Real-Time Water Quality Deployment Report

Lower Churchill River Network

September 25 to November 7, 2012

Newfoundland Labrador

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

Contents

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General

- Department of Environment and Conservation staff monitors the real-time web pages regularly.
- This deployment report discusses water quality related events occurring at the four stations on the Lower Churchill River: below Metchin River, below Grizzle Rapids and above and below Muskrat Falls.
- On September 25-26, 2012, real-time water quality monitoring instruments were deployed at the four Lower Churchill River Stations for periods of 37-44 days. Instruments were removed on October 31, November 1 & 7.

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 1).

Table 1: 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 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.

- Deployment and removal comparison rankings for the Lower Churchill River stations deployed from September 25-26 to October 31, and November 1 & 7, 2012 are summarized in Table 2.

Table 2: Comparison rankings for Lower Churchill River stations, September 25-26 – October 31, November 1 & 7, 2012

Churchill River Station and Instrument Number	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Below Metchin River (45701)	Sep 25, 2012	Deployment	Excellent	Excellent	Excellent	n/a†	Excellent
	Oct 31, 2012	Removal	Excellent	Marginal	Excellent	Good	Excellent
Below Grizzle Rapids (45699)	Sep 25, 2012	Deployment	Excellent	Excellent	Excellent	n/a†	Excellent
	Nov 7, 2012	Removal	Excellent	Marginal	Excellent	Excellent	Excellent
Above Muskrat Falls (47590)	Sep 25, 2012	Deployment	Excellent	Excellent	Excellent	n/a†	Good
	Nov 1, 2012	Removal	Excellent	Marginal	Good	Excellent	Good
Below Muskrat Falls (47589)	Sep 26, 2012	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	Nov 1, 2012	Removal	Good	Poor	Excellent	Excellent	Good

†Comparison ranking unavailable due to dissolved oxygen sensor malfunction on the QAQC instrument 47592 on September 25.

- At the station below Metchin River, all parameters ranked 'excellent' at deployment except for dissolved oxygen which was not ranked due to sensor malfunction on the QAQC instrument s/n 47592.

  At removal, temperature, specific conductivity, dissolved oxygen and turbidity all ranked either 'good' or 'excellent' while pH ranked 'marginal'.

  For pH, the field instrument read a value of 7.32 and the QAQC instrument read a value of 6.48. The discrepancy in these values leading to the 'marginal' ranking may in part be caused by the limited time the QAQC instrument was left to stabilize to the environment or the instrument may not have calibrated correctly in the laboratory prior to the field visit.

- At the station below Grizzle Rapids, all parameters ranked 'excellent' at deployment except for dissolved oxygen which was not ranked due to sensor malfunction on the QAQC instrument s/n 47592.

  At removal, temperature, specific conductivity, dissolved oxygen and turbidity all ranked 'excellent' while pH ranked 'marginal'.

  For pH the field instrument read a value of 6.93 and the QAQC instrument read a value of 6.12. The discrepancy in these values leading to the 'marginal' ranking may in part be caused by the limited time the QAQC instrument was left to stabilize to the environment or the instrument may not have calibrated correctly in the laboratory prior to the field visit.

- At the station above Muskrat Falls, all parameters ranked either 'good' or 'excellent' at deployment except for dissolved oxygen which was not ranked due to sensor malfunction on the QAQC instrument s/n 47592.

  At removal, temperature, specific conductivity, dissolved oxygen and turbidity all ranked either 'good' or 'excellent' while pH ranked 'marginal'.

For pH, the field instrument read a value of 6.88 and the QAQC instrument read a value of 6.05. The discrepancy in these values leading to the 'marginal' ranking may in part be caused by the limited time the QAQC instrument was left to stabilize to the environment or the instrument may not have calibrated correctly in the laboratory prior to the field visit.

- At the station below Muskrat Falls, all parameters ranked 'excellent' at deployment.

  At removal, temperature, specific conductivity, dissolved oxygen and turbidity all ranked either 'good' or 'excellent' while pH ranked 'poor'.

  For pH, the field instrument read a value of 6.47 and the QAQC instrument read a value of 5.30. The discrepancy in these values leading to the 'poor' ranking may in part be caused by the limited time the QAQC instrument was left to stabilize to the environment or the instrument may not have calibrated correctly in the laboratory prior to the field visit.

Data Interpretation

- The following graphs and discussion illustrate significant water quality-related events from September 25-26 to October 31, November 1 & 7 in the Lower Churchill River Network.
- 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.

Churchill River below Metchin River

- Water temperature ranges from 1.60 °C to 11.90°C during the deployment period (Figure 1).
- Water temperature is decreasing throughout the deployment period. This trend is expected due to the cooling air temperatures in the fall season (Figure 2).

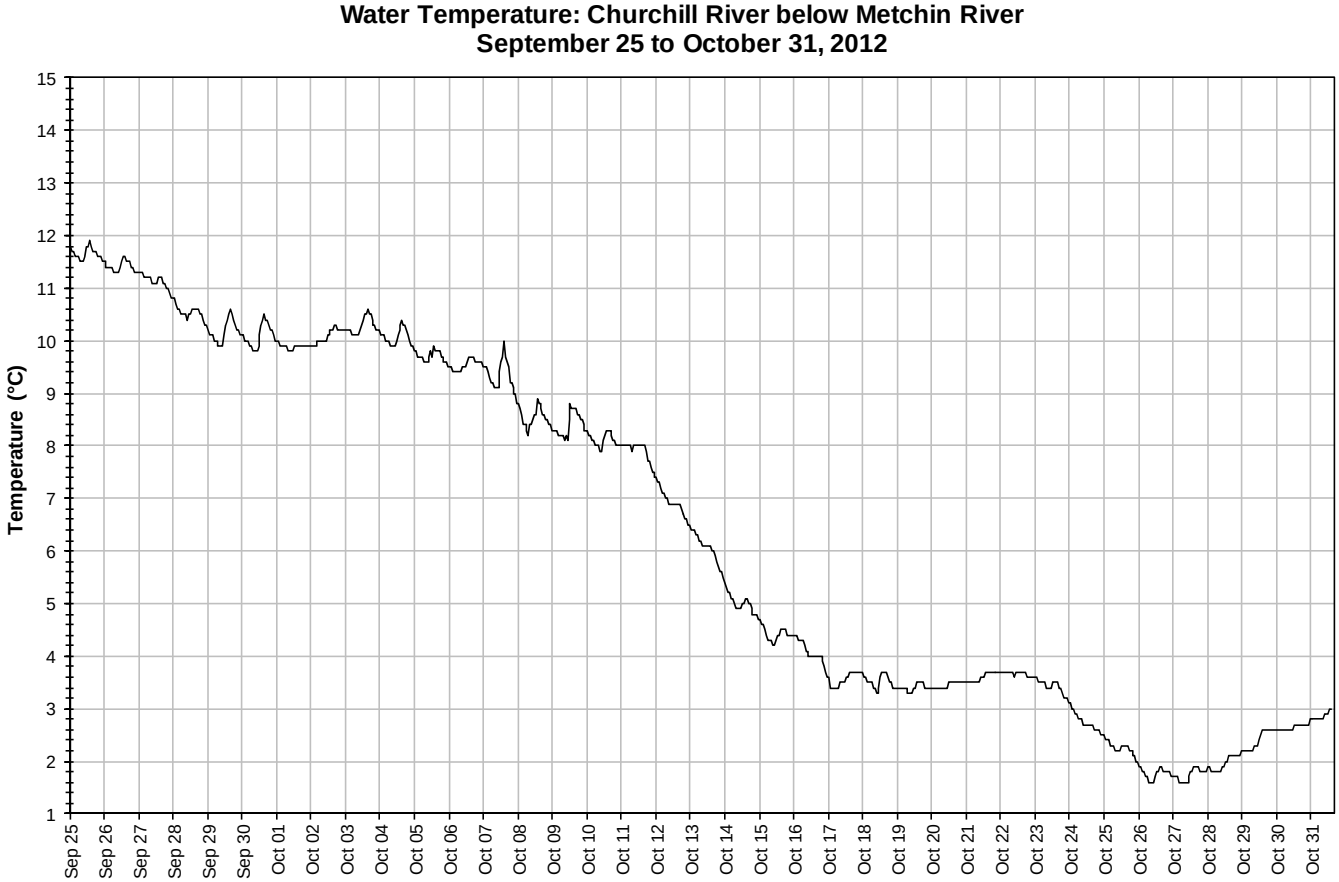

Figure 1: Water temperature at Churchill River below Metchin River

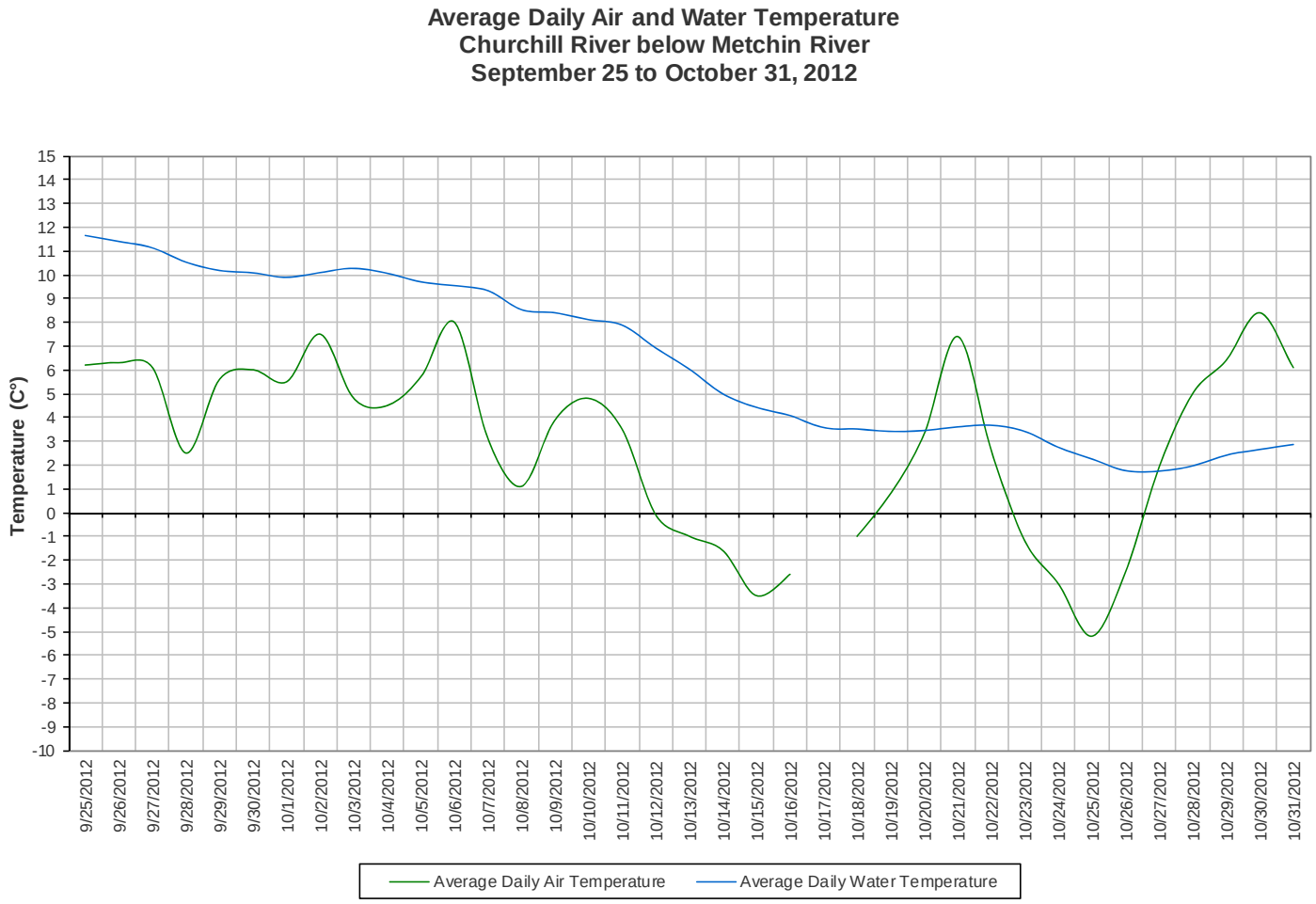

Figure 2: Average daily air and water temperature at Churchill River below Metchin River

(weather data recorded at Churchill Falls, NL)

- pH ranges between 6.98 and 7.20 pH units and remains very stable throughout the deployment period (Figure 3). Trends in pH levels were very similar at all stations in the network.
- All values during the deployment are within the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 3).

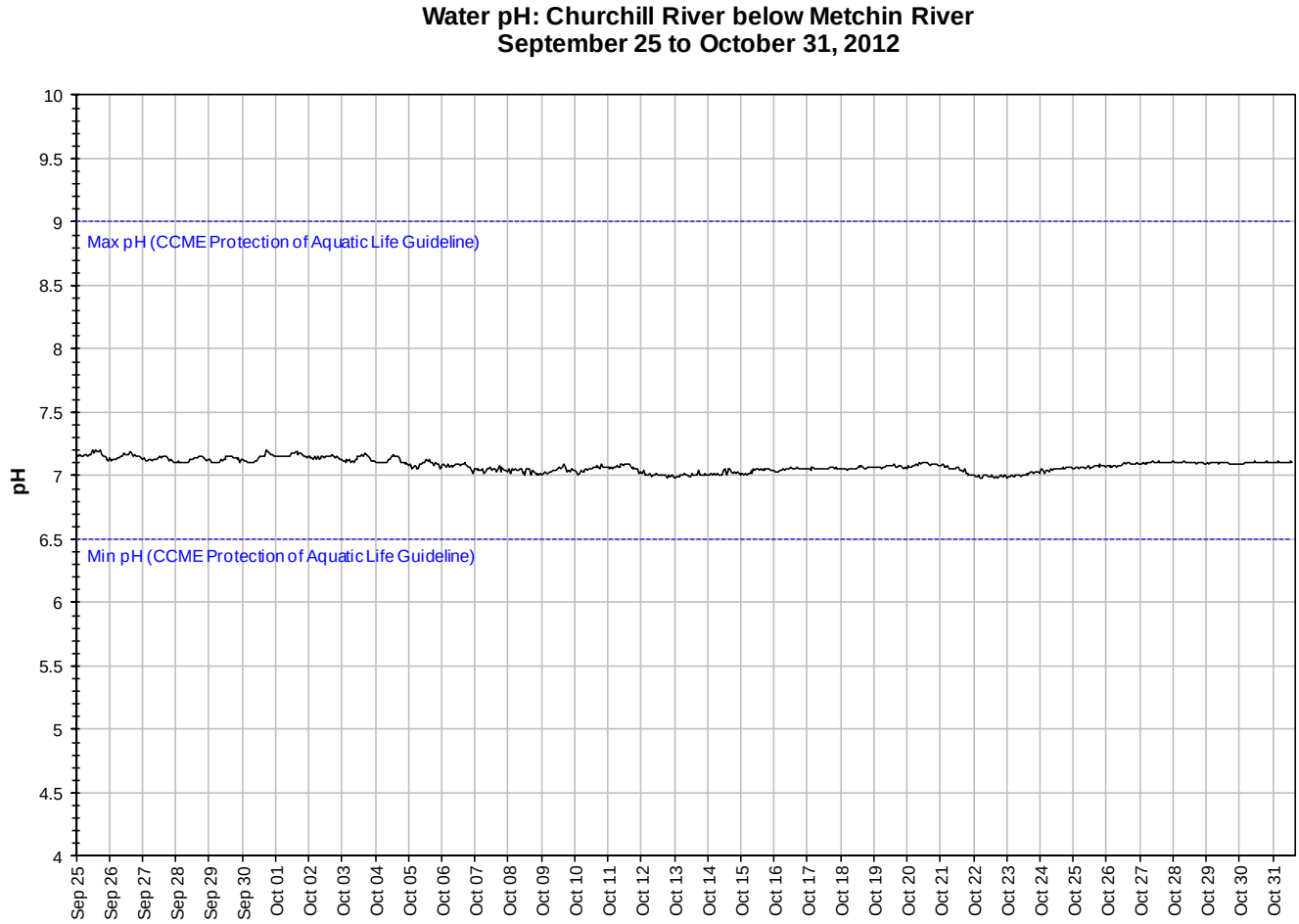

Figure 3: pH at Churchill River below Metchin River

- Specific conductivity generally ranges between 18.3 to 24.0µS/cm during the deployment period, averaging 20.5µS/cm (Figure 4).
- Specific conductivity is stable in the first 10 days of the deployment period and then increases to 24uS/cm for a period of 48 hours on October 7-9. This increase corresponds with a decrease in stage. Specific conductivity decreases after this for the remainder of the deployment period. This event is highlighted on Figure 4 in red.
- Stage is included in Figure 4 to illustrate the inverse relationship between conductivity and water level. Stage is fluctuating throughout most of the deployment period. Generally, as stage levels decrease, specific conductivity generally increases due to the increasing concentration of dissolved solids in the water column. Inversely, when stage increases, specific conductivity usually decreases as the concentration of dissolved solids is diluted. This trend is visible in the data collected during the deployment period and is indicated by red arrows in Figure 4.

