared to 2010 and 2011 for the same time period (June 29 to November 1).

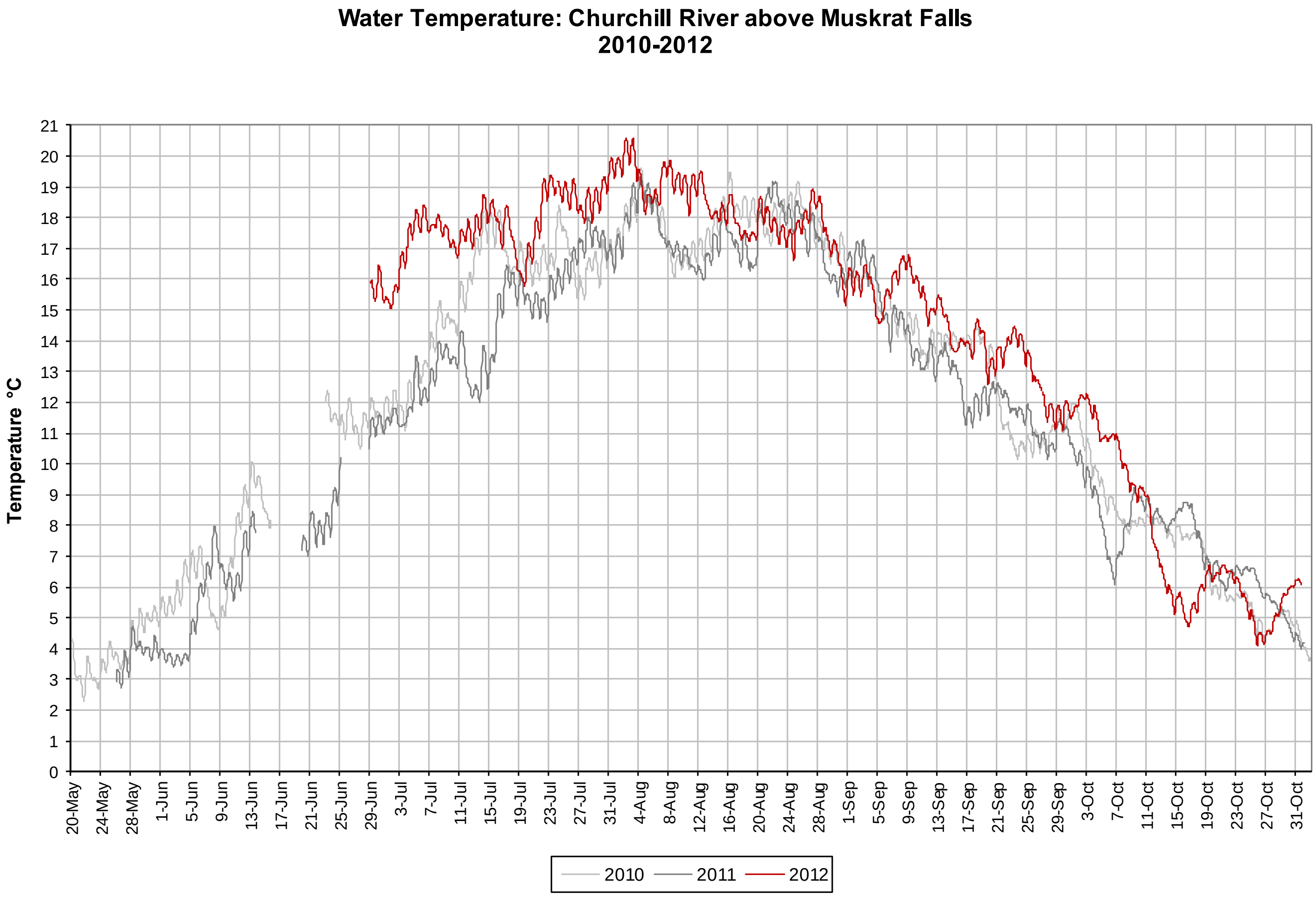


Figure 17: Water temperature at Churchill River above Muskrat Falls

Temperature	2012	2011	2010
Median	16.2	13.4	14.6
Max	20.6	19.3	19.6
Min	4.1	4.0	4.1

- Water temperature values show a typical seasonal trend (Figure 18). Because of the late deployment start in the end of June, water temperatures are at or near seasonal highs shortly after the first deployment. Water and air temperatures are warm until they begin to decrease in late August. Average air and water temperatures decrease throughout the fall season until the instrument is removed for the winter season on November 1.

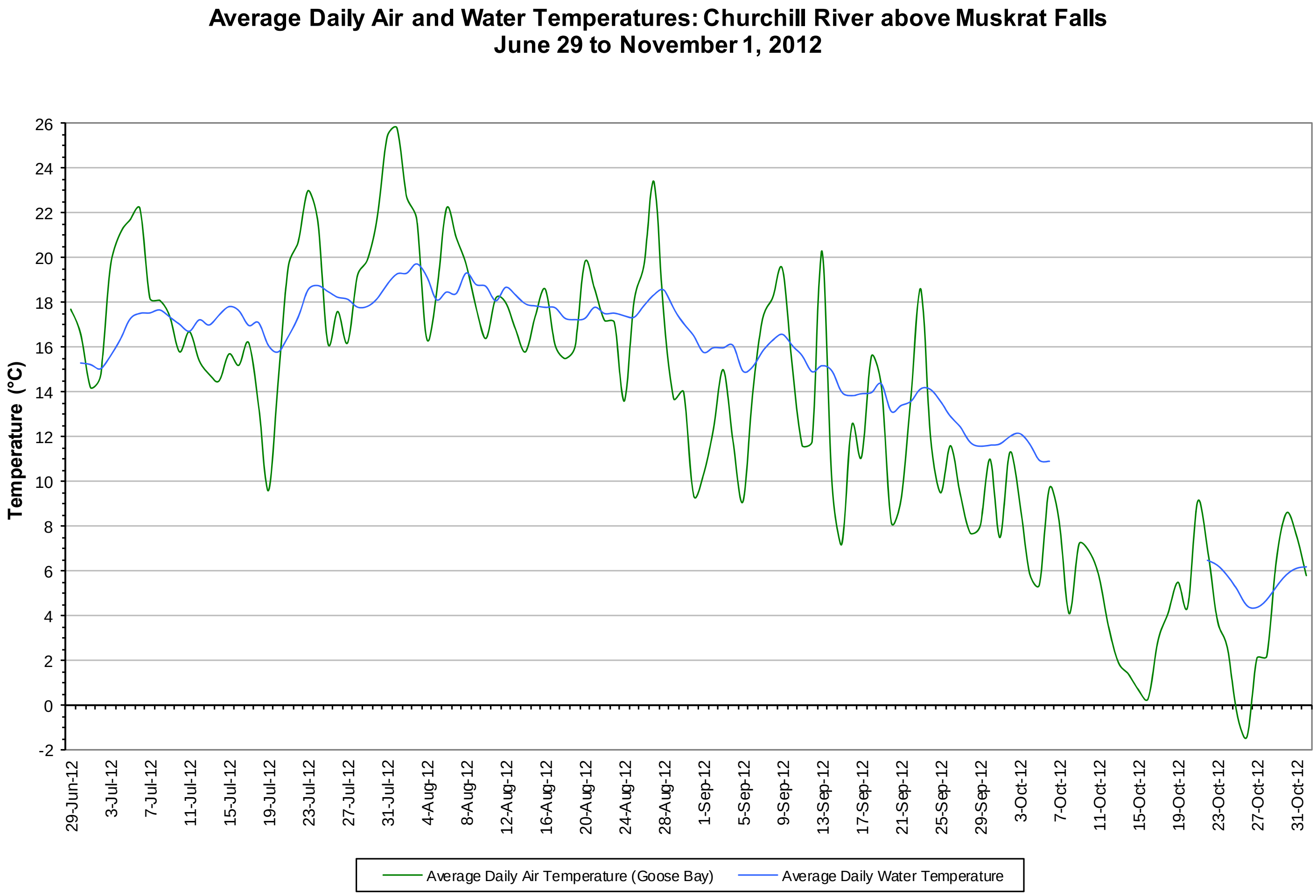


Figure 18: Average daily air and water temperatures at Churchill River above Muskrat Falls (weather data recorded at Goose Bay)

- pH ranged between 6.78 and 7.33 pH units during the 2012 deployment season, with a median value of 7.16 pH units (Figure 19).
- pH values are relatively stable during the deployment season except for at the very end of the last deployment period when pH values drop slightly. This trend is noticed in previous years as well around the same time of year.
- All values during the 2012 deployment season are within the CCME Guidelines for the Protection of Aquatic Life (>6.5 and <9.0 pH units).Guidelines are indicated in blue on Figure 11.
- pH values are slightly higher than in previous years when compared for the same time period (June 29 to November 1).

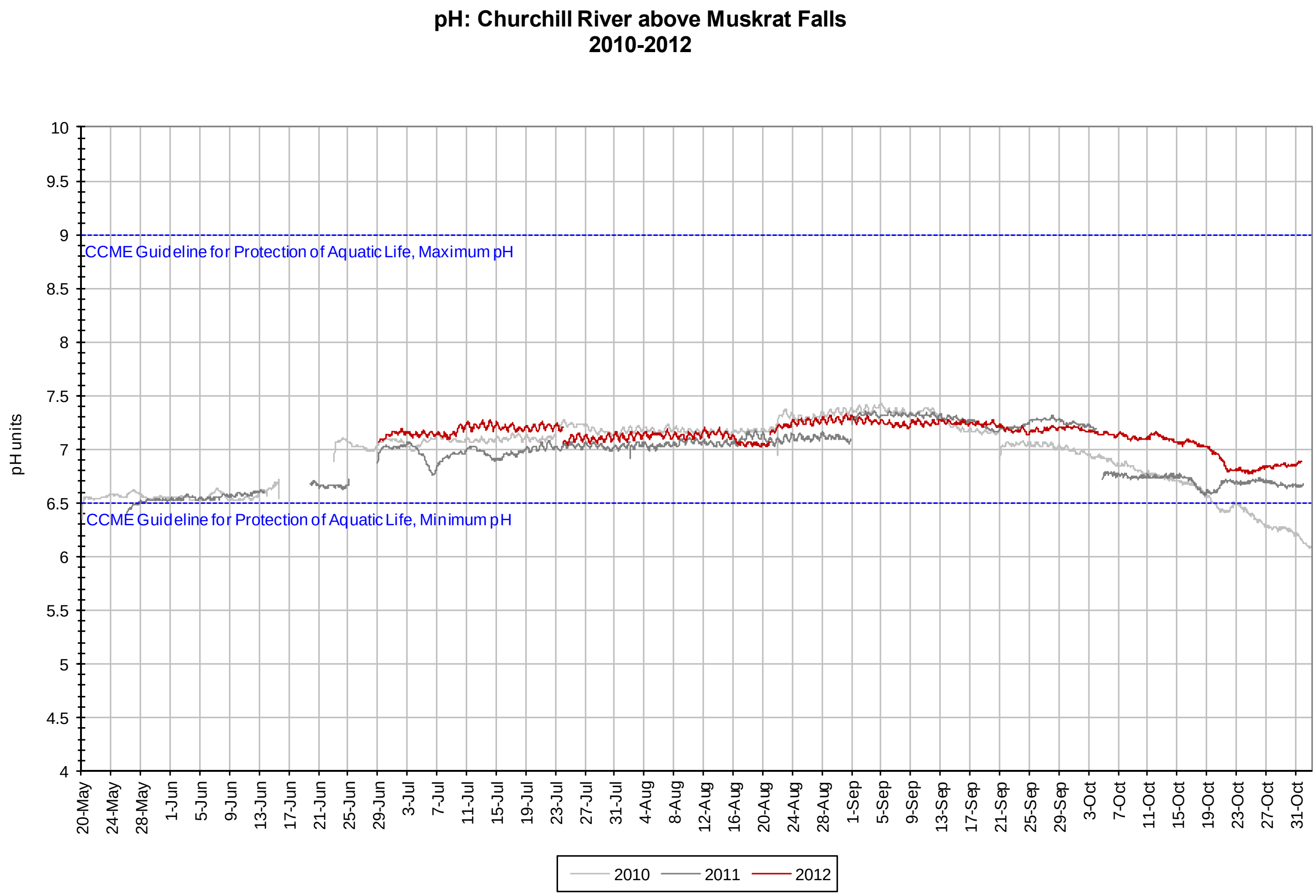


Figure 19: pH at Churchill River above Muskrat Falls

pH (units)	2012	2011	2010
Median	7.16	7.04	7.12
Max	7.33	7.36	7.43
Min	6.78	6.57	6.15

- Specific conductivity ranged from 14.7 µS/cm to 25.6µS/cm during the 2012 deployment season, with a median value of 20.9µS/cm (Figure 20).
- Specific conductance values in the first deployment period in 2012 are higher than expected which is indicated by the difference between the end of deployment period 1 and the start of deployment period 2 (July 24). This trend is also noticeable at other stations in the network indicating that a calibration error likely occurred prior to the first deployment. In the second deployment period, specific conductivity is slightly lower but there is still a significant difference between deployment period 2 and deployment period 3 (August 21). The last two deployment periods probably best represent the specific conductivity values at this station as the transition between deployment periods is relatively seamless on September 25. Variability between deployment periods is not unusual for this station as this trend is seen in previous years as well. Data collected in 2010-2011 is similar in trend but slightly lower when compared for the same time period.
- 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.

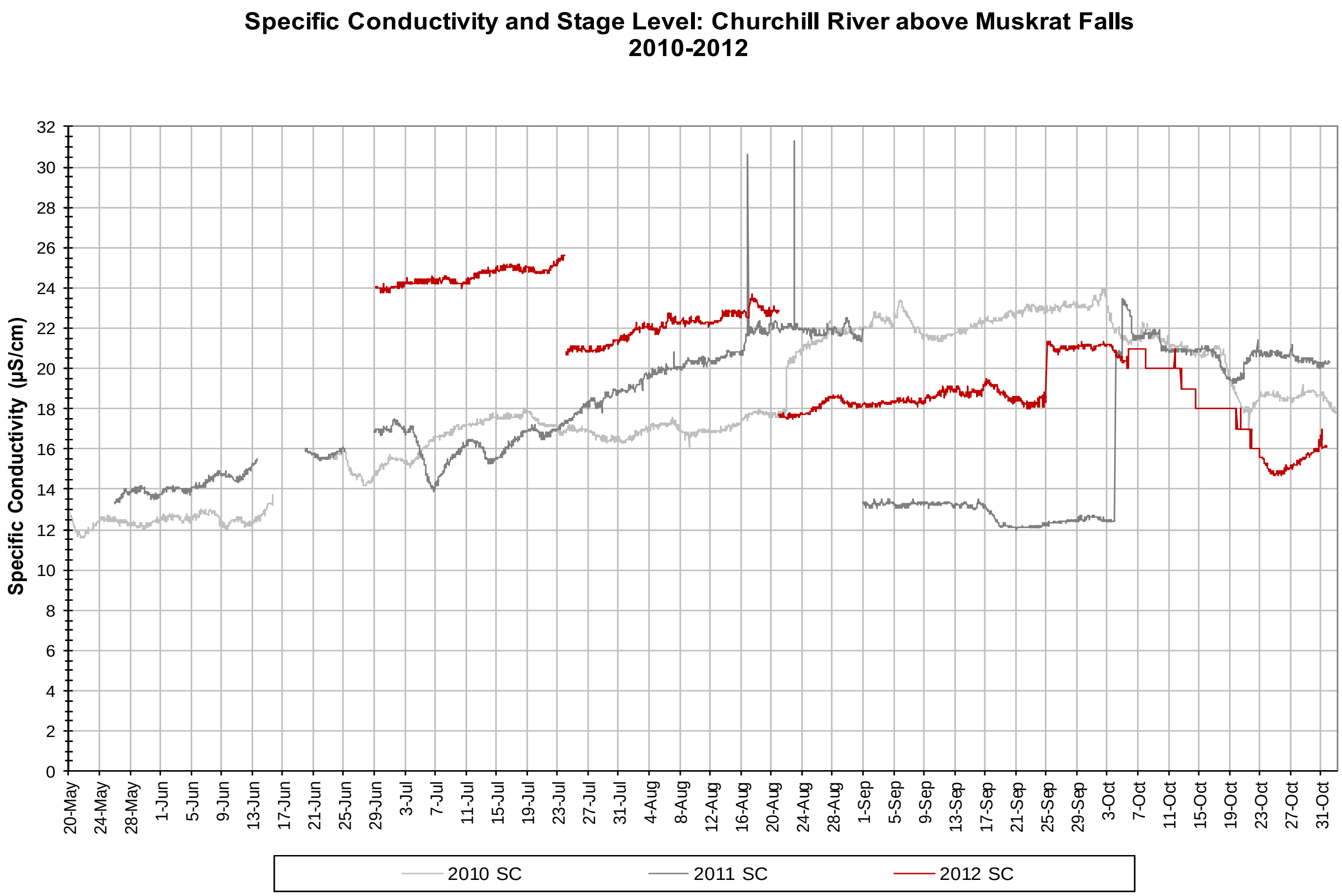


Figure 20: Specific conductivity at Churchill River above Muskrat Falls

Specific Conductivity (µS/cm)	2012	2011	2010
Median	20.9	18.5	18.7
Max	25.6	31.3	24.0
Min	14.7	12.0	14.7

- Throughout the 2012 deployment season, dissolved oxygen ranged from 8.87mg/l and 12.38mg/l, with a median value of 9.47mg/L, while percent saturation ranged from 92.4% to 101.8%, with a median value of 96.5% (Figure 21).
- 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 first two deployment periods, most values were 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 content shows a typical seasonal fluctuation in 2012. Because of the late deployment start in 2012, the decreasing trend normally observed in the spring and early summer season is not captured. Dissolved oxygen values are low and consistent through the warmest part of the season and increase later in the summer and fall season as air and water temperatures cool. Dissolved oxygen content fluctuates regularly on a daily basis.
- Dissolved oxygen content is slightly higher in previous years for the same time period however this would be expected given the slight increase in water temperature in 2012 (Figure 17).

