Real-Time Water Quality Deployment Report

Lower Churchill River Network

July 22/23 to
August 12/14, 2014

Newfoundland Labrador

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

Contents

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Real Time Water Quality Monitoring

- Department of Environment and Conservation staff monitors the real-time web pages regularly.
- This deployment report discusses water quality related events occurring at five stations on the Lower Churchill River: below Metchin River, below Grizzle Rapids, above and below Muskrat Falls and at English Point.
- There was no instrument deployed at the station on Lake Melville east of Little River. Instrument deployments at this station have been suspended until a buoy system can be established at this site.
- On July 22/23, 2014, real-time water quality monitoring instruments were deployed at the five Lower Churchill River Stations for periods of 20-21 days. Less than 12 hours after deployment, the instrument at below Lower Muskrat Falls was buried in sand, resulting in inaccurate water quality data for the deployment period. Instruments at all stations were removed on August 12/14, 2014.

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 > 35µS/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 July 22/23 to August 12/14, 2014 are summarized in Table 2.

Table 2: Comparison rankings for Lower Churchill River stations, July 22/23 to August 12/14, 2014

Churchill River Station and Instrument Number	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Below Metchin River (45042)	July 22, 2014	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	August 12, 2014	Removal	Excellent	Good	Excellent	Excellent	Excellent
Below Grizzle Rapids (47384)	July 22, 2014	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	August 12, 2014	Removal	Good	Good	Excellent	Excellent	Excellent
Above Muskrat Falls (45700)	July 23, 2014	Deployment	Excellent	Excellent	Excellent	Excellent	Good
	August 14, 2014	Removal	Excellent	Excellent	Excellent	N/A**	Poor
Below Muskrat Falls (47590)	July 23, 2014*	Deployment	Good	Good	Excellent	Excellent	Poor
	August 14, 2014*	Removal	N/A	N/A	N/A	N/A	N/A
At English Point (45701)	July 23, 2014	Deployment	Good	Fair	Excellent	Good	Good
	August 14, 2014	Removal	Excellent	Good	Excellent	Good	Poor

* Sonde was buried in sand shortly after deployment. Removal rankings unavailable as the sonde was buried in sand during removal on August 14, 2014.

** Dissolved oxygen on QA/QC instrument not working, thus ranking not available.

- At the station below Metchin River, temperature, pH, specific conductivity, dissolved oxygen and turbidity all rank either 'good' or 'excellent' at deployment.

  At removal, temperature, pH, specific conductivity, dissolved oxygen and turbidity all rank 'excellent' or 'good'.

- At the station below Grizzle Rapids, temperature, pH, specific conductivity, dissolved oxygen and turbidity all rank either 'good' or 'excellent' at deployment.

  At removal, temperature, pH, specific conductivity, dissolved oxygen and turbidity all rank 'excellent' or 'good'.

- At the station above Muskrat Falls, temperature, specific conductivity, pH and dissolved oxygen all rank 'excellent' while turbidity ranks 'good' at deployment.

  At removal, temperature, specific conductivity and pH all rank 'excellent' while turbidity ranks 'poor'. Dissolved oxygen could not be ranked on removal as the DO sensor on the QA/QC was not functioning. The turbidity field value was 21.7 NTU and the QA/QC reading was 4.7 NTU. This discrepancy may be due to sedimentation of the sensor, as the field turbidity reading had steadily increased for several hours before removal.

- At the station below Muskrat Falls, temperature, specific conductivity, pH and dissolved oxygen all rank either 'good' or 'excellent' at deployment, while turbidity ranked 'poor'. The field turbidity value was 41.8NTU and the QA/QC value was 58.7NTU. This discrepancy may be attributed to a lag in taking both readings as sediment in the water column may have settled or stirred up between readings.

  At removal, the sensors could not be ranked as the instrument was buried in sand and thus recording invalid measurements.

- At the station at English Point, specific conductivity ranked 'excellent', while temperature, dissolved oxygen and turbidity ranked 'good' at deployment. The pH sensor ranked 'fair' on deployment. The pH field sonde reading was 6.53 while the QA/QC sonde reading was 6.00. This discrepancy is likely from the QA/QC sonde reading being taken too early before it was fully acclimated in the water.

  At removal, temperature, pH, specific conductivity and dissolved oxygen ranked either 'good' or 'excellent' while turbidity ranked 'poor'. The turbidity field reading was 62.5 NTU while the QA/QC sonde reading was 11.0 NTU. This discrepancy is likely from biofouling of the field sonde as the values had steadily risen to 60NTU for the 3 days preceding the sonde's removal.

Data Interpretation

- The following graphs and discussion illustrate water quality related events occurring between July 22/23 and August 12/14 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.
- The below Muskrat Falls station is experiencing issues with the sediment in the area. The sonde has been repeatedly buried in sand during deployment. This limits the data available for interpretation at this station.

Churchill River below Metchin River

- Water temperature ranges from 16.30°C to 19.80°C during the deployment period (Figure 1).
- Water temperature is generally stable throughout the deployment period. This trend is expected due to the warm air temperatures in the July-August summer season (Figure 2).

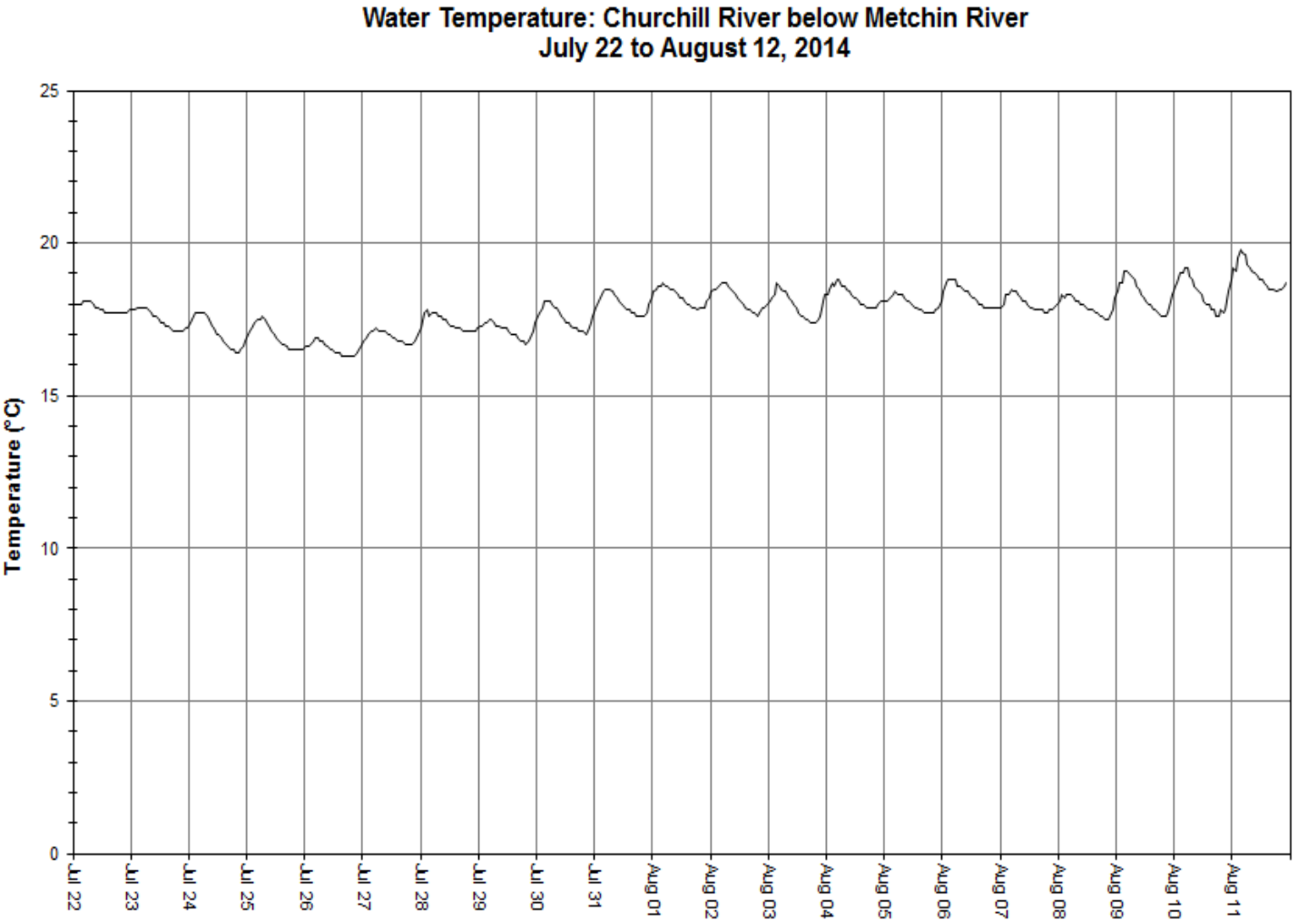

Figure 1: Water temperature at Churchill River below Metchin River

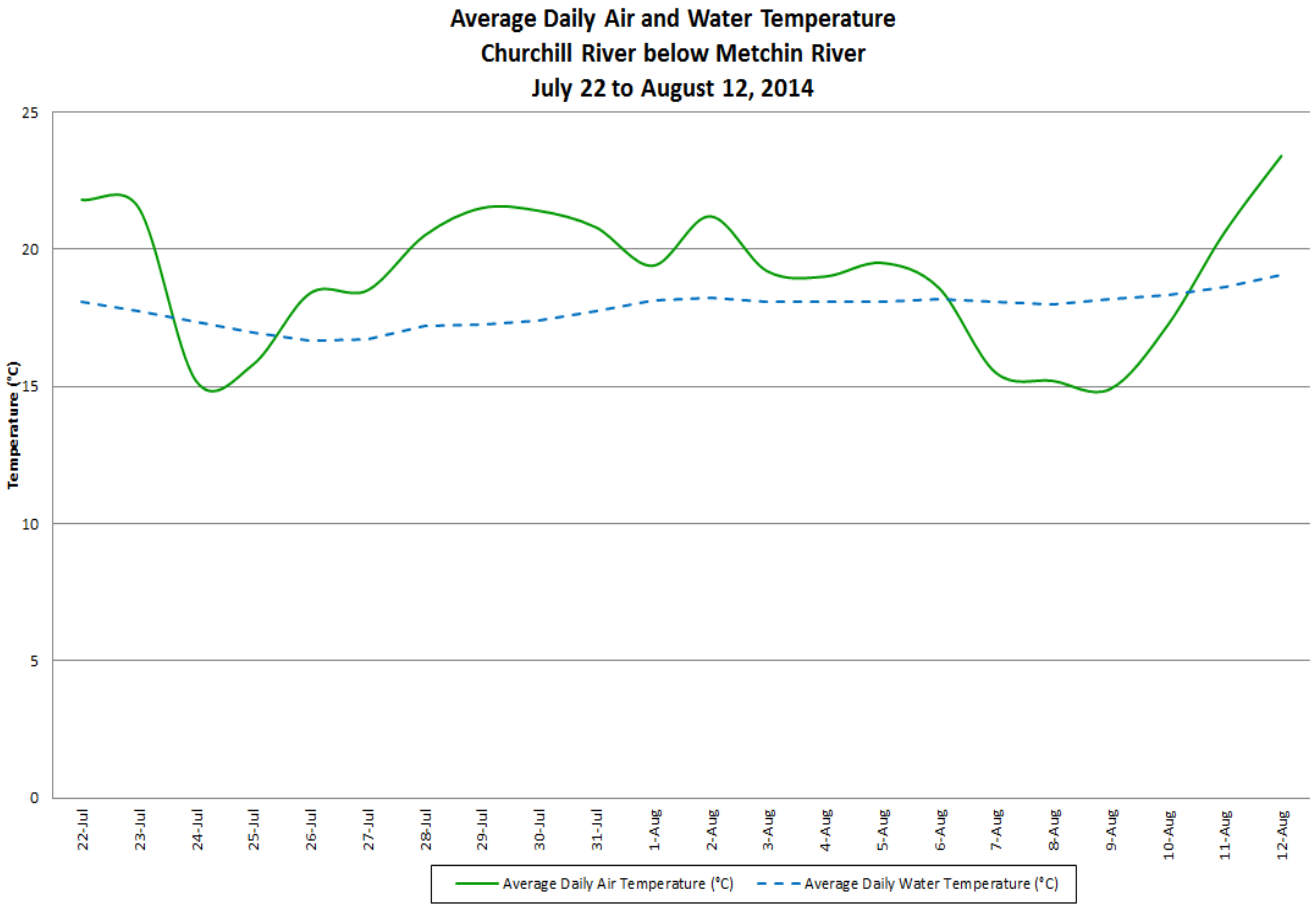

Figure 2: Average daily air and water temperature at Churchill River below Metchin River (weather data recorded at Goose Bay, NL; Churchill Falls data unavailable)

- pH ranges between 7.02 and 7.26 pH units and is very stable throughout the deployment period regardless of the changing stage levels (Figure 3).
- All pH values during the deployment are within the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 3).

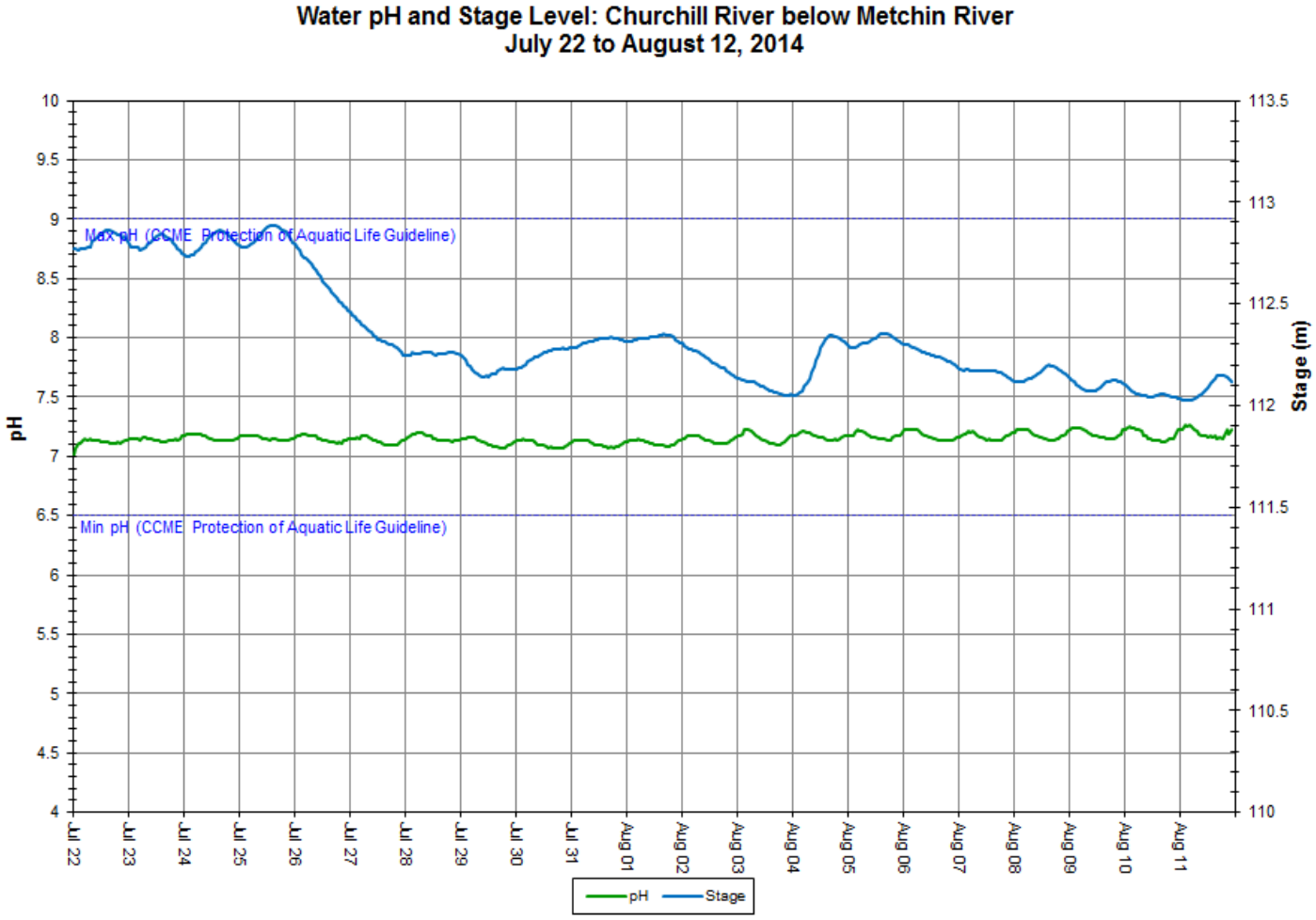

Figure 3: pH and stage level at Churchill River below Metchin River

- Specific conductivity ranges between 18.5µS/cm to 32.9µS/cm during the deployment period, averaging 19.6µS/cm (Figure 4).
- An event affecting specific conductivity lasted a period of 8 hours on August 8-9. It is unknown what caused this event as there is no corresponding change in other water quality parameters, though it may be related to a corresponding increase in stage at this time.
- Stage is included in Figure 4 to illustrate the inverse relationship between conductivity and water level. Stage is fluctuating significantly throughout 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 not visible in the data collected during the deployment period as specific conductivity is relatively stable during this period.