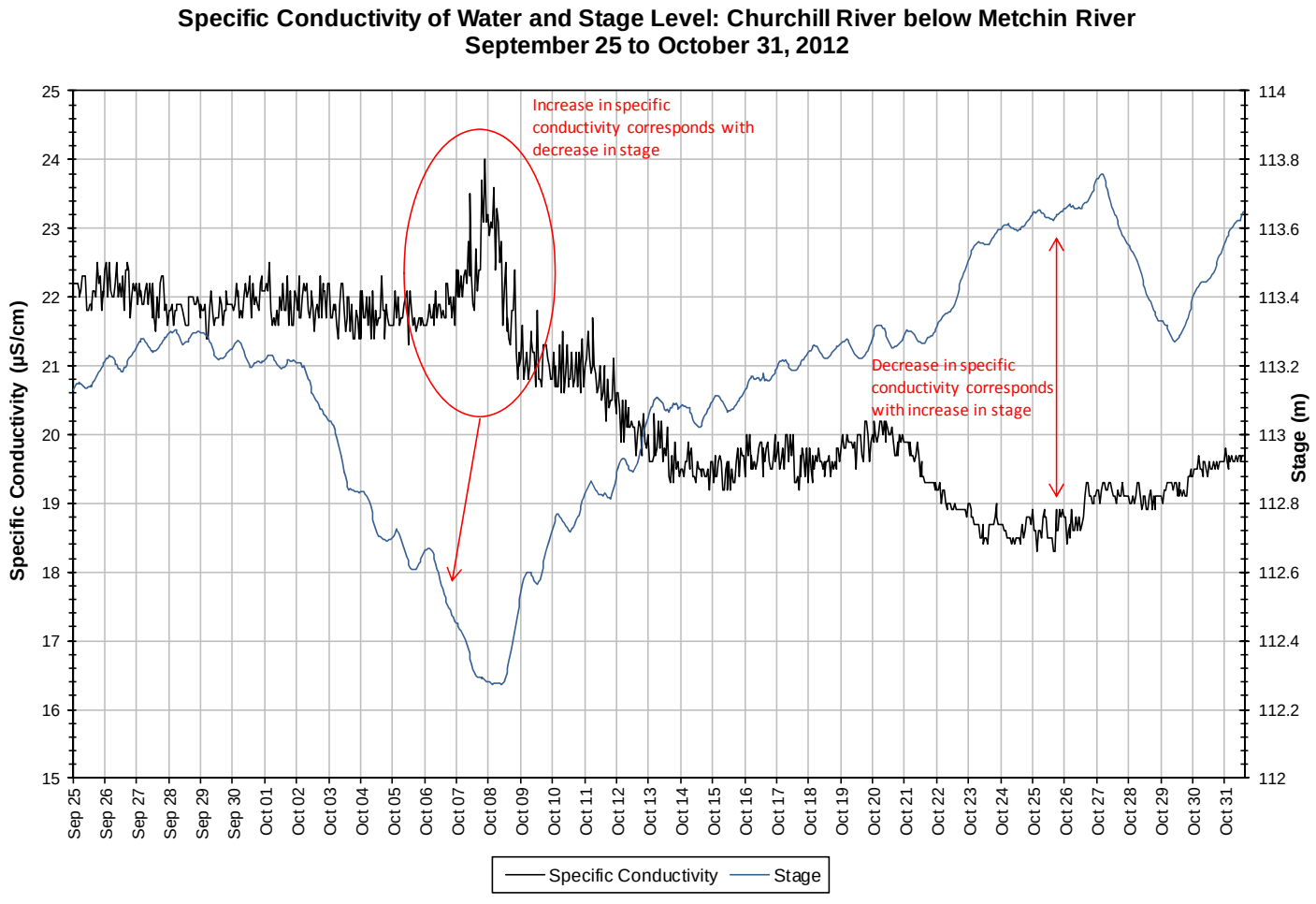

Figure 4: Specific conductivity and stage level at Churchill River below Metchin River

- Dissolved oxygen content ranges between 10.07mg/L and 12.80mg/L. The saturation of dissolved oxygen ranges from 88.4 to 95.8% (Figure 5).
- All values were above both the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages of 6.5 mg/l and Early Life Stages of 9.5 mg/l. The guidelines are indicated in blue on Figure 5.
- Dissolved oxygen content is increasing throughout the deployment period. This trend is expected given the cooling air and water temperatures (Figure 2).

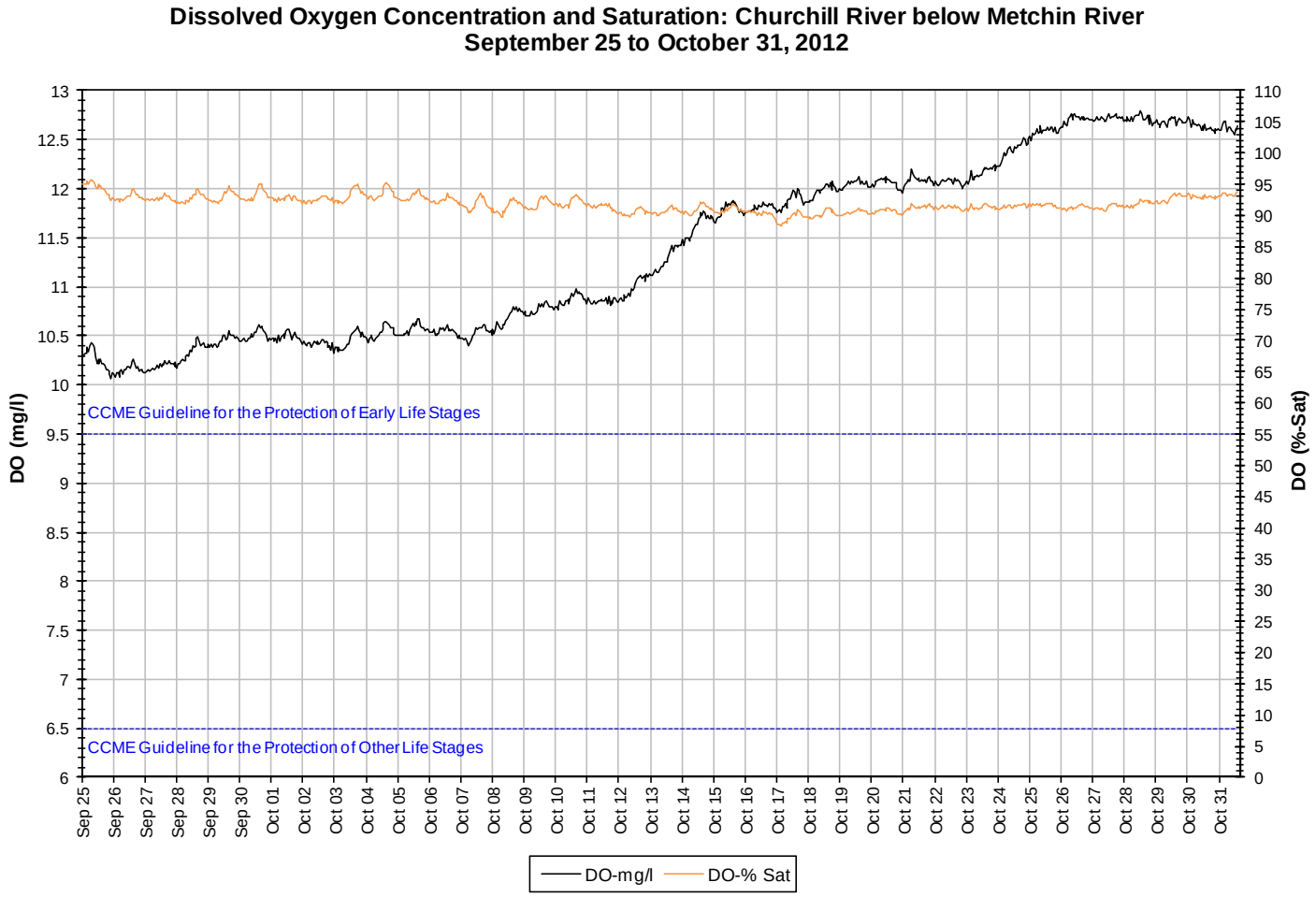

Figure 5: Dissolved oxygen and percent saturation at Churchill River below Metchin River

- Turbidity generally remains at 0NTU for the majority of the deployment period (Figure 6). A median value of 0NTU indicates there is no natural background turbidity value at this station.
- There are a few instances when turbidity increases above 0NTU. These turbidity increase are short-lived (1-2 hours) and low in magnitude (<18NTU). These insignificant events are unlikely to be caused by rainfall events.

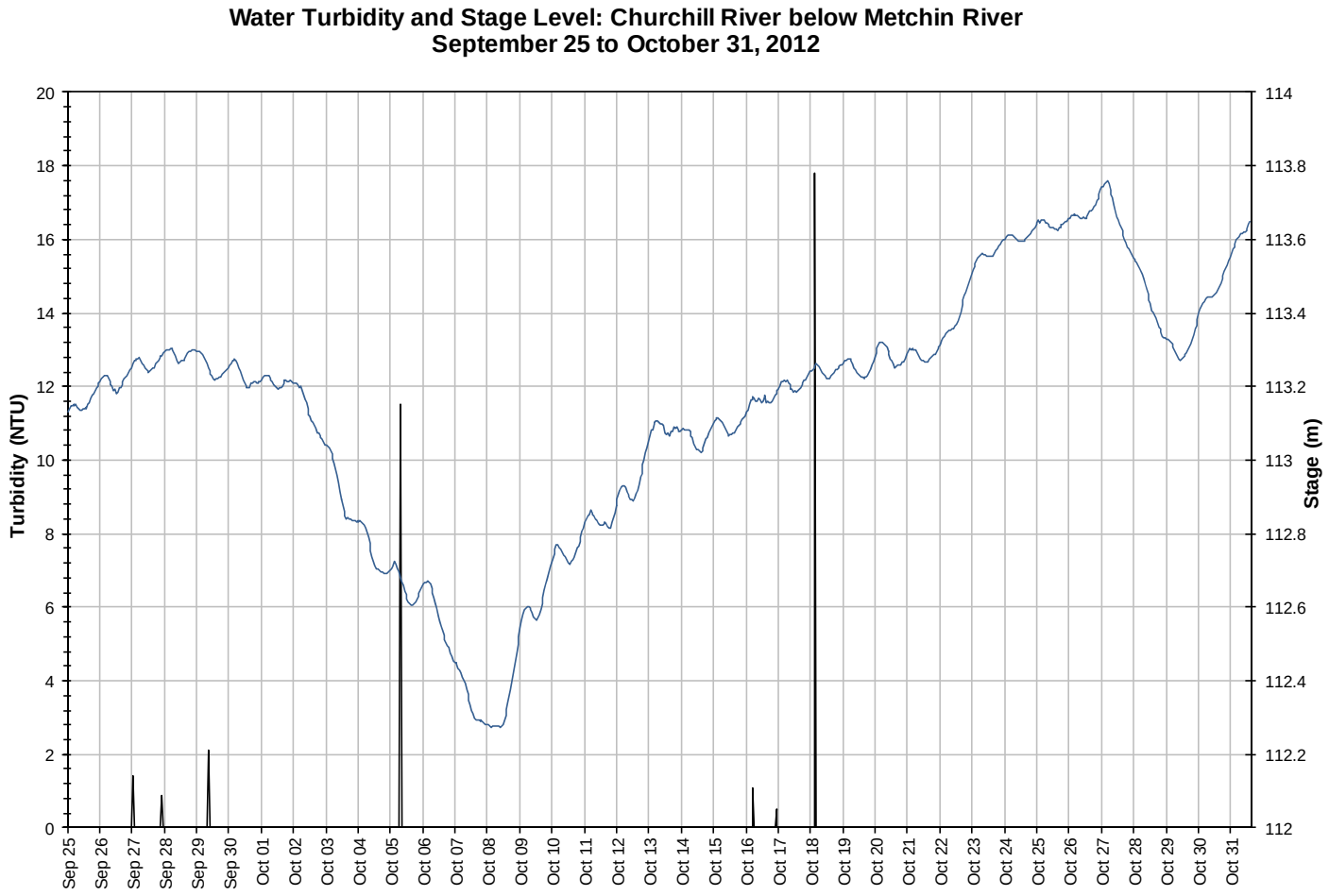

Figure 6: Turbidity and stage level at Churchill River below Metchin River

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 7). Stage is fluctuating throughout the deployment period, increasing throughout the majority. Precipitation records are generally low with one major event mid deployment. Stage ranges between 112.27m and 113.76m, a difference of 1.49m.

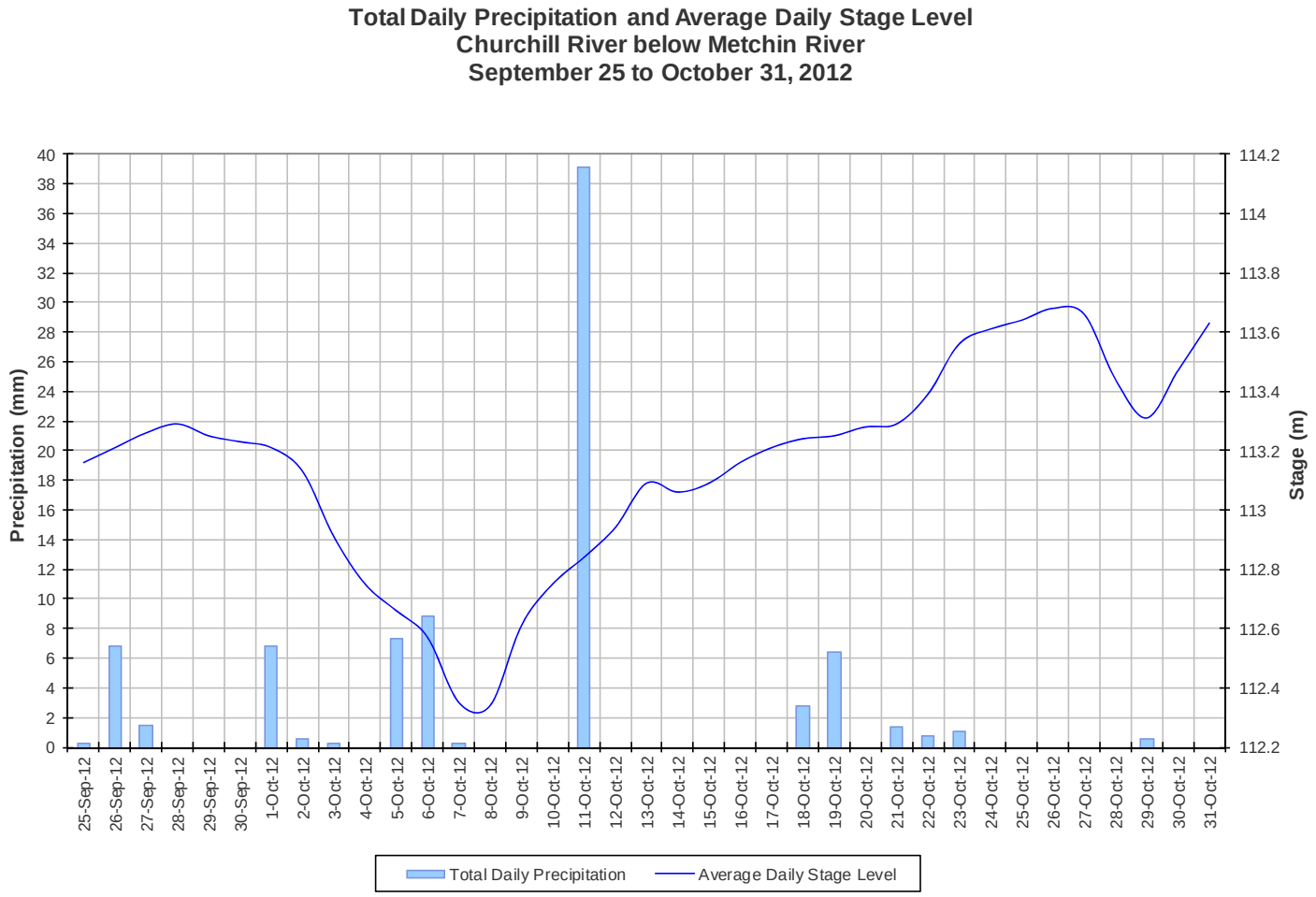

Figure 7: Daily precipitation and average daily stage level at Churchill River below Metchin River (weather data recorded at Churchill Falls)

Churchill River below Grizzle Rapids

- Water temperature ranges from 3.80 to 13.00^{o}C during the deployment period (Figure 8).
- Water temperature is decreasing throughout the deployment period. This trend is expected due to the cooling ambient air temperatures in the fall season (Figure 9). Water temperature fluctuates diurnally.

