Real-Time Water Quality Deployment Report

Lower Churchill River Network

June 26 to
August 13, 2013

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 for 2013 because of deployment issues in both 2011 and 2012 that caused significant damage to the instrument.
- On June 26/27, 2013, real-time water quality monitoring instruments were deployed at the five Lower Churchill River Stations for periods of 42-47 days. Instruments were removed on August 8, 9, & 13, 2013.

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 June 26/27 to August 8/9/13 are summarized in Table 2.

Table 2: Comparison rankings for Lower Churchill River stations, June 26/27– August 8, 9, & 13, 2013

Churchill River Station and Instrument Number	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Below Metchin River (45707)	June 26, 2013	Deployment	Good	Good	Excellent	Good	Excellent
	Aug 8, 2013	Removal	Excellent	Excellent	Excellent	Excellent	Excellent
Below Grizzle Rapids (45699)	June 26, 2013	Deployment	Good	Poor	Good	Excellent	Excellent
	Aug 8, 2013	Removal	Excellent	Good	Excellent	Excellent	Excellent
Above Muskrat Falls (47590)	June 27, 2013	Deployment	Excellent	Marginal	Excellent	Poor	Excellent
	Aug 8, 2013	Removal	Excellent	Good	Excellent	n/a†	Good
Below Muskrat Falls (45700)	June 27, 2013	Deployment	Good	Marginal	Excellent	Excellent	Good
	Aug 9, 2013	Removal	Good	Good	Excellent	Excellent	Poor
At English Point (45042)	June 27, 2013	Deployment	Excellent	Fair	Excellent	Excellent	Good
	Aug 13, 2013	Removal	Excellent	Good	Excellent	n/a†	Good

†Comparison ranking unavailable due to dissolved oxygen sensor malfunction on the QAQC instrument 47592 on June 26/27.

- At the station below Metchin River, all parameters ranked 'good' or 'excellent' at deployment.

  At removal, all parameters ranked 'excellent'.

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

  For pH at deployment, the field instrument read a value of 6.92 while the QAQC instrument read a value of 8.06 pH units, a difference of 1.14 pH units. The QAQC instrument is reading exceptionally high for this station and continues to read high for pH values collected the same day (June 26). It is likely that the pH sensor on the QAQC instrument did not have sufficient time to stabilize to the environment or there was an error experienced during calibration.

  At removal, all parameters ranked either 'good' or 'excellent'.

- At the station above Muskrat Falls, temperature, specific conductivity and turbidity ranked 'excellent' at deployment. pH and dissolved oxygen ranked 'marginal' and 'poor' respectively.

  For pH, the field instrument read a value of 6.53 while the QAQC instrument read a value of 7.40, a difference of 0.87 pH units. The QAQC instrument is reading high for this station and continues to read high for pH values collected the same day (June 26). It is likely that the pH sensor on the QAQC instrument did not have sufficient time to stabilize to the environment or there was an error experienced during calibration.

  For dissolved oxygen, the field instrument read a value of 9.30mg/l while the QAQC instrument read a value of 10.58mg/l, a difference of 1.28mg/l. Since the instrument deployed just previous to this reading was unavailable because the instrument was out of the water, there is no third value available to verify that the dissolved oxygen content in the river was at around 10.58mg/l as opposed to 9.44mg/l. The dissolved oxygen content for the deployment period will be compared to the data collected at the other stations to help determine its validity.

  At removal, temperature, pH, specific conductivity and turbidity all ranked either 'good' or 'excellent'. Dissolved oxygen was not ranked due to an error with the dissolved oxygen sensor on the QAQC instrument (s/n: 47592).

- At the station below Muskrat Falls, 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 6.38 while the QAQC instrument read a value of 7.38, a difference of 1.00 pH units. The QAQC instrument is reading high for this station and continues to read high for pH values collected the same day (June 26). It is likely that the pH sensor on the QAQC instrument did not have sufficient time to stabilize to the environment or there was an error experienced during calibration.

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

  For turbidity, the field instrument read a value of 60NTU while the QAQC instrument read a value of 4.8NTU. The turbidity is increasing consistently in the last 2 weeks of the deployment period to values around 60NTU. This value is likely a true reading for the instrument however does not accurately represent the water body entirely. Silt and sand are likely to have been causing this increase in turbidity values during the deployment period. These trends will be evaluated further in the Data Interpretation section for this station.

- At the station at English Point, temperature, specific conductivity