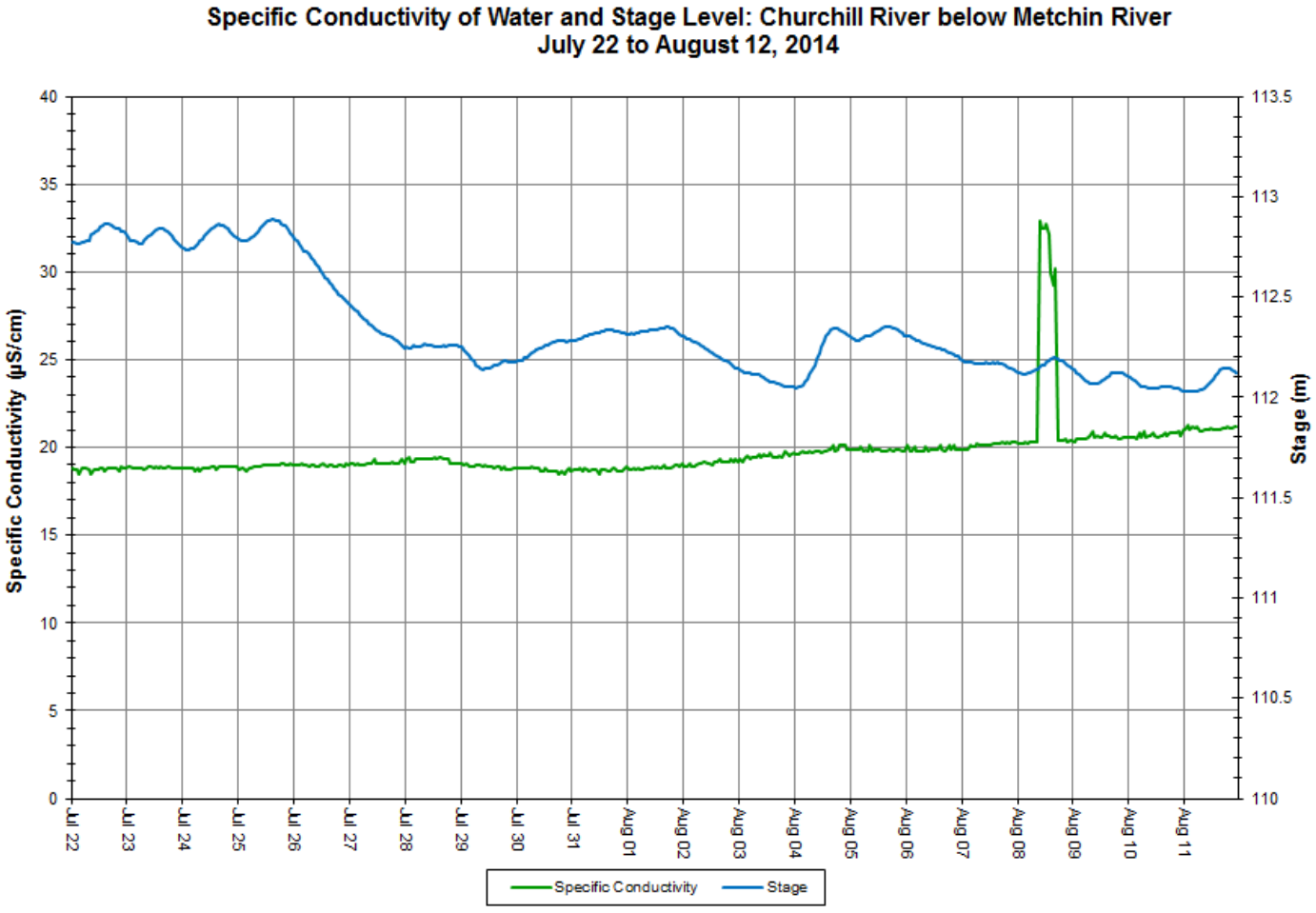

Figure 4: Specific conductivity and stage level at Churchill River below Metchin River

- Dissolved oxygen content ranges between 8.71mg/l and 9.14mg/l. The saturation of dissolved oxygen ranges from 90.5% to 98.5% (Figure 5).
- All values are above the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages of 6.5mg/l, and below the CCME Guidelines for the Protection of Early Life Stages of 9.5mg/l. The guidelines are indicated in blue on Figure 5.
- Dissolved oxygen content is stable throughout the deployment period. This trend is expected as the air and water temperatures are generally stable during mid-summer (July-August) (Figure 2).

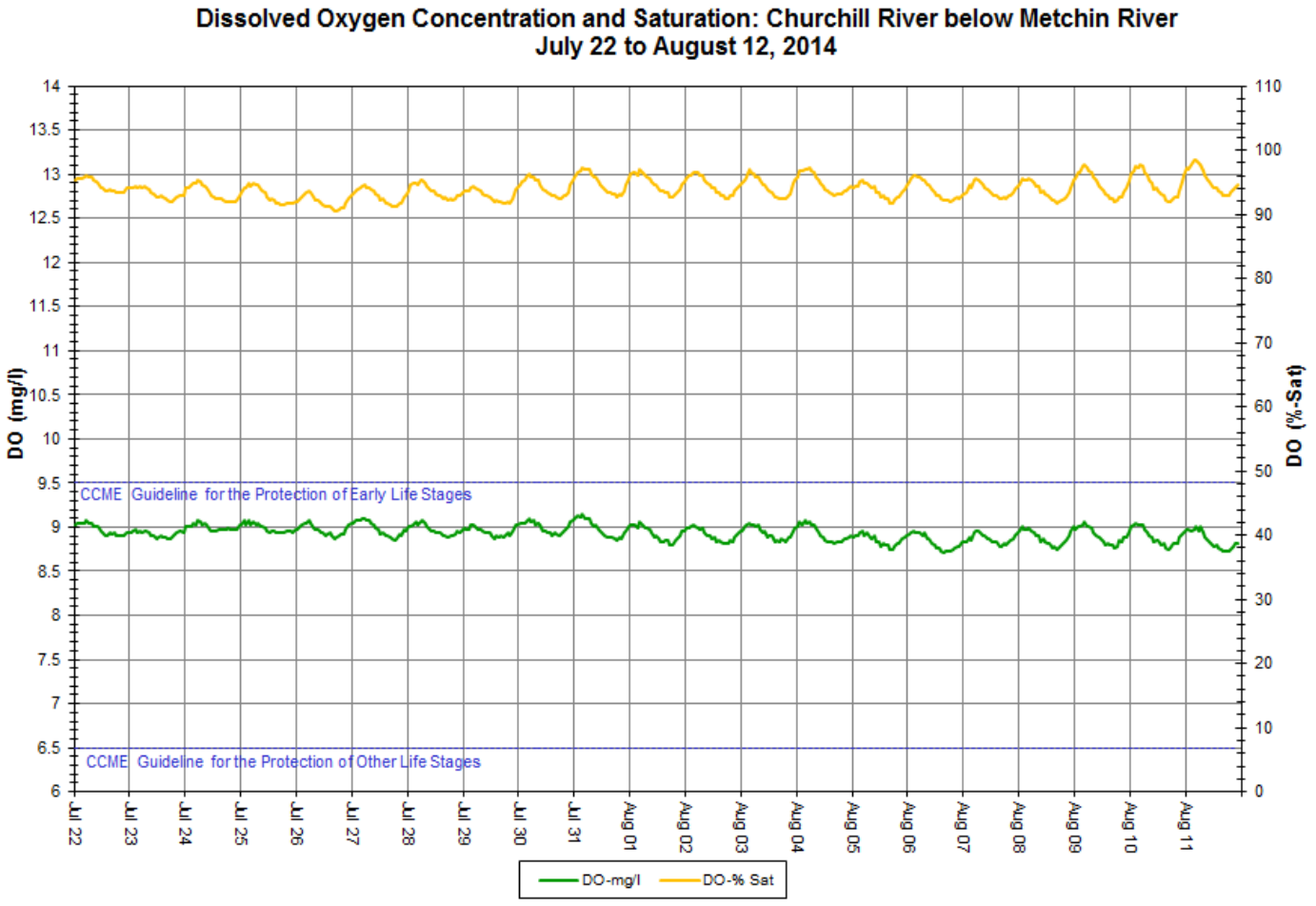

Figure 5: Dissolved oxygen and percent saturation at Churchill River below Metchin River

- 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.
- During this deployment period, turbidity rarely increases to values >0NTU. These events are generally low in magnitude and drop again rapidly, likely from debris passing the turbidity sensor. The increase on July 26 may be associated with a precipitation event at this time.

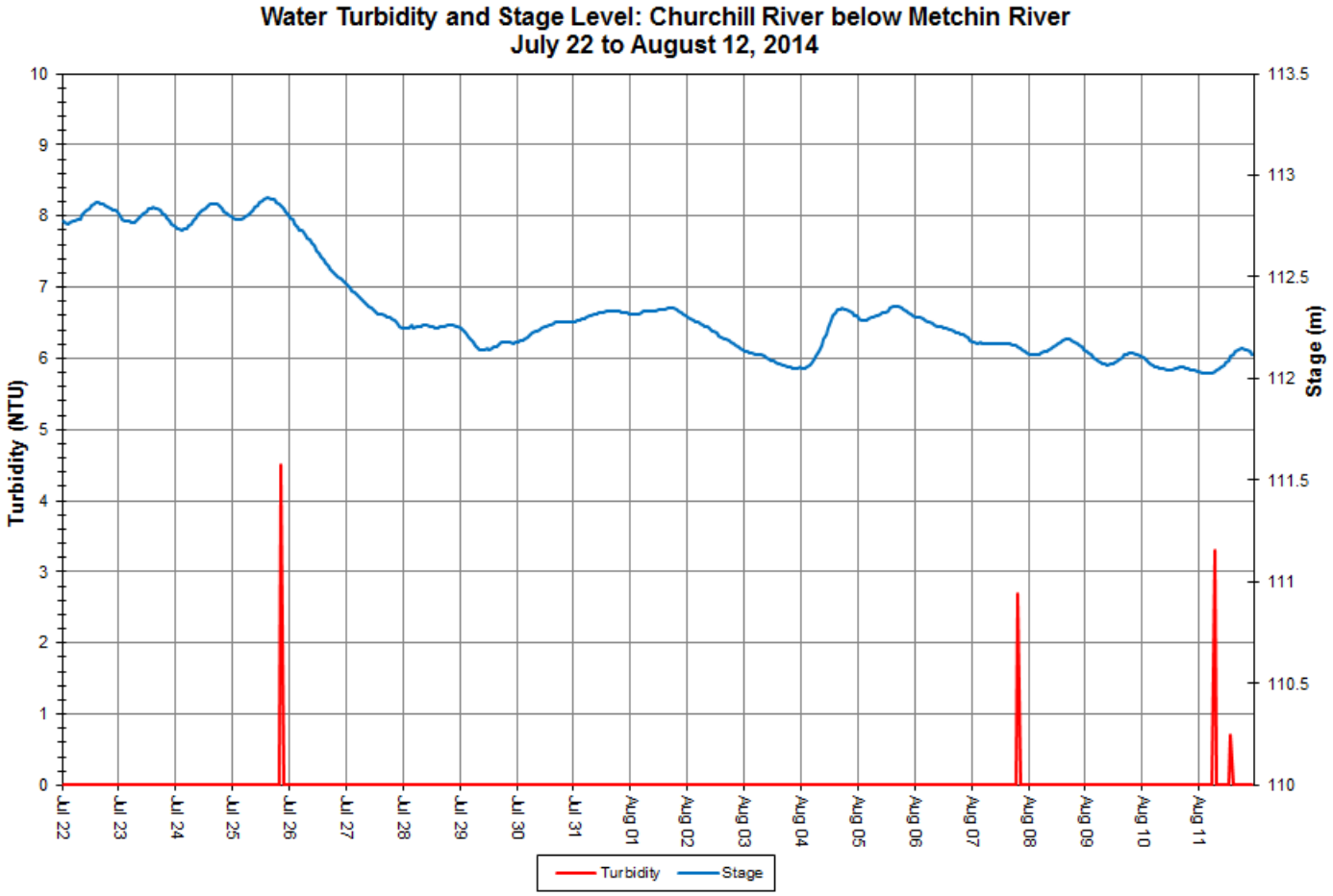

Figure 6: Turbidity and stage level at Churchill River below Metchin River

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 7). Stage is generally decreasing throughout the deployment period. Precipitation occurs on 9 of the days in the deployment period. Precipitation amounts are generally low, peaking at 18.2mm on August 1. Stage ranges between 112.03m and 112.89m, a difference of 0.86m.

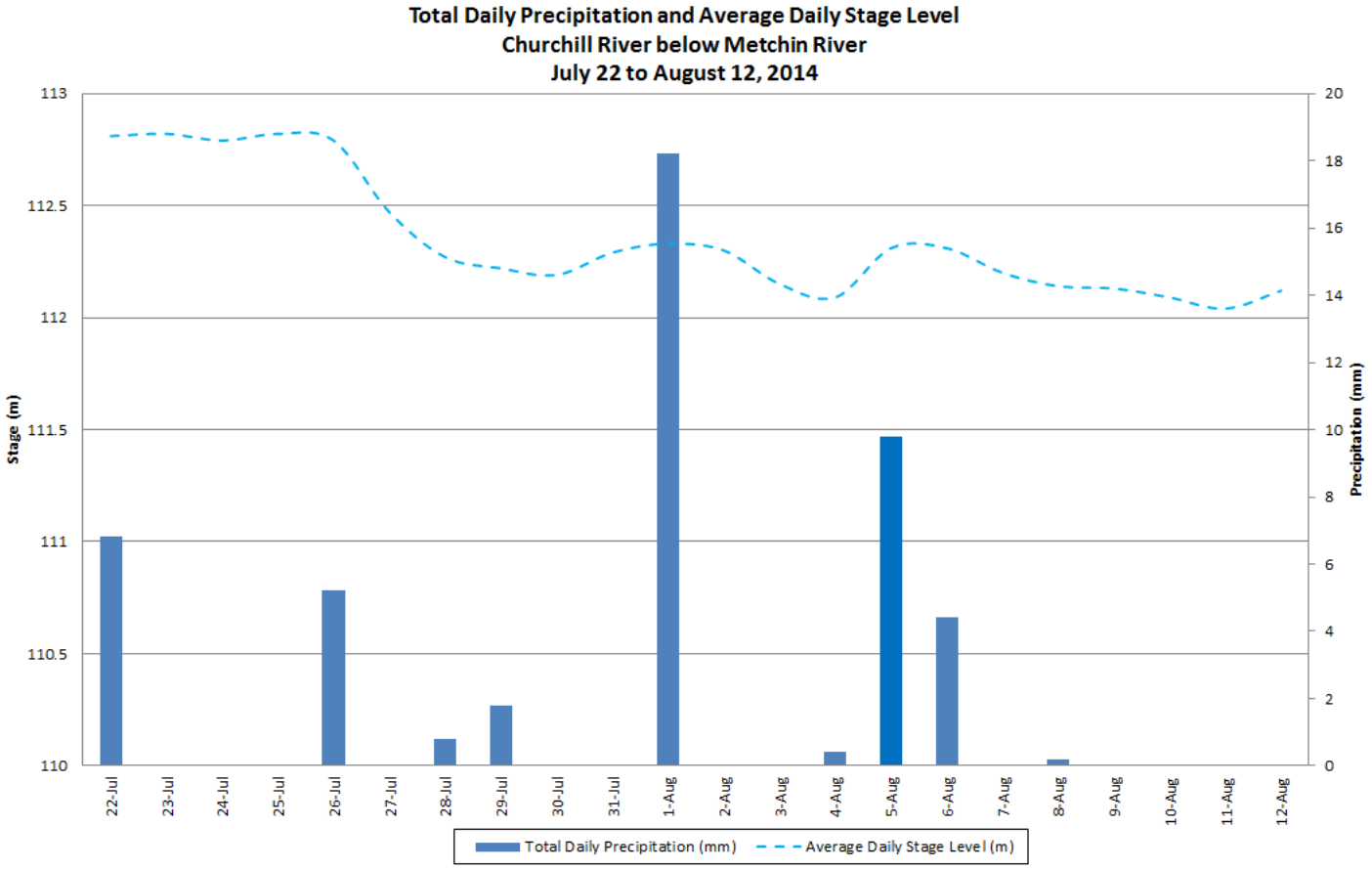

Figure 7: Daily precipitation and average daily stage level at Churchill River below Metchin River (weather data recorded at Churchill Falls)

Churchill River below Grizzle Rapids

- Water temperature ranges from 16.30°C to 21.50°C during the deployment period (Figure 8).
- Water temperature is gradually increasing throughout the deployment period. This trend is expected due to the warm ambient air temperatures in the summer season (Figure 9).