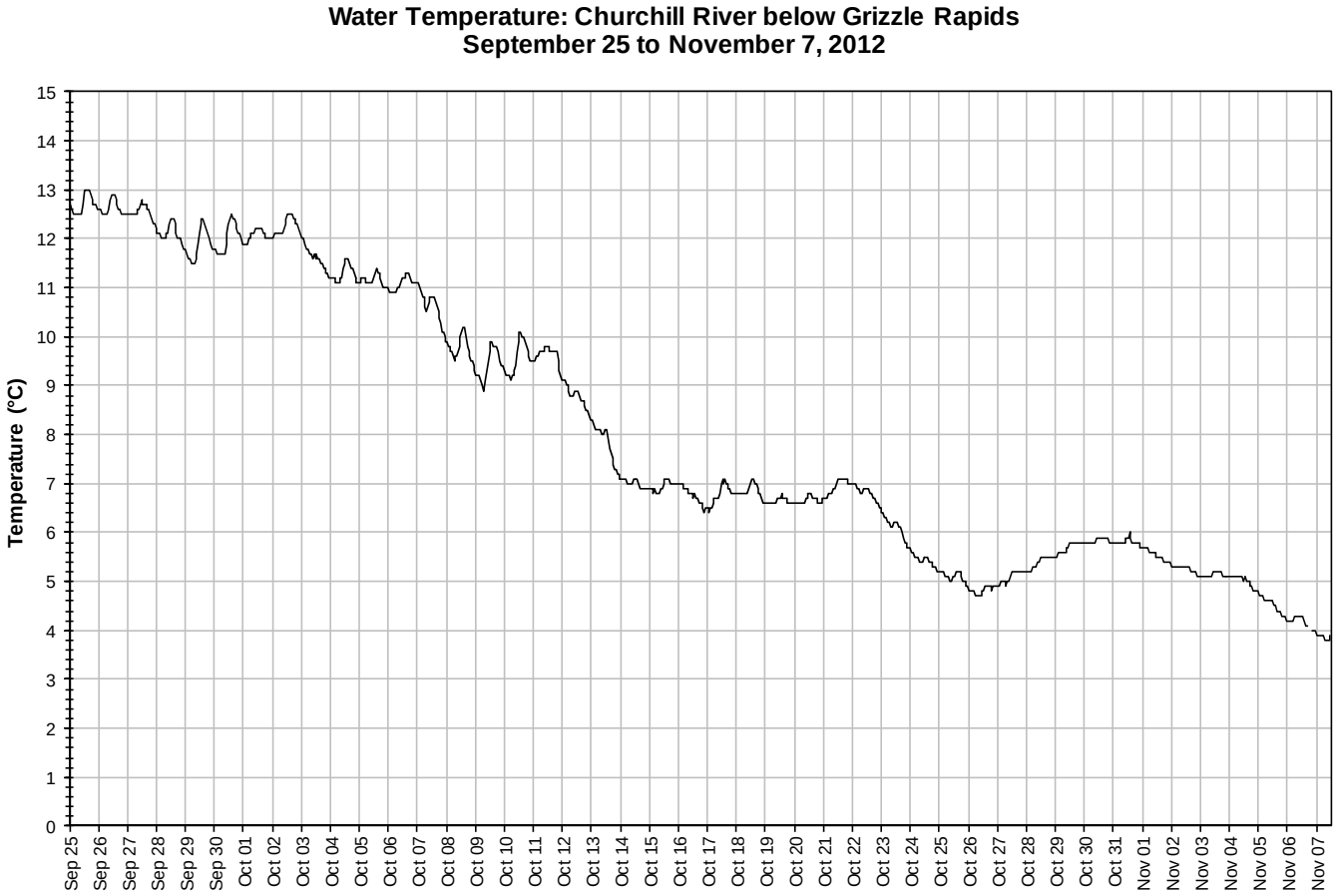

Figure 8: Water temperature at Churchill River below Grizzle Rapids

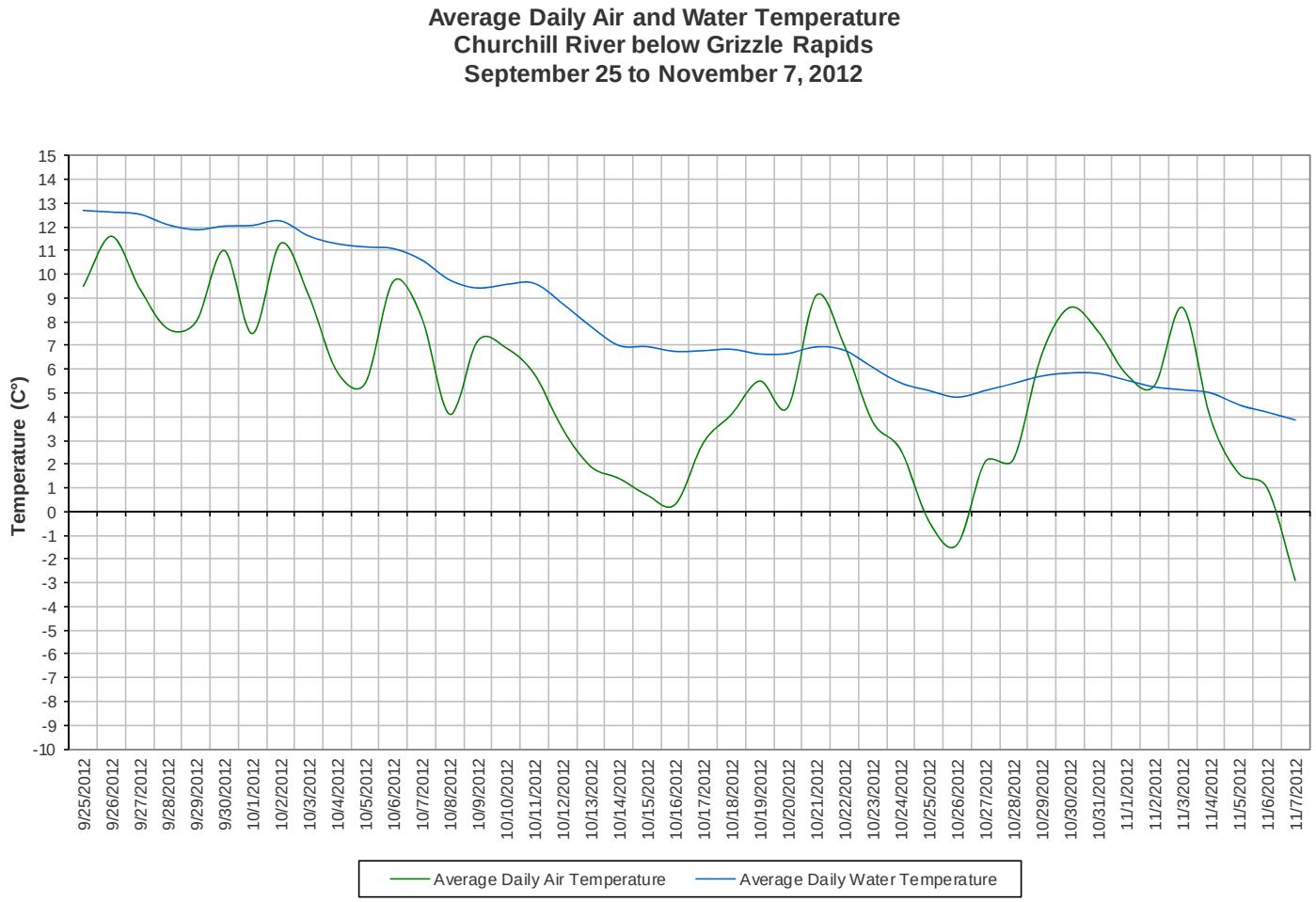

Figure 9: Average daily air and water temperature at Churchill River below Grizzle Rapids (weather data recorded at Goose Bay)

- pH ranges between 6.85 and 7.34 pH units (Figure 10). pH fluctuates consistently on a daily basis until about mid deployment. pH values then decrease slightly and remain very stable for the remainder of the deployment period. This pH decrease corresponds with a substantial decrease in water temperature around the same time. Trends in pH levels were very similar at all stations in the network.
- All values during the deployment are within the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 10).

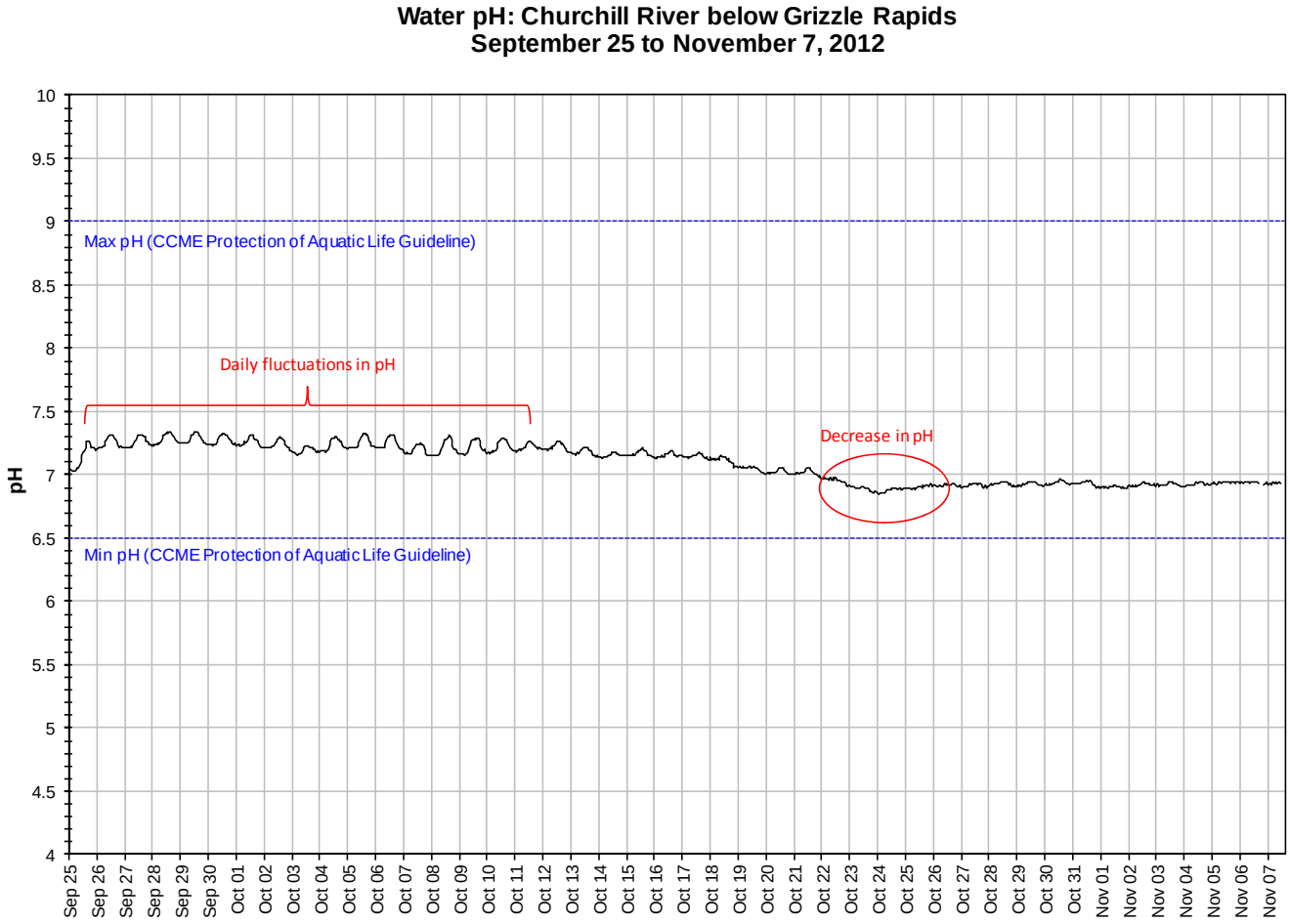

Figure 10: pH at Churchill River below Grizzle Rapids

- Specific conductivity ranges from 16.1 to 22.9µS/cm during the deployment period, averaging 19.3µS/cm (Figure 11).
- Specific conductance is decreasing throughout the first three weeks of the deployment period from ~22uS/cm to ~17uS/cm and stabilizes in the final two weeks.
- Stage is included in Figure 11 to illustrate the inverse relationship between conductivity and water level. Typically, stage is increasing throughout the deployment period with some fluctuations. Generally, as stage levels decrease, specific conductivity generally increases due to the increasing concentration of dissolved solids in the water column. Inversely, when stage increases, specific conductivity usually decreases as the concentration of dissolved solids is diluted.

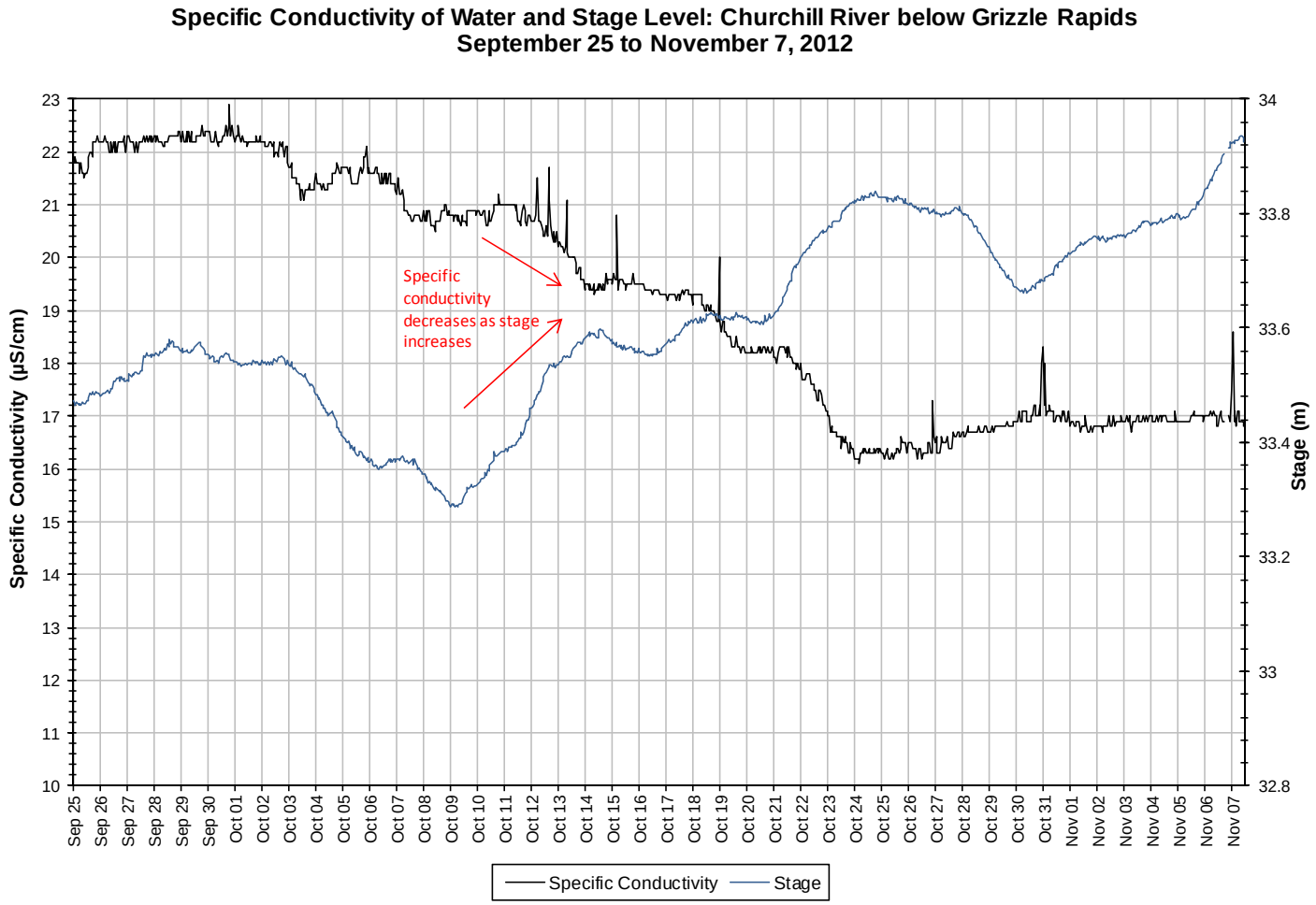

Figure 11: Specific conductivity and stage level at Churchill River below Grizzle Rapids

- Dissolved oxygen content ranges between 10.04mg/L and 12.34g/L. The saturation of dissolved oxygen ranges from 92.6 to 99.4% (Figure 12).
- All values were above both the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages of 6.5 mg/l and Early Life Stages of 9.5 mg/l. The guidelines are indicated in blue on Figure 12.
- Dissolved oxygen content is increasing throughout the deployment period. This trend is expected given the cooling air and water temperatures (Figure 9).