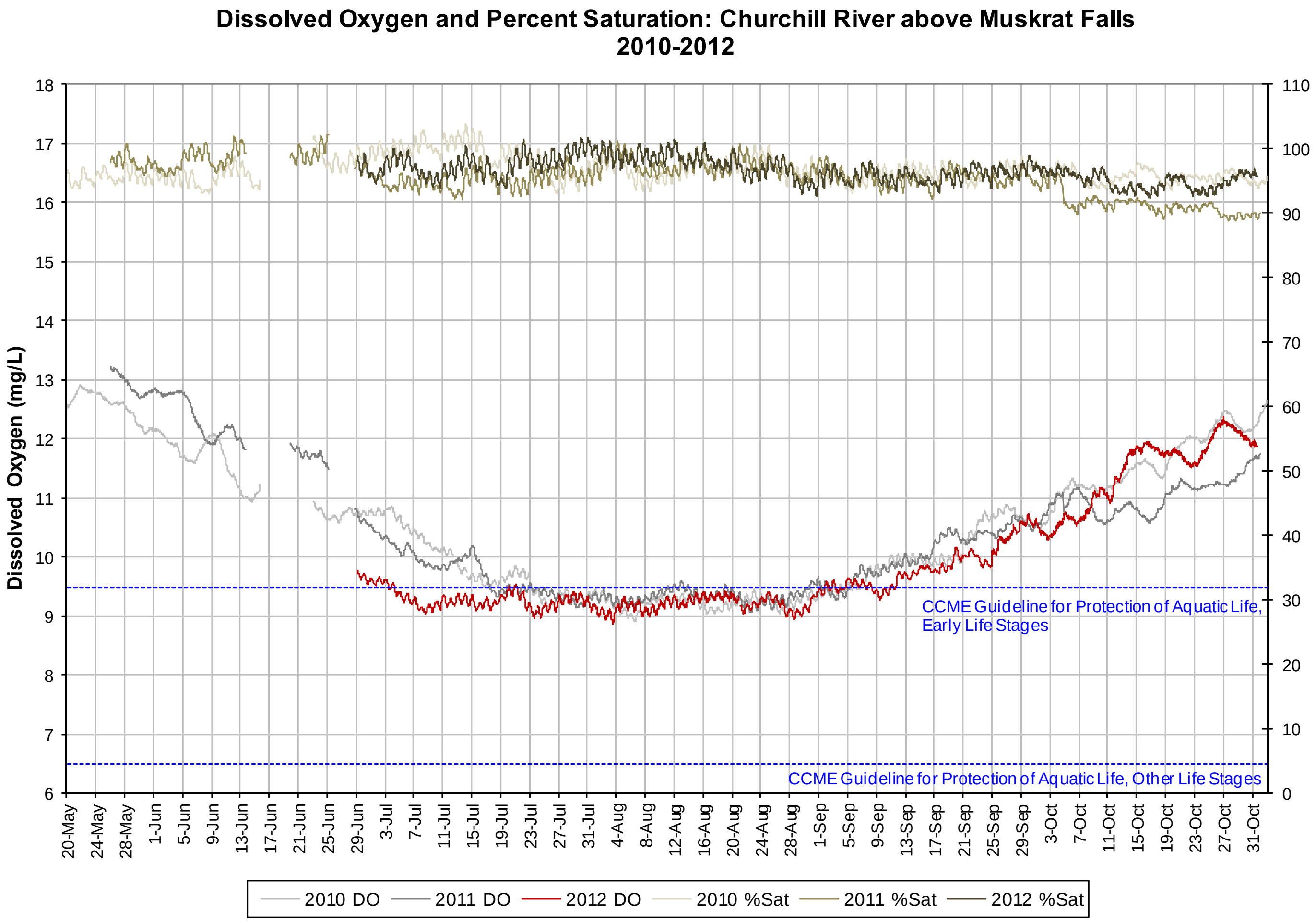
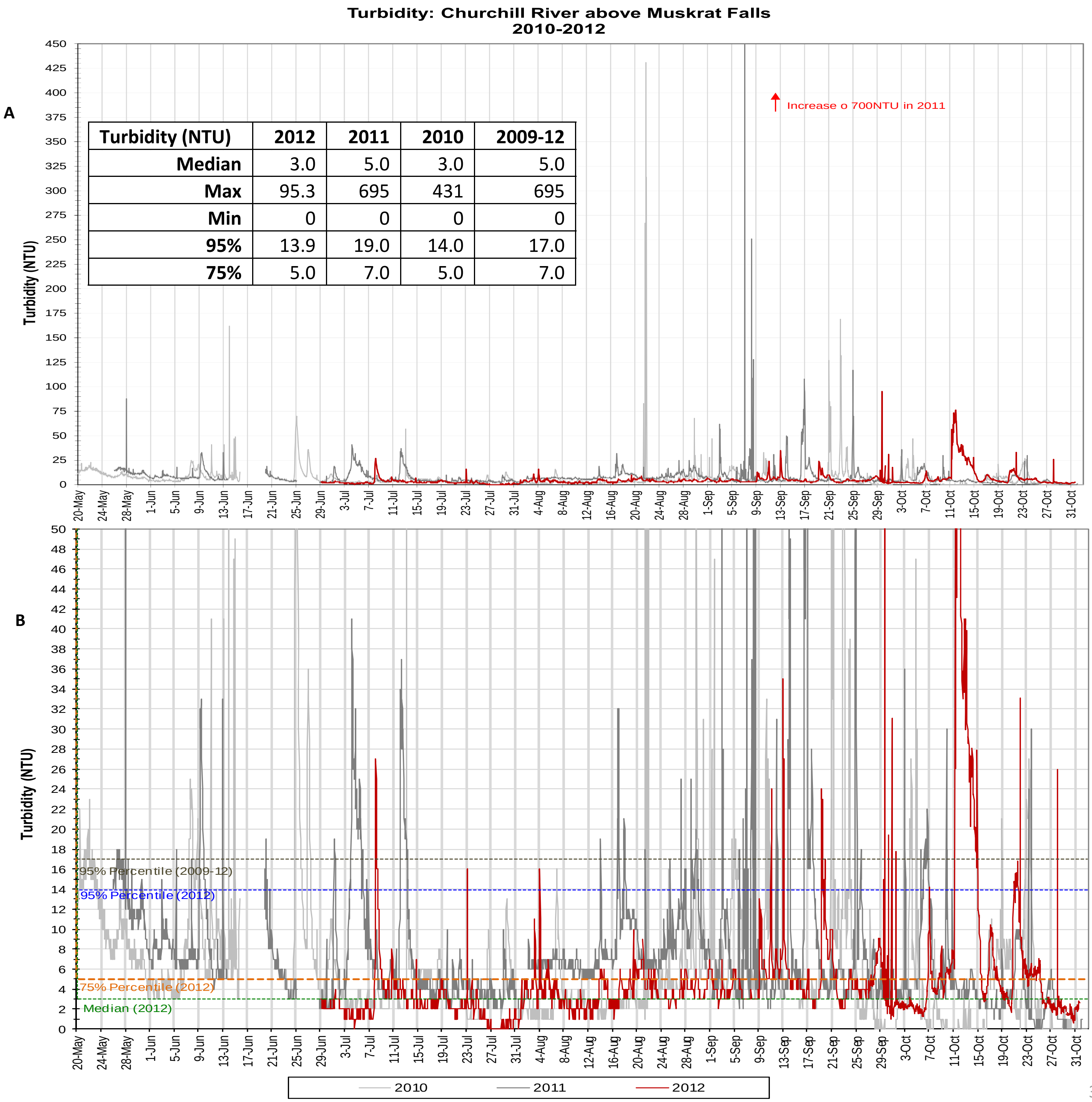


Figure 21: Dissolved oxygen and percent saturation at Churchill River above Muskrat Falls

Dissolved Oxygen (mg/L)	2012	2011	2010		Percent Saturation	2012	2011	2010
Median	9.47	9.90	9.91		Median	96.5	95.5	96.6
Max	12.38	11.71	12.48		Max	101.8	101.2	103.8
Min	8.87	9.06	8.92		Min	92.4	88.9	93.2

- The majority of turbidity values (95%) were <13.9NTU during the 2012 deployment season (Figure 22 a & b). A median value of 3.0NTU indicates there is a consistent natural background turbidity value at this station. Turbidity values from 2010 to 2012 are depicted in Figures 22 a & b.
- Figure 22a shows data up to 450NTU. On a number of occasions in 2012, turbidity increased above median background levels for short periods of time throughout the deployment season, to as high as 95.3NTU.
- Figure 22b shows data at a smaller scale, focusing on the regular consistent background levels, below 50NTU. In the 2012 season, median value was calculated to be 3.0NTU and the 95th percentile value was 13.9NTU. When data from all years is combined (2009 to 2012), the median value increases slightly to 5.0NTU and the 95th percentile is 17.0. Data from all years is similar in trend and comparable for the same time period.



Turbidity (NTU)	2012	2011	2010	2009-12
Median	3.0	5.0	3.0	5.0
Max	95.3	695	431	695
Min	0	0	0	0
95%	13.9	19.0	14.0	17.0
75%	5.0	7.0	5.0	7.0

Figure 22a (top): Turbidity to 450NTU at Churchill River above Muskrat Falls

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

- Stage levels in 2012 tend to decrease in the spring and summer months reaching a seasonal low in early September (Figure 23).
- Stage levels from 2010-2012 are graphed below to show how stage levels vary throughout the season and from year to year. Stage levels were very similar when compared to throughout the three years for the same time period (June 29 to November 1). Stage ranged between 1.51m and 2.13m

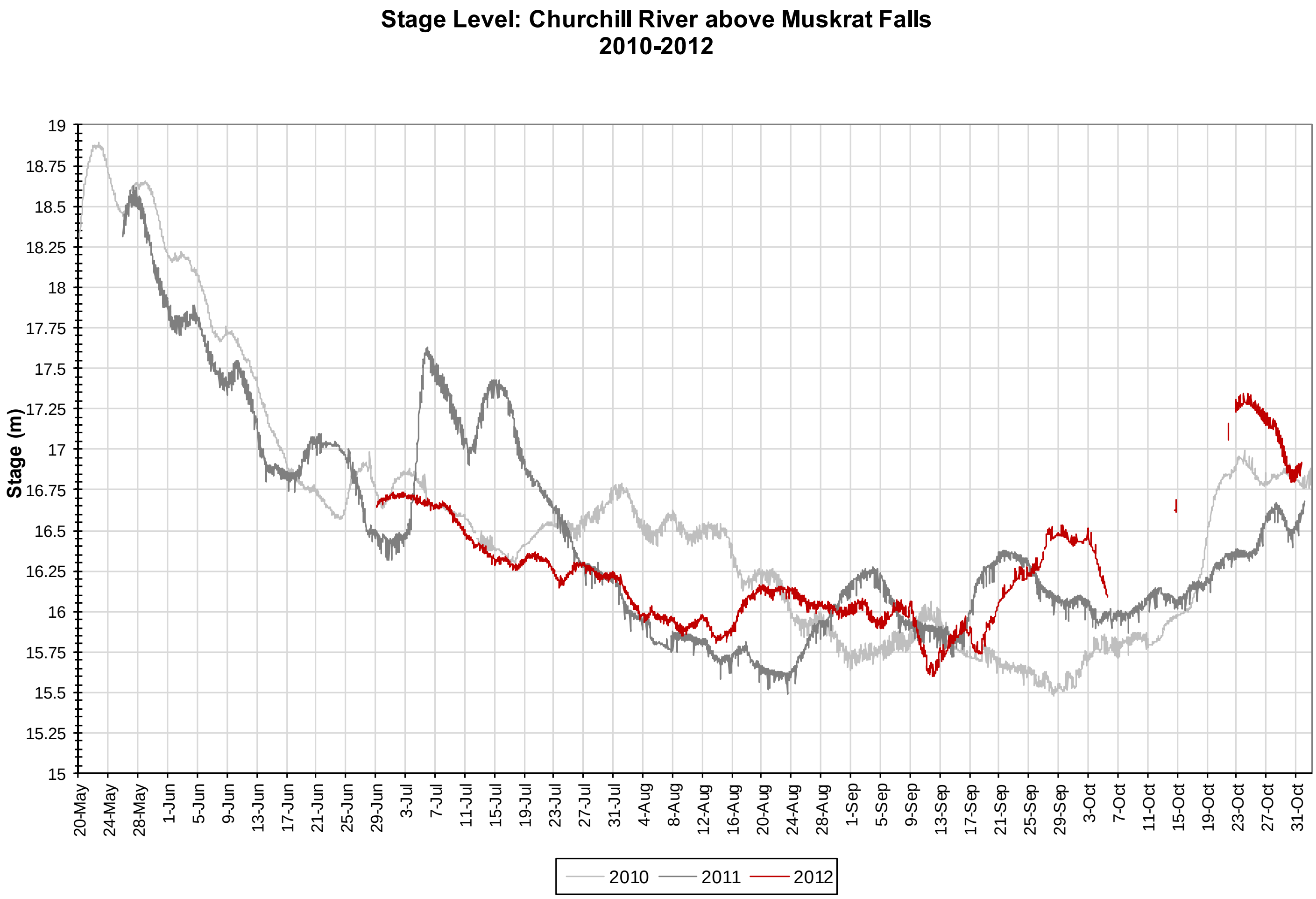


Figure 23: Daily stage level at Churchill River above Muskrat Falls

Stage (m)	2012	2011	2010
Median	16.18	16.14	16.25
Max	17.35	17.63	16.99
Min	15.60	15.50	15.48
Range	2.05	2.13	1.51

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 24).
- Stage is decreasing for much of the first half of the deployment season. Stage begins to increase again in early to mid-September. A significant decrease occurs in early October but this trend is quickly reversed and water levels increase rapidly for the remainder of the deployment season. This trend is inferred as average daily stage values are missing during a transmission error from mid to late October.

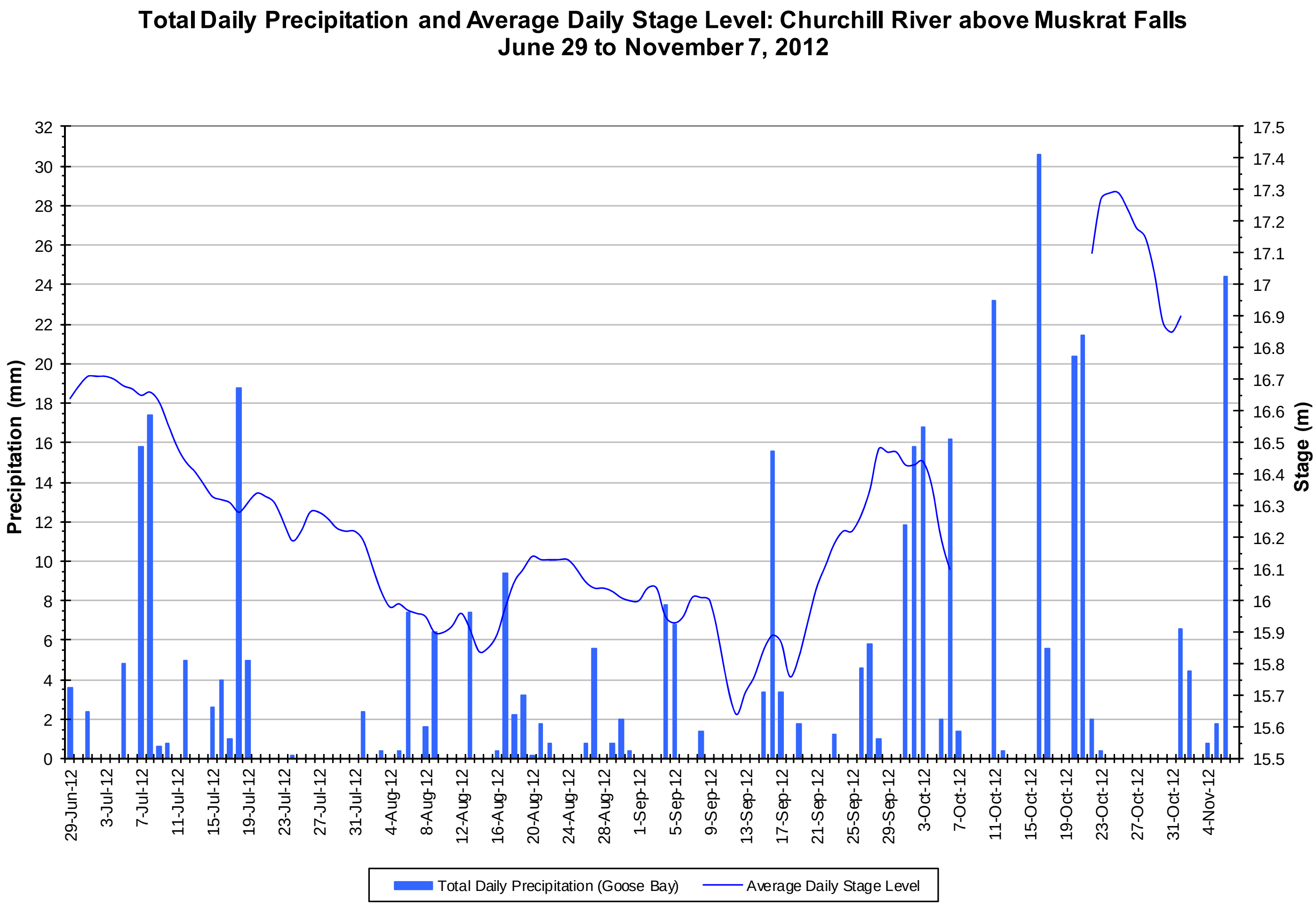


Figure 24: Daily precipitation and average daily stage level at Churchill River above Muskrat Falls

(weather data recorded at Goose Bay)

Churchill River below Muskrat Falls

- Water temperature ranged from 4.5°C to 20.6°C during the 2012 deployment season, with a median value of 16.2°C (Figure 25).
- Water temperatures are warmer in 2012 when compared to 2010 and 2011 for the same time period (June 29 to November 1).

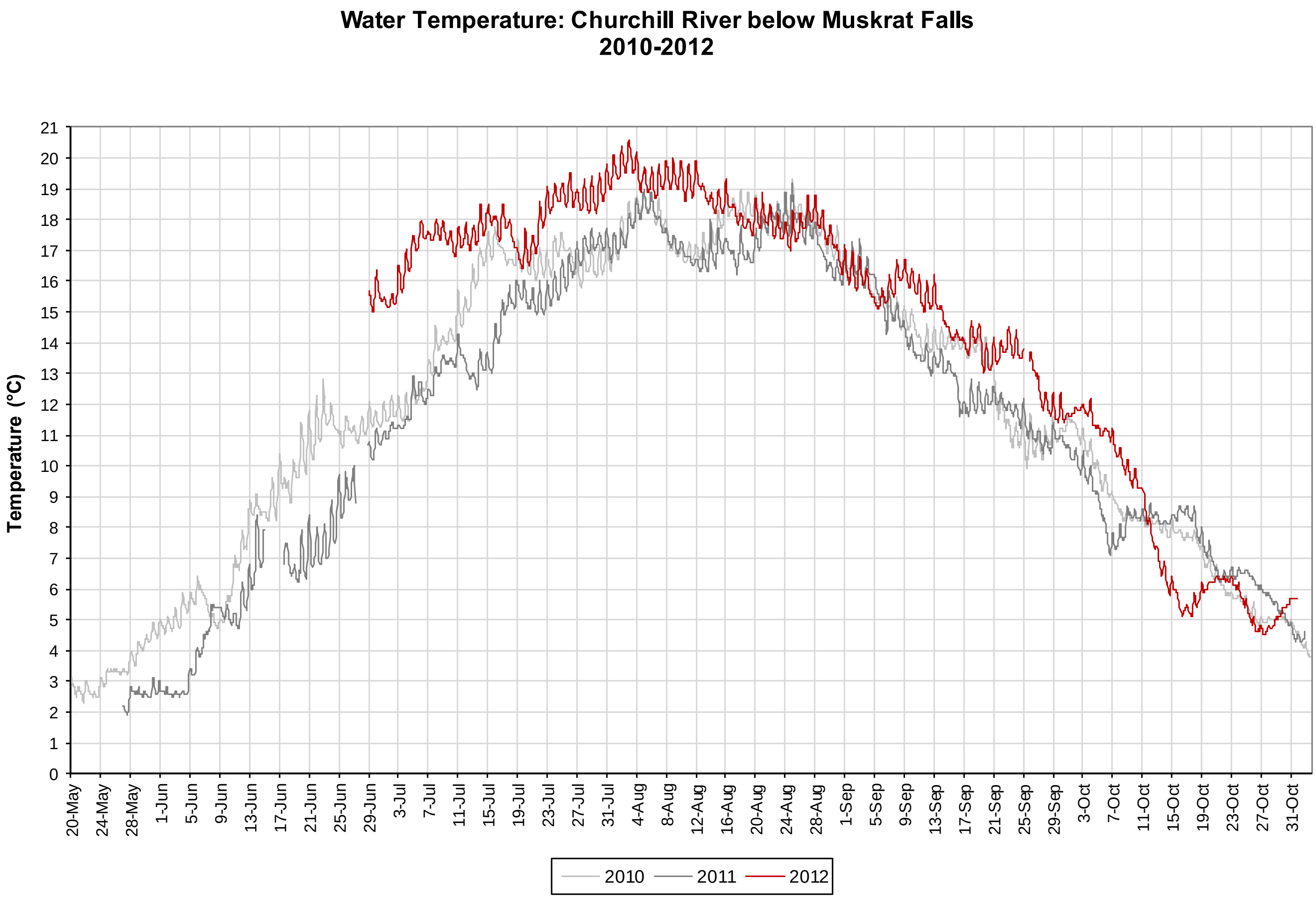


Figure 25: Water temperature at Churchill River below Muskrat Falls

Temperature	2012	2011	2010
Median	16.2	13.4	14.4
Max	20.6	19.2	19.3
Min	4.5	4.3	4.5

- Water temperature values show a typical seasonal trend (Figure 26). Because of the late deployment start in the end of June, water temperatures are at or near seasonal highs shortly after the first deployment. Water and air temperatures are warm until they begin to decrease in late August. Average air and water temperatures decrease throughout the fall season until the instrument is removed for the winter season on November 1.