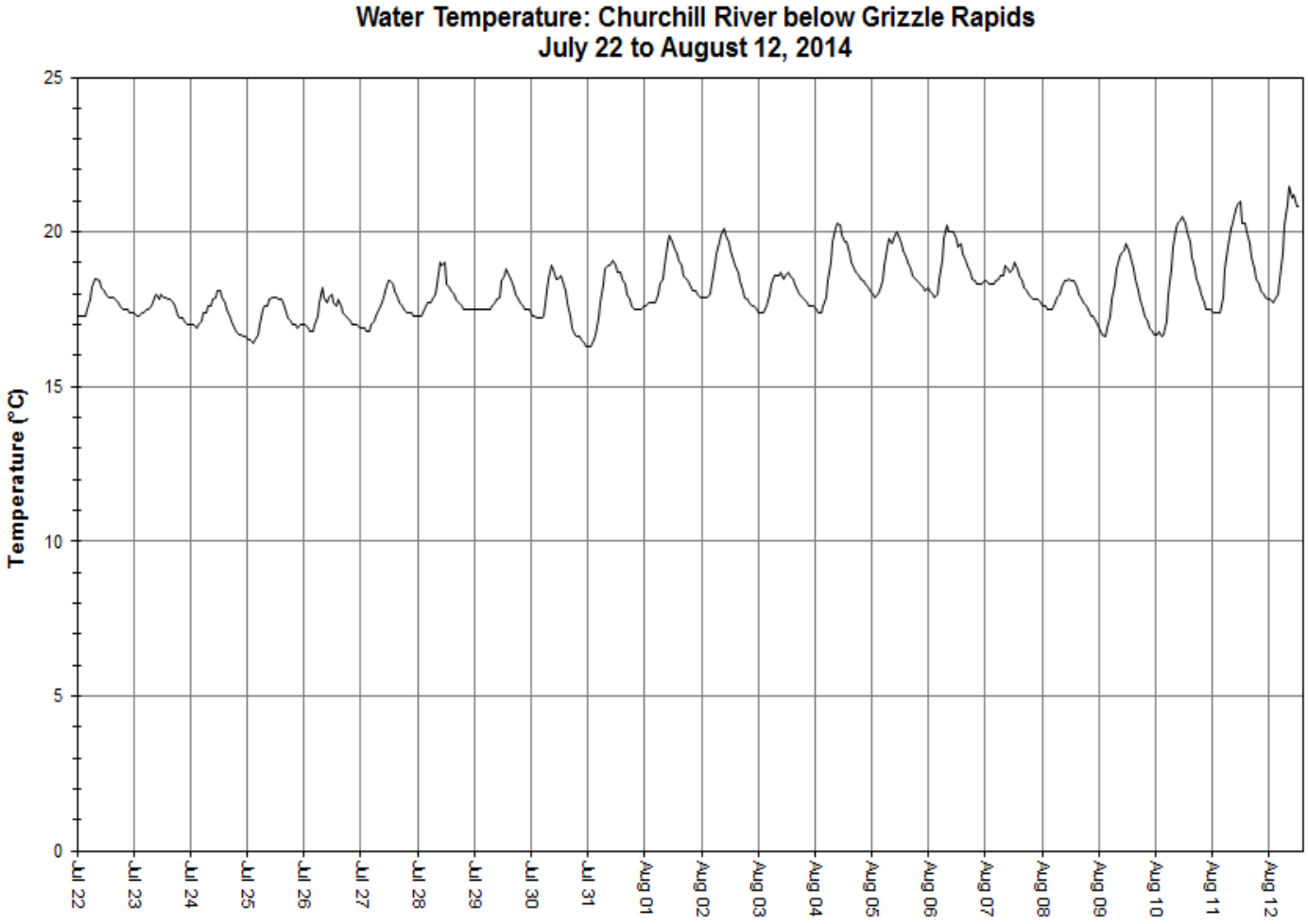

Figure 8: Water temperature at Churchill River below Grizzle Rapids

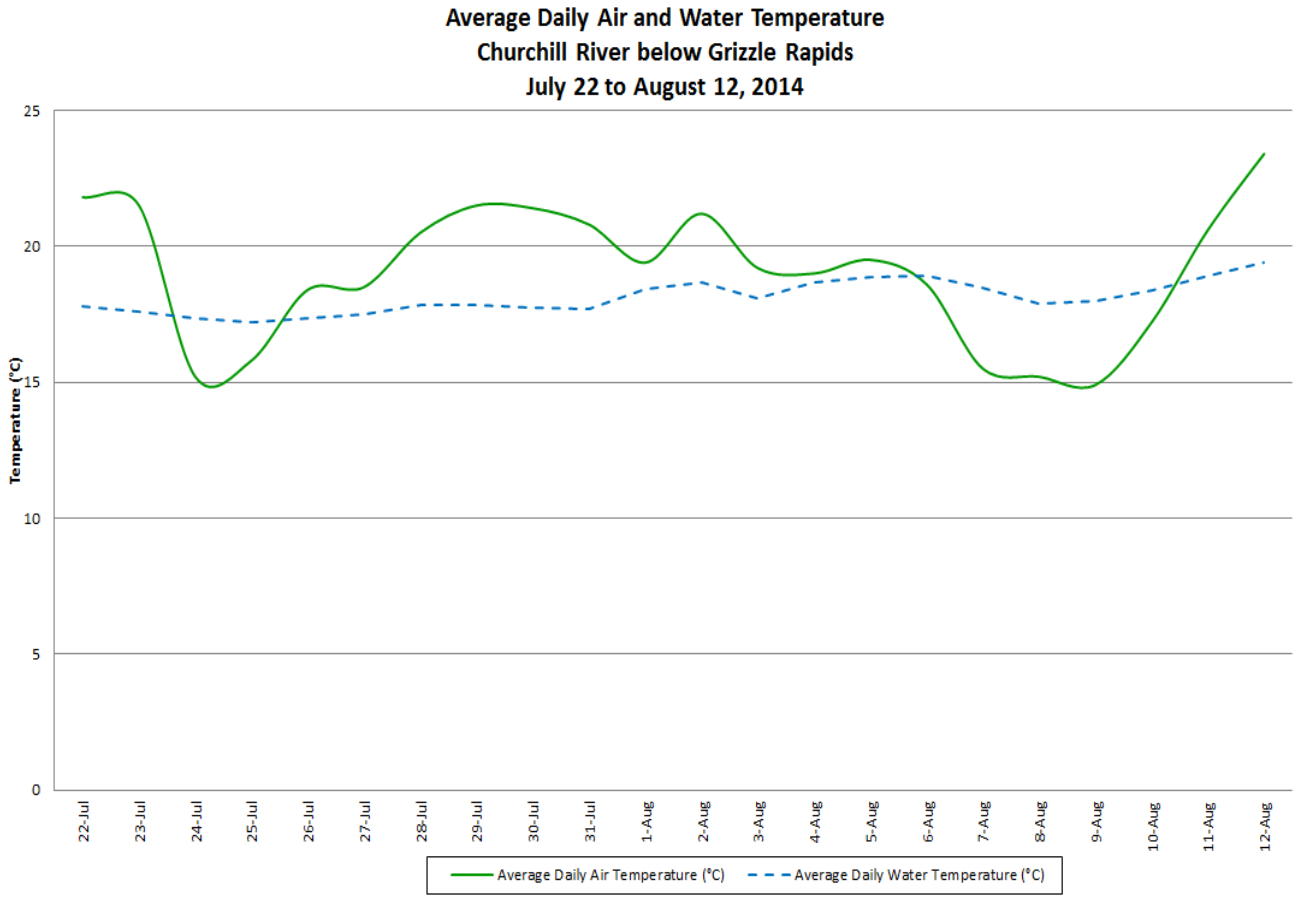

Figure 9: Average daily air and water temperature at Churchill River below Grizzle Rapids (weather data recorded at Goose Bay)

- pH ranges between 6.87 and 7.32 pH units (Figure 10). pH values are very stable throughout the deployment period regardless of changing water levels. pH values generally fluctuate on a daily basis.
- All values during the deployment are within the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 10).

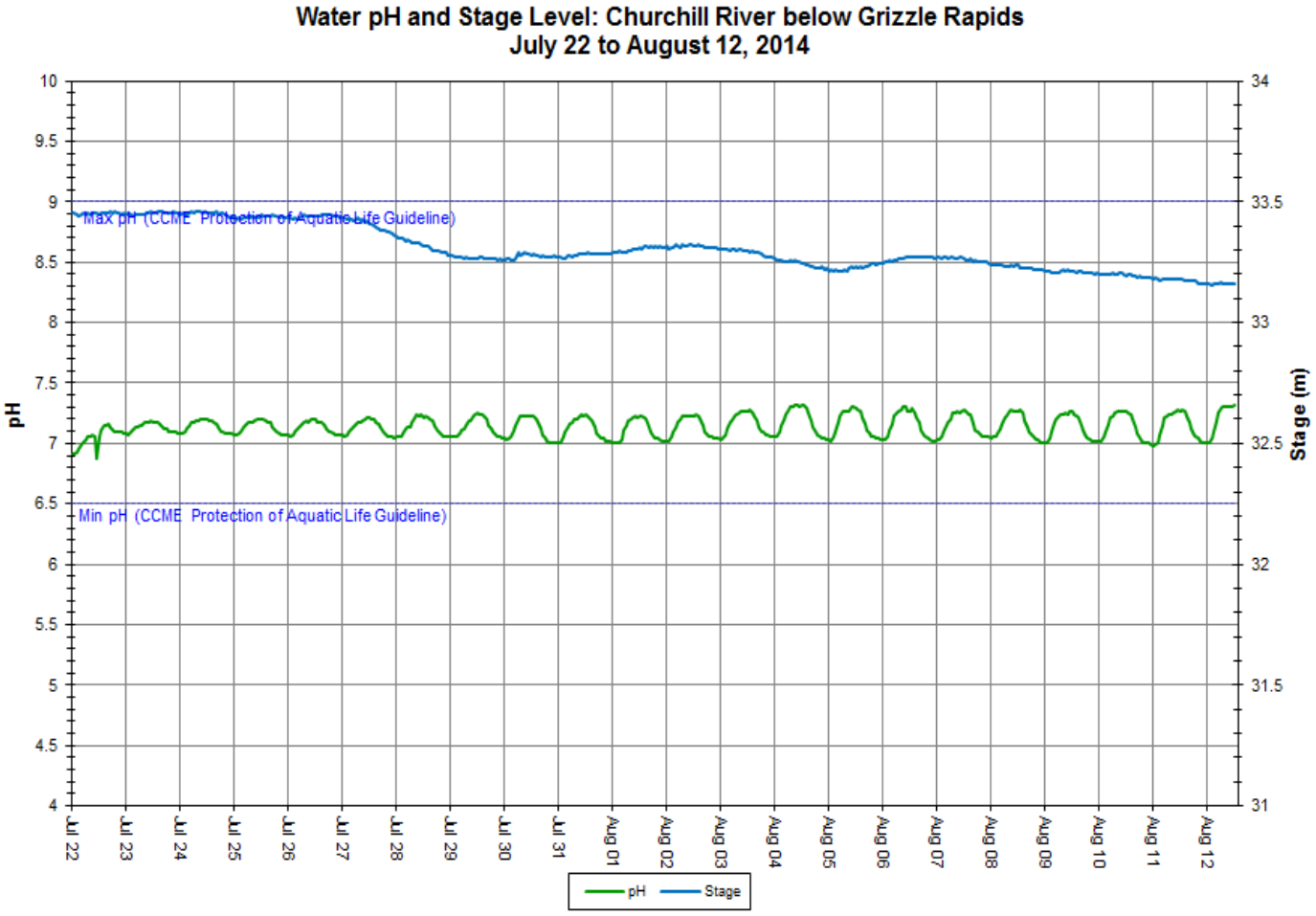

Figure 10: pH and stage level at Churchill River below Grizzle Rapids

- Specific conductivity ranges from 17.2µS/cm to 19.4µS/cm during the deployment period, averaging 18.2µS/cm (Figure 11).
- Stage is included in Figure 11 to illustrate the inverse relationship between conductivity and water level. Generally, as stage levels increase, specific conductivity decreases due to the dilution of dissolved solids in the water column. Inversely, when stage decreases, specific conductivity usually increases as the concentration of dissolved solids is increased. This trend is visible in the data collected during the deployment period; as water levels drop throughout deployment, specific conductivity increases.