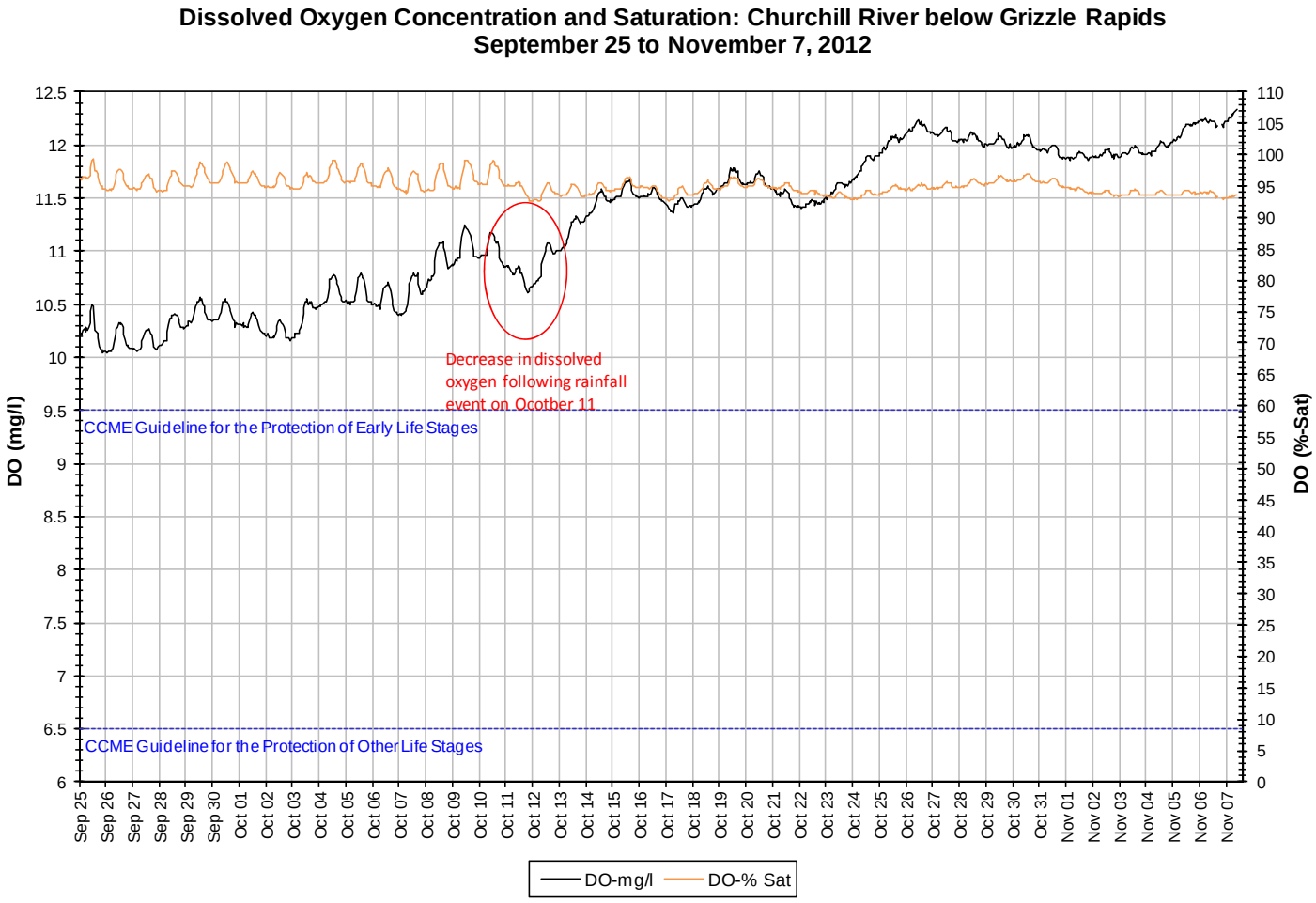

Figure 12: Dissolved oxygen and percent saturation at Churchill River below Grizzle Rapids

- Turbidity values generally remained at 0NTU for the majority of the deployment period (Figure 13). A median value of 0NTU at this station indicates there is no natural background turbidity.
- This trend is typical of this station as the river reach runs clearly and quickly though Grizzle Rapids. There is one instance where turbidity is recorded at 8.3NTU for a period of one hour.

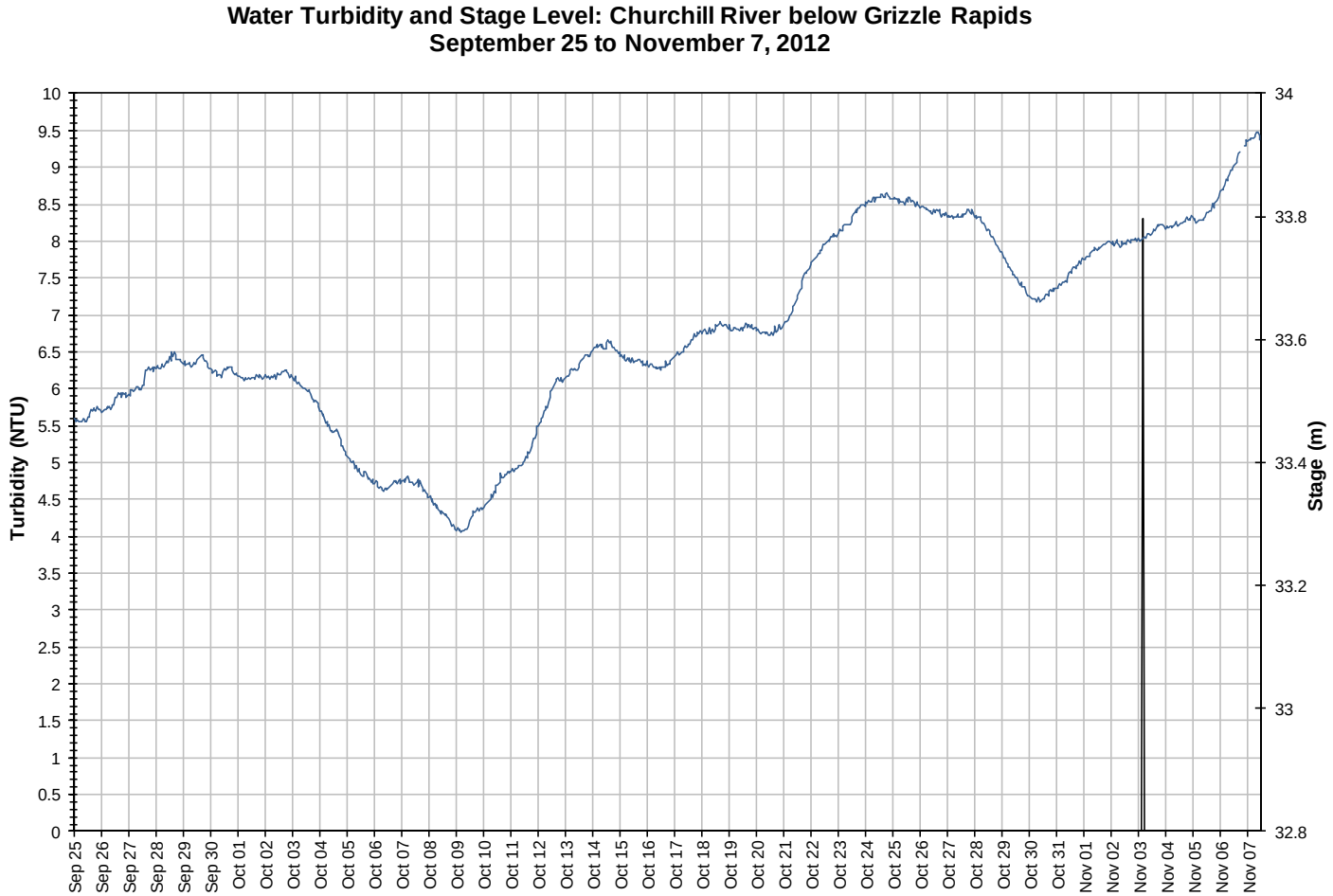

Figure 13: Turbidity at Churchill River below Grizzle Rapids

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 14). Stage is increasing slightly throughout the majority of the deployment period. Precipitation amounts are moderate in frequency and magnitude. Stage ranges between 33.29 and 33.94m, a difference of 0.65m.

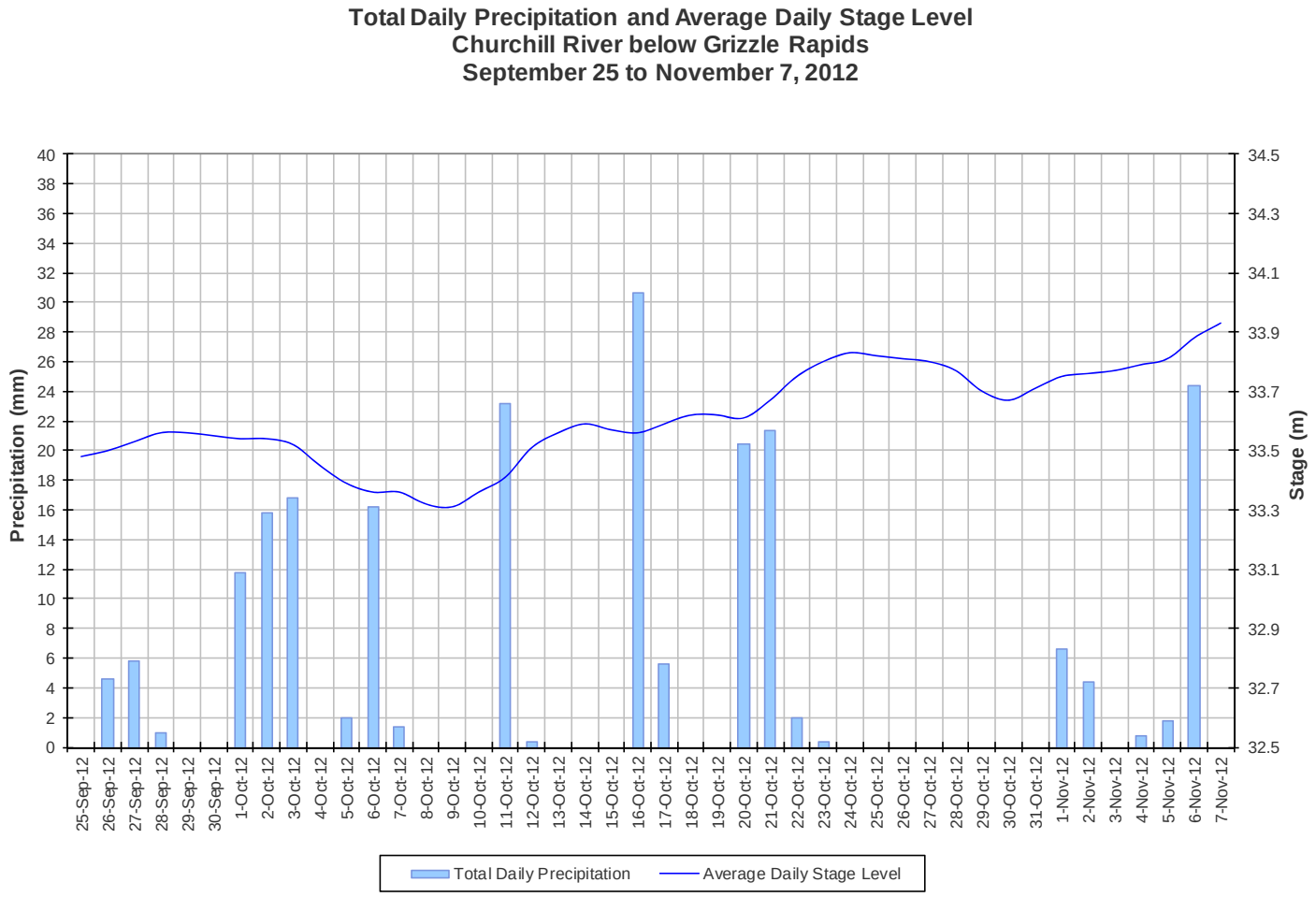

Figure 14: Daily precipitation and average daily stage level at Churchill River below Grizzle Rapids (weather data recorded at Goose Bay)

Churchill River above Muskrat Falls

- There was a transmission error at this station from October 6 to 23. During this time, water quality data retrieved from the instruments internal log file was used to illustrate water quality trends. Stage data is not available and daily averages are not calculated for this time period.
- Water temperature ranges from 4.10 to 13.67^{o}C during the deployment period (Figure 15).
- Water temperature is decreasing throughout the deployment period. This trend is expected given the cooling ambient air temperatures in the fall season (Figure 16). Water temperature fluctuates diurnally.