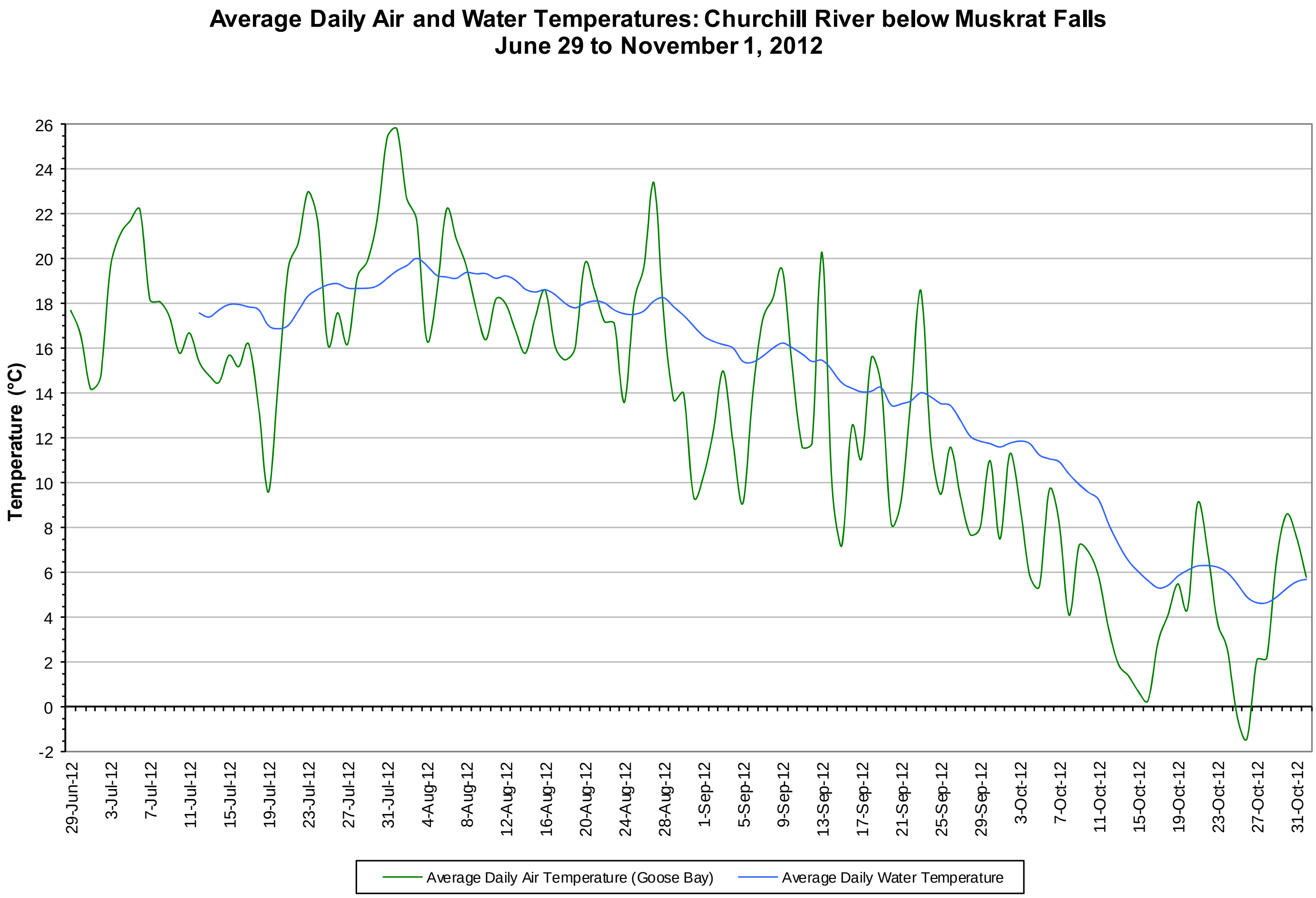


Figure 26: Average daily air and water temperatures at Churchill River below Muskrat Falls

(weather data recorded at Goose Bay)

- pH ranges between 6.63 and 7.29 pH units during the 2012 deployment season, with a median value of 7.10 pH units (Figure 27).
- pH values are increasing throughout most of the deployment season. pH values begin to decrease in mid September.
- All values during the 2012 deployment season are within the CCME Guidelines for the Protection of Aquatic Life (>6.5 and <9.0 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.

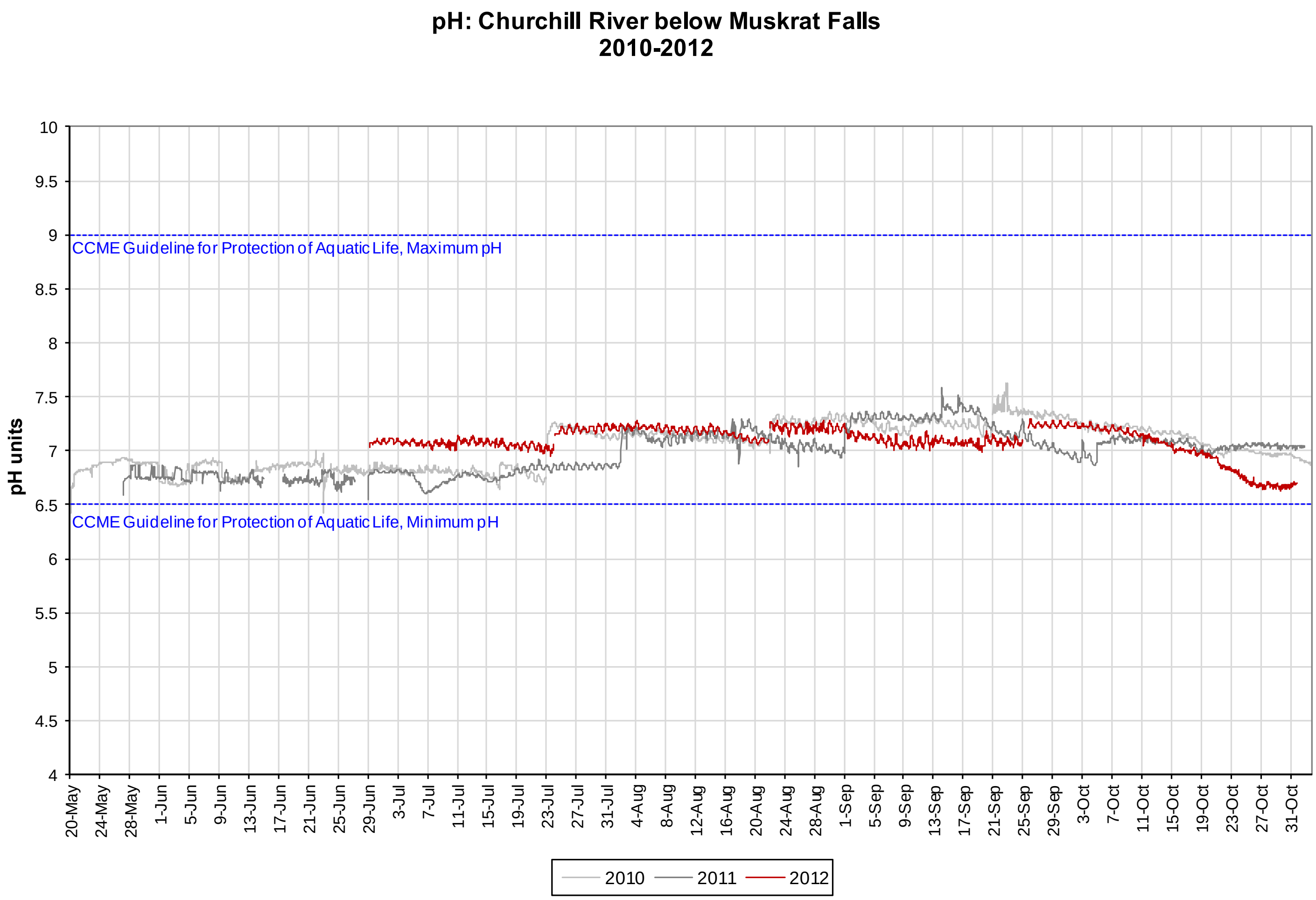


Figure 27: pH at Churchill River below Muskrat Falls

pH (units)	2012	2011	2010
Median	7.10	7.10	7.20
Max	7.29	7.58	7.63
Min	6.63	6.61	6.65

- Specific conductance ranged between 15.8µS/cm and 25.7µS/cm, with a median value of 21.1µS/cm during the 2012 deployment season (Figure 28).
- Specific conductance values in the first deployment period in 2012 are higher than expected which is indicated by the difference between the end of deployment period 1 and the start of deployment period 2 (July 24). This trend is also noticeable at other stations in the network indicating that a calibration error likely occurred prior to the first deployment. In the second deployment period, specific conductivity is slightly lower but there is still a significant difference between deployment period 2 and deployment period 3 (August 22). This trend was also noticed at the station above Muskrat Falls. If deployment periods are examined individually, during the first three deployment periods, specific conductivity appears to be increasing which is expected given that the stage level is decreasing during this time. During the last deployment period, specific conductivity is decreasing as stage levels are increasing.
- Variability between deployment periods is not unusual for this station as this trend is seen in previous years as well. Data collected from 2010-2011 is similar and comparable with slightly lower median values for the same time period.
- 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.

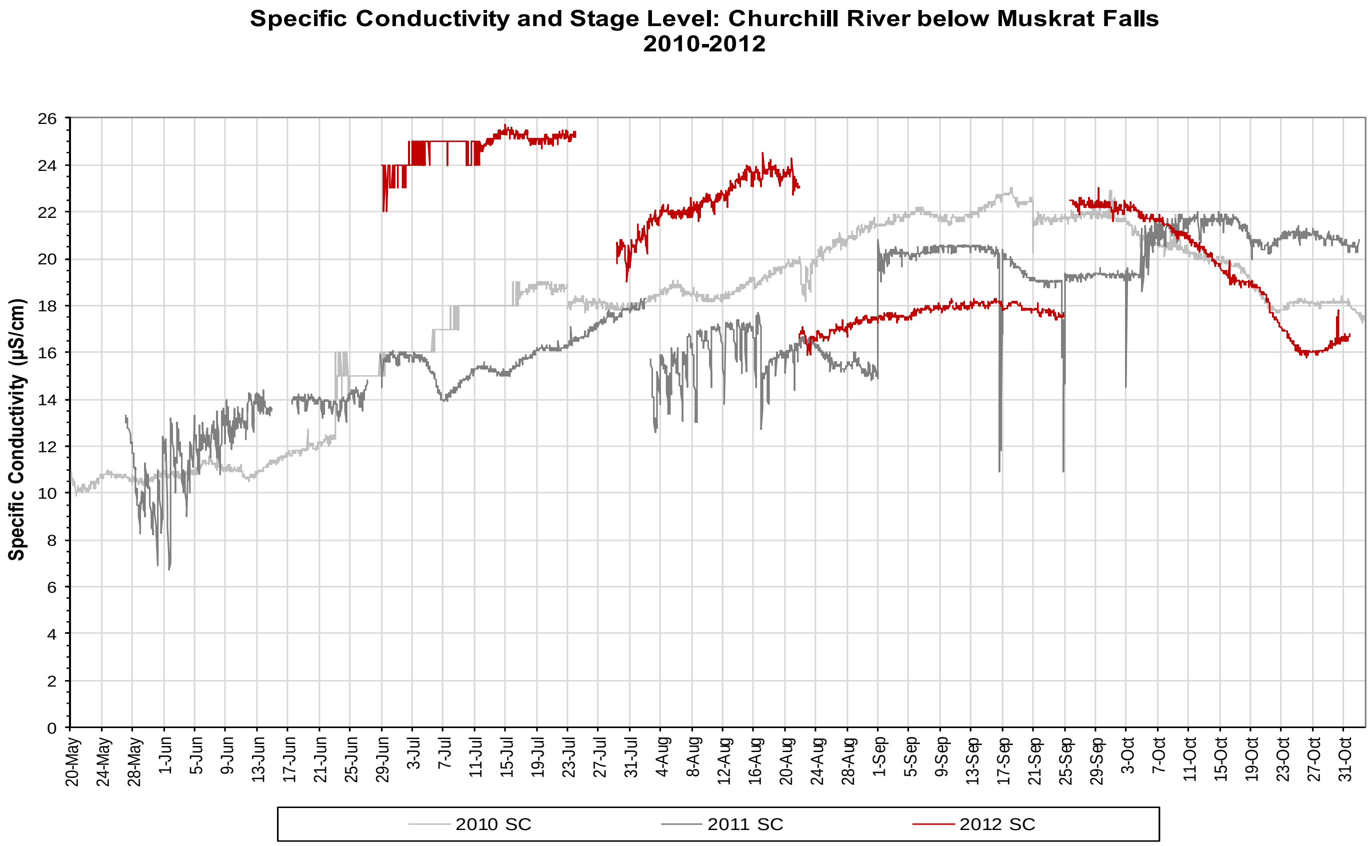


Figure 28: Specific conductivity at Churchill River below Muskrat Falls

Specific Conductivity (µS/cm)	2012	2011	2010
Median	21.1	17.8	19.1
Max	25.7	22.0	23.0
Min	15.8	10.9	15.0

- Throughout the 2012 deployment season, dissolved oxygen ranged from 9.76mg/l and 14.26mg/l, with a median value of 10.70mg/l, while percent saturation ranged from 97.7% to 115.5%, with a median value of 109.4% (Figure 29).
- 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 shows a typical seasonal fluctuation in 2012. Because of the late deployment start in 2012, the decreasing trend normally observed in the spring and early summer season is not captured. Dissolved oxygen values are low and consistent through the warmest part of the season and increase later in the summer and fall season as air and water temperatures cool. Dissolved oxygen content fluctuates regularly on a daily basis. 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.
- Dissolved oxygen content is slightly higher in previous years for the same time period however this would be expected given the slight increase in water temperature in 2012 (Figure 25).

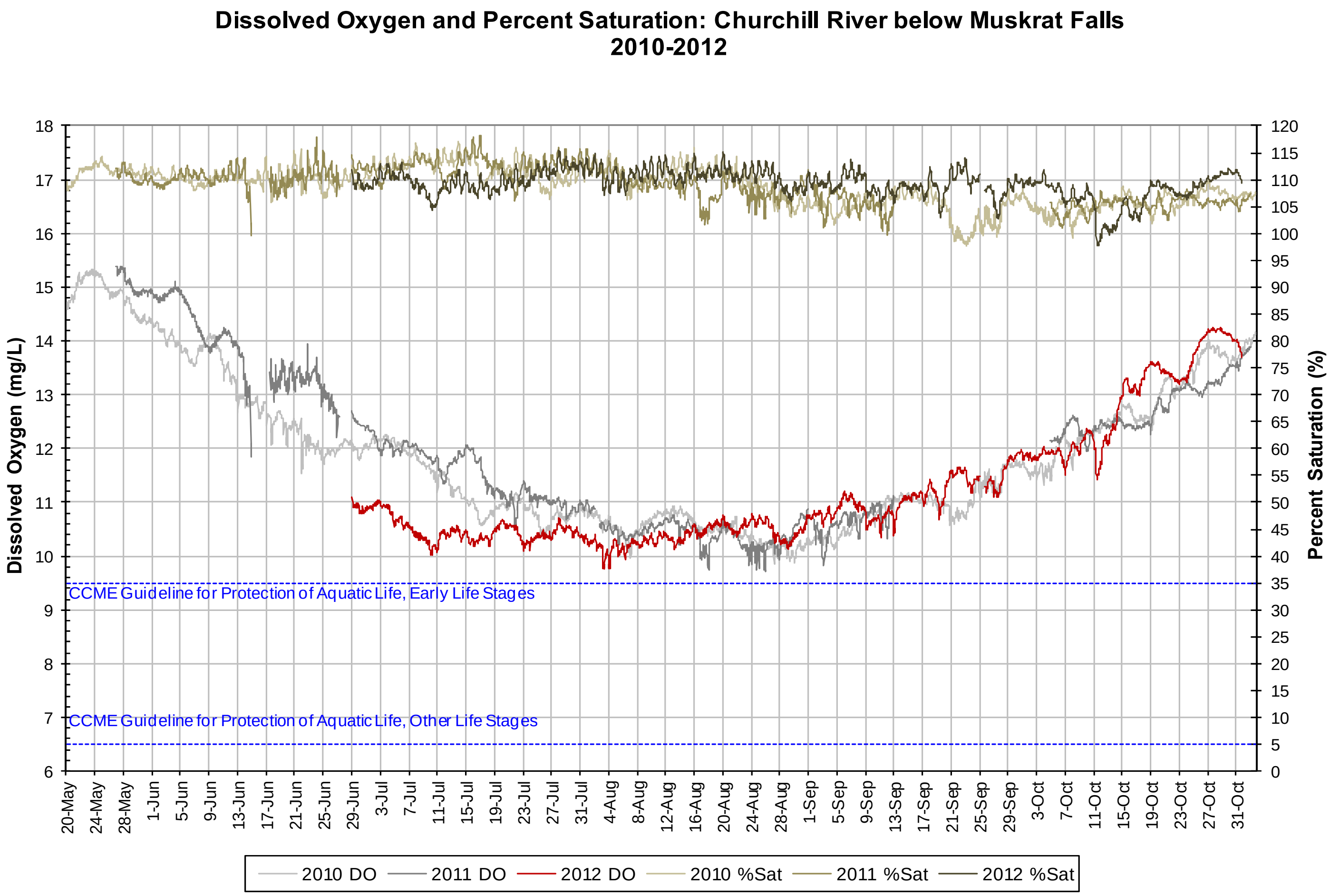
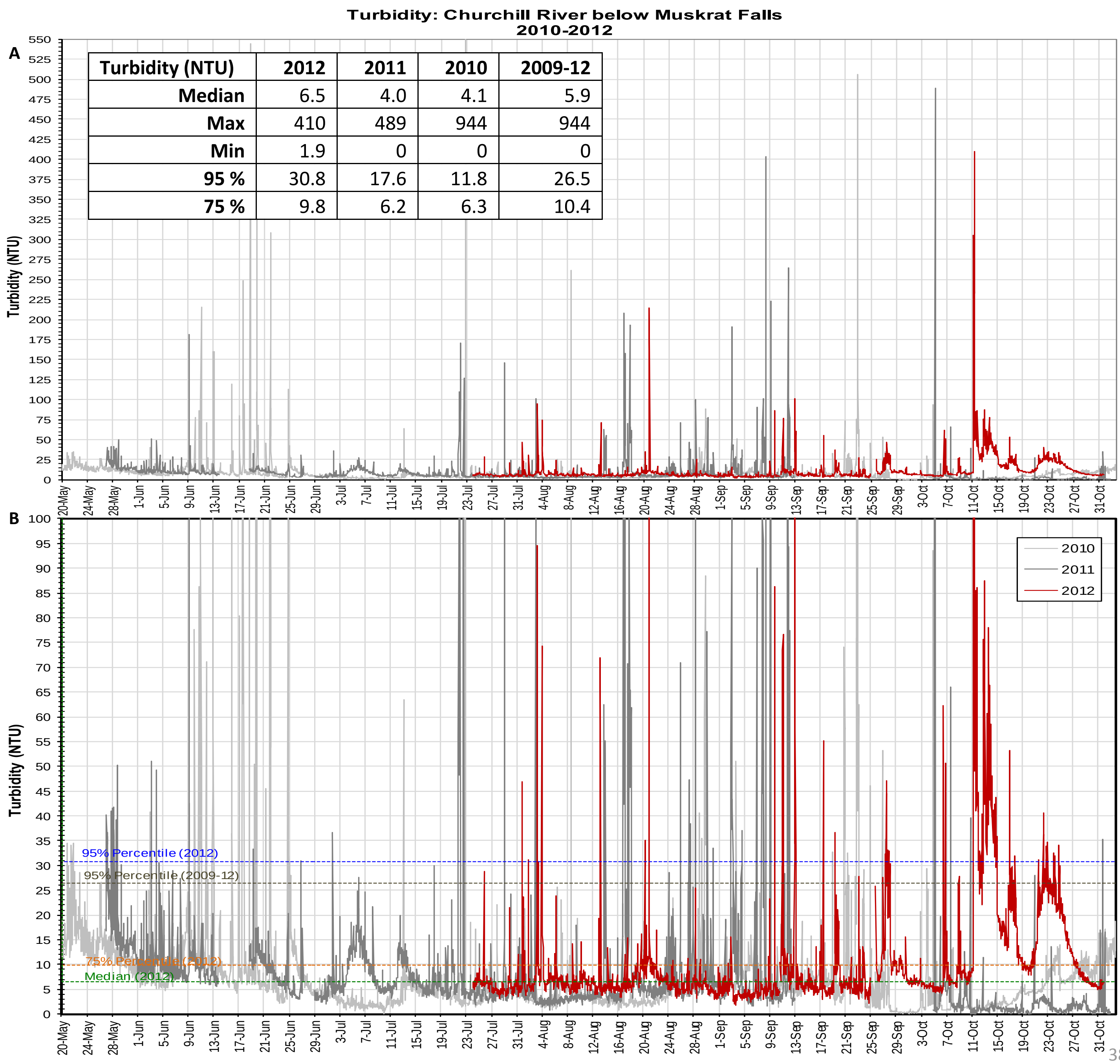