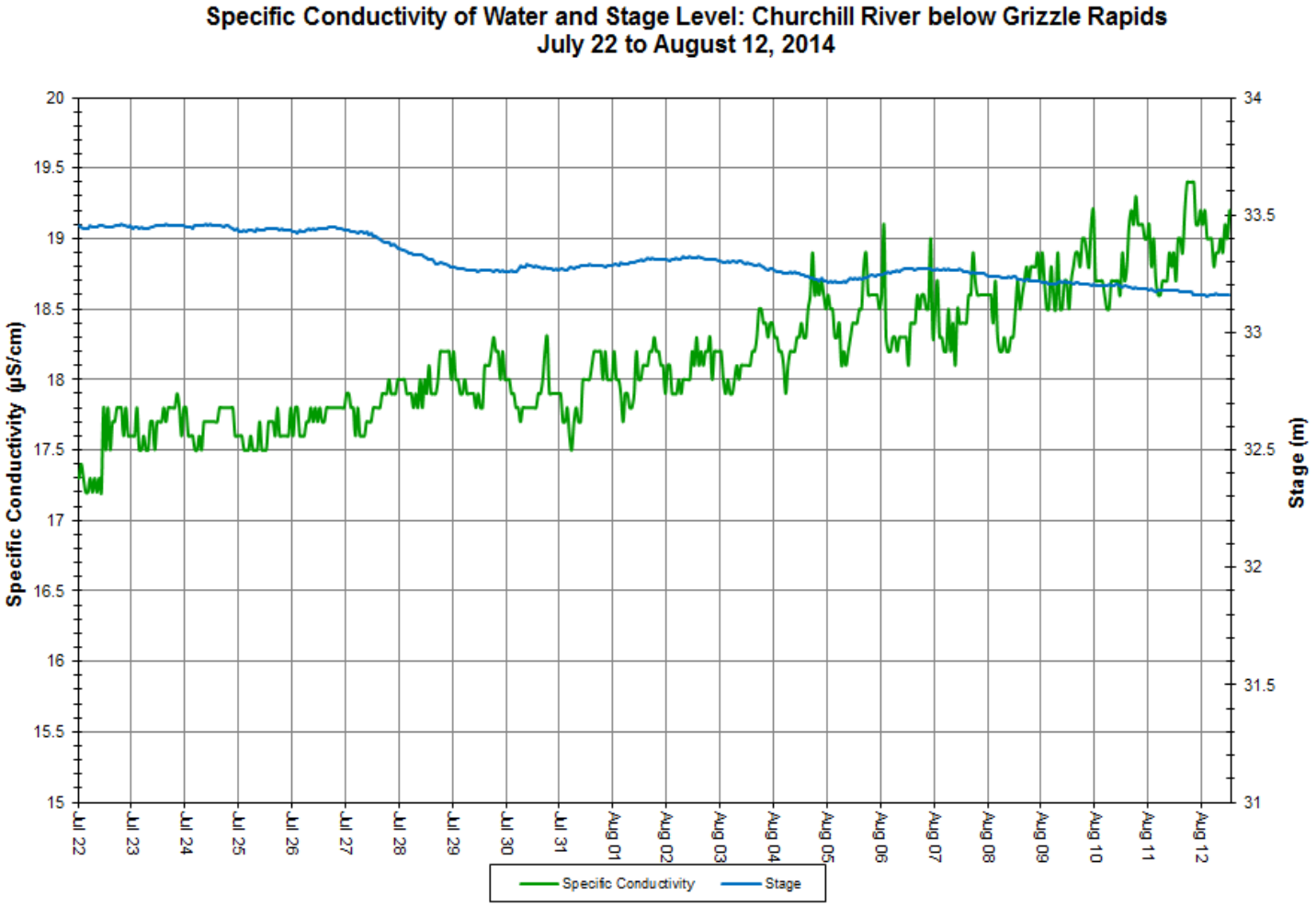

Figure 11: Specific conductivity and stage level at Churchill River below Grizzle Rapids

- Dissolved oxygen content ranges between 8.93mg/l and 9.74mg/l. The saturation of dissolved oxygen ranges from 95.0% to 105.9% (Figure 12).
- All values were above the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages of 6.5mg/l. The values hover around the CCME Guideline for the Protection of Early Life Stages of 9.5mg/l. The guidelines are indicated in blue on Figure 12.
- Dissolved oxygen content is lower than this year's previous deployments as warmer water temperatures can hold less oxygen. The dissolved oxygen levels were relatively stable during this deployment period. (Figure 9). A slight rise in dissolved oxygen on July 31 occurred as water temperatures dropped at this time.

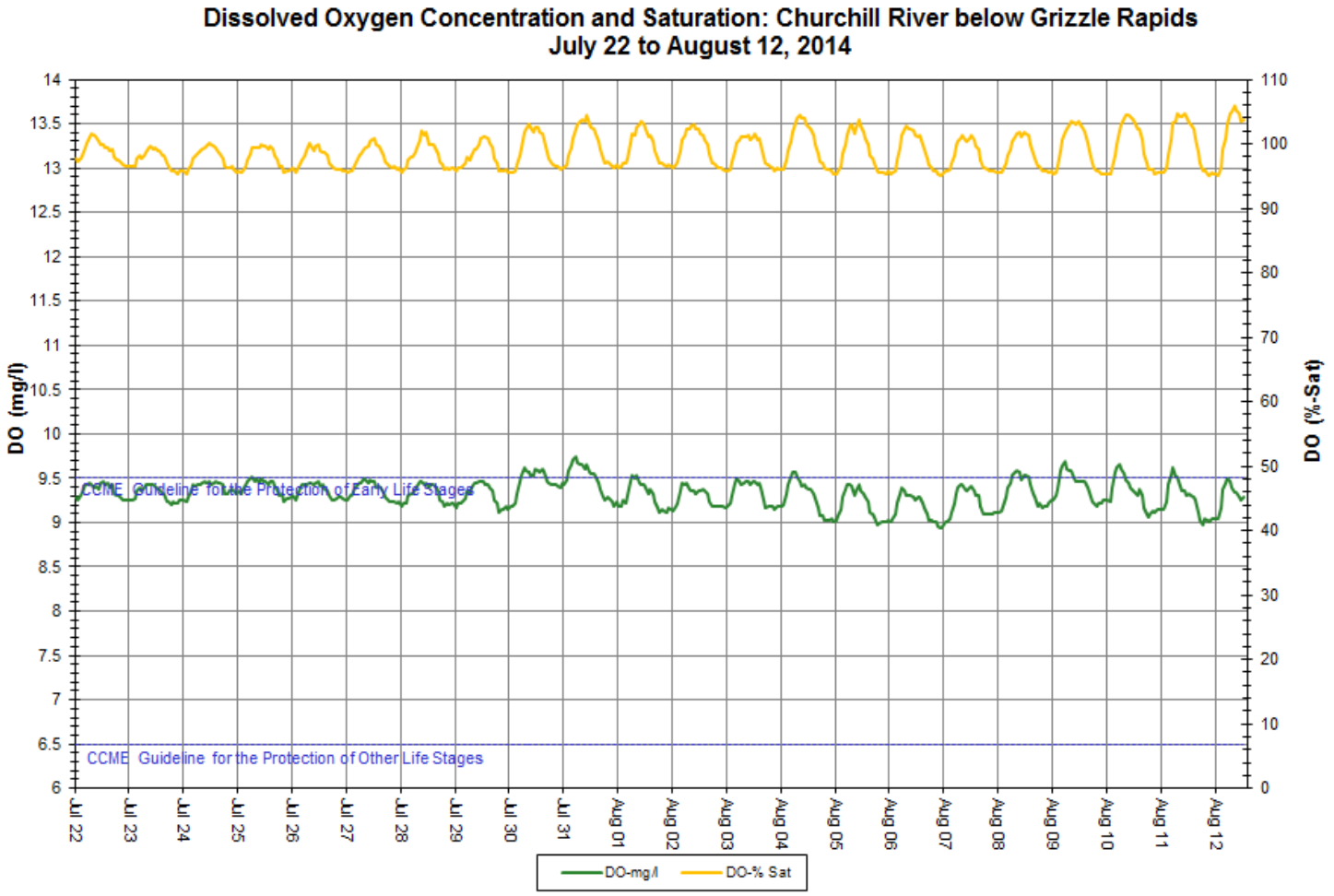

Figure 12: Dissolved oxygen and percent saturation at Churchill River below Grizzle Rapids

- Turbidity values remain at 0NTU for most 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.
- Turbidity increases up to 161.2NTU near the end of the deployment period on August 11. As this was the only high reading at this time, it is likely due to debris passing the sensor.

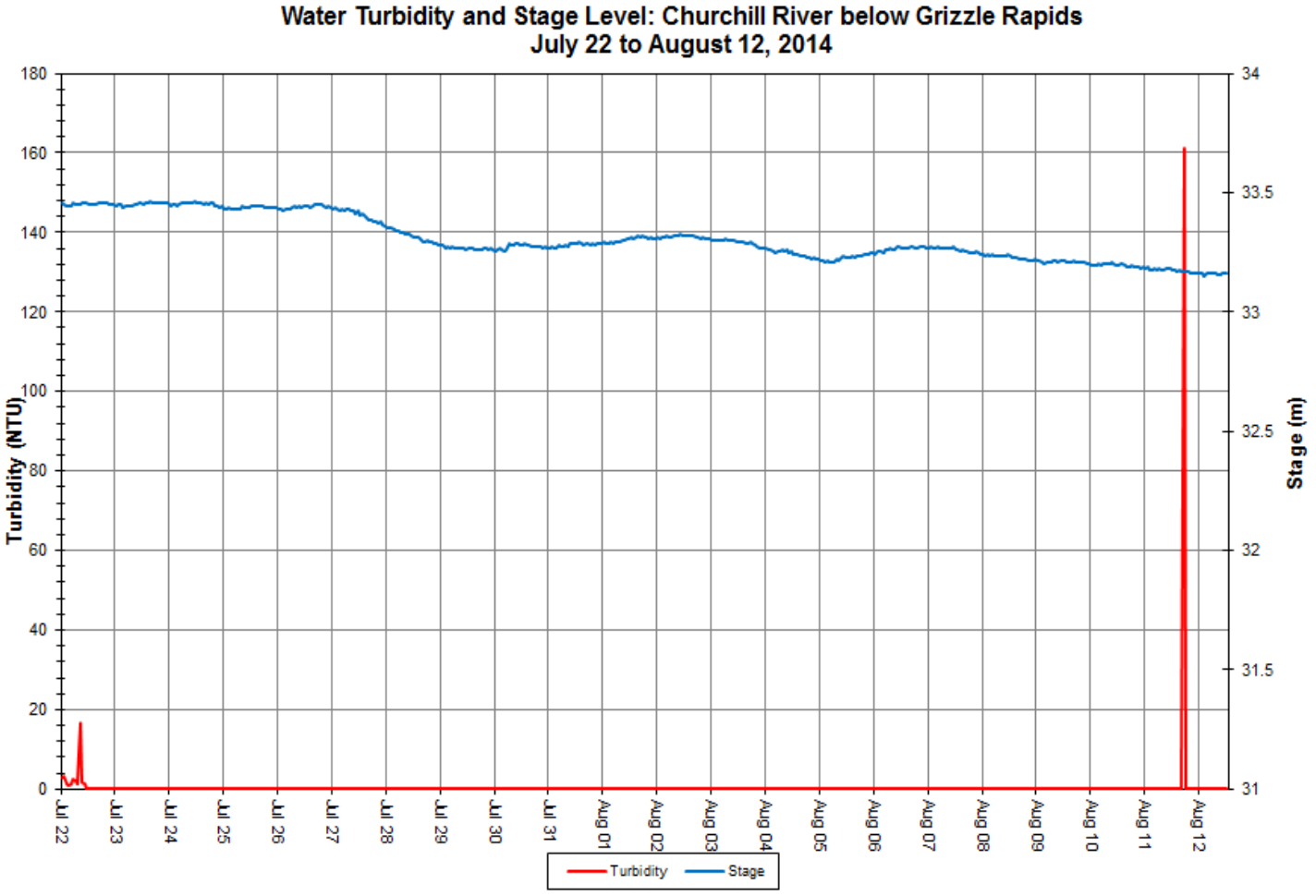

Figure 13: Turbidity and stage level at Churchill River below Grizzle Rapids

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 14). Stage is steadily decreasing throughout the deployment period. Precipitation occurs on 9 days of the deployment period and amounts are generally low, peaking at 18.2mm on August 1. Stage ranges between 33.15m and 33.46m, a difference of 0.31m.

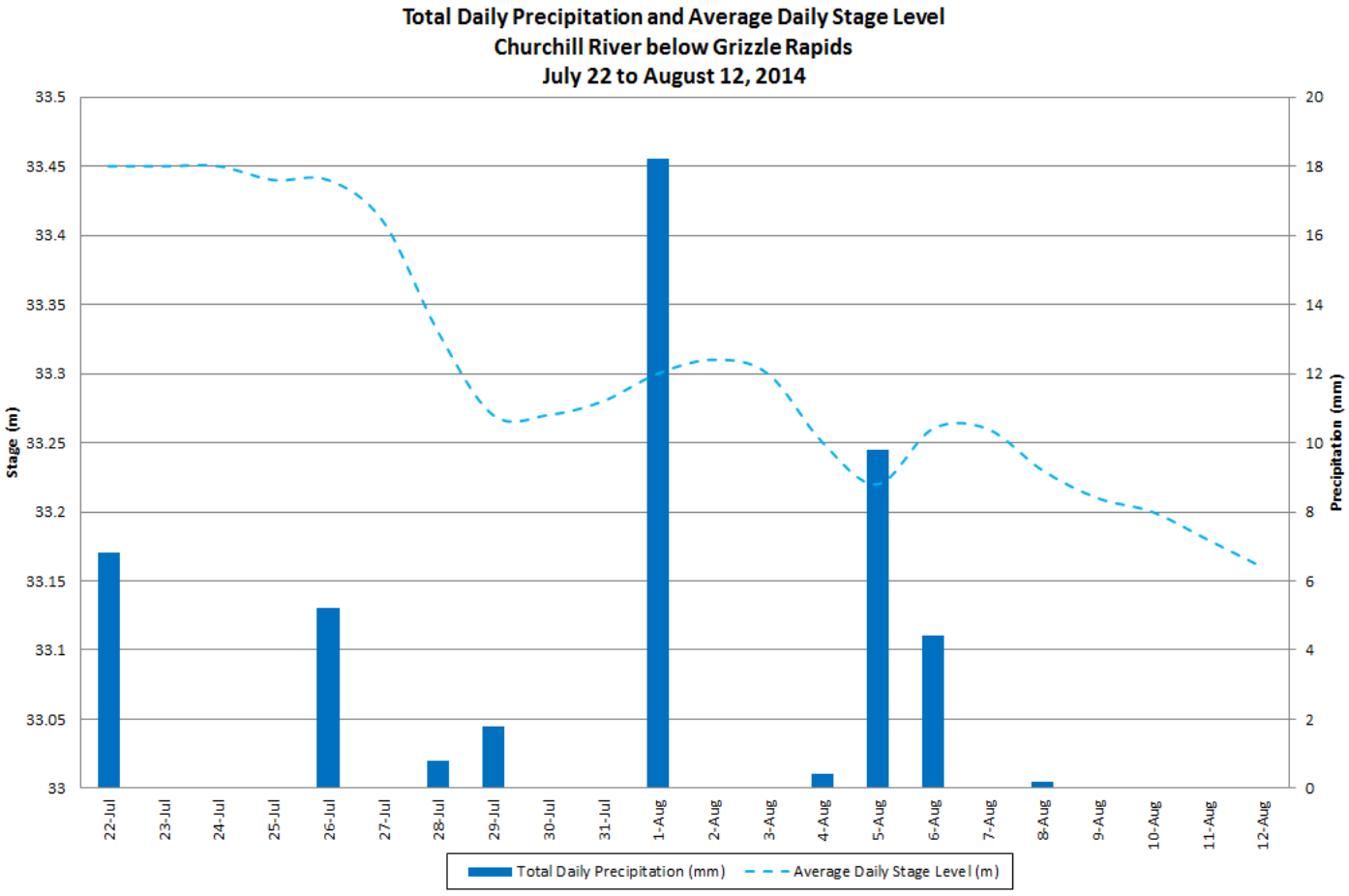

Figure 14: Daily precipitation and average daily stage level at Churchill River below Grizzle Rapids (weather data recorded at Goose Bay)

Churchill River above Muskrat Falls

- Water temperature ranges from 17.07°C to 24.30°C during the deployment period (Figure 15).
- Water temperature is relatively stable throughout the deployment period (Figure 16). This trend is expected as air temperatures during the summer months are relatively stable.
- The maximum temperature (24.30°C)was much higher than the other values recorded at this time, and corresponds to drops in dissolved oxygen and specific conductivity on August 13. Stage levels at this time were also at their minimum, indicating that at this time, the sonde may have been out of the water or in very shallow water. It was noted on removal August 14th that the instrument was almost high and dry out of the water. As the values recorded at this time may not be accurate, data for August 13 will be removed from the dataset.