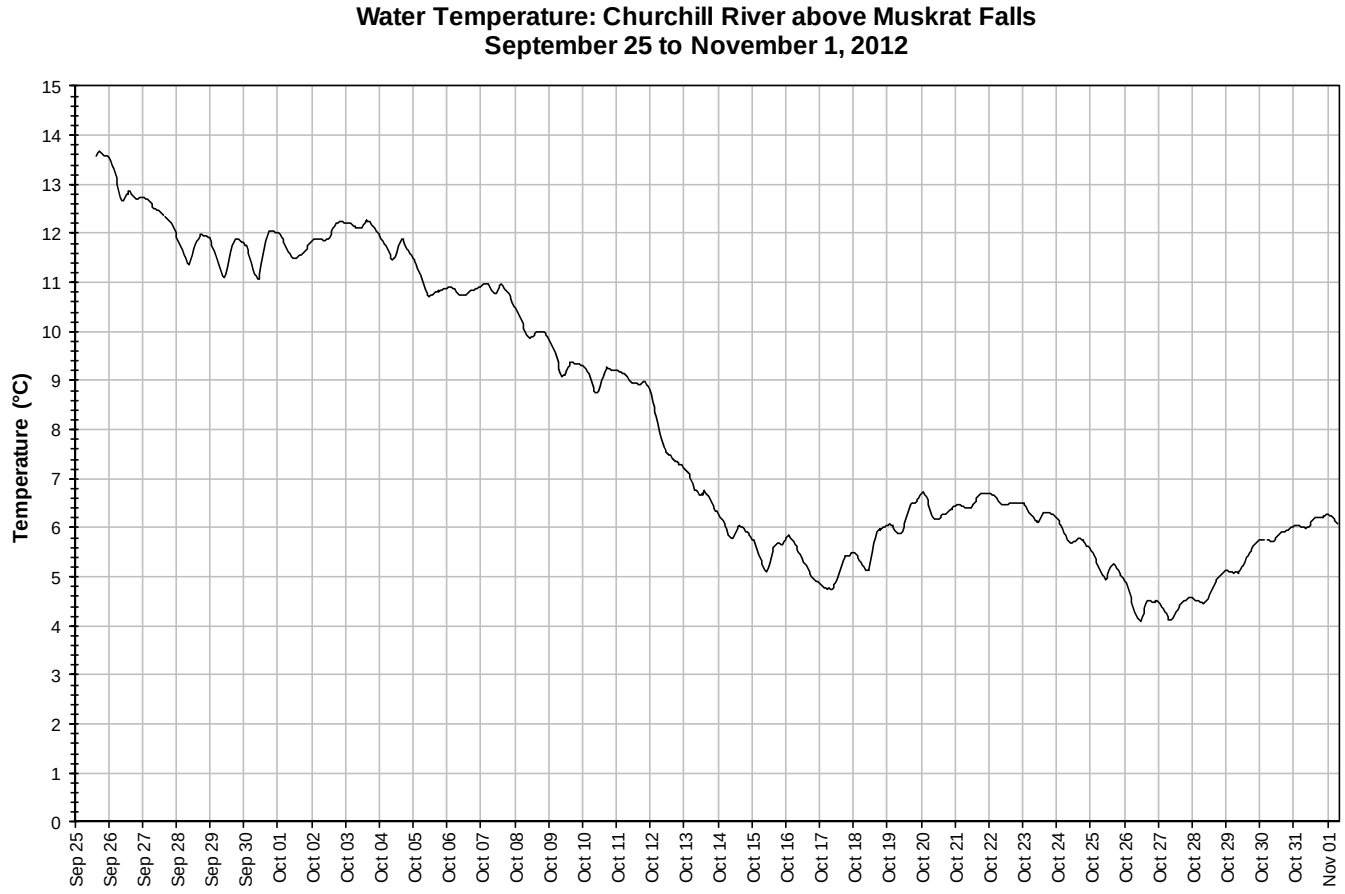

Figure 15: Water temperature at Churchill River above Muskrat Falls

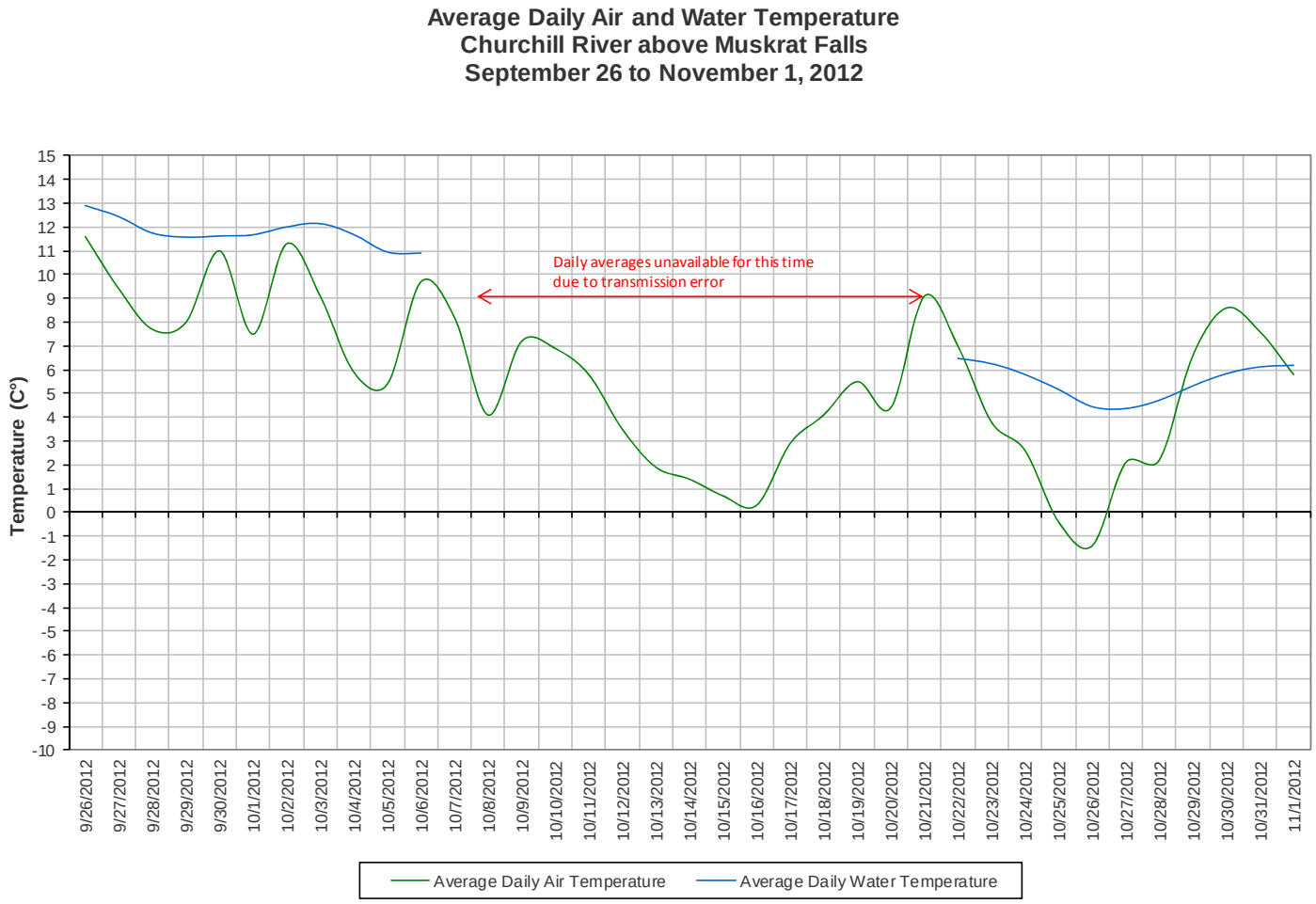

Figure 16: Average daily air and water temperature at Churchill River above Muskrat Falls (weather data recorded at Goose Bay)

- pH ranges between 6.78 and 7.22 pH units (Figure 17). pH values are very stable throughout the deployment period. There is a decrease in pH over October 21-22. This pH decrease corresponds with a substantial decrease in water temperature around the same time. Trends in pH levels were very similar at all stations in the network.
- All pH values recorded are within the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 17).

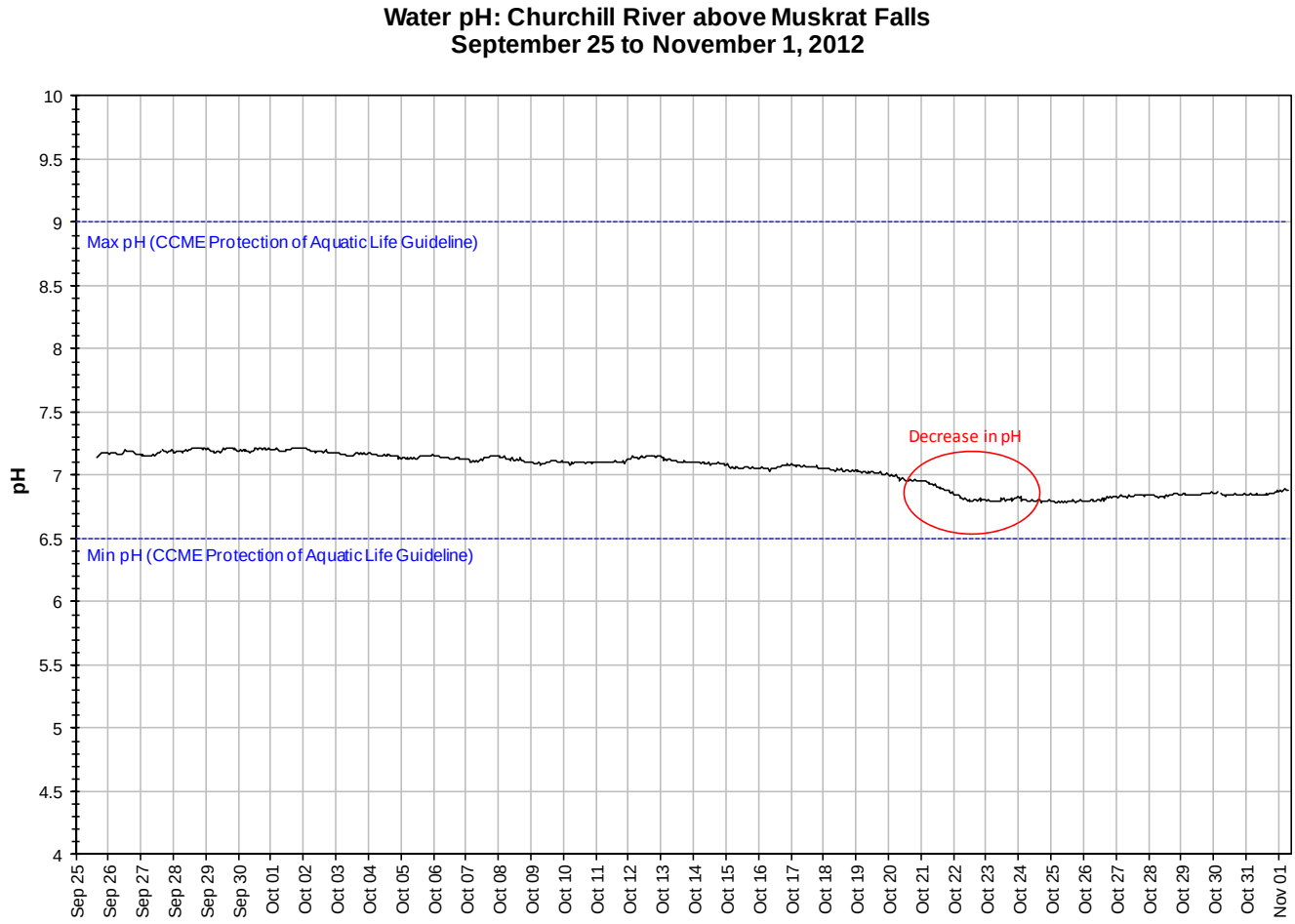

Figure 17: pH at Churchill River above Muskrat Falls

- Specific conductivity ranges from 14.7 to 21.3µS/cm during the deployment period, averaging 18.7µS/cm. (Figure 18).
- Specific conductance is decreasing throughout the majority of the deployment period. Between October 6 and 23, when the instruments internal log file data is used, specific conductivity is measured to 0 decimal places.
- Stage is included in Figure 18 to illustrate the inverse relationship between conductivity and water level. Stage is fluctuating throughout the majority of the deployment period. Generally, as stage levels decrease, specific conductivity generally increases due to the increasing concentration of dissolved solids in the water column. Inversely, when stage increases, specific conductivity usually decreases as the concentration of dissolved solids is diluted.

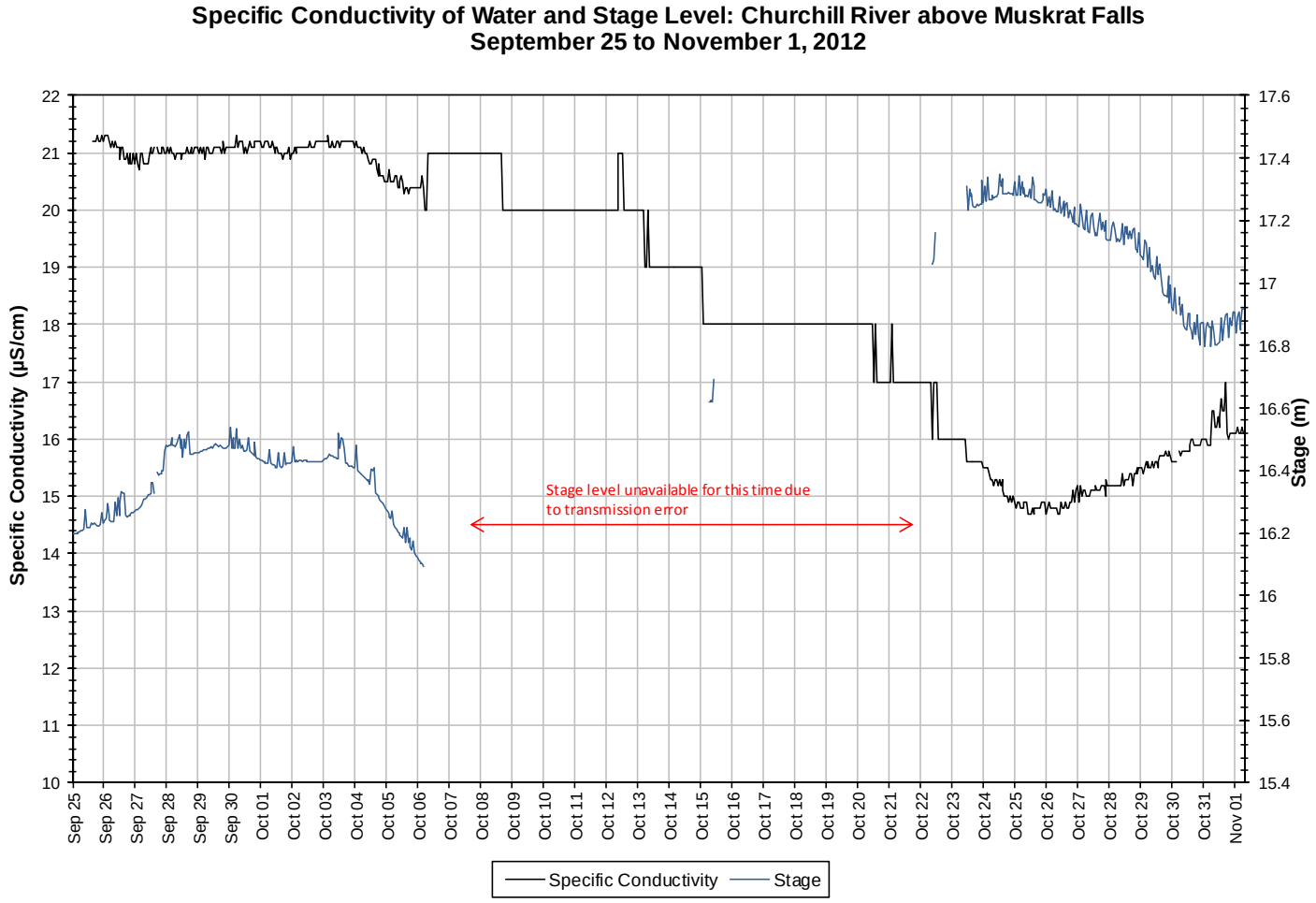

Figure 18: Specific conductivity and stage level at Churchill River above Muskrat Falls

- Dissolved oxygen content ranges between 10.04mg/L and 12.38g/L. The saturation of dissolved oxygen ranges from 92.4 to 99.0% (Figure 19).
- All values were above both the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages of 6.5 mg/l and Early Life Stages of 9.5 mg/l. The guidelines are indicated in blue on Figure 19.
- Dissolved oxygen content is increasing throughout the deployment period. This trend is expected given the cooling air and water temperatures (Figure 16).

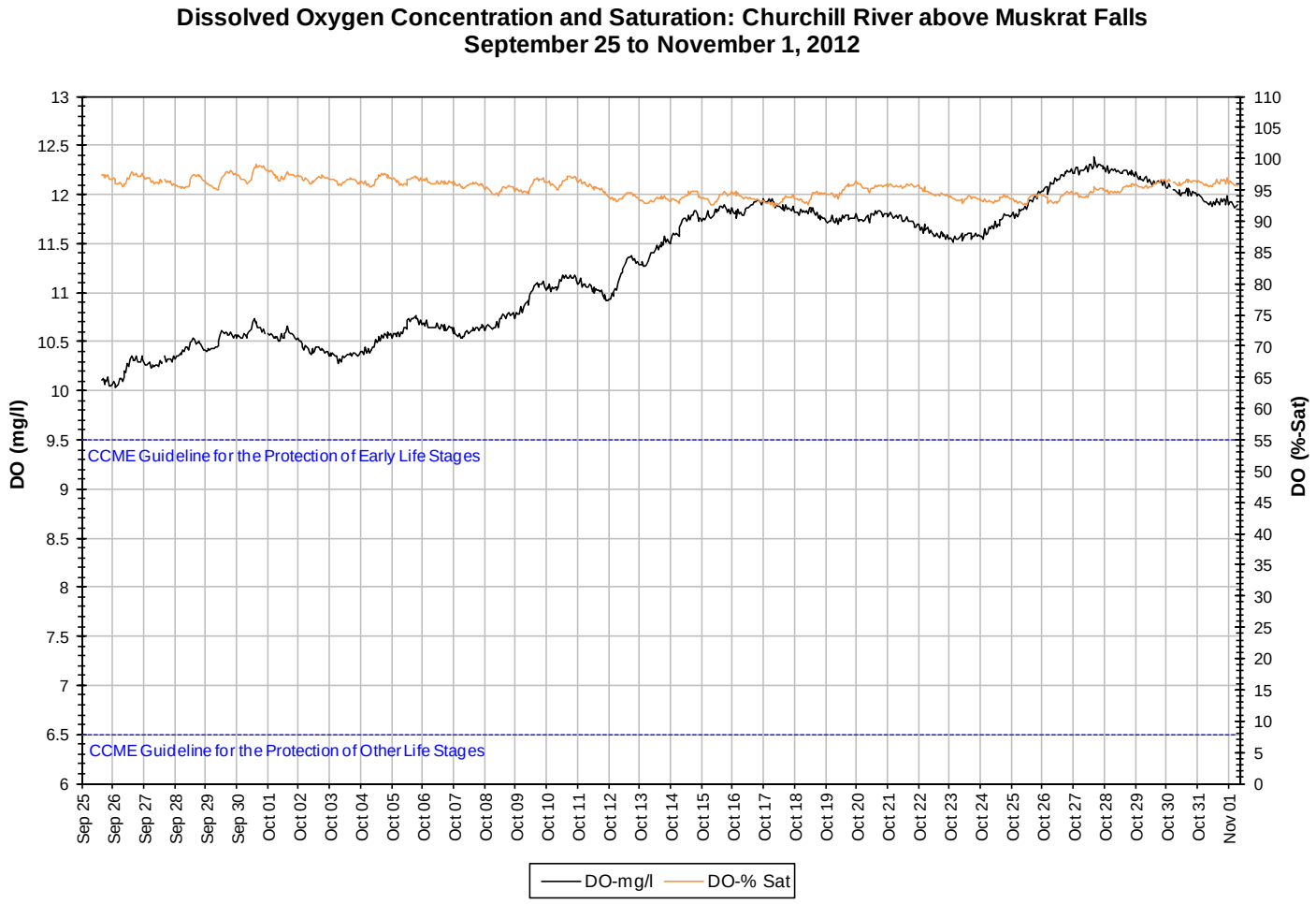

Figure 19: Dissolved oxygen and percent saturation at Churchill River above Muskrat Falls

- Turbidity generally ranges between 1 and 95NTU, averaging 8.1NTU (Figure 20). A median value of 4.2NTU indicates there is a consistent natural background turbidity value. This trend is typical at this station.
- There are several increases in turbidity throughout the deployment period lasting between 1 hour and 4 days. On September 30, turbidity increases several times throughout the day however, does not remain consistently high. This event does not correspond with any weather related events. On October 7-8, turbidity increases slightly following a rainfall event on October 6. Similarly, following a rainfall event on October 11, turbidity increases in the days following however this time at a greater magnitude for a longer period of time (October 12-16). These events and others are highlighted by the red arrows on Figure 20.