Figure 29: Dissolved oxygen and percent saturation at Churchill River below Muskrat Falls

Dissolved Oxygen (mg/L)	2012	2011	2010		Percent Saturation	2012	2011	2010
Median	10.70	11.10	11.00		Median	109.4	108.3	108.0
Max	14.26	13.74	14.03		Max	115.5	118.2	117.0
Min	9.76	9.71	9.85		Min	97.7	9.71	97.6

- The majority of turbidity values (95%) were <30.8NTU during the 2012 deployment season (Figure 30 a & b). A median value of 6.5NTU indicates there is a consistent natural background turbidity value at this station. Turbidity values from 2010 to 2012 are depicted in Figures 30 a & b below.
- Turbidity data collected during the first deployment period was deemed inaccurate due to sensor failure and has been removed from the data set.
- Figure 30a shows data up to 550NTU. On a number of occasions in 2012, turbidity increased above median background levels for short periods of time throughout the deployment season, to as high as 410.0NTU.
- Figure 30b shows data at a smaller scale, focusing on the regular consistent background levels, below 100NTU. In the 2012 season, median value was calculated to be 6.5NTU and the 95th percentile value was 30.8NTU. When data from all years is combined (2009 to 2012), the median value stays relatively the same at 5.9NTU and the 95th percentile is 26.5NTU. Turbidity values appear to be increasing slightly each year.



Turbidity (NTU)	2012	2011	2010	2009-12
Median	6.5	4.0	4.1	5.9
Max	410	489	944	944
Min	1.9	0	0	0
95 %	30.8	17.6	11.8	26.5
75 %	9.8	6.2	6.3	10.4

Figure 30a (top): Turbidity to 550NTU at Churchill River below Muskrat Falls

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

- Stage levels in 2012 are unavailable until mid-July. By this time in the deployment season, stage levels are already low, having decreased earlier in the season. Stage level reaches a seasonal low in early September (Figure 31).
- Stage levels from 2010-2012 are graphed below to show how stage levels vary throughout the season and from year to year. Stage levels were very similar when compared to throughout the three years for the same time period (June 29 to November 1). Stage ranges between 0.91m and 1.32m each year.

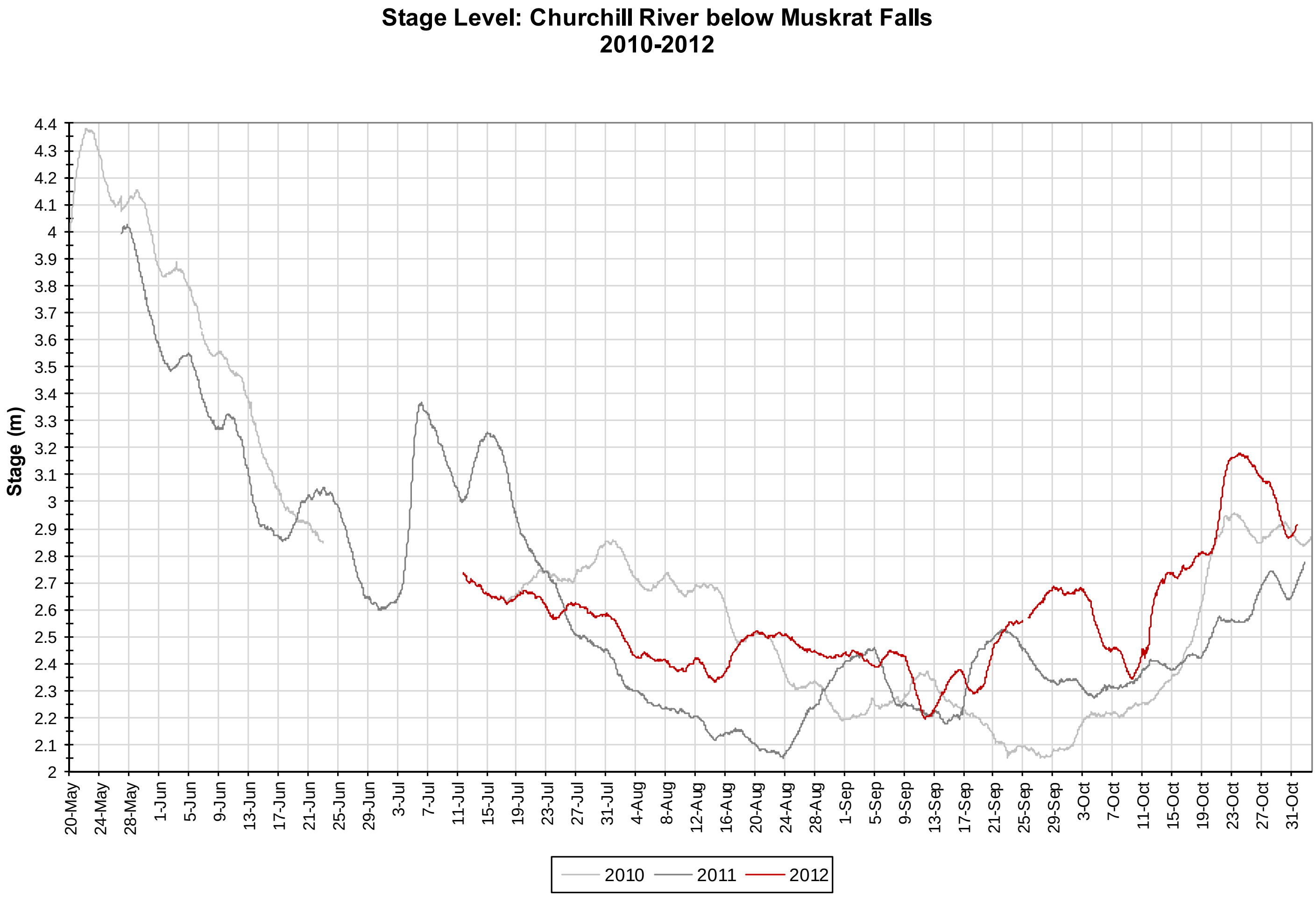


Figure 31: Stage level at Churchill River below Muskrat Falls

Stage (m)	2012	2011	2010
Median	2.50	2.40	2.40
Max	3.18	3.37	2.96
Min	2.19	2.05	2.05
Range	0.99	1.32	0.91

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 32).
- Stage is decreasing for much of the first half of the deployment season. Stage begins to increase again in early to mid-September. A significant decrease occurs in early October but this trend is quickly reversed and water levels increase rapidly for the remainder of the deployment season. This trend is inferred as average daily stage values are missing during a transmission error from mid to late October.

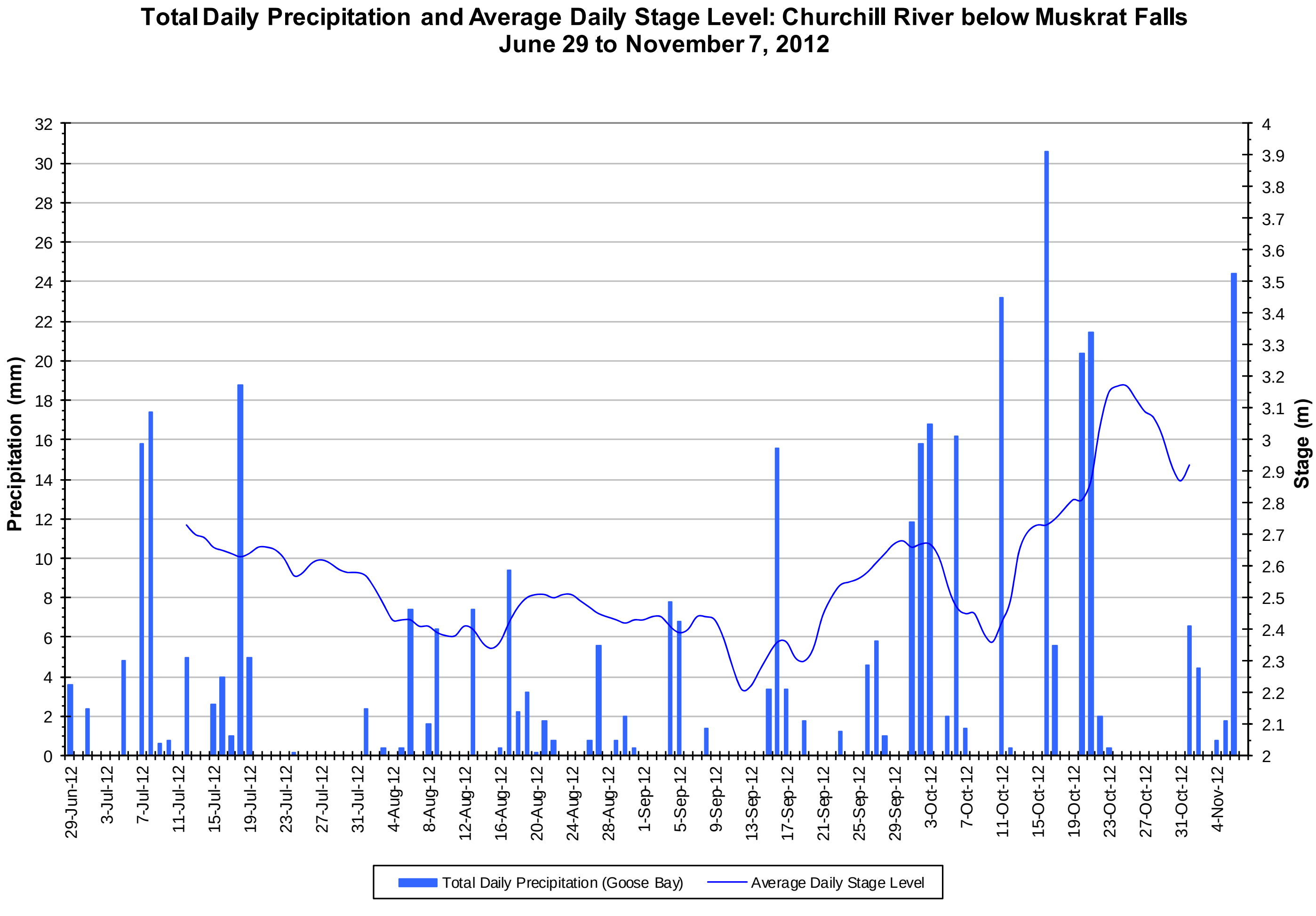


Figure 32: Daily precipitation and average daily stage level at Churchill River below Muskrat Falls (weather data recorded at Goose Bay)

Churchill River at English Point

- Water temperature ranged from 4.2°C to 22.1°C during the 2012 deployment season, with a median value of 16.5°C (Figure 33).
- Water temperatures are warmer when compared to data collected in 2011 for the same time period (June 29 to November 1).

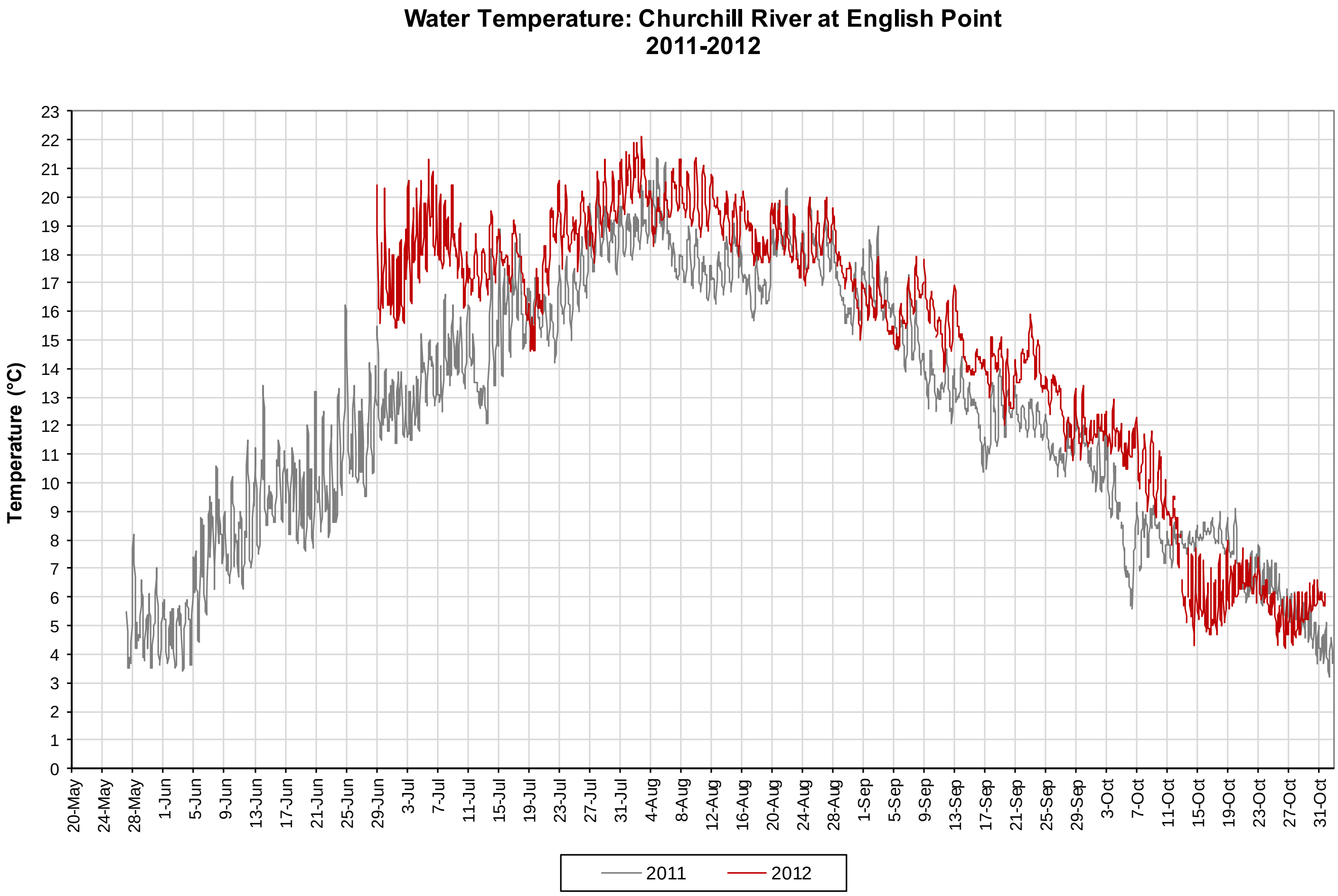


Figure 33: Water temperature at Churchill River at English Point

Temperature	2012	2011
Median	16.5	14.0
Max	22.1	21.4
Min	4.2	3.7

- Water temperature values show a typical seasonal trend (Figure 34). Because of the late deployment start in the end of June, water temperatures are at or near seasonal highs shortly after the first deployment. Water and air temperatures are warm until they begin to decrease in late August. Average air and water temperatures decrease throughout the fall season until the instrument is removed for the winter season on November 1.

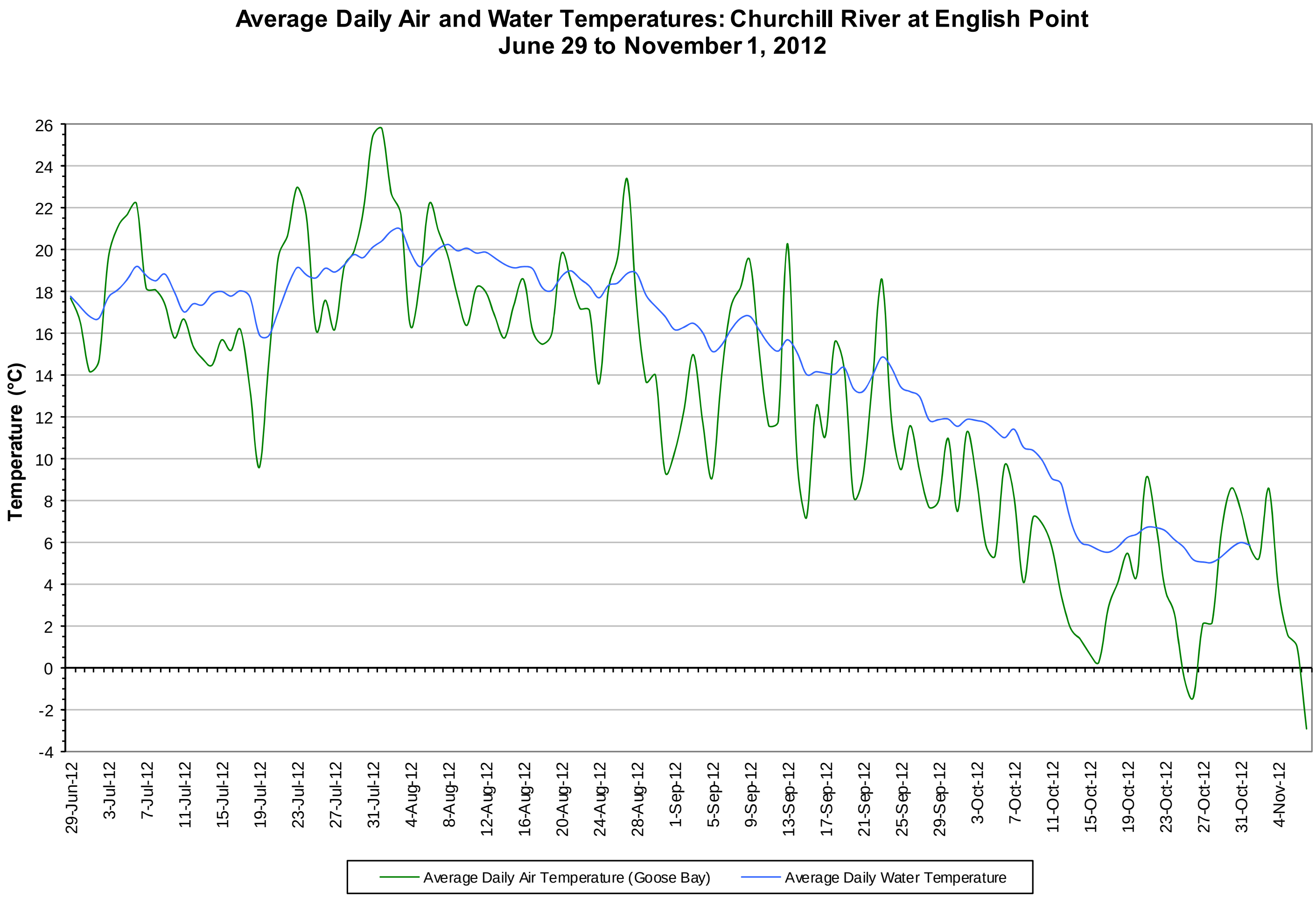


Figure 34: Average daily air and water temperatures at Churchill River at English Point

(weather data recorded at Goose Bay)

- pH ranges between 6.21 and 7.53 pH units during the 2012 deployment season, with a median value of 6.97 pH units (Figure 35).
- pH values are increasing throughout most of the deployment season. pH values begin to decrease in mid-September. pH values are most variable at this station and fluctuate on a daily basis.
- pH data collected from September 13-26 was deemed inaccurate due to sensor failure and has been removed from the data set.
- Most pH values during the 2012 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 mid-July and again in late October. Guidelines are indicated in blue on Figure 35.
- pH trends and values are similar for both years during which data was collected for the same time period.