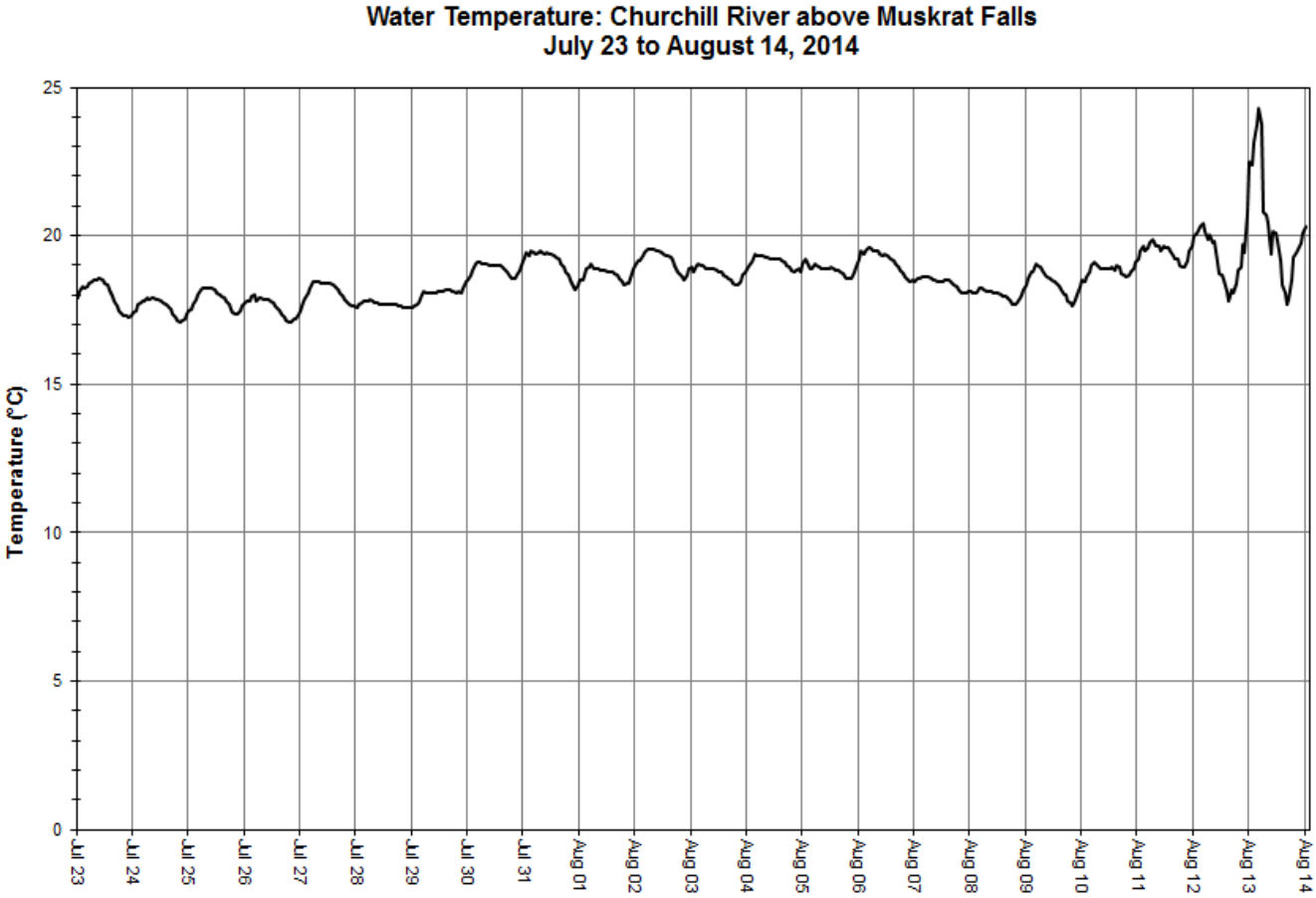

Figure 15: Water temperature at Churchill River above Muskrat Falls

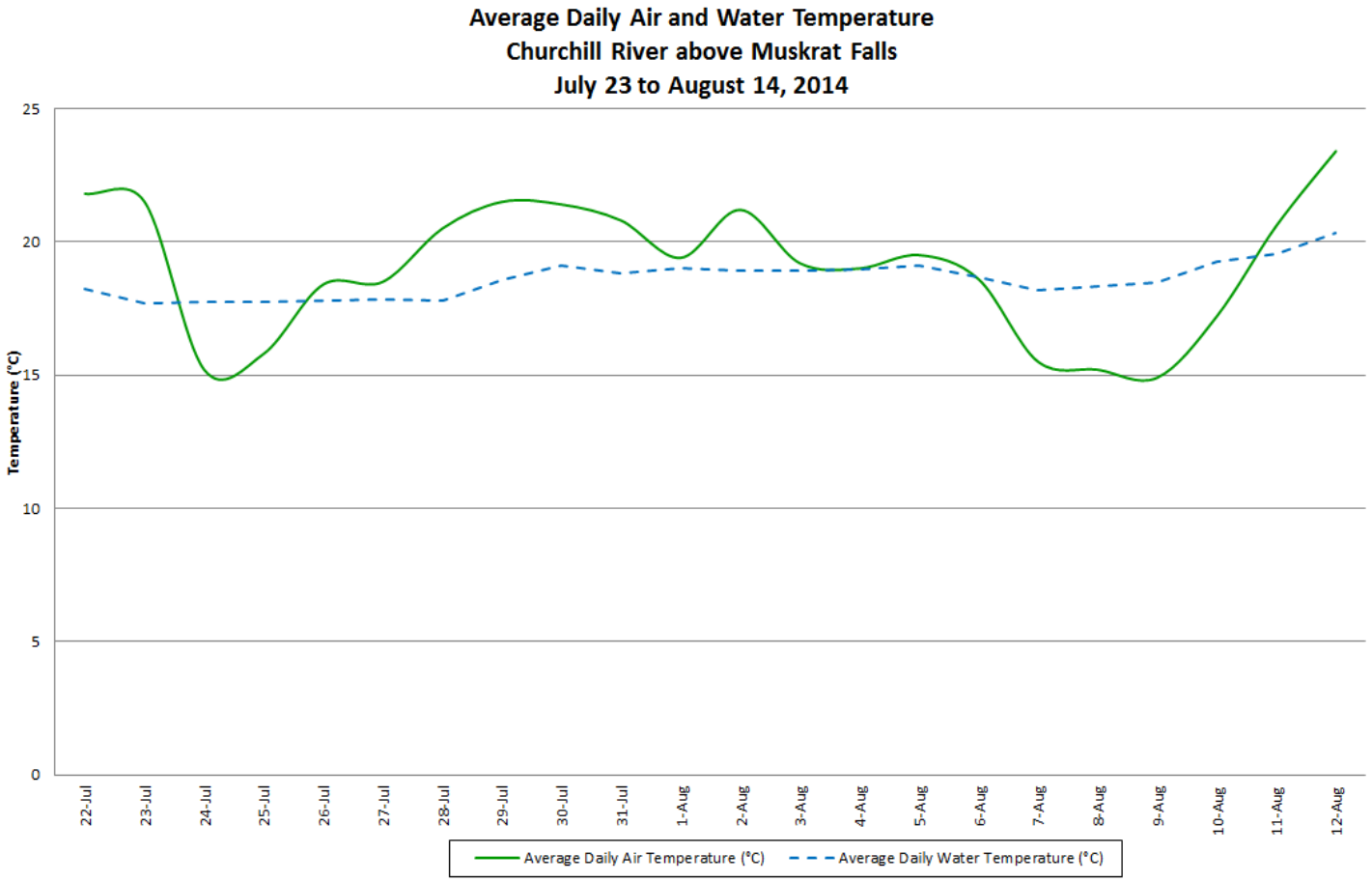

Figure 16: Average daily air and water temperature at Churchill River above Muskrat Falls (weather data recorded at Goose Bay)

- pH ranges between 6.86 and 7.18 pH units (Figure 17). pH values are relatively stable throughout the deployment period, dropping slightly when stage levels rise due to dilution.
- All pH values recorded are within the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 17).
- As the sonde was likely out of the water on August 13, the data for this day may not be accurate and has been removed from the dataset.

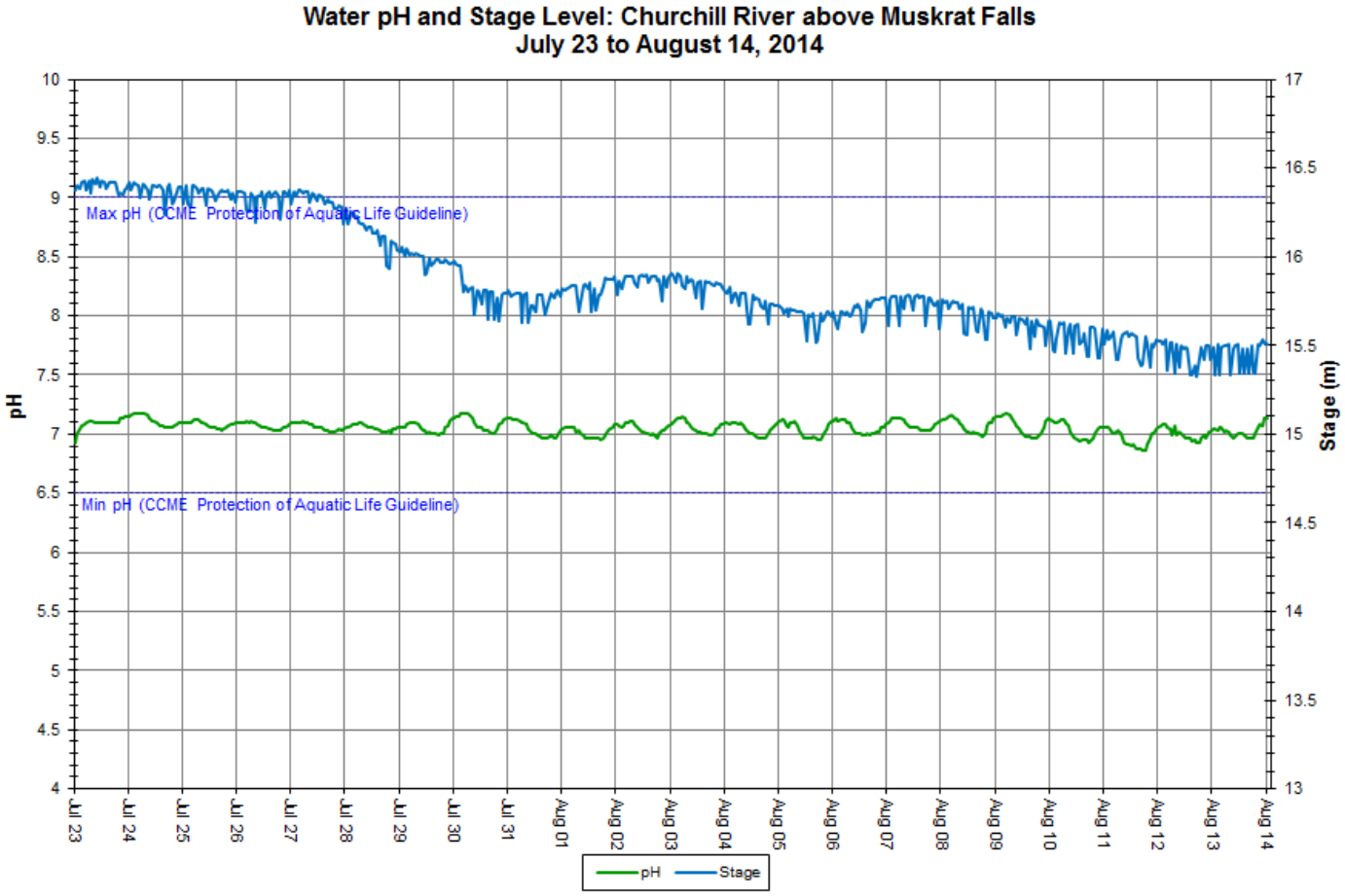

Figure 17: pH and stage at Churchill River above Muskrat Falls

- Specific conductivity ranges from 17.5µS/cm to 21.2µS/cm during the deployment period, averaging 18.6µS/cm. (Figure 18).
- Stage is included in Figure 18 to illustrate the inverse relationship between conductivity and water level. Generally, as stage levels increase, specific conductivity decreases due to the dilution of dissolved solids in the water column. Inversely, when stage decreases, specific conductivity usually increases as the concentration of dissolved solids is increased. This trend is visible in the data collected during the deployment period, particularly during the drop in stage and rise in conductivity August 7-14.
- A notable drop in specific conductance on August 13 corresponds to abnormally low dissolved oxygen and high water temperatures at the same time, indicating that the sonde may have been out of the water at this point due to falling stage levels. As the data for August 13 may not be accurate, it has been removed from the dataset.

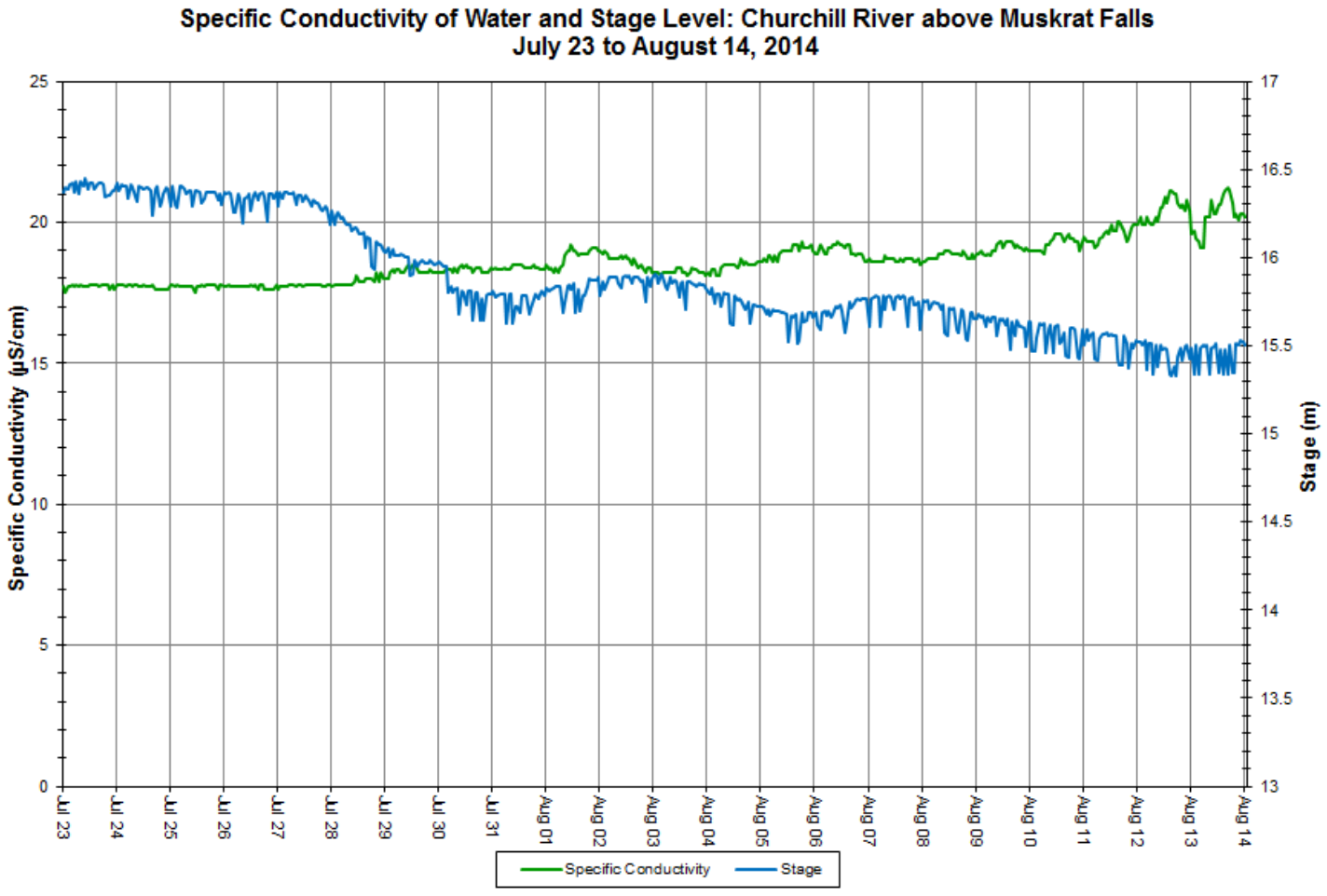

Figure 18: Specific conductivity and stage level at Churchill River above Muskrat Falls

- Dissolved oxygen content ranges between 8.17mg/l and 9.37mg/l. The saturation of dissolved oxygen ranges from 93.8% to 101.5% (Figure 19).
- All values are above the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages of 6.5mg/l, and below the CCME Guidelines for the Protection of Early Life Stages of 9.5mg/l. The guidelines are indicated in blue on Figure 19.
- Dissolved oxygen content is stable throughout the deployment period. This trend is expected as the air and water temperatures are generally stable during mid-summer (July-August) (Figure 16).
- The minimum value of 8.17 mg/L occurred at the same time a drop in conductivity and rise in temperature was observed, indicating the sonde may have been out of the water at this point due to dropping stage levels. As data on August 13 may not be accurate, it has been removed from the dataset.