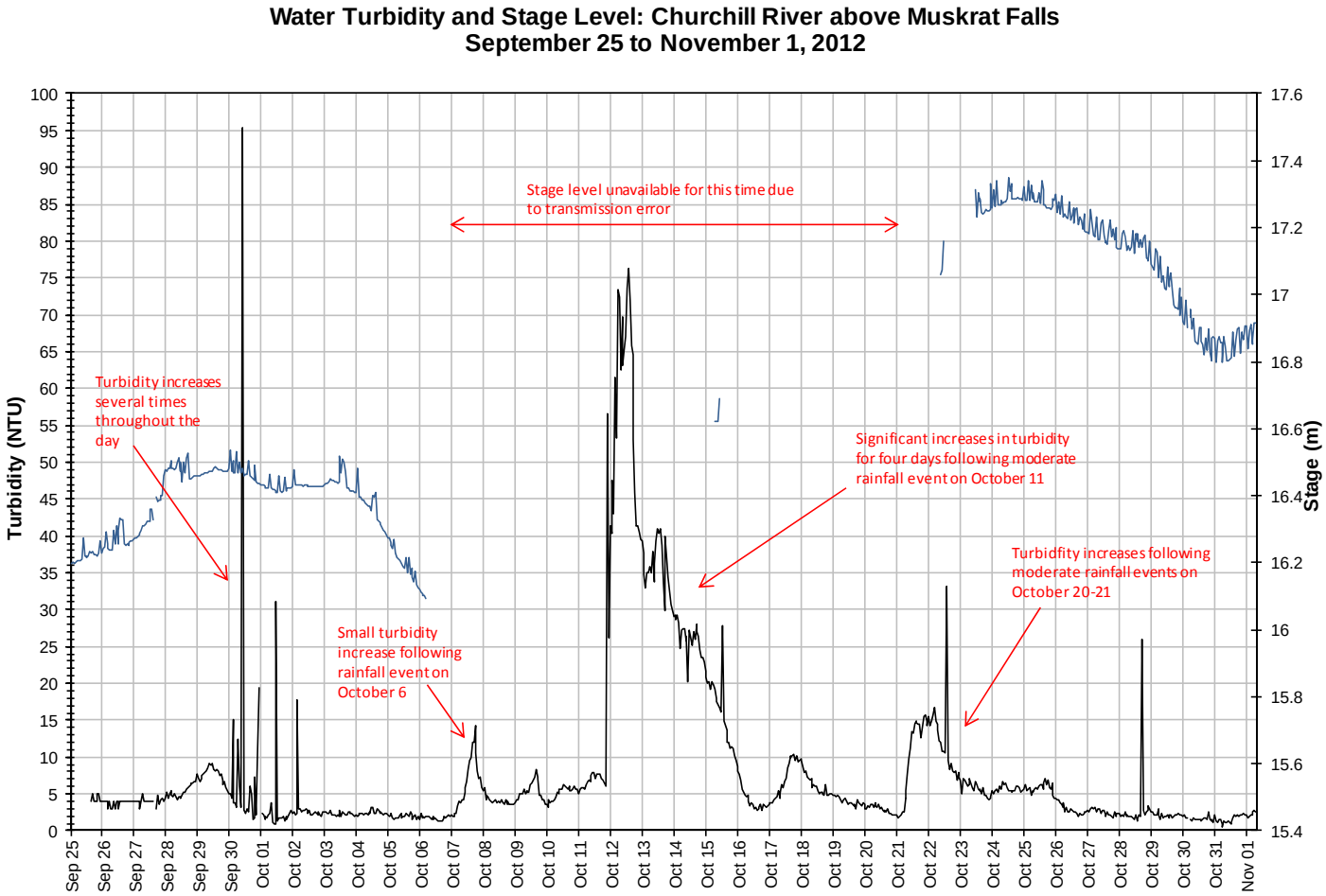

Figure 20: Turbidity and stage level at Churchill River above Muskrat Falls

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 21). Stage data is unavailable for much of the deployment period due to a transmission error from October 6 to 23. Precipitation records are moderate in frequency and magnitude. From the information available, stage ranges between 16.09 and 16.62m, a difference of 0.53m.

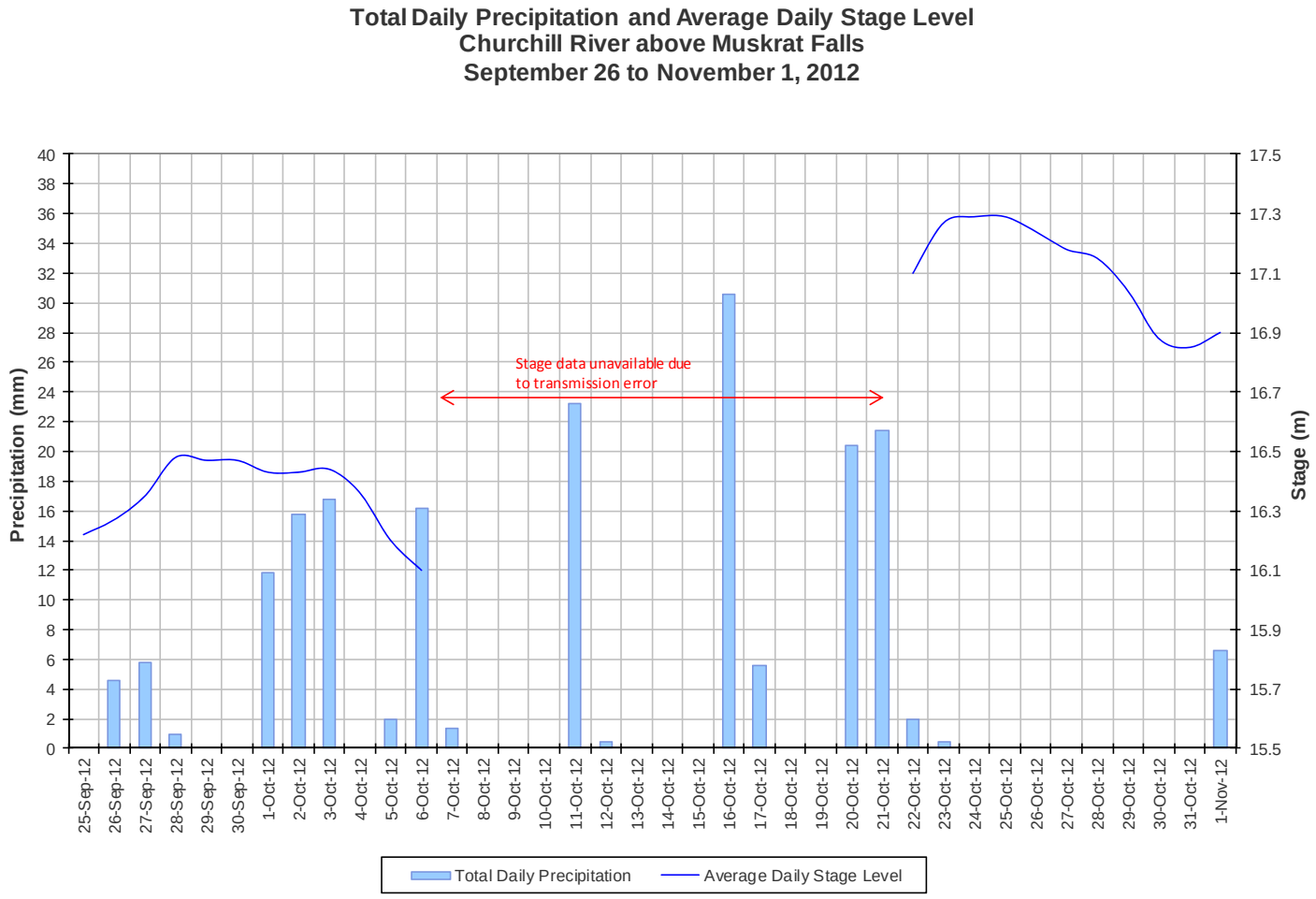

Figure 21: Daily precipitation and average daily stage level at Churchill River above Muskrat Falls (weather data recorded at Goose Bay)

Churchill River below Muskrat Falls

- Water temperature ranges from 4.50 to 13.70^{o}C during the deployment period (Figure 22).
- Water temperature is decreasing throughout the deployment period. This trend is expected given the cooling ambient air temperatures in the fall season (Figure 23). Water temperature fluctuates diurnally.

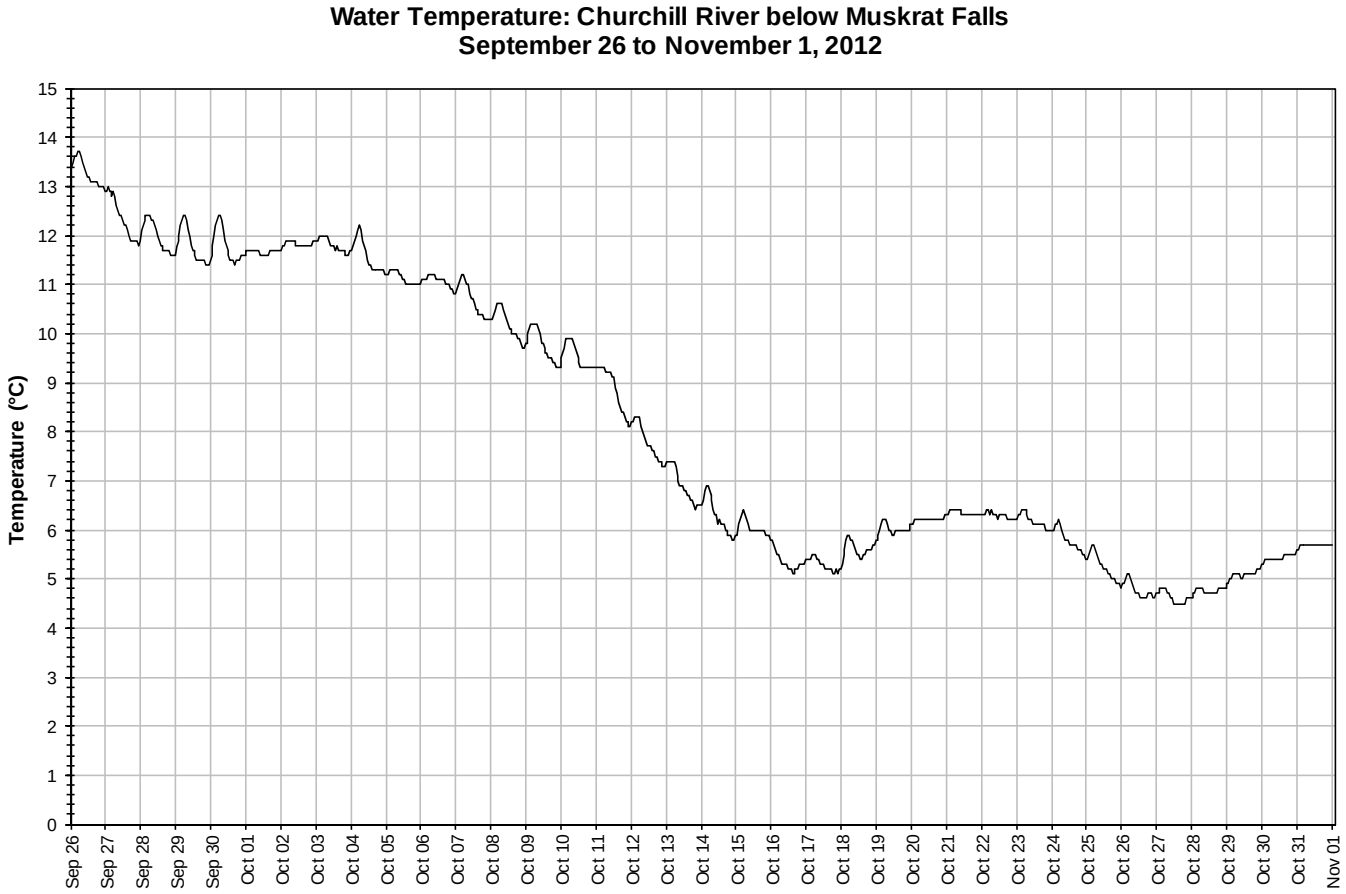

Figure 22: Water temperature at Churchill River below Muskrat Falls

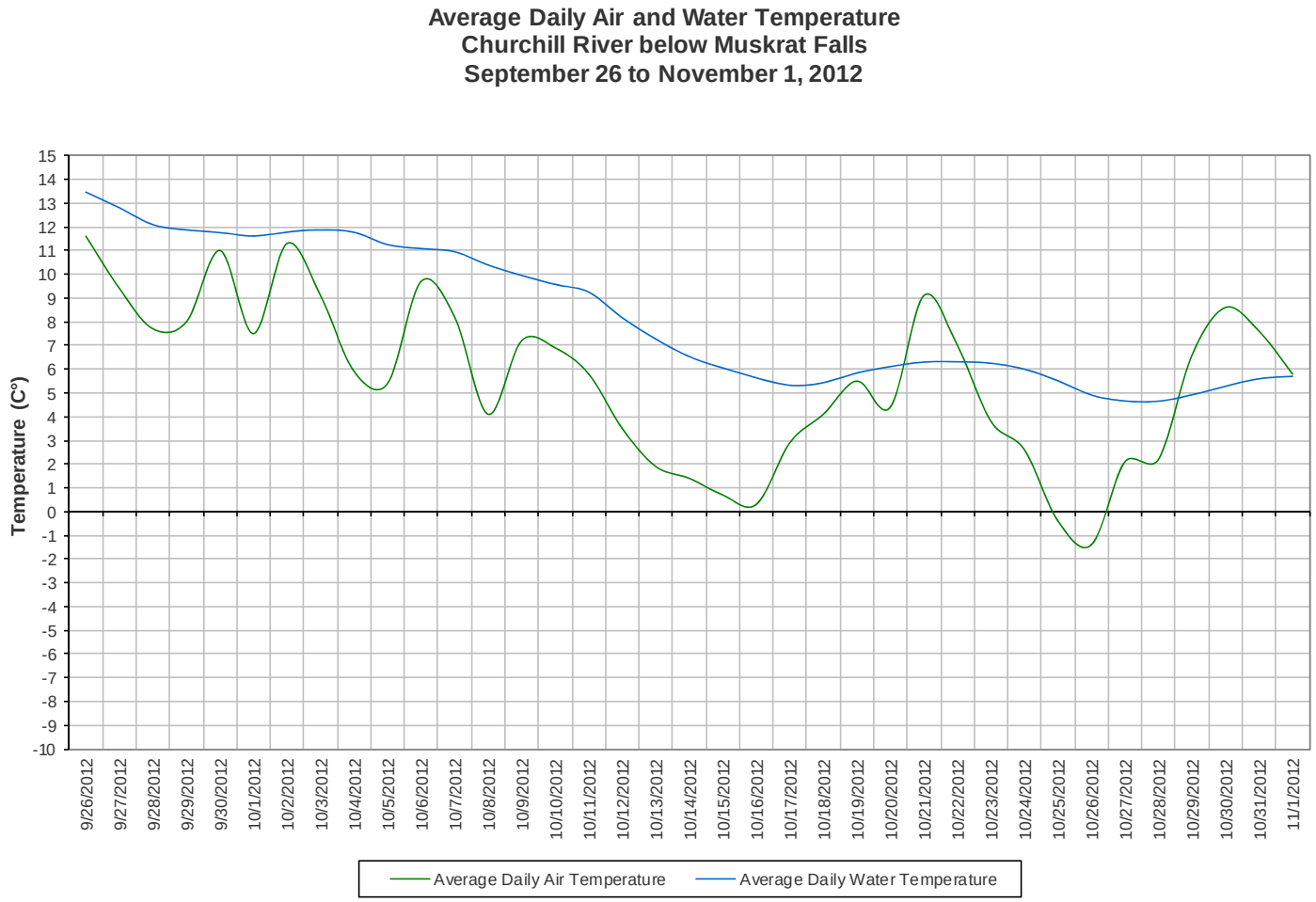

Figure 23: Average daily air and water temperature at Churchill River below Muskrat Falls

(weather data recorded at Goose Bay)

- pH ranges between 6.63 and 7.29 pH units (Figure 24). pH fluctuates slightly on a daily basis until about mid deployment. pH values then decrease gradually for the remainder of the deployment period. This pH decrease corresponds with a substantial decrease in water temperature around the same time. Trends in pH levels were very similar at all stations in the network.
- All values during the deployment are within the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 24).