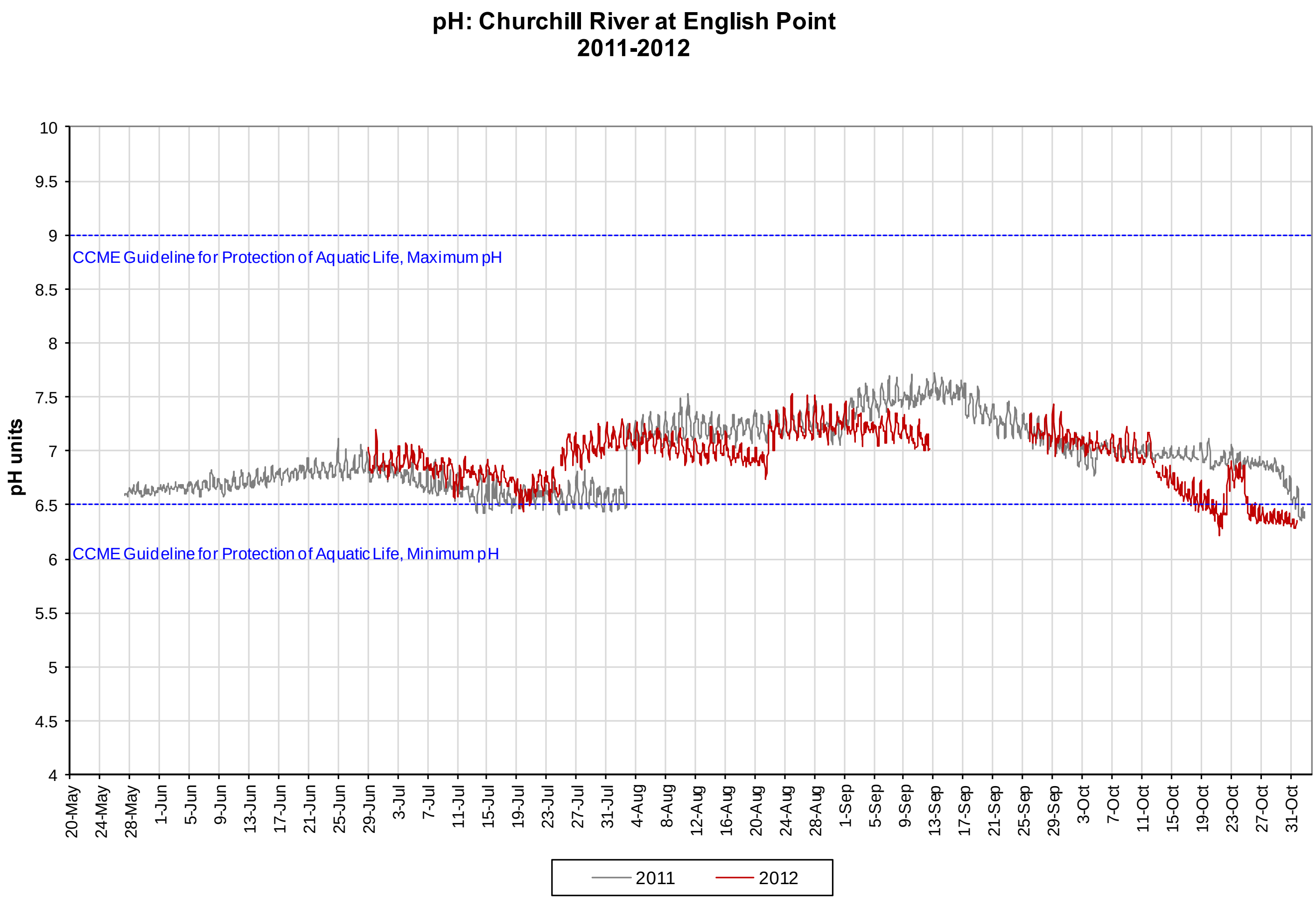


Figure 35: pH at Churchill River at English Point

pH (units)	2012	2011
Median	6.97	7.03
Max	7.53	7.72
Min	6.21	6.41

- Specific conductance ranged between 15.6µS/cm and 71.1µS/cm, with a median value of 34.2µS/cm during the 2012 deployment season (Figure 36).
- Specific conductivity data collected from September 13-26 and October 28-November 1 was deemed inaccurate due to sensor failure and has been removed from the data set.
- 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 2011 and 2012 are similar for the same time period.

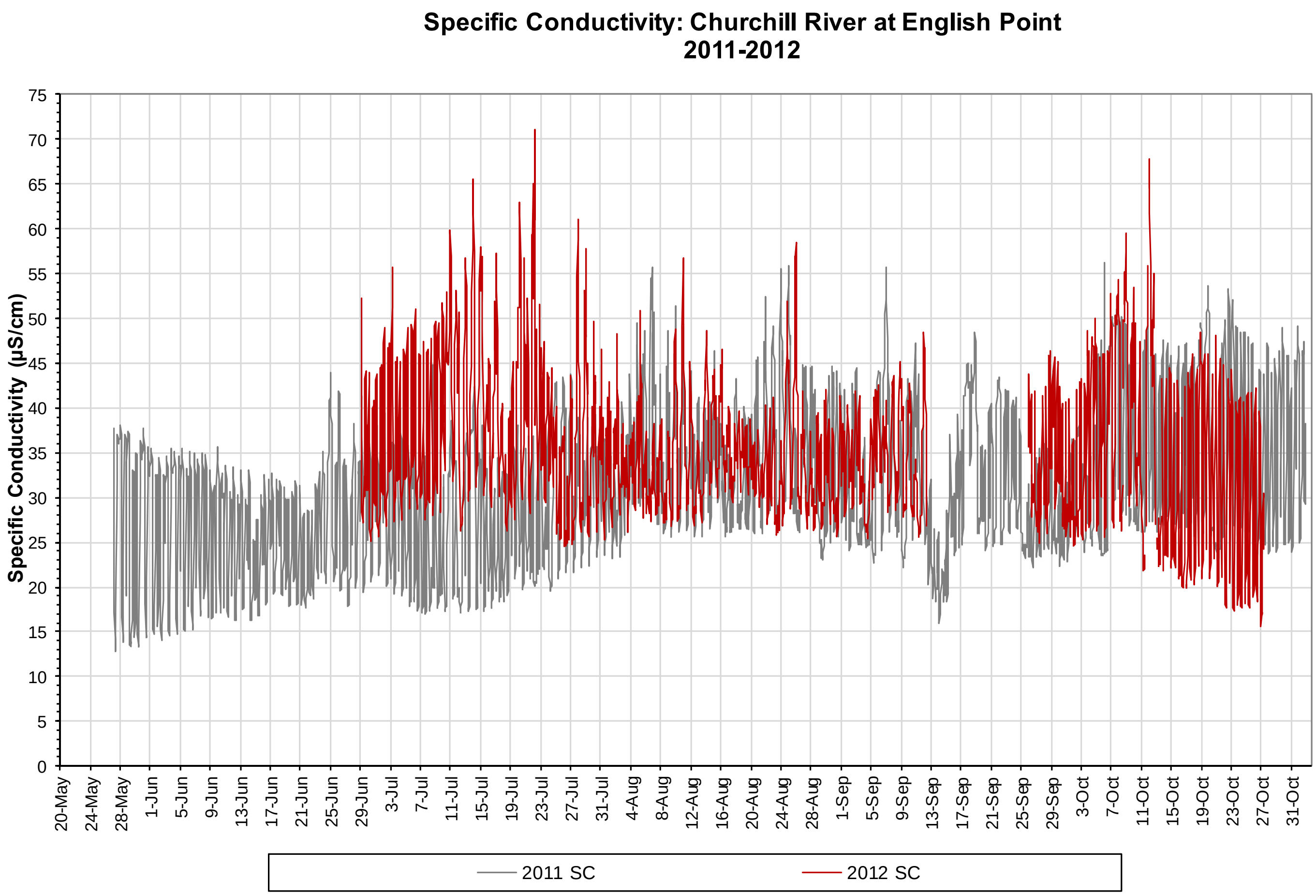


Figure 36: Specific conductivity at Churchill River at English Point

Specific Conductivity (µS/cm)	2012	2011
Median	34.2	31.1
Max	71.1	56.3
Min	15.6	15.9

- Throughout the 2012 deployment season, dissolved oxygen ranged from 8.56mg/l and 13.52mg/l, with a median value of 9.84mg/l, while percent saturation ranged from 87.1% to 112.3%, with a median value of 100.8% (Figure 37).
- 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 first two deployment periods, most values were either just above 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 37.
- Dissolved oxygen content shows a typical seasonal fluctuation in 2012. Because of the late deployment start in 2012, the decreasing trend normally observed in the spring and early summer season is not captured. Dissolved oxygen values are low and consistent through the warmest part of the season and increase later in the summer and fall season as air and water temperatures cool. Dissolved oxygen content fluctuates considerably on a regular daily basis. Dissolved oxygen and percent saturation data collected from September 19-26 was deemed inaccurate due to sensor failure and has been removed from the data set.
- Dissolved oxygen content is slightly less than in 2011 for the same time period (June 29 to November 1). This trend would be expected given the slight increase in water temperature in 2012 (Figure 33).

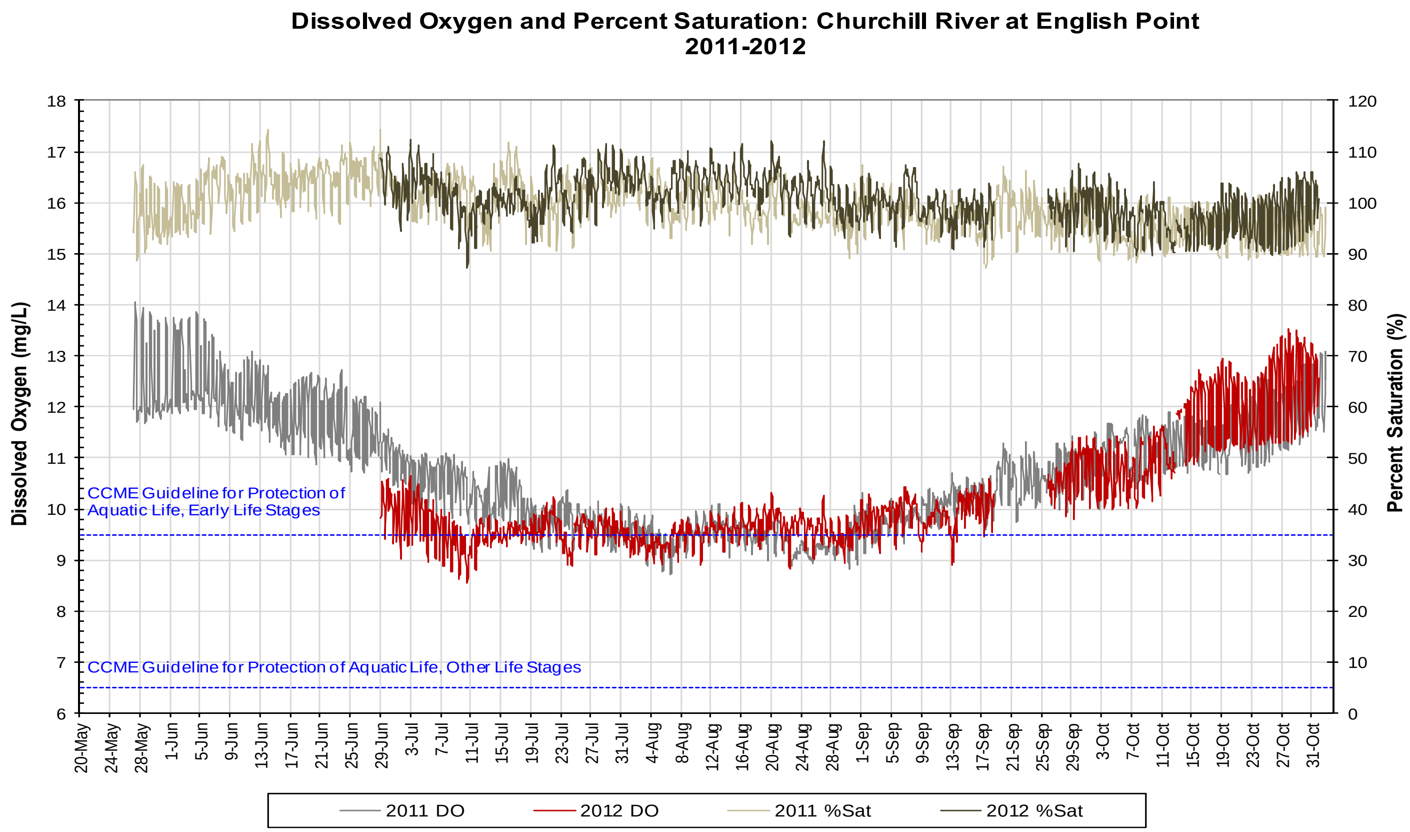
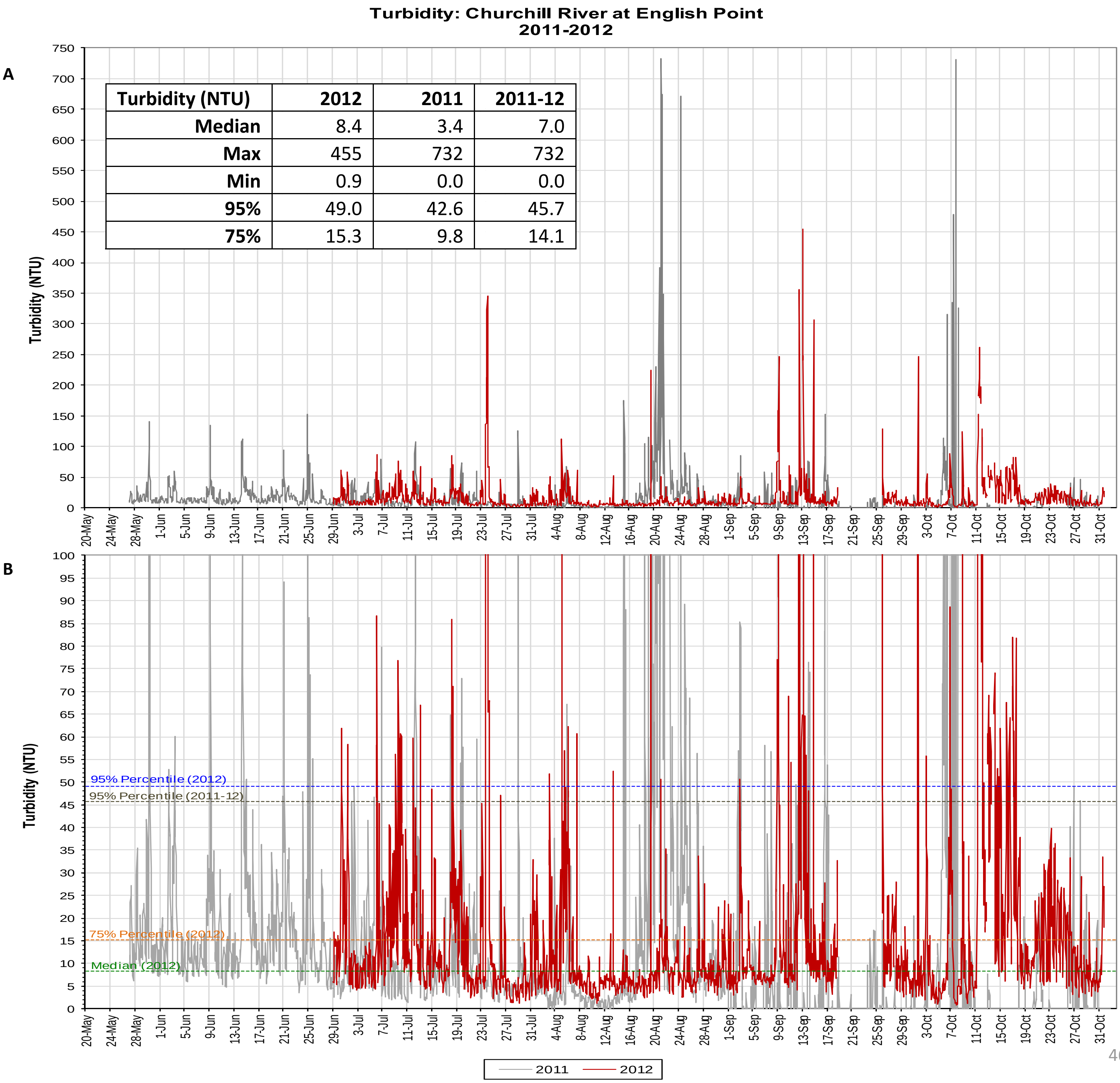


Figure 37: Dissolved oxygen and percent saturation at Churchill River at English Point

Dissolved Oxygen (mg/L)	2012	2011		Percent Saturation	2012	2011
Median	9.84	10.14		Median	100.8	98.5
Max	13.52	12.84		Max	112.3	111.8
Min	8.56	8.72		Min	87.1	87.1

- The majority of turbidity values (95%) were <49.0NTU during the 2012 deployment season (Figure 38 a & b). A median value of 8.4NTU indicates there is a consistent natural background turbidity value at this station. Turbidity values from 2011 and 2012 are depicted in Figures 38 a & b below.
- Turbidity data collected from September 19-26 was deemed inaccurate due to sensor failure and has been removed from the data set.
- Figure 38a shows data up to 750NTU. On a number of occasions in 2012, turbidity increased above median background levels for short periods of time throughout the deployment season, to as high as 455NTU.
- Figure 38b shows data at a smaller scale, focusing on the regular consistent background levels, below 100NTU. In the 2012 season, median value was calculated to be 8.4NTU and the 95th percentile value was 49.0NTU. When data from 2011 and 2012 is combined, the median value decreases slightly to 7.4NTU and the 95th percentile is 42.5. Turbidity values appeared to increase in 2012 when compared to data collected in 2011 for the same time period.