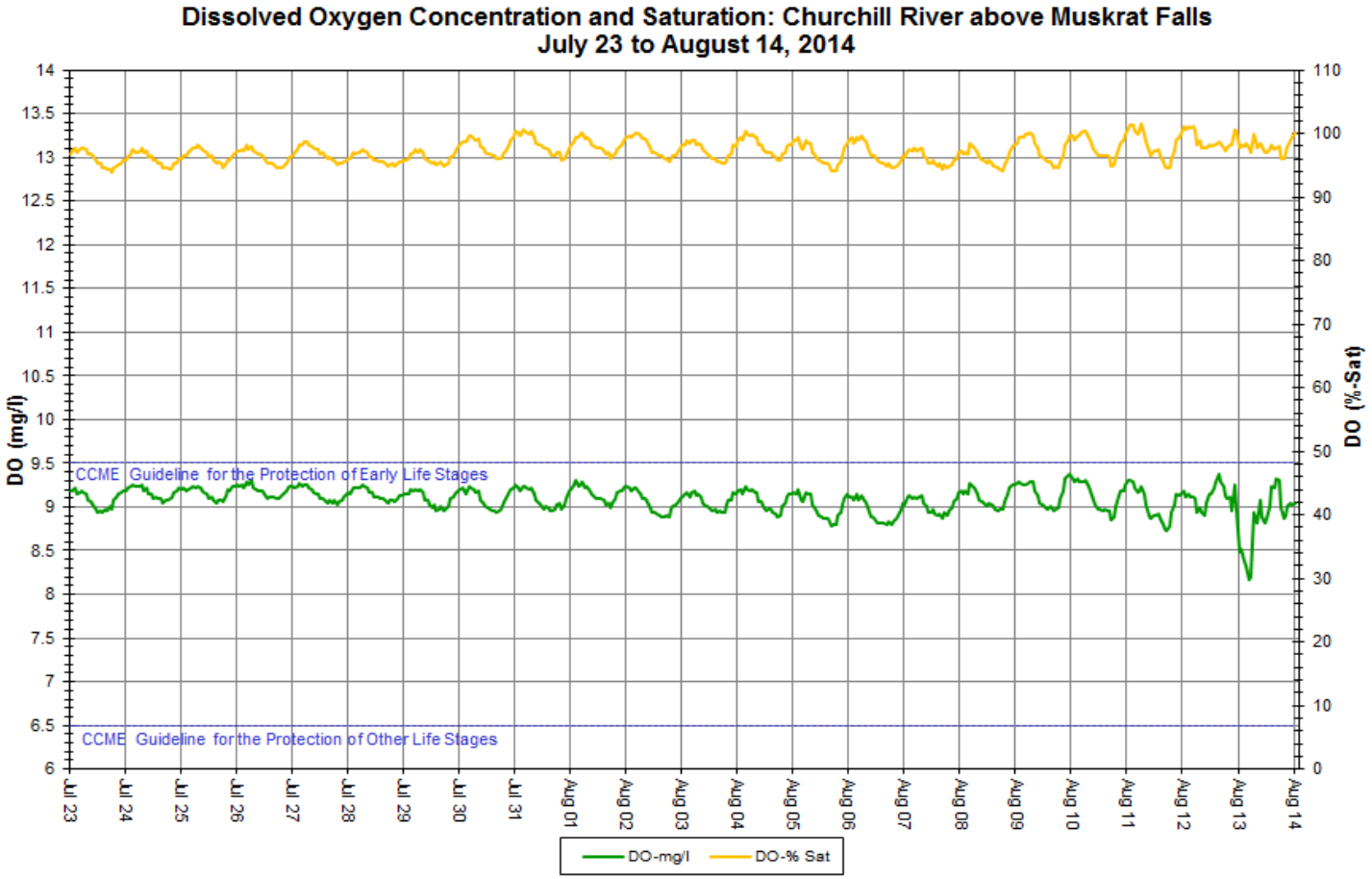

Figure 19: Dissolved oxygen and percent saturation at Churchill River above Muskrat Falls

- Turbidity ranges between 0.0NTU and 90.7NTU, averaging 2.8 NTU during the deployment (Figure 20). A median value of 1.6NTU suggests there is consistent natural background turbidity value. This trend is typical at this station.
- The majority of turbidity events are of small magnitude. The maximum value of 90.7 was reached at the same time that other parameters were affected by the sonde likely being out of the water, and thus the turbidity spikes from August 12-14 are likely from debris and shoreline sediment washing over the sonde as it lies in very shallow or no water. As the data from August 13 may not be accurate, it has been removed from the dataset.

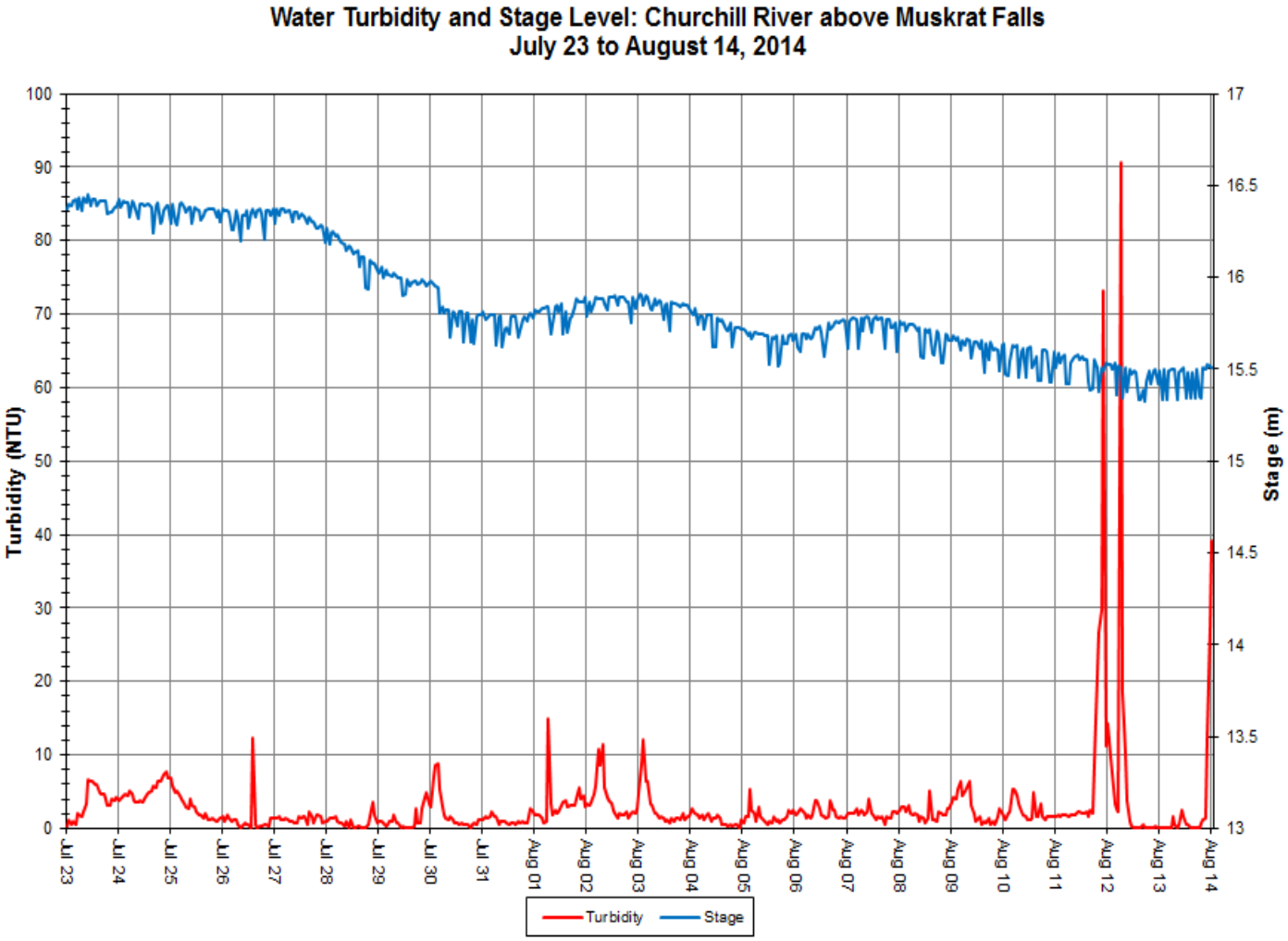

Figure 20: Turbidity and stage level at Churchill River above Muskrat Falls

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 22). Stage is steadily decreasing throughout the deployment period. Precipitation events led to short-term increases in stage. Precipitation occurs on 8 days of the deployment period and amounts are generally small in magnitude, peaking at 18.2mm on August 1. Stage ranges between 15.33m and 16.45m, a difference of 1.12m. Discharge ranges from 947m^3/s to 1510m^3/s.

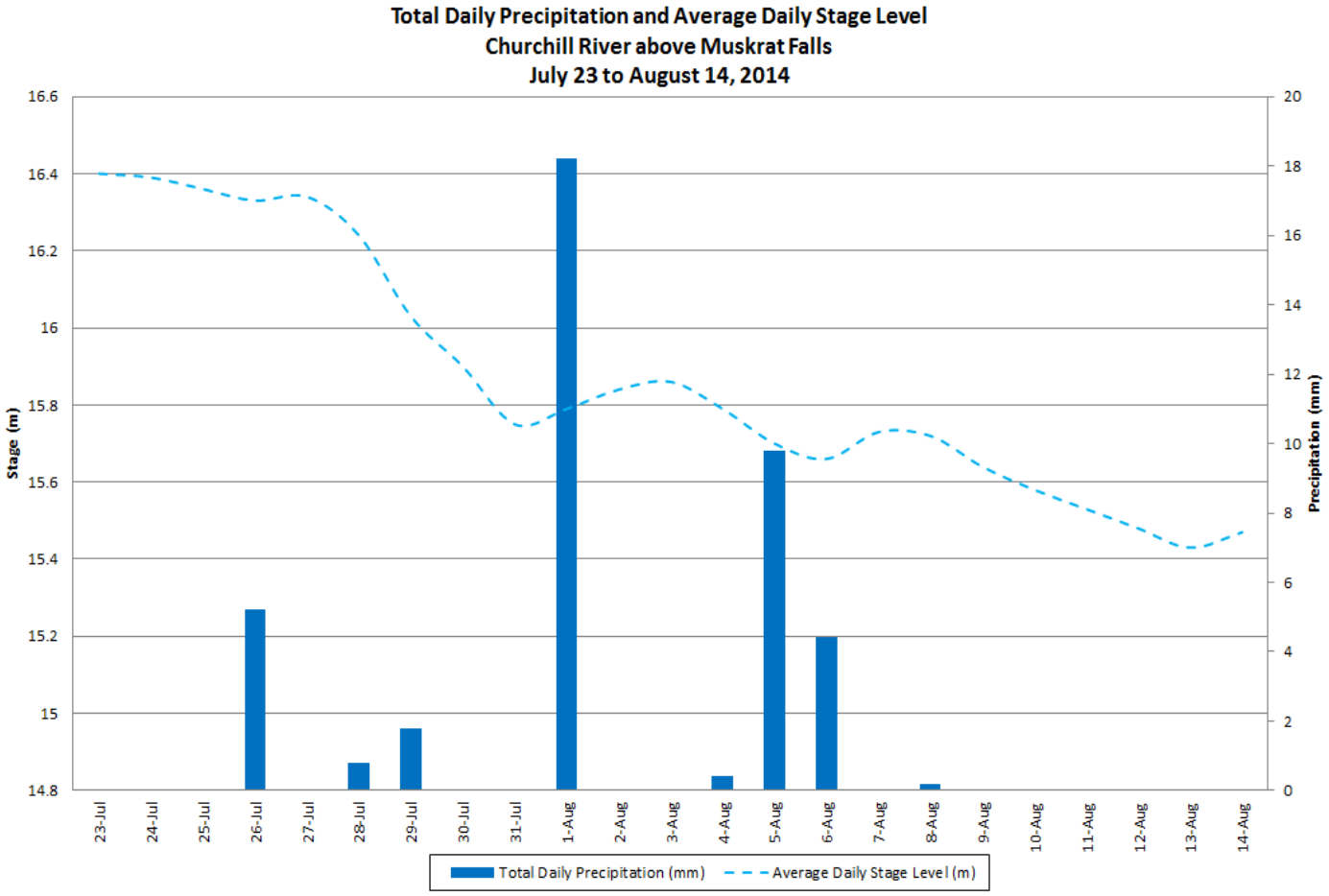

Figure 22: Daily precipitation and average daily stage level at Churchill River above Muskrat Falls (weather data recorded at Goose Bay)

Churchill River below Muskrat Falls

- The sonde located at this station was reburied in sand less than 12 hours after the initial deployment, and thus there is no reliable data available from this station for this deployment period. All data from this period has been removed from the dataset.
- Due to the possibility of damage to the sonde by the sand, the decision was made to not redeploy this station on August 14.
- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 23). Stage decreases steadily during the deployment period. Precipitation occurs on 8 of the days in the deployment period and amounts are small in magnitude, peaking at 18.2 mm on August 1. Stage ranges between 2.30m and 2.77m, a difference of 0.47m.
- The photographs (Figure 24) show the extent of the sand in the area of the station on August 14, 2014. Currently, the helicopter is landing on the beach area as the landing pad has not been repaired.

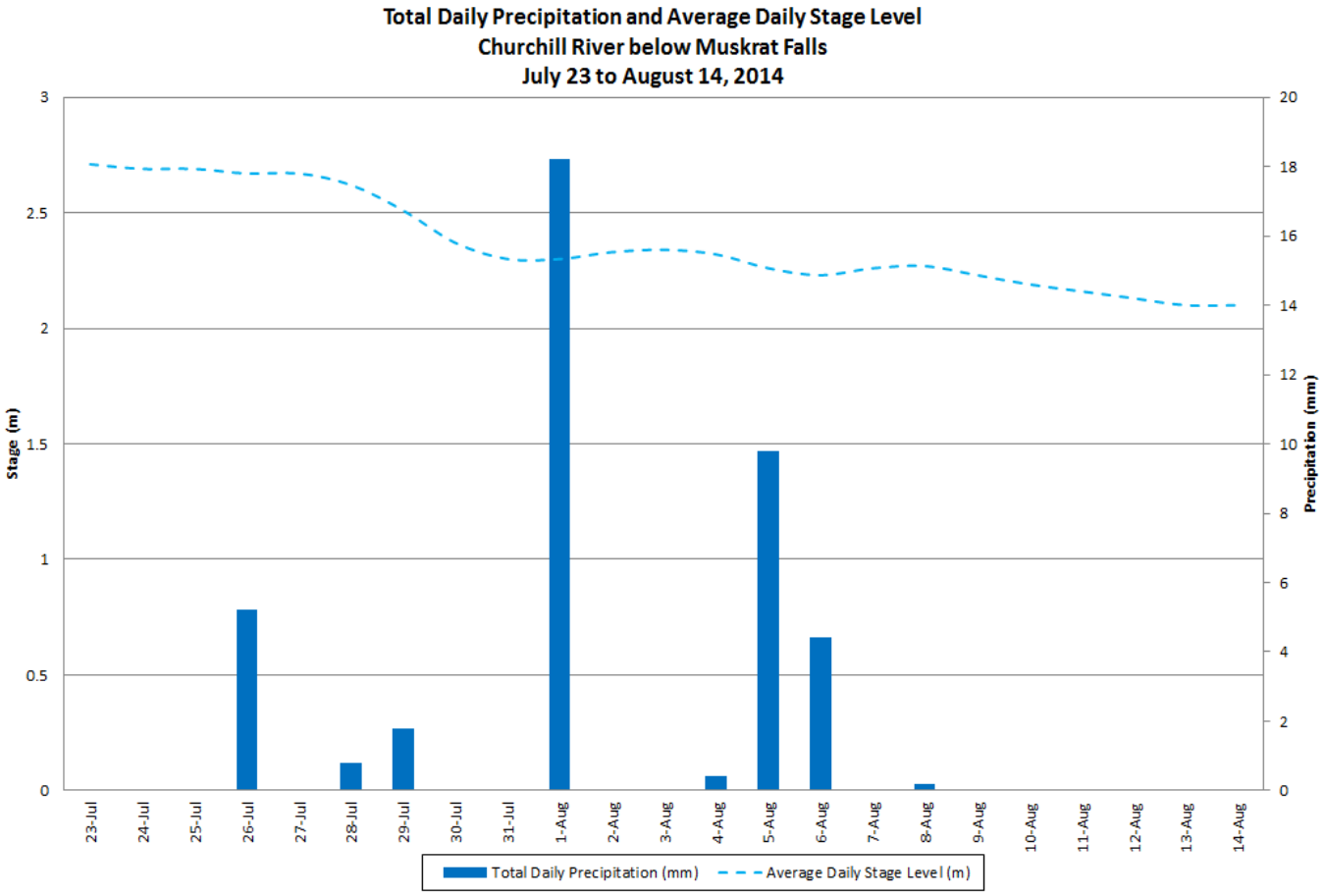

Figure 23: Daily precipitation and average daily stage level at Churchill River below Muskrat Falls (weather data recorded at Goose Bay)

(a)

(b)

(c)

Figure 24: Photographs of the below Lower Muskrat Falls station on August 14, 2014(a-c)

Churchill River at English Point

- Water temperature ranges from 16.30°C to 21.90°C during the deployment period (Figure 25).
- Water temperature is relatively stable throughout this period. This trend is expected as ambient air temperatures in the summer season are relatively stable (Figure 26). Water temperature fluctuates diurnally.