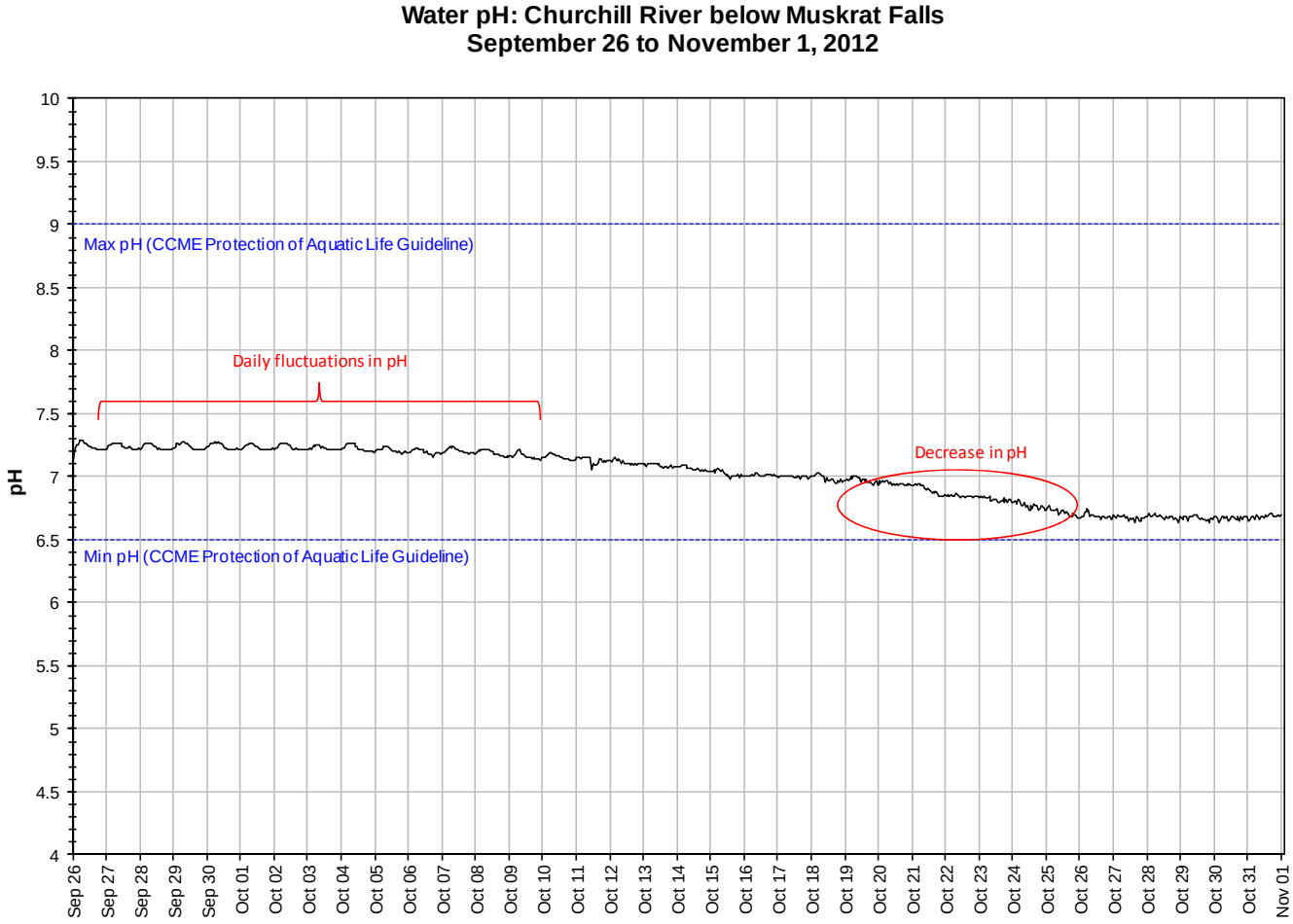

Figure 24: pH at Churchill River below Muskrat Falls

- Specific conductance ranges between 15.8 and 23.0µS/cm during the deployment period, averaging 19.7µS/cm (Figure 25).
- Specific conductivity is generally decreasing throughout the deployment period as stage is increasing.
- Stage is included in Figure 25 to illustrate the inverse relationship between conductivity and water level. Generally, as stage levels decrease, specific conductivity generally increases due to the increasing concentration of dissolved solids in the water column. Inversely, when stage increases, specific conductivity usually decreases as the concentration of dissolved solids is diluted.

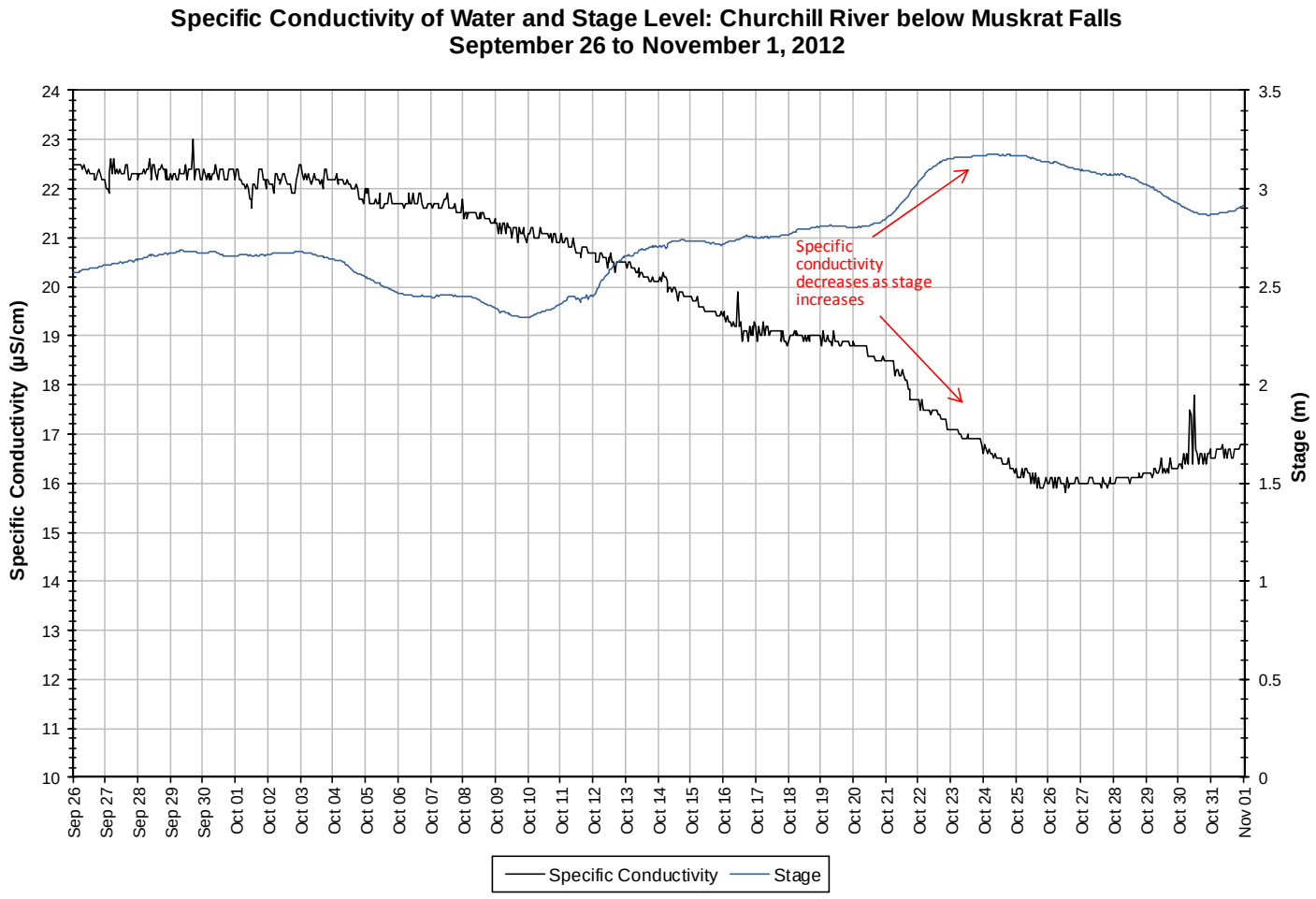

Figure 25: Specific conductivity and stage level at Churchill River below Muskrat Falls

- Dissolved oxygen content ranges between 11.09mg/L and 14.26g/L. The saturation of dissolved oxygen ranges from 97.7 to 112.0% (Figure 26).
- All values were above both the minimum CCME Guidelines for the Protection of Cold Water Biota at Other Life Stage of 6.5 mg/l and at Early Life Stages of 9.5mg/l. The guidelines are indicated in blue on Figure 26.
- Dissolved oxygen content is increasing throughout the deployment period. This trend is expected given the cooling air and water temperatures (Figure 23). 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.

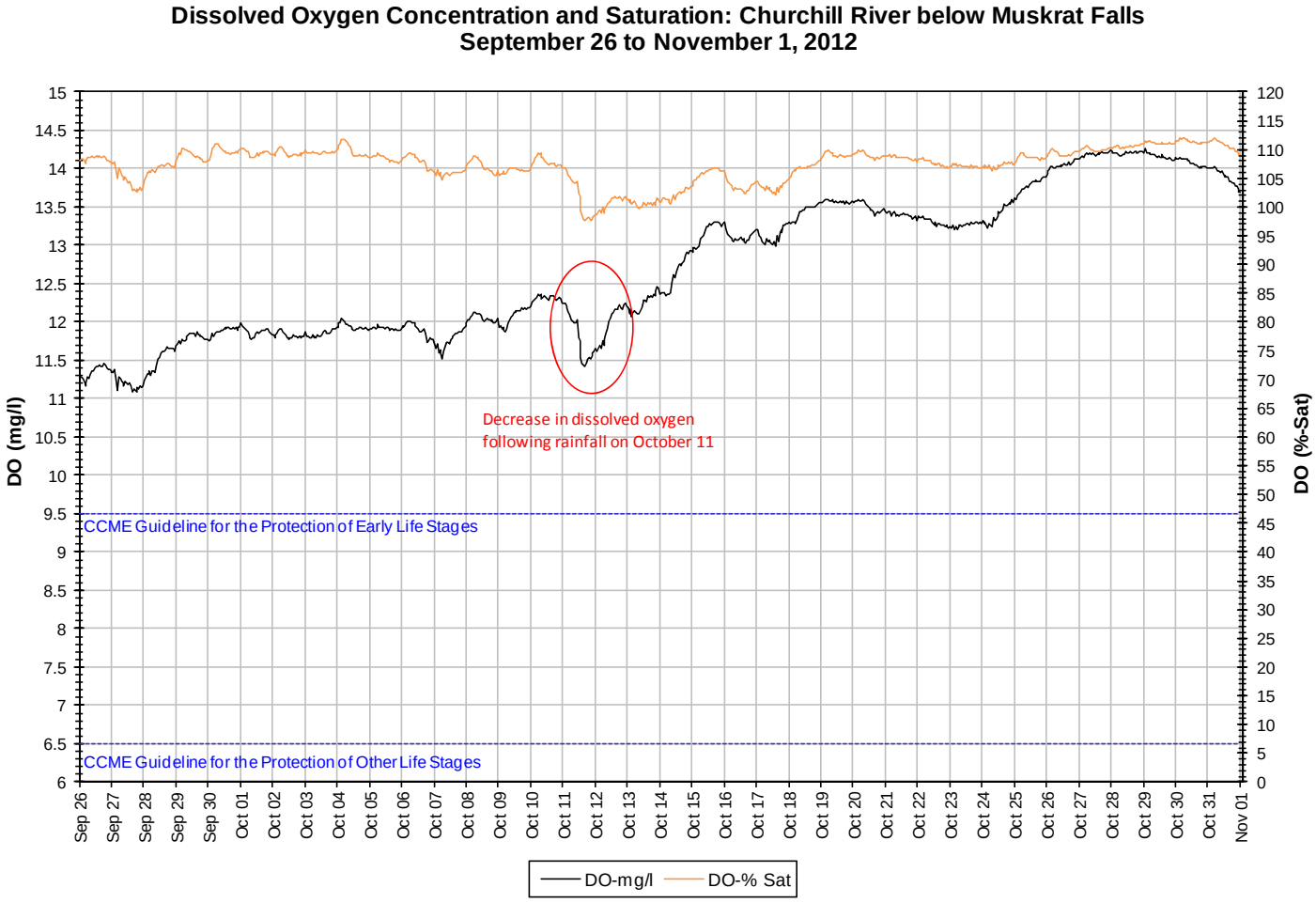

Figure 26: Dissolved oxygen and percent saturation at Churchill River below Muskrat Falls

- Turbidity ranges between 4.2 and 410.0NTU throughout the deployment period (Figure 27). A median value of 10.1NTU indicates there is a consistent natural background turbidity value at this station. This trend is typical at this station.
- Turbidity values are depicted in Figure 27a on a scale from 0 to 450NTU to show the full range of turbidity events. Generally, turbidity values are <10NTU (median value) however, there is one instance on October 11-12 when turbidity values increase of >400NTU. This event is short lived (~5 hours) and corresponds with a rainfall event recorded on October 11. Dissolved oxygen decreases at this instance as well (Figure 26). Turbidity events at this station are similar to those events recorded at the station upstream above Muskrat Falls (Figure 20).

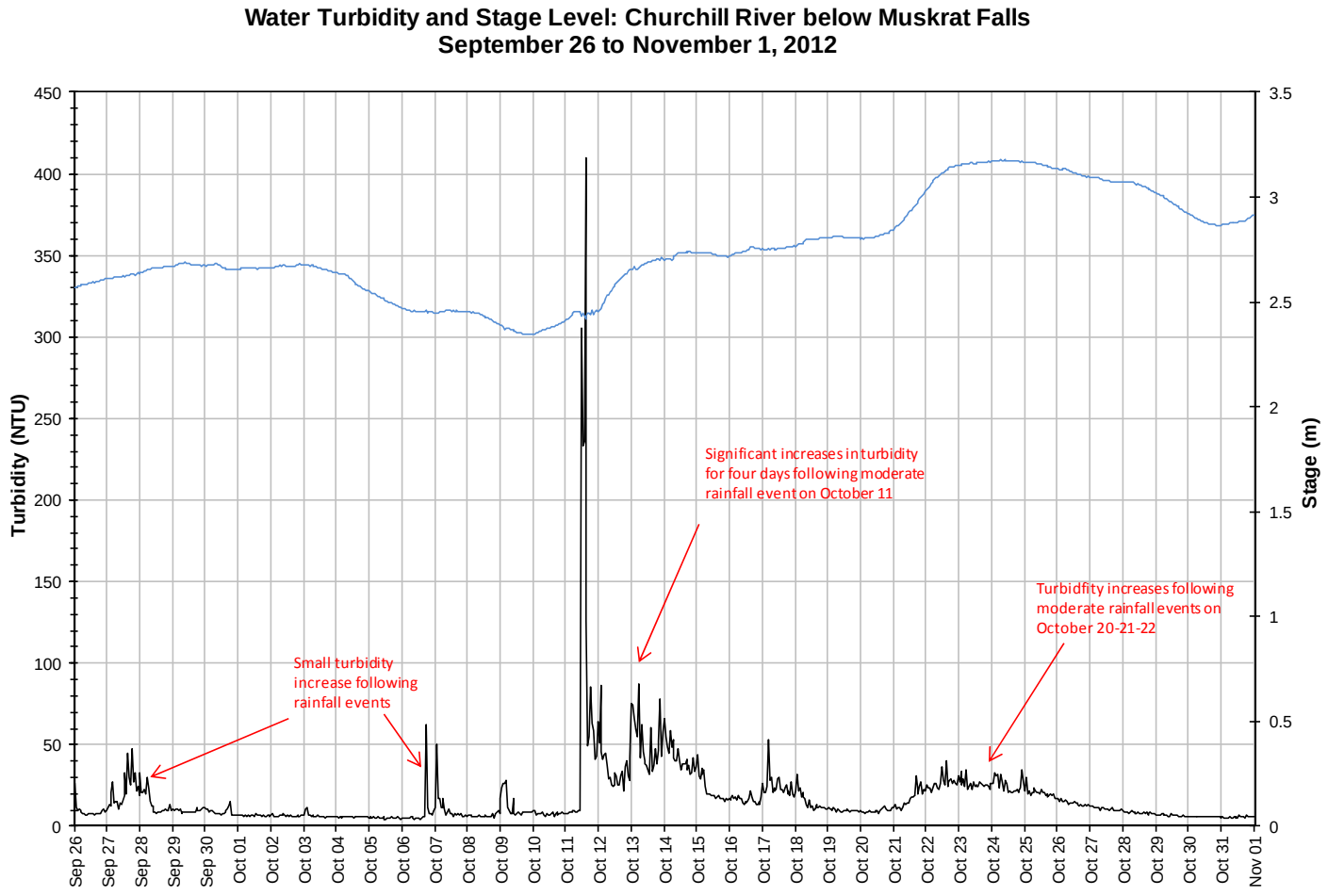

Figure 27a: Turbidity and stage level (0 to 450NTU) at Churchill River below Muskrat Falls

- Turbidity values are depicted in Figure 27b on a scale from 0 to 50NTU to show in better detail the majority of the turbidity events and background values. Generally, turbidity remains below 10NTU throughout the deployment period. Turbidity values are fluctuating in a wave like pattern for much of the deployment period. This trend is not exactly typical for turbidity values and background turbidity levels are slightly higher than previous deployment in the season (4NTU vs.10NTU).

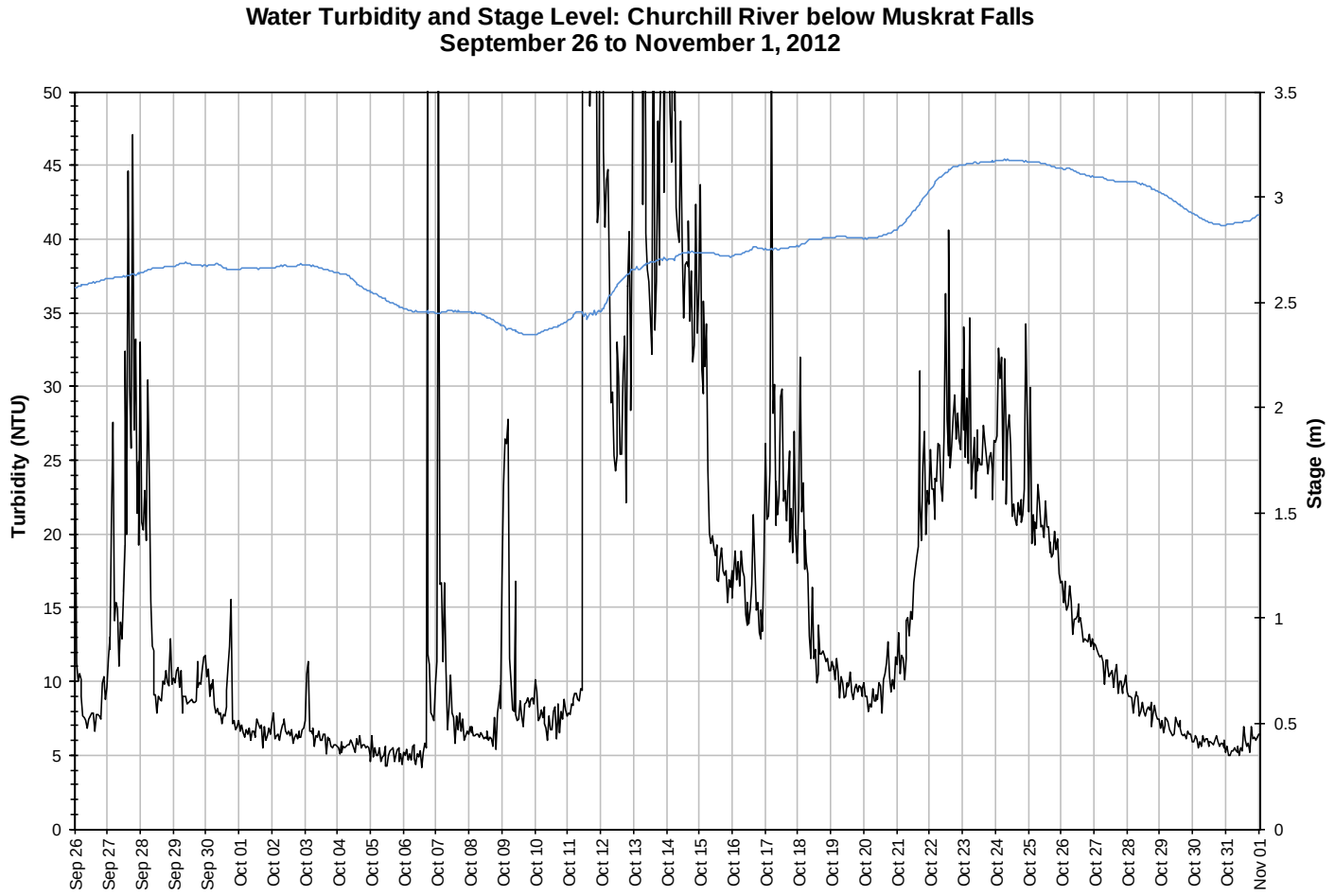

Figure 27b: Turbidity and stage level (0 to 50NTU) at Churchill River below Muskrat Falls

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 28). Stage is generally increasing throughout the deployment period. Precipitation amounts are moderate in frequency and magnitude. Stage ranges between 2.34 and 3.18m, a difference of 0.84m.

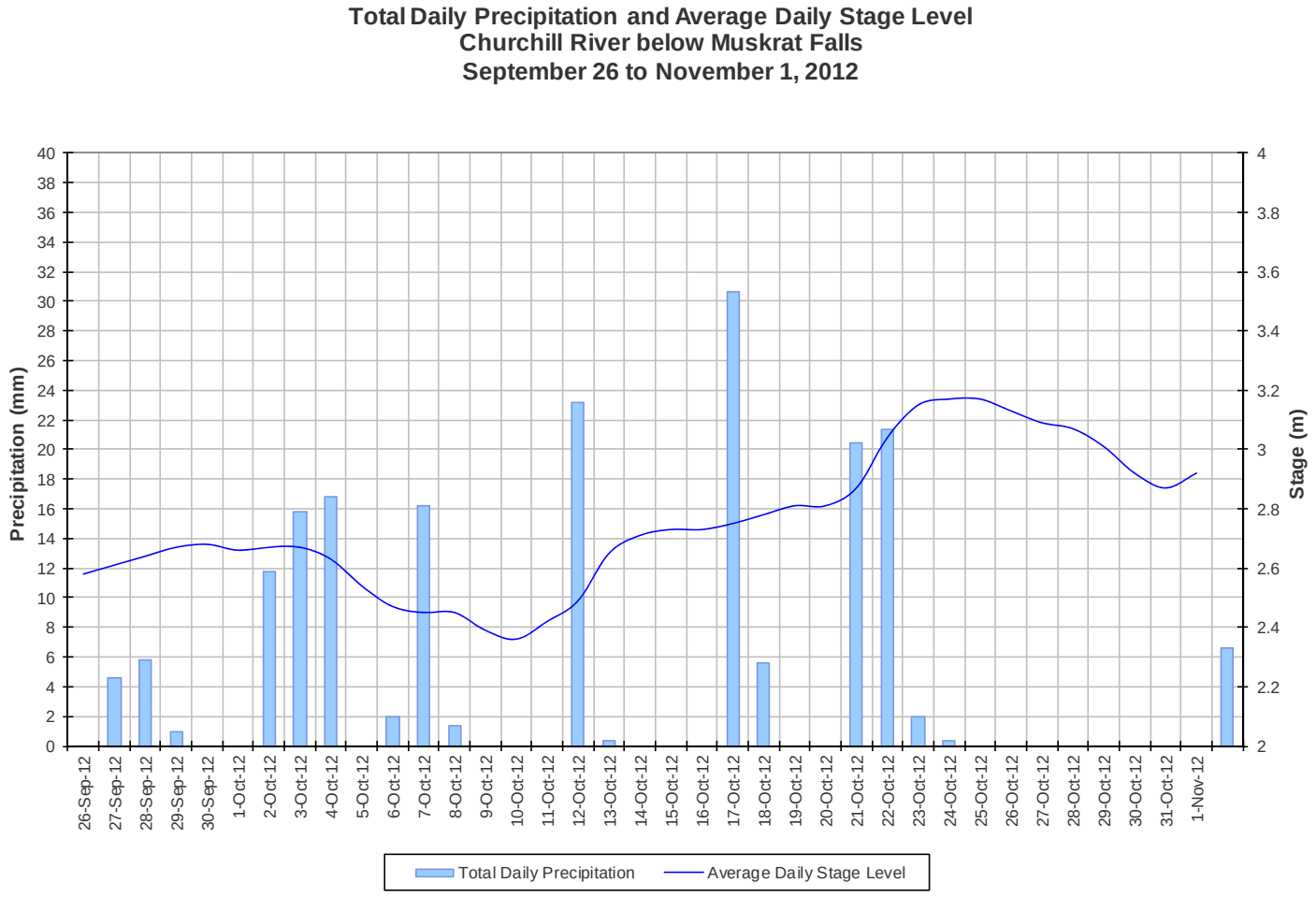

Figure 28: Daily precipitation and average daily stage level at Churchill River below Muskrat Falls (weather data recorded at Goose Bay)

Conclusions

- Instruments at four water quality monitoring stations on the Lower Churchill River were deployed from September 25-26 to October 31, and November 1 & 7, 2012. In most cases, weather related events or increase/decreases in water level could be used to explain the fluctuations.
- Stage levels fluctuated at all stations throughout the deployment period between 0.5 and 1.5m. Generally water levels were decreasing for the first 2 weeks followed by an increasing trend for the rest of the deployment period.
- Water temperature was decreasing at all stations throughout the deployment period due to the cooling ambient air temperatures in the region in the fall season. Water temperature typically ranged between 2 and 14°C.
- pH values were all within the recommended CCME Guidelines for the Protection of Aquatic Life and generally consistent at all stations. pH is generally very neutral and stable at all stations along the Lower Churchill River ranging between 6.6 and 7.3 pH units. pH values fluctuate daily, most evidently at station below Grizzle Rapids and below Muskrat Falls. There is a decrease beginning around October 20 that is noticeable at all stations in the network.
- Specific conductivity was generally decreasing at all stations and changing with increasing and decreasing stage levels. Specific conductivity typically averaged between 16 and 24µS/cm.
- Dissolved oxygen content was increasing throughout the deployment period. All values were above both the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota at Other Life Stages at 6.5mg/l and Early Life Stages of 9.5mg/l. The station below Muskrat Falls consistently has high dissolved oxygen content due to the location of the Muskrat Falls, 6km upstream.
- Turbidity values at the stations below Metchin River and below Grizzle Rapids remained mostly at 0NTU throughout the deployment period which is typical of these stations. Background turbidity values were 10.0 and 4.2NTU at the stations above and below Muskrat Falls, respectively. There are a number of turbidity increases at both stations as well, which most times correspond with weather related events.

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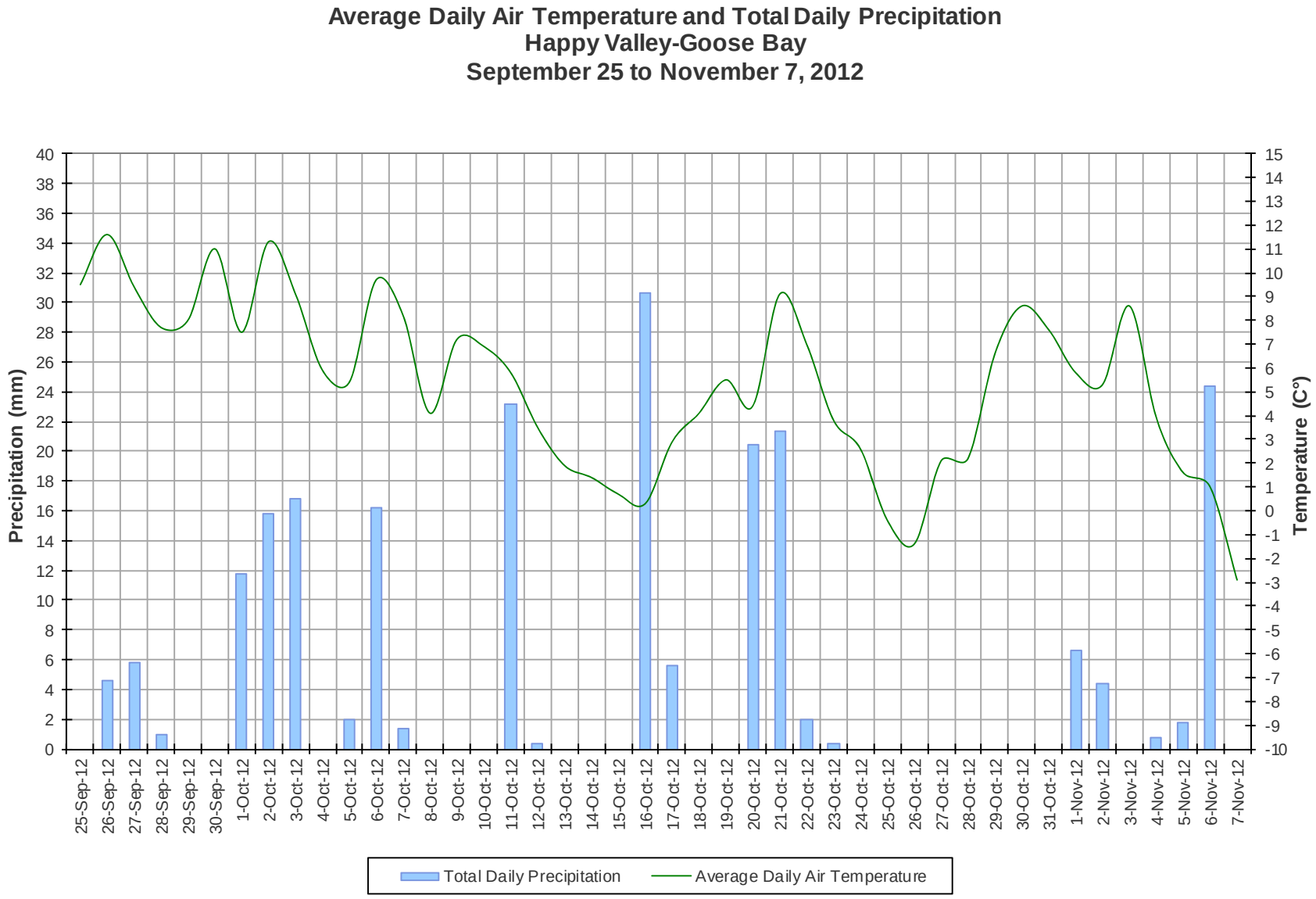
Appendix 1 – Weather Data – Environment Canada Historical Weather and Climate Database



Average Daily Air Temperature and Total Daily Precipitation
Churchill Falls
September 25 to November 7, 2012