Turbidity (NTU)	2012	2011	2011-12
Median	8.4	3.4	7.0
Max	455	732	732
Min	0.9	0.0	0.0
95%	49.0	42.6	45.7
75%	15.3	9.8	14.1

Figure 38 (a) (top): Turbidity to 750NTU at Churchill River at English Point (b) (bottom): Turbidity to 100NTU at Churchill River at English Point

Lower Churchill River, Newfoundland and Labrador

- Stage levels in 2012 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 2011-2012 are graphed below to show how stage levels vary throughout the season and from year to year. Stage levels in both years were very similar when compared to throughout the three years for the same time period (June 29 to November 1). Stage ranged between 1.13m and 1.27m each year.

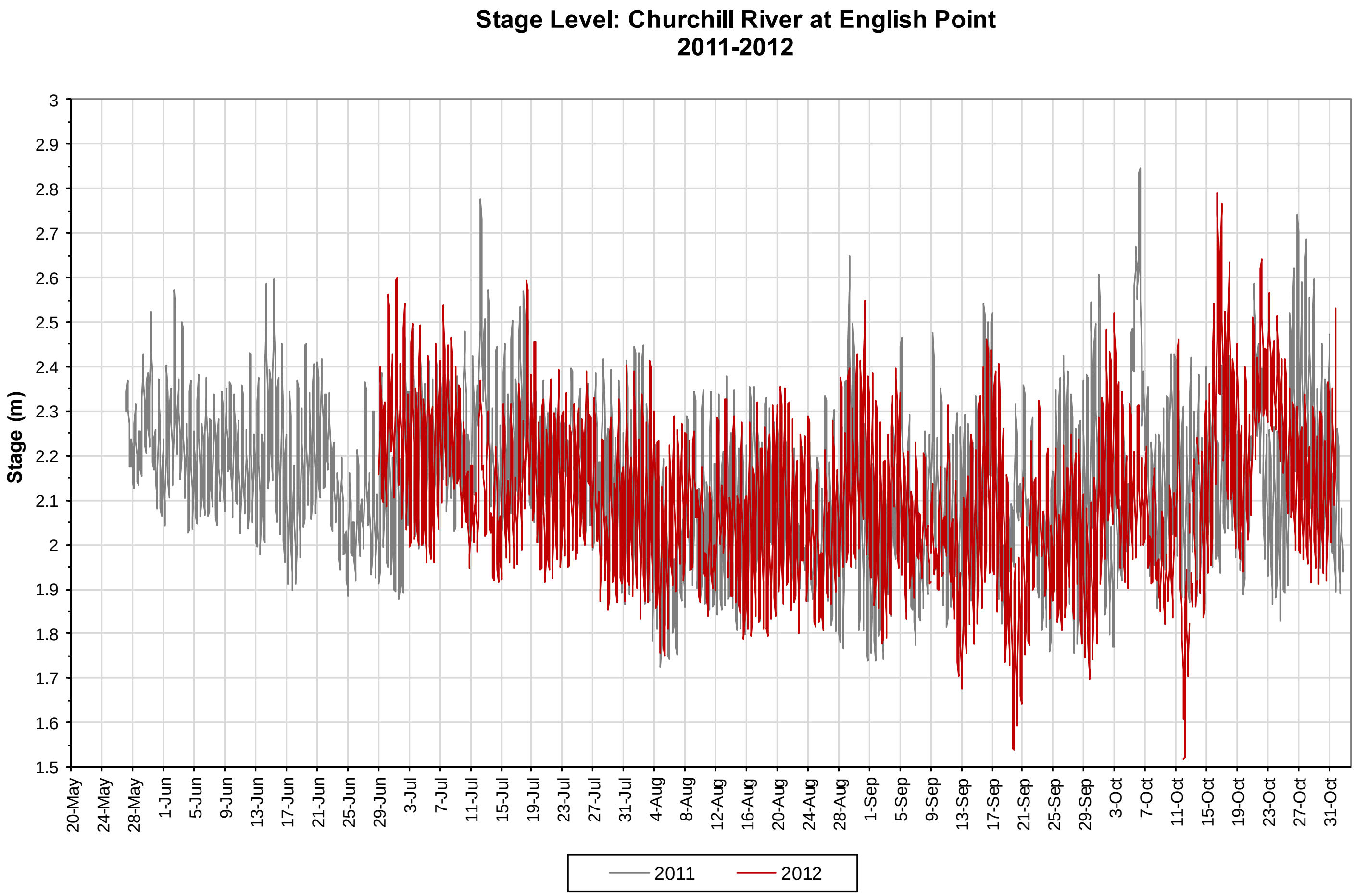


Figure 39: Stage level at Churchill River at English Point

Stage (m)	2012	2011
Median	2.09	2.13
Max	2.79	2.85
Min	1.52	1.72
Range	1.27	1.13

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 40).
- Stage is decreasing very slightly during the first half of the deployment season. Stage increases slightly in early October. 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.

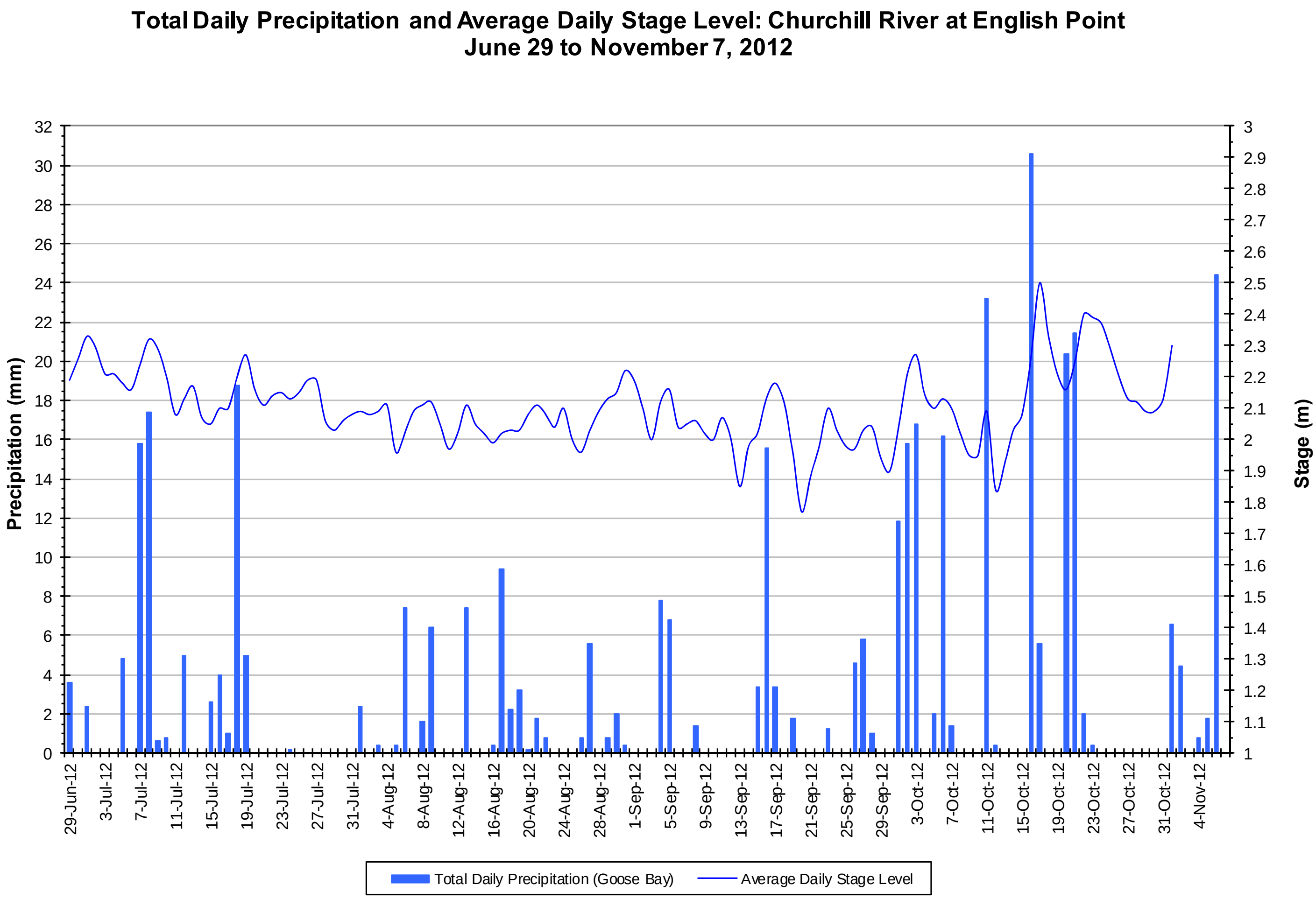


Figure 40: Daily precipitation and average daily stage level at Churchill River at English Point

(weather data recorded at Goose Bay)

Station Comparison

- Water temperature at each of the five stations shows a similar trend throughout the 2012 deployment season (Figure 41).
- Water temperature was warmest at Churchill River at English Point and also had the greatest diurnal fluctuations. The coolest water temperatures were found at Churchill River below Grizzle Rapids however this station is the first to warm up in the spring and the first to cool down in fall. Stations above and below Muskrat falls were very similar as is expected with their close proximity to one another (~7km).

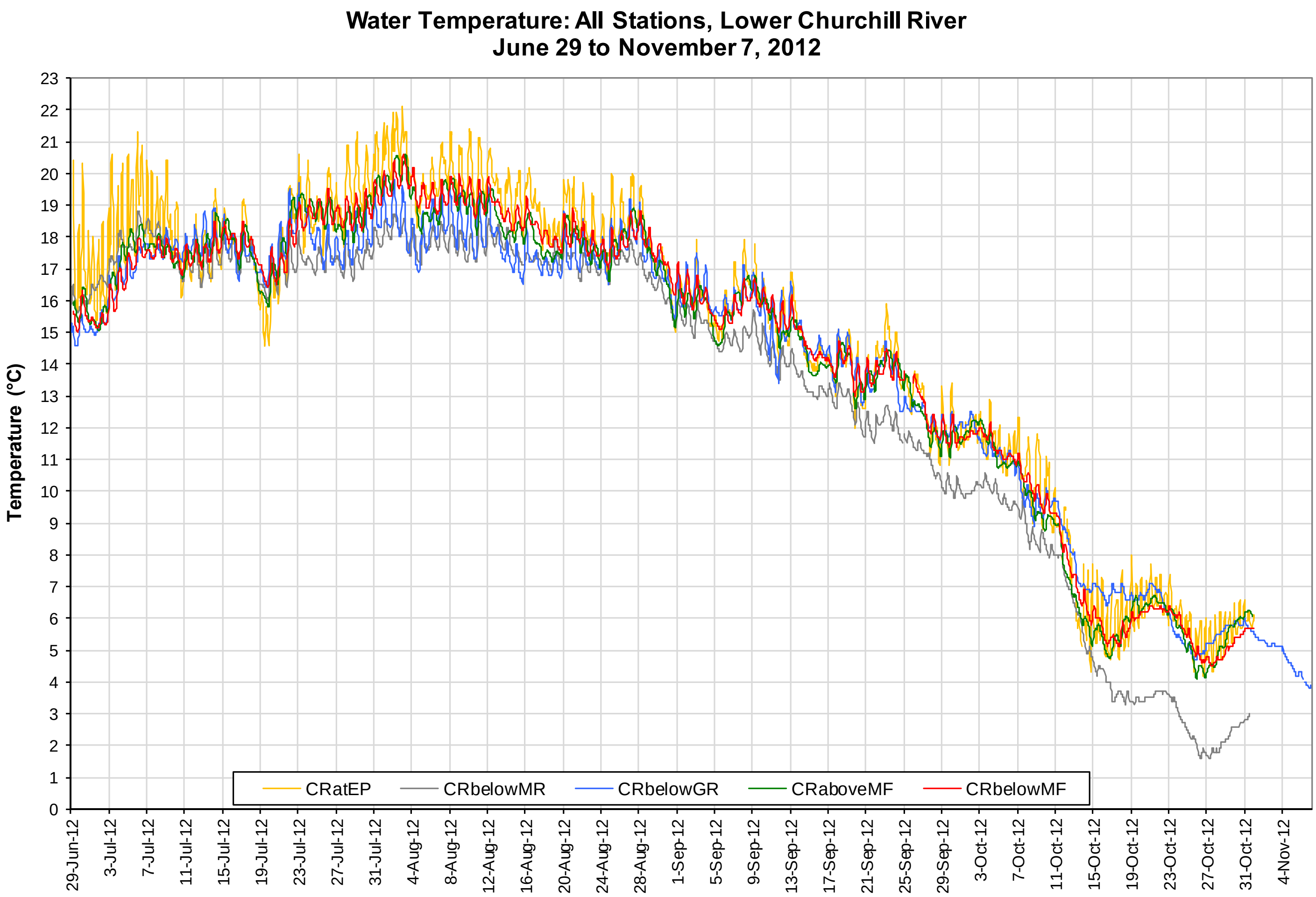


Figure 41: Temperature at all stations in 2012, Lower Churchill River

Temperature	CRbelowMR	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Median	16.0	15.9	16.2	16.2	16.5
Max	18.8	20.0	20.6	20.6	22.1
Min	1.6	3.8	4.1	4.5	4.2

<u>*Lower Churchill River, Newfoundland and Labrador*</u>

- Water temperatures at all five stations display clear seasonal trends in response to changes in air temperatures throughout the deployment season (Figure 42).

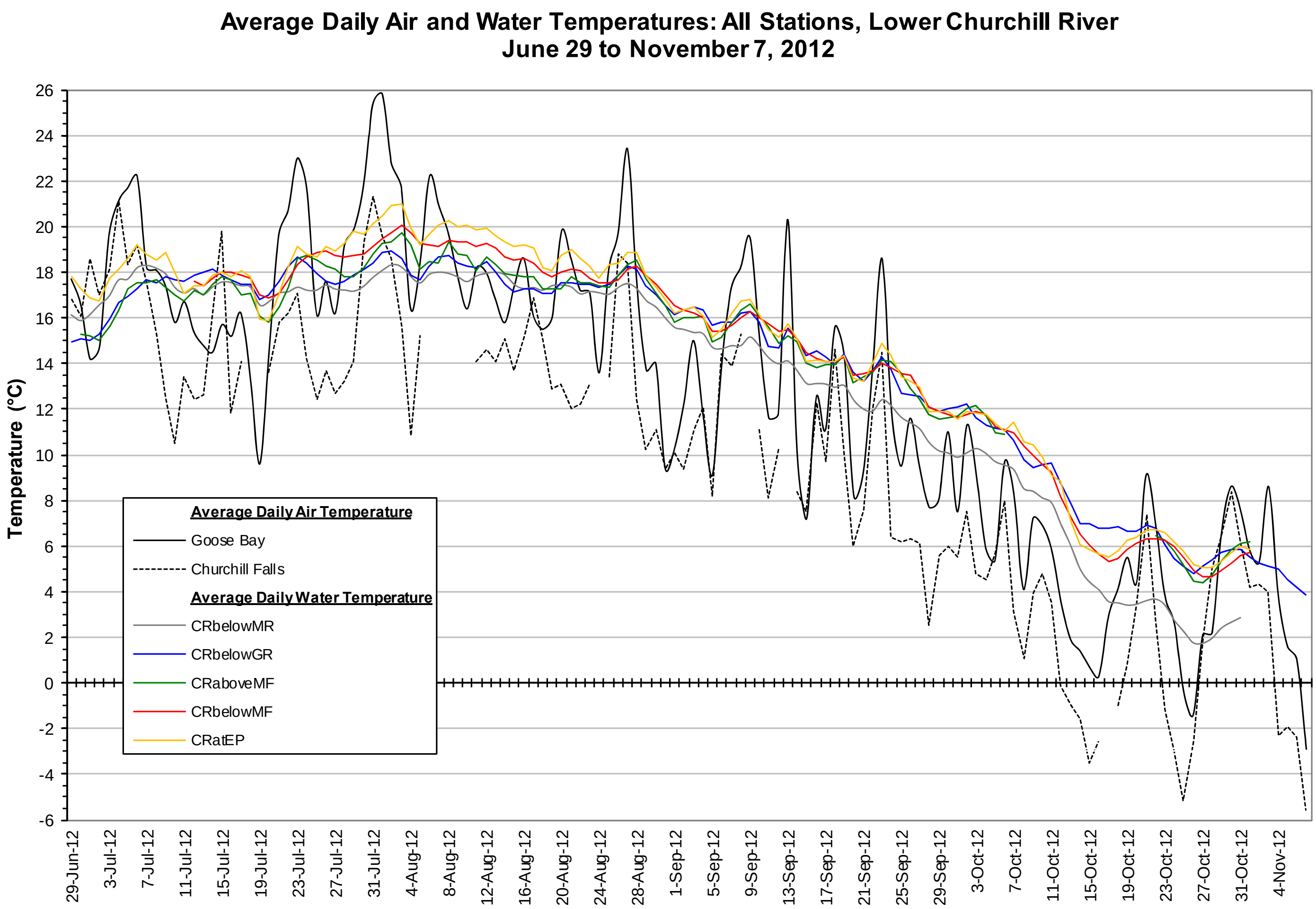


Figure 42: Average daily air and water temperatures at all stations in 2012, Lower Churchill River

- pH values are similar at the five monitoring sites throughout the 2012 deployment season (Figure 43).
- Median values range between 6.97 (Churchill River at English Point) and 7.17 (Churchill River below Grizzle Rapids). Values at the station at English Point are the most variable 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.
- pH decreases at all stations late in the final deployment period in October.

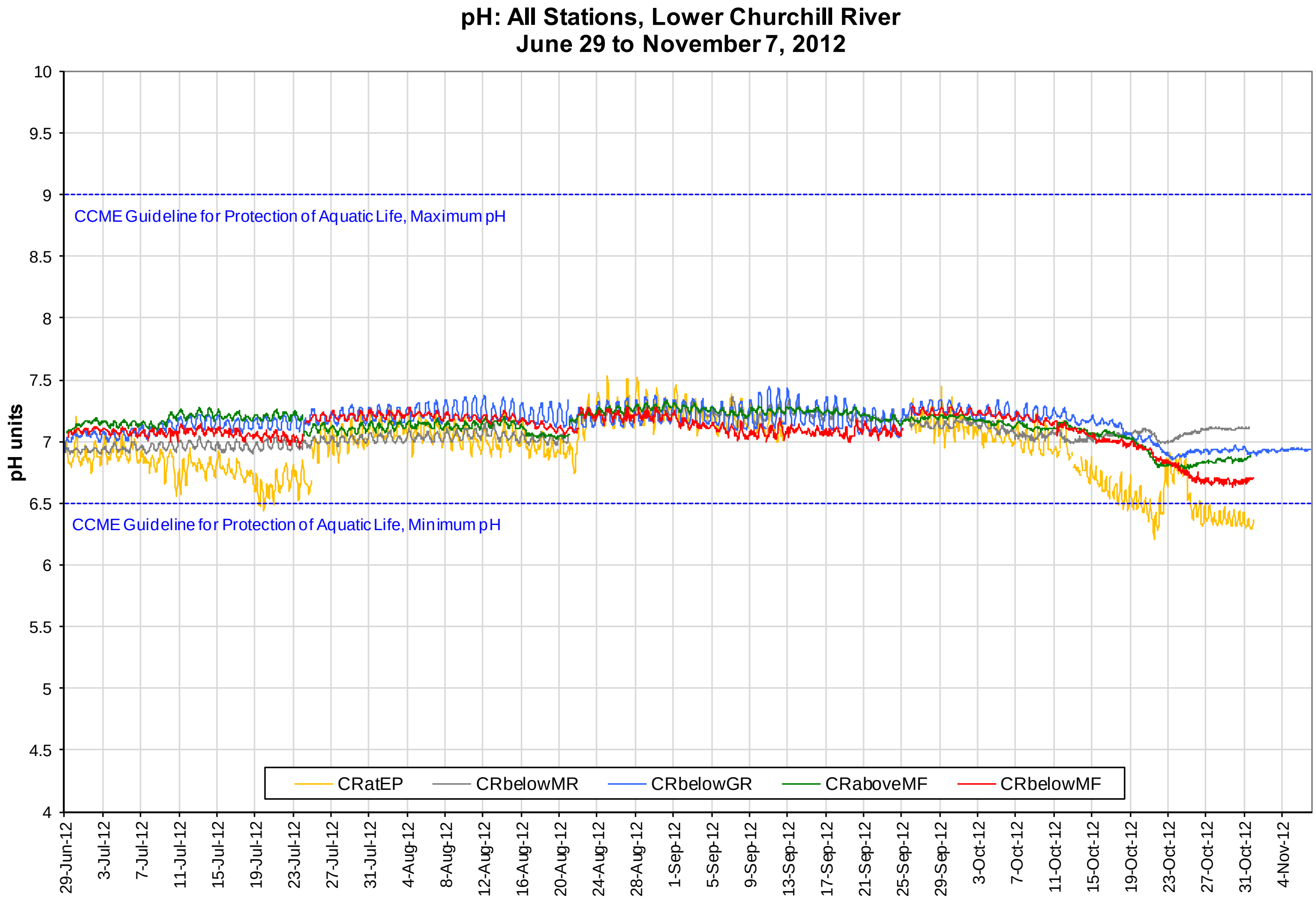


Figure 43: pH at all stations in 2012, Lower Churchill River

pH (units)	CRbelowMR	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Median	7.06	7.17	7.16	7.11	6.97
Max	7.36	7.44	7.33	7.29	7.53
Min	6.90	6.85	6.78	6.63	6.21

- 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, fluctuating only a few micro Siemens during a deployment period. This makes the instrument calibration process particularly important. The solution used to calibrate the instrument is a factory standard of 100 µS/cm. After opening, the solution can quickly become contaminated if only by a few units which in turn greatly affects the precision of the measurement. This is why there is often a distinguishable difference between the deployment periods. The trends captured by the instruments however, remain accurate.
- Trends for each deployment period suggest that specific conductivity is increasing for the first three deployment periods at all stations except for the one at English Point. Specific conductivity at the four stations above English Point tend to decrease in the final deployment period from September 25 to November 7.
- 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.

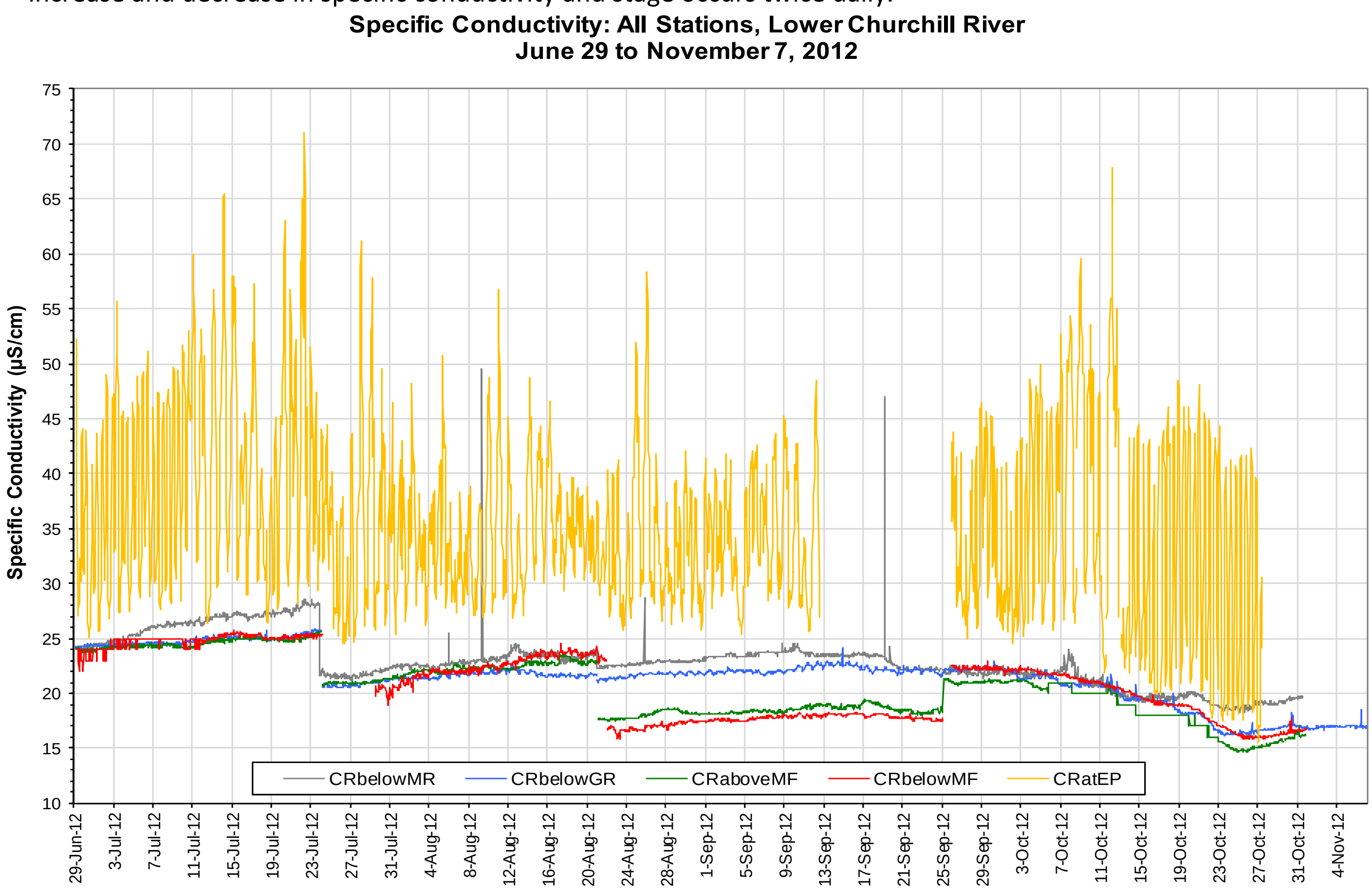


Figure 44: Specific conductivity at all stations in 2012, Lower Churchill River

Specific Conductivity (µS/cm)	CRbelowMR	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Median	22.8	21.8	20.9	21.1	34.2
Max	49.5	25.9	25.6	25.7	71.1
Min	18.3	16.1	14.7	15.8	15.6

- Dissolved oxygen content and percent saturation values are very similar at stations above Muskrat Falls, below Grizzle Rapids and below Metchin River, with a median values from 9.38mg/l to 9.72mg/l and 94.5% to 97.2 % (Figure 45).
- Values at the station below Muskrat Falls have a median value of 10.73mg/l for dissolved oxygen and 109.4 % for percent saturation. This is due to the location of Muskrat Falls upstream from the station. Water as it moves over Muskrat Falls is aerated and increases the amount of oxygen in the water. 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.
- The station at English Point is located below Muskrat Falls (approximately 36km) however the effect of the aeration at Muskrat Falls is not noticeable at this distance downstream. The dissolved oxygen content closely resembles that of stations upstream of Muskrat Falls but varies more widely on a daily basis. This is likely due to the tidal influence of the Atlantic Ocean and the changing water temperatures each day at the tide goes in and out.
- All stations experience a typical seasonal fluctuation in 2012. Because of the late deployment start in 2012, the decreasing trend normally observed in the spring and early summer season is not captured. Dissolved oxygen values are low and consistent through the warmest part of the season and increase later in the summer and fall season as air and water temperatures cool.

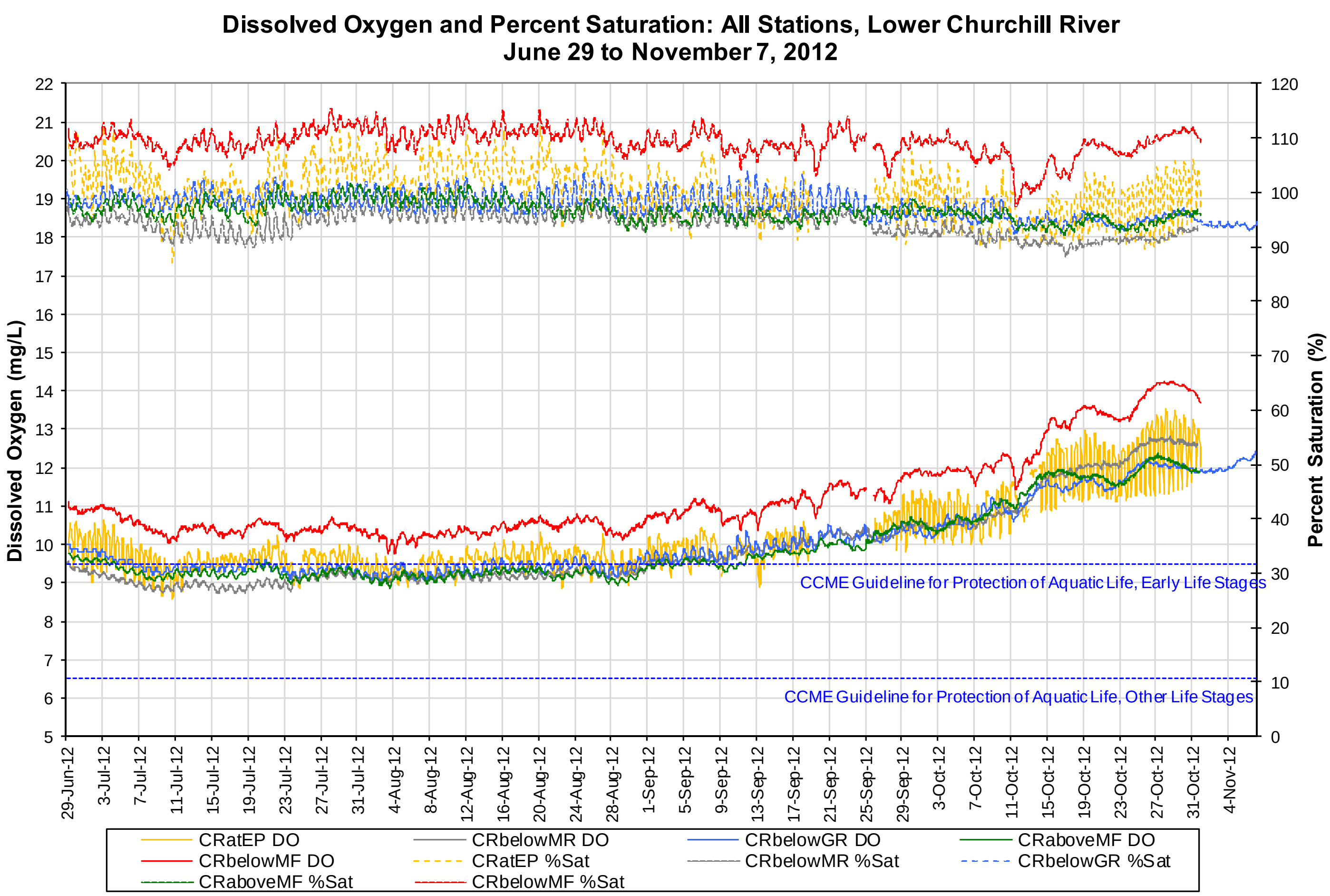


Figure 45: Dissolved oxygen and percent saturation at all stations in 2012, Lower Churchill River

	Dissolved Oxygen (mg/l)				
	CRbelowMR	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Median	9.38	9.72	9.47	10.73	9.84
Max	12.80	12.41	12.38	14.26	13.52
Min	8.72	9.06	8.87	9.76	8.56
	Percent Saturation (%)				
	CRbelowMR	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Median	94.5	97.2	96.5	109.4	100.8
Max	99.3	103.9	101.8	115.5	112.3
Min	88.4	92.6	92.4	97.7	87.1

- Turbidity values at stations below Grizzle Rapids and below Metchin River are generally 0.0NTU 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, the water quality is generally more turbid and the water is visibly cloudy. Median turbidity values at these three stations range between 3.0NTU and 8.4NTU for the 2012 deployment season. Increases in turbidity often correspond with weather related events. Background turbidity values appear to increase the further the station is located downstream.

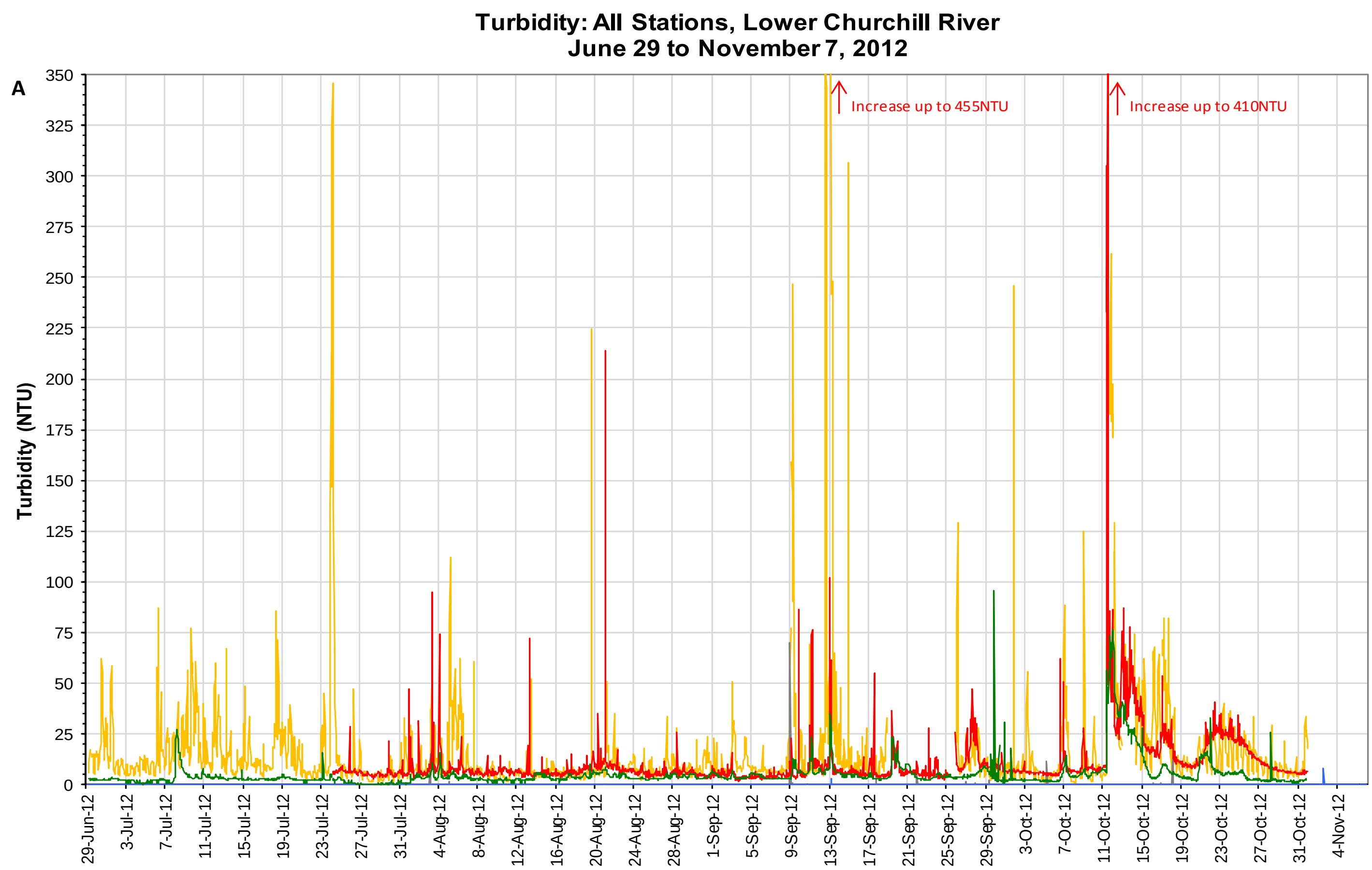


Figure 46a: Turbidity to 400NTU at all stations in 2012, Lower Churchill River

- Figure 46a shows turbidity data on a scale from 0 to 350NTU to illustrate the higher magnitude events. Figure 46b displays the same data on a smaller scale, 0 to 100NTU, to clearly show the background turbidity values throughout the deployment season.
- Stations below Metchin River and below Grizzle Rapids are barely visible on Figure 46 a or b due to the large presence of turbidity at the stations above and below Muskrat Falls and at English Point. There is a clear relationship and pattern associated with turbidity at each of the three stations given their proximity to one another (~40km). During times of turbidity increases (above background levels), increases such as the one experienced in mid-October following a significant rainfall event, is noticeable at all three stations. Turbidity levels at English Point vary more widely on a daily basis like many of the other parameters recorded at the station.

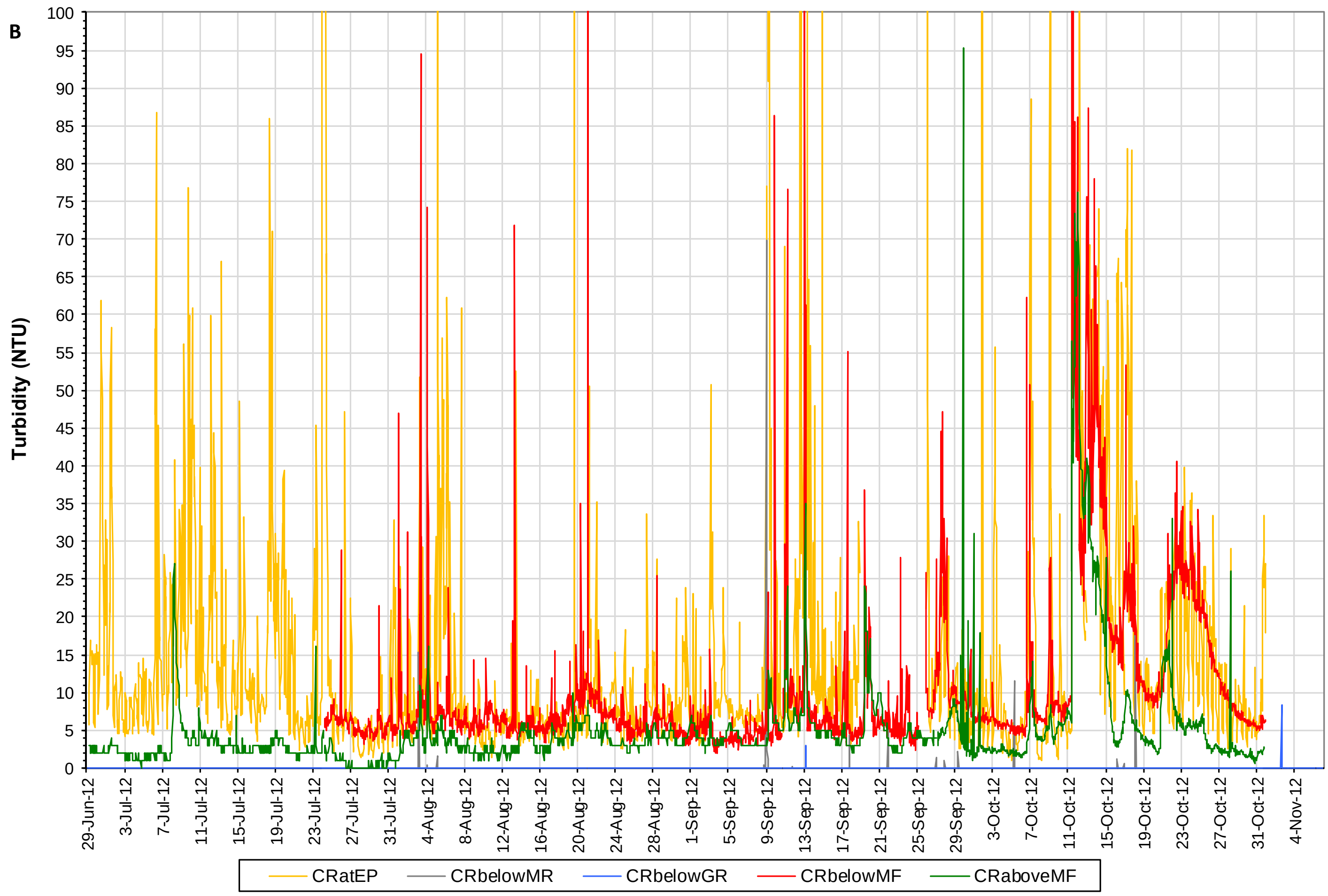


Figure 46b: Turbidity to 100NTU at all stations in 2012, Lower Churchill River

Turbidity (NTU)	CRbelowMR	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Median	0.0	0.0	3.0	6.5	8.4
Max	69.9	8.3	95.3	410	455
Min	0	0	0	1.9	0.9

- Stage levels are similar across the network throughout the 2012 deployment season (Figure 47). Stage is decreasing at all stations deployed in late June through the month of July and into August. Stage levels remain low throughout the summer months and reach a seasonal low in early to mid-September. Stage levels begin to increase again in late September until the end of the deployment season in November. Stage ranges between 0.74m and 1.75m 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 the other station in the network.

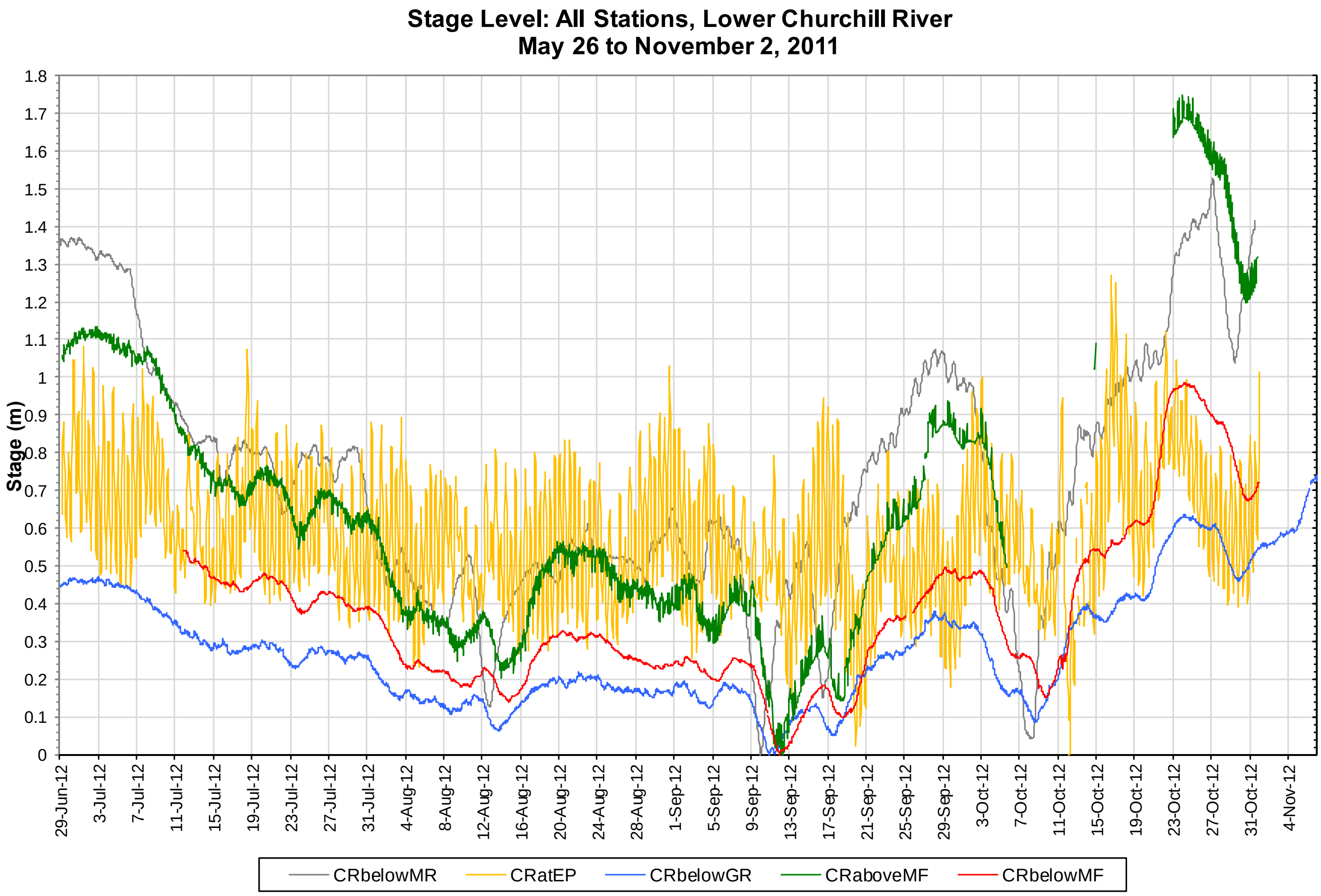


Figure 47: Stage levels at all stations in 2012, Lower Churchill River

	CRbelowMR	CRbelowGR	CRaboveMF	CRbelowMF	CRatEP
Stage Range (m)	1.53	0.74	1.75	0.98	1.27

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 June 29 to October 31-November 1 & 7. The deployment season was late starting due to necessary instrument repairs and difficulty securing helicopter transportation during a high demand season.
- 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 station at English Point has been covered in this annual report for the first time since its first transmitted data in 2011. This station offers a last measurement of water quality in the Lower Churchill River before the rivers flows into Lake Melville.
- 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.
    - At the first deployment on June 29 at the station below Muskrat Falls, the station was experiencing a transmission error. Environment Canada staff were on site to fix the issue on July 12. Data from the instrument's internal log file was used during the period of transmission failure.
    - A similar transmission error occurred at the station above Muskrat Falls between October 6 and 23. Again, Environment Canada resolved the issue at their next site visit and the instrument's internal log file data was used to fill the gap in data transmission.
    - At the station below Metchin River, turbidity data collected during the first deployment period was deemed inaccurate due to sensor failure and has been removed from the data set. Similarly, turbidity data collected during the first deployment period at the station below Muskrat Falls was also considered inaccurate due to sensor failure and has been removed from the data set.
    - At the station at English Point, there were more than a few sensor failures resulting in compromised data. pH, and specific conductivity data collected from September 13-26 and dissolved oxygen and turbidity data collected from September 19-26 was deemed inaccurate due to sensor failure and was been removed from the data set. Specific conductivity data collected at the end of the last deployment period from October 28-November 1 was also removed from the data set due to inaccuracies.
- Data collected in 2012 is comparable with datasets from previous years in 2011 and 2010. Water quality parameters do not tend to vary significantly. Stage appears to be the greatest variable from year to year.
- Most values recorded were within ranges as suggested by the CCME Guidelines for the Protection of Aquatic Life for pH.
- 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 (late July to early September). All values at all stations remained above the minimum CCME Guideline for the Protection of Aquatic Life during other life stages (6.5mg/L)

Path Forward

In order for this agreement to be successful, it is essential to continually evaluate and move forward. The 2012 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.

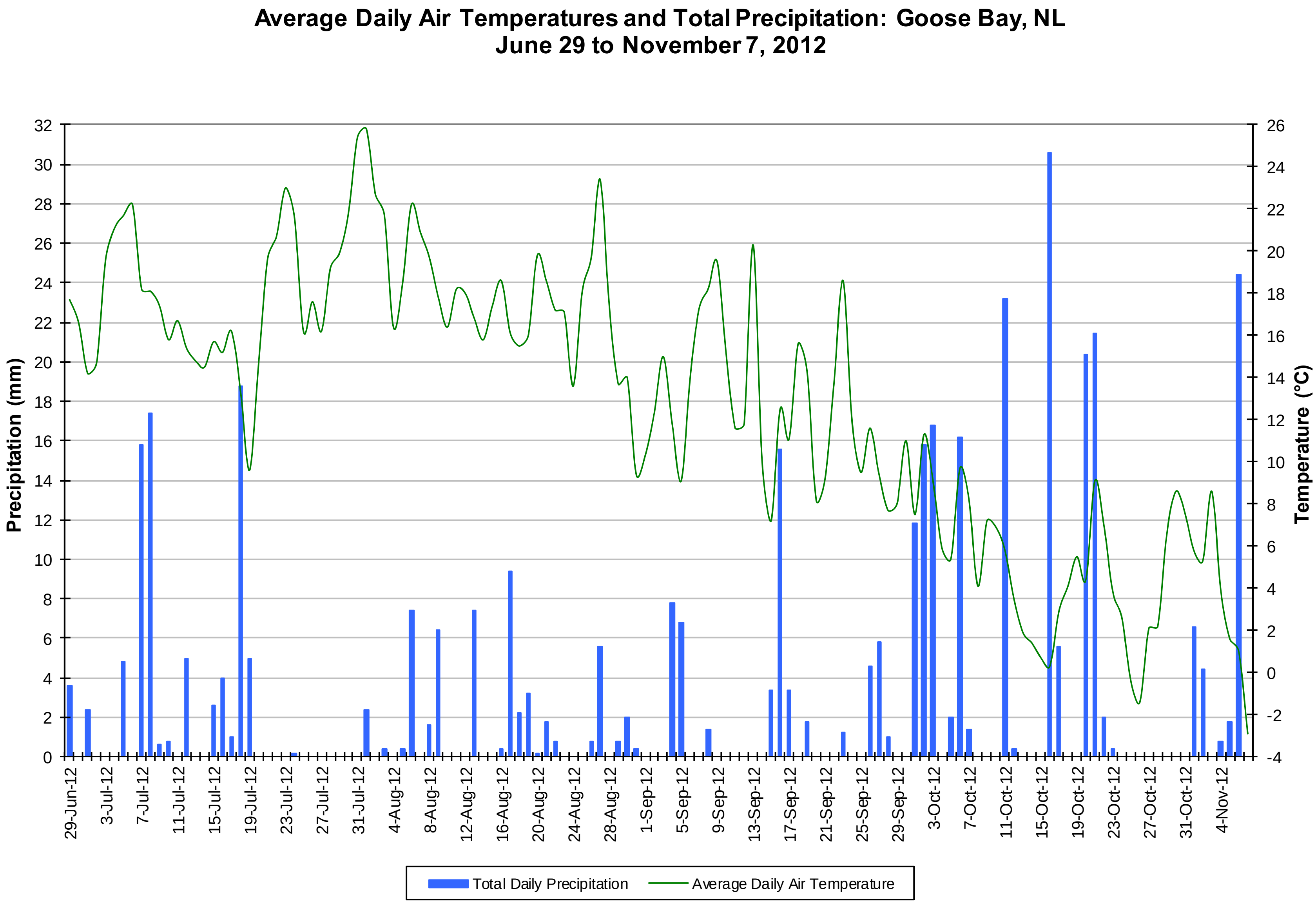
- ENVC has successfully established 2 RTWQM stations in the Lower Churchill River and Lake Melville area. These stations are located at the mouth of the Churchill River at English Point and approximately 70km east of Goose Bay on Lake Melville east of Little River. These stations are owned and operated by ENVC, however Nalcor has to date been provided with data and monthly reports from these stations.
    - The lake Melville station has experienced deployment issues in both 2011 and 2012 causing damage to the instrument. The data collected at this station has not been consistent and does not offer any comparison value to the data collected in the Lower Churchill River Network. ENVC has decided to cease RTWQ data collection at this station for the 2013 season. Water quantity data will still be collected continuously and during site visits by Environment Canada, a grab sample will be taken and analyzed for major ions, nutrients and metals as was done in the past. ENVC will continue to explore new deployment techniques for this station.
    - Water quality data collection at the English Point station has been excellent and offers an interesting last look at the water quality at the Mouth of the Churchill River as was presented in this 2012 annual report. Water quality and quantity monitoring will continue at this station and the English Point station will be added to the monthly deployment reports for the Lower Churchill River meaning there will be one monthly report now covering the five stations, similar to this annual report. The English Point station will now effectively be included when referring to the Lower Churchill River Network.
- ENVC staff will deploy RTWQ instruments in spring 2013 when ice conditions allow and perform regular site visits throughout the 2013 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 on a 3 month basis unless otherwise 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.
- Deployment techniques have been reviewed at stations above and below Muskrat Falls where previous concern from Nalcor had indicated that the river bottom was interfering with the quality of data collected. ENVC has determined that the deployment techniques are satisfactory and are providing excellent baseline data in advance of the project construction. ENVC however would like to test a new deployment technique beginning at the station below Muskrat Falls. Details of the secondary deployment at this station will be discussed and determined in collaboration with Nalcor employees in the Spring of 2013.
- Chlorophyll sensors were been 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 2012. The data loggers were not programmed to transmit this data during the 2012 season and an additional daughter board was required to ensure the Chlorophyll sensors were functioning properly. All instruments have been

upgraded and calibrated for the 2013 season. The spring deployment trip will be made in conjunction with the spring Environment Canada trip to ensure both stations are programmed to transmit this data at the beginning of the deployment season.

- Investigation into stand-alone TSS sensors are undergoing at test sites near St. John's however information has not been conclusive as of yet to implement this type of monitoring at the stations above and below Muskrat Falls. It was decided by ENVC and Nalcor staff that efforts would be focused on changing or adjusting deployment techniques instead.
- ENVC will work towards the development of models using RTWQM data and grab sample data to estimate a variety of additional water quality parameters (*i.e.* TSS, major ions *etc*.). To date, 12 samples have been analyzed for TSS at the stations above and below Muskrat Falls. These sample results along with field and QAQC instrument readings and transmitted data from the stations have been examined for a linear relationship. Additional research is required to confirm the relationship and the ability to predict TSS from turbidity values at these two stations. Grab samples will continue to be taken and analyzed for TSS at all stations on the Churchill River and in Lake Melville. Work on the prediction model in ongoing in 2013.
- Research in to the use of remote sensing and satellite imagery to predict water quality indices will continue in 2013. Satellite imagery will be acquired by WRMD and analyzed for correlation and relationships.
- There were plans to install a new hydrometric station (between Upper and Lower Muskrat Falls); a web camera station equipped with two cameras; and a back-up gauge station at the existing above Grizzle Rapids hydrometric station in the 2011-12 fiscal year. However, it was decided by Nalcor that some of the work needed to be postponed until a later date. The back-up gauge station above Grizzle Rapids was installed in 2012. Additional developments remain on hold for the 2012-13 year.

Prepared by:
Grace De Beer – Environmental Scientist
Department of Environment and Conservation
Water Resources Management Division
Phone: 709.896.5542
Fax: 709.896.9566

Appendix 1


Average Daily Air Temperatures and Total Precipitation: Goose Bay, NL
June 29 to November 7, 2012
Precipitation (mm)
Temperature (°C)
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
26
24
22
20
18
16
14
12
10
8
6
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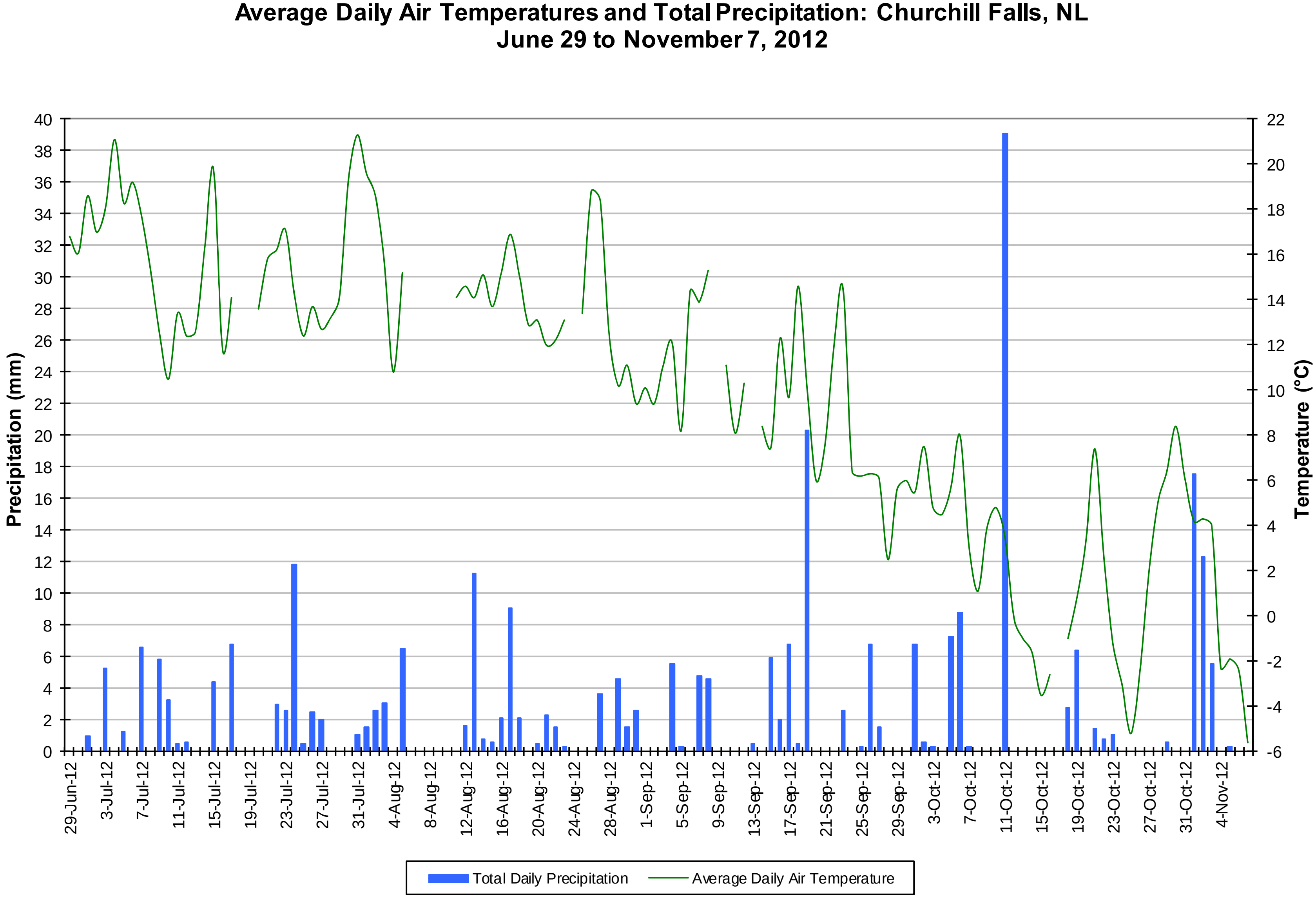
2
0
-2
-4
29-Jun-12
3-Jul-12
7-Jul-12
11-Jul-12
15-Jul-12
19-Jul-12
23-Jul-12
27-Jul-12
31-Jul-12
4-Aug-12
8-Aug-12
12-Aug-12
16-Aug-12
20-Aug-12
24-Aug-12
28-Aug-12
1-Sep-12
5-Sep-12
9-Sep-12
13-Sep-12
17-Sep-12
21-Sep-12
25-Sep-12
29-Sep-12
3-Oct-12
7-Oct-12
11-Oct-12
15-Oct-12
19-Oct-12
23-Oct-12
27-Oct-12
31-Oct-12
4-Nov-12
Total Daily Precipitation
Average Daily Air Temperature


Average Daily Air Temperatures and Total Precipitation: Churchill Falls, NL
June 29 to November 7, 2012
Precipitation (mm)
Temperature (°C)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
-6
-4
-2
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29-Jun-12
3-Jul-12
7-Jul-12
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3-Oct-12
7-Oct-12
11-Oct-12
15-Oct-12
19-Oct-12
23-Oct-12
27-Oct-12
31-Oct-12
4-Nov-12
Total Daily Precipitation
Average Daily Air Temperature