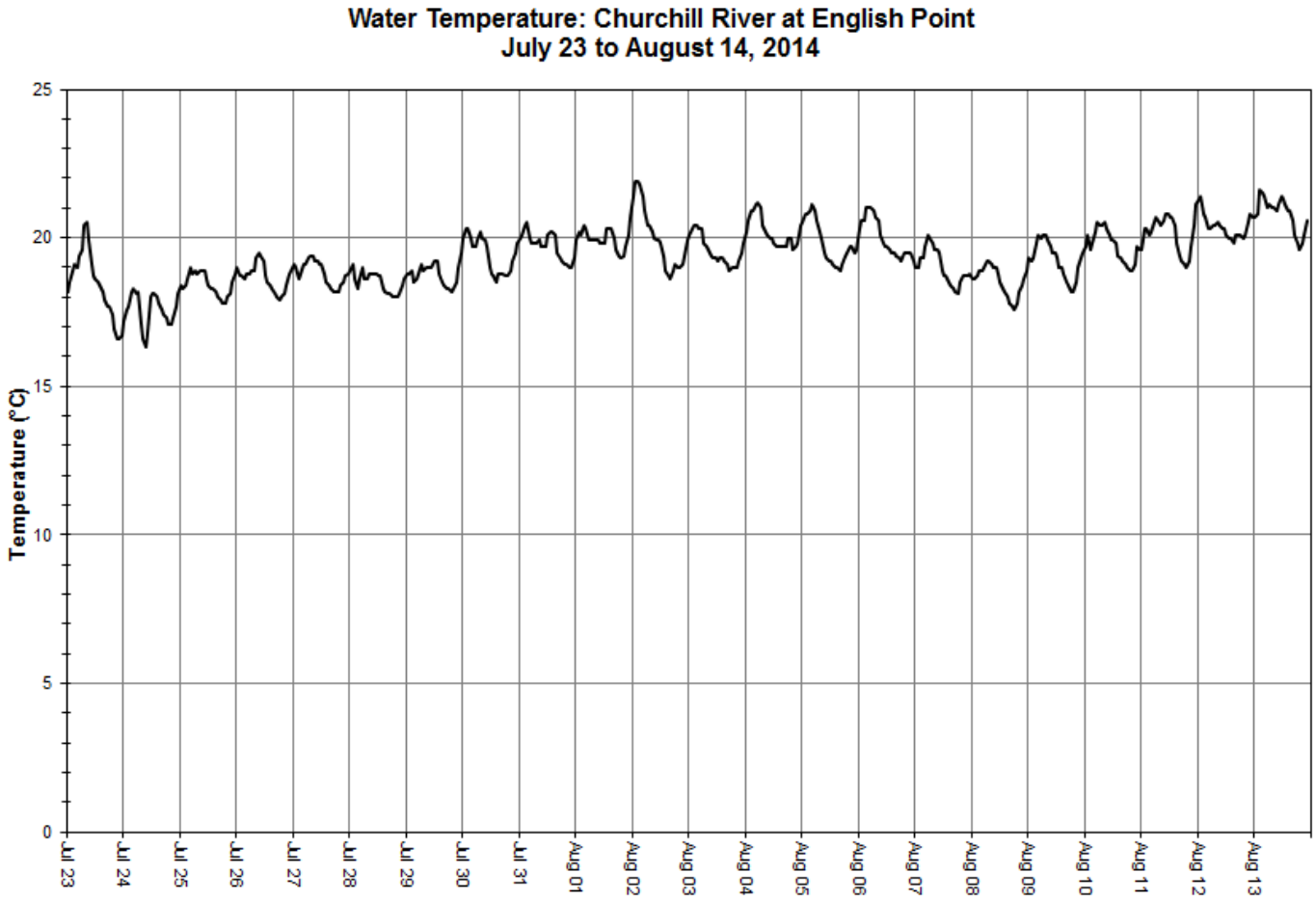

Figure 25: Water temperature at Churchill River at English Point

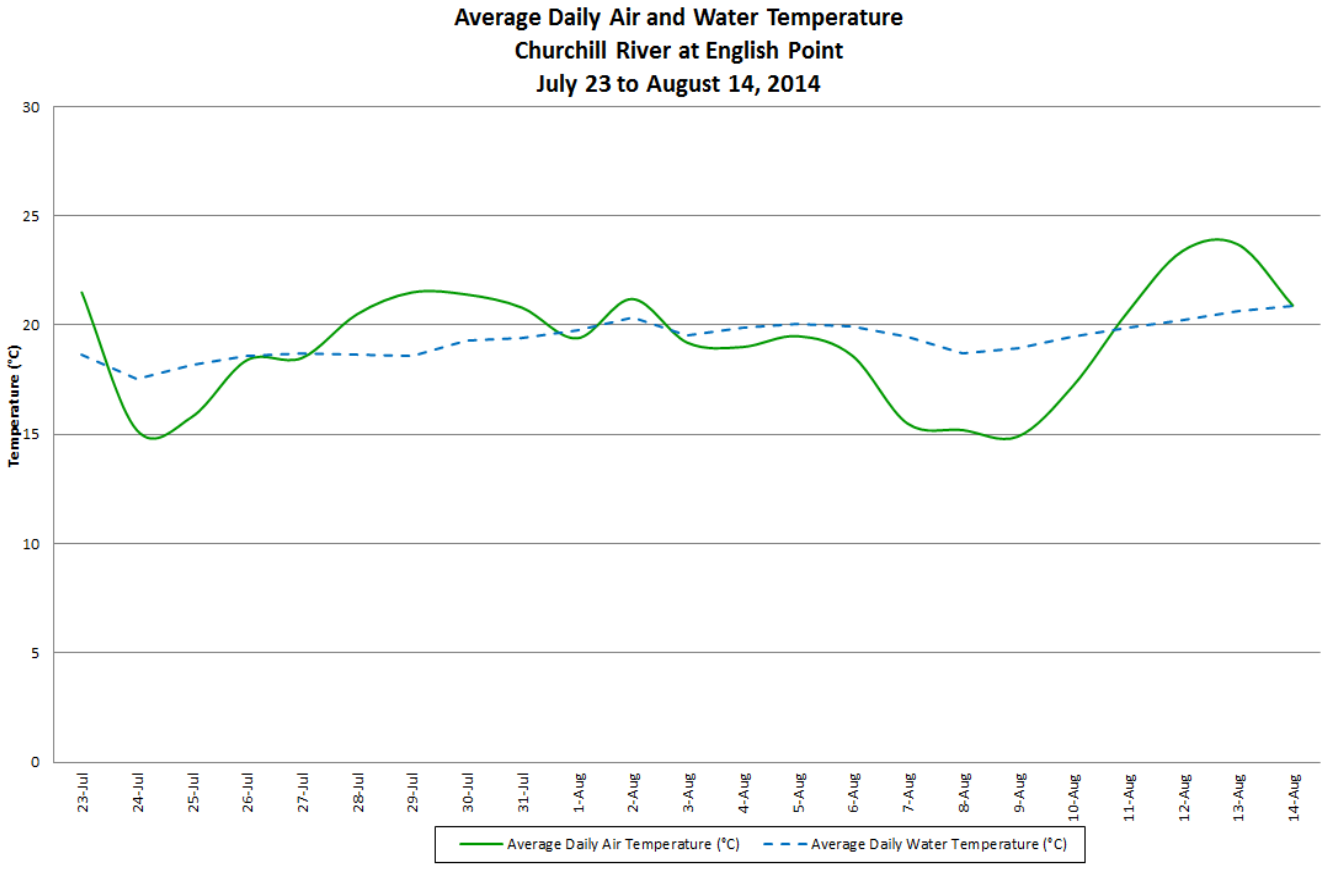

Figure 26: Average daily air and water temperature at Churchill River at English Point

(weather data recorded at Goose Bay)

- pH ranges between 6.89 and 7.33 pH units during the deployment period (Figure 27).
- All pH values recorded are within the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 27).

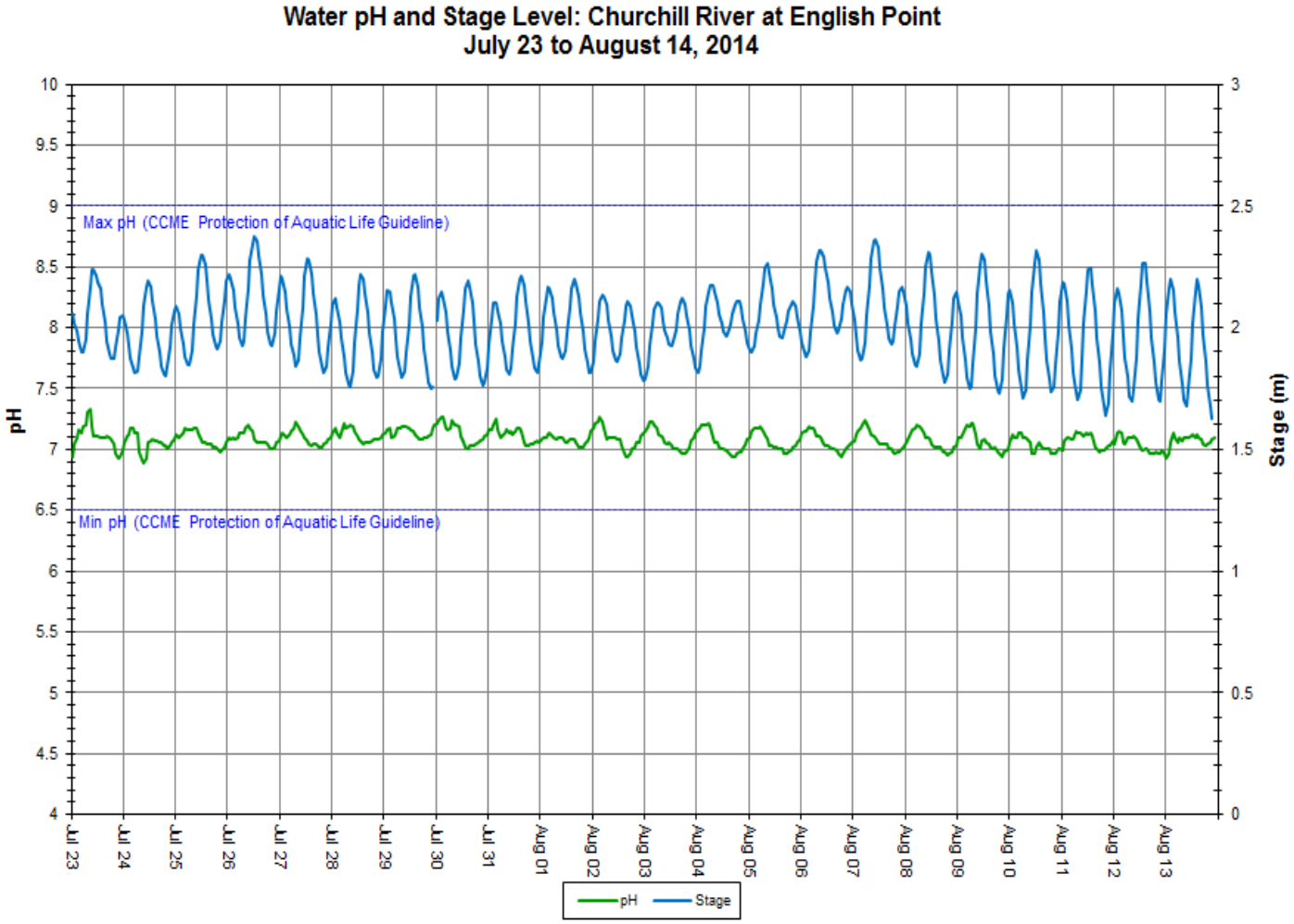

Figure 27: pH and stage level at Churchill River at English Point

- Specific conductance ranged between 19.4µS/cm and 58.7µS/cm during the deployment period, averaging 31.9µS/cm (Figure 28).
- Specific conductivity fluctuates considerably at this location 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. This pattern is generally consistent throughout the deployment period.
- A new moon phase on August 10 and associated 'spring tides' caused higher and lower than normal tides at the station August 9-11, which led to corresponding spikes in specific conductance.

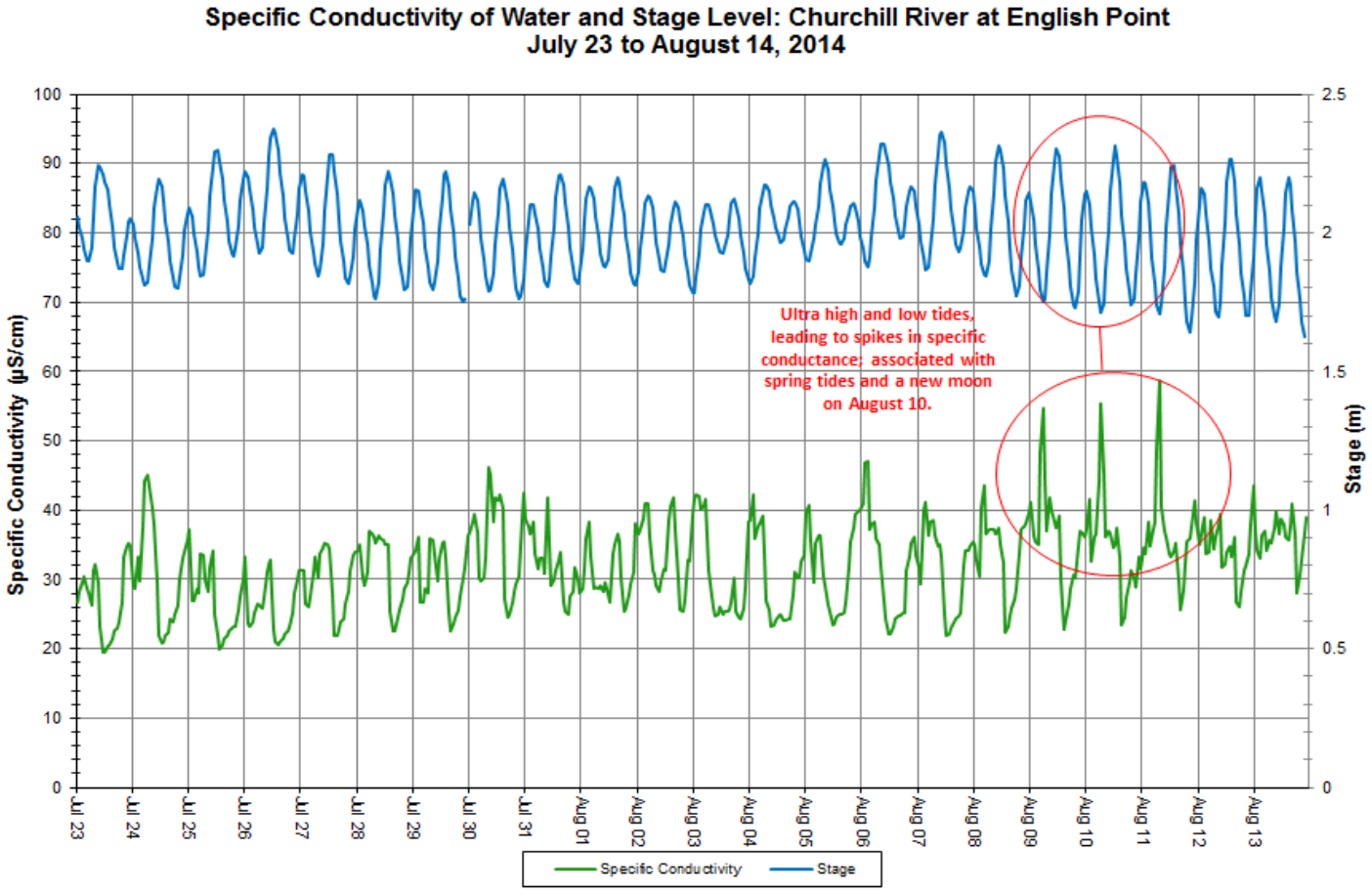

Figure 28: Specific conductivity and stage level at Churchill River at English Point

- Dissolved oxygen content ranges between 8.82mg/l and 10.12mg/l during the deployment period. The saturation of dissolved oxygen ranges from 94.4% to 112.4% (Figure 29).
- The majority of values were above both the minimum CCME Guidelines for the Protection of Cold Water Biota at Other Life Stage of 6.5mg/l and at Early Life Stages of 9.5mg/l. The guidelines are indicated in blue on Figure 29. The values dropped below the Early Life Stages Guideline on only a few occasions.
- Dissolved oxygen content is relatively stable throughout the deployment period. This trend is expected as ambient air and water temperatures are stable during this deployment period (Figure 26). A notable drop in dissolved oxygen on August 2 is correlated to a spike in water temperature at the same time, as warmer water can hold less oxygen.

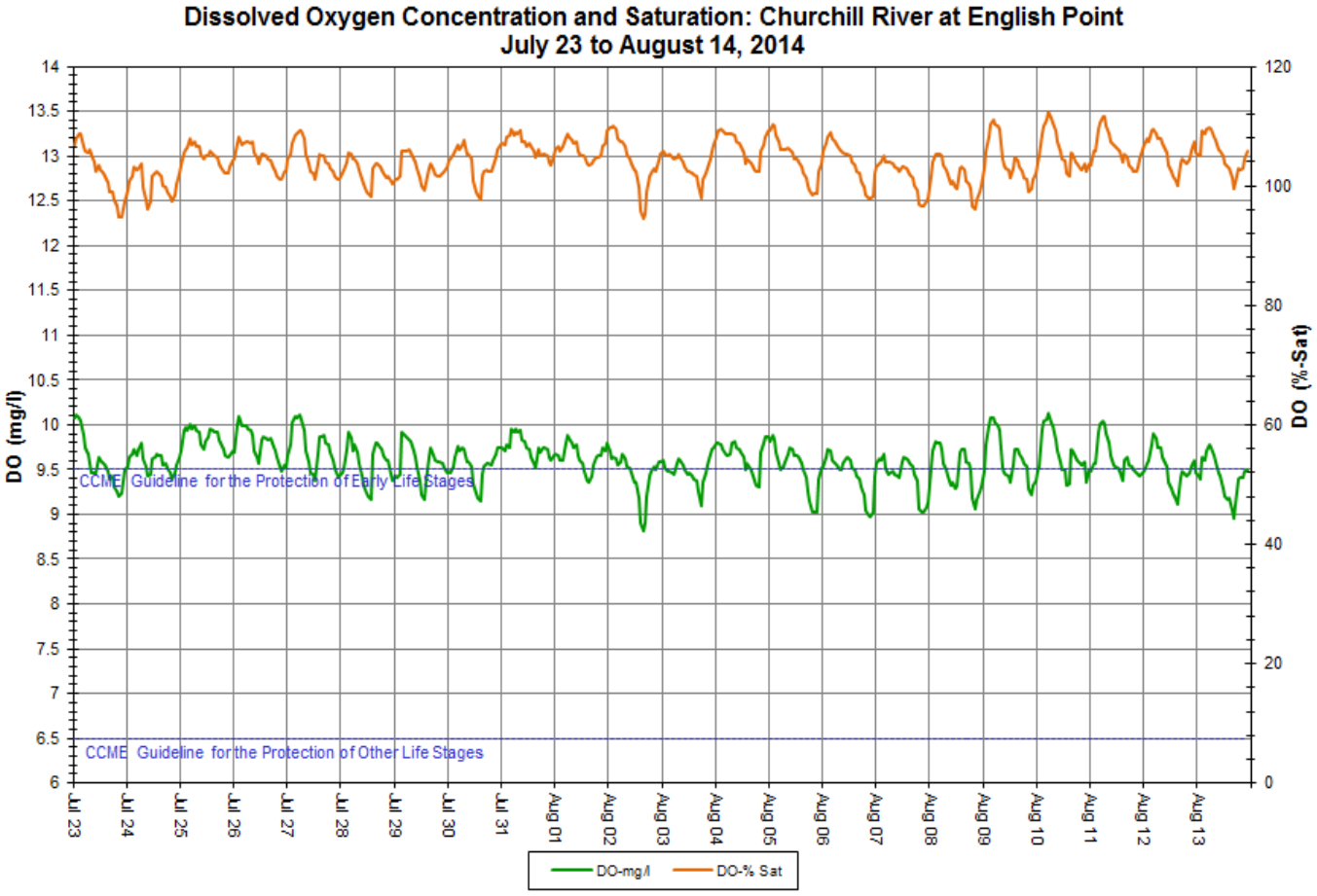

Figure 29: Dissolved oxygen and percent saturation at Churchill River at English Point

- Turbidity ranges from 4.3NTU to 103.2NTU during the deployment period (Figure 30).
- A turbidity increase on July 23 corresponds with a precipitation event recorded in the region. This event is highlighted in red on Figure 30. The increase in turbidity August 11-14 is likely from the suspension of sediment as the higher than normal spring tides reach further onto the shoreline, suspending sediment into the water column. The turbidity increase may also be from fouling of the sensor due to suspended sediment and organic material. As this data may be inaccurate, it will be removed from the dataset.

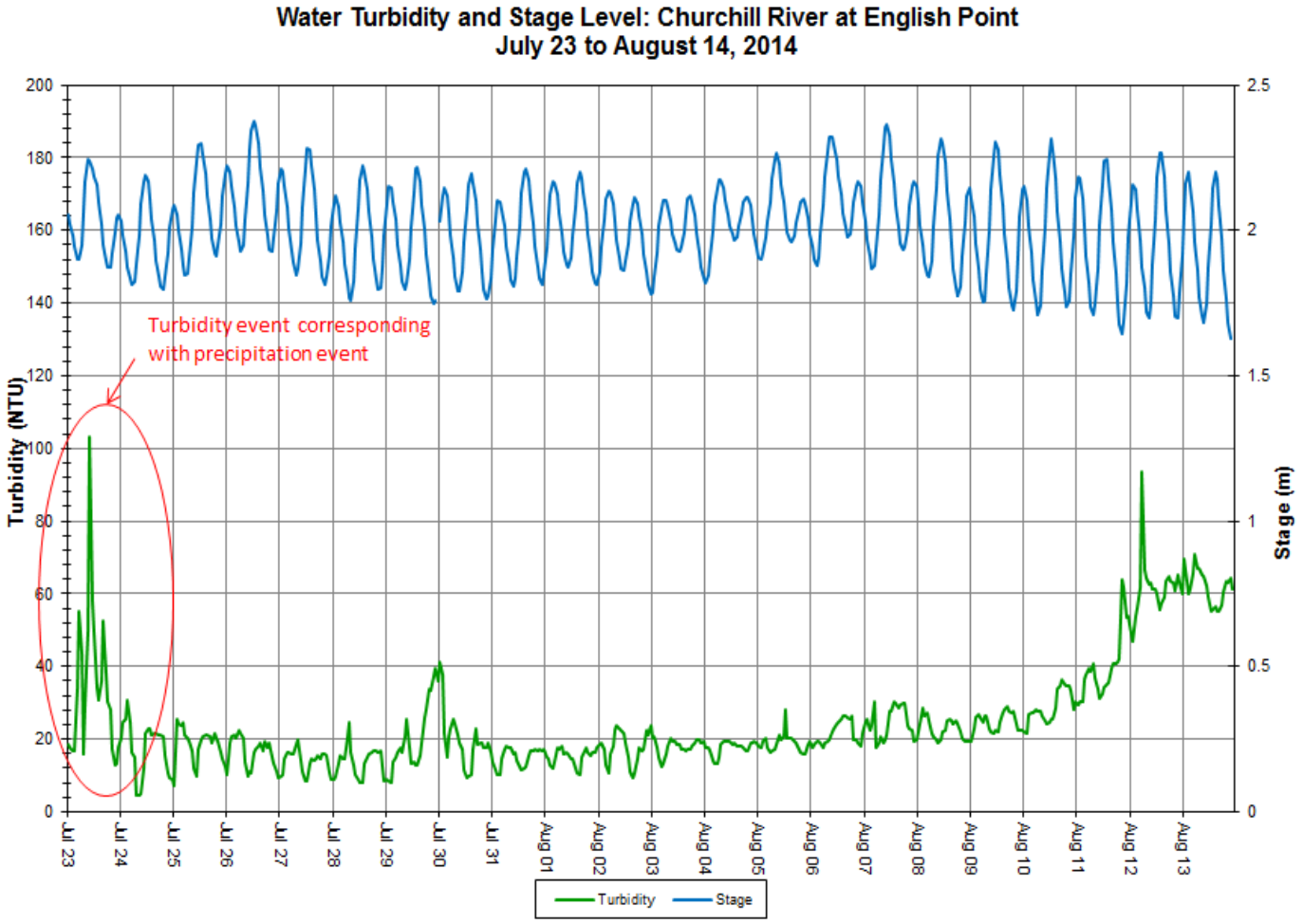

Figure 30: Turbidity and stage level at Churchill River at English Point

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 31). Stage is fluctuating throughout the deployment period. Precipitation occurs on 8 days during the deployment period and amounts are small in magnitude, peaking at 18.2mm on August 1. Stage ranges between 1.63m and 2.37m, a difference of 0.74m.

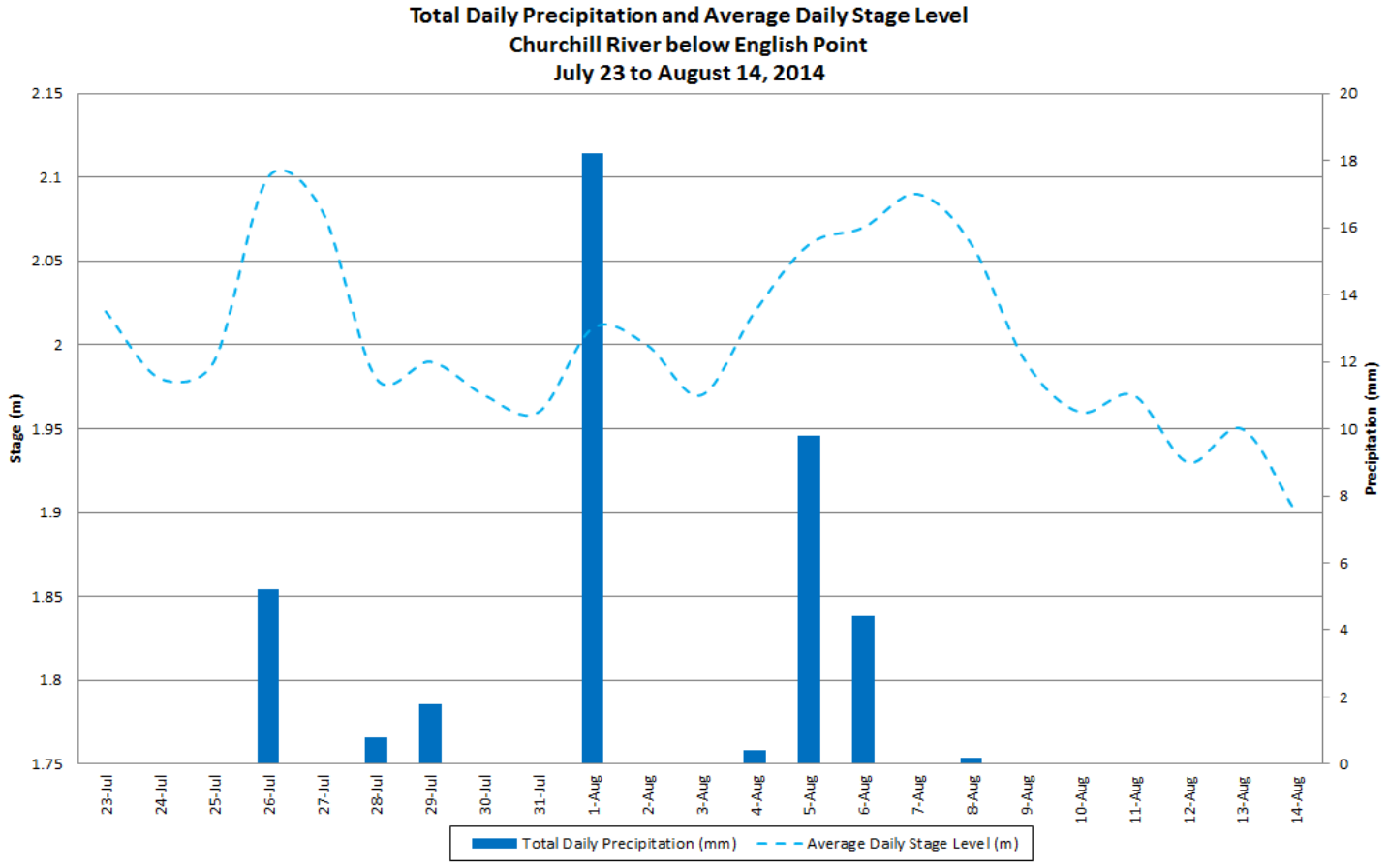

Figure 31: Daily precipitation and average daily stage level at Churchill River at English Point (weather data recorded at Goose Bay)

Conclusions

- Instruments at five water quality monitoring stations on the Lower Churchill River were deployed from July 22/23 to August 12/14, 2014.
- Stage levels are generally decreasing at all stations throughout the deployment as there are few precipitation events occurring which could add more water to the system and raise the stage levels. Water level changes at the each of the stations ranged between 0.31m and 1.12m.
- Water temperature was relatively stable at all stations throughout the deployment period due to the constant, warm ambient air temperatures in the region in the summer season. Water temperature typically ranged between 16.30°C and 24.30°C.
- pH is generally neutral and stable at stations along the Lower Churchill River ranging between 6.86 and 7.32 pH units. All pH values at all stations were within the recommended CCME Guidelines for the Protection of Aquatic Life.
- Specific conductivity was relatively stable at all stations regardless of the fluctuating stage levels. All stations showed little variation in values except at English Point, which is influenced by the tides in Lake Melville. A new moon on August 10 led to spring tides and higher conductivity levels at English Point. Specific conductivity ranged between 17.2µS/cm and 32.9µS/cm at the stations below Metchin River, below Grizzle Rapids and above Muskrat Falls. Specific conductivity values at the station at English Point ranged higher at 19.4µS/cm to 58.7µS/cm .
- Dissolved oxygen content was low throughout the deployment period as it is inversely related to water temperatures, which were warm. Values ranged between 8.17mg/l and 10.12mg/l. All values were above the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota at Other Life Stages at 6.5mg/l, but dipped below the Guideline for Early Life Stages of 9.5mg/l when water temperatures were high.
- Turbidity data at the stations below Metchin River and below Grizzle Rapids remained mostly at 0NTU throughout the deployment period which is typical of these stations. Turbidity values at the stations above Muskrat Falls and at English Point were typical for the stations, reporting background values of 1.6NTU and 19.5NTU respectively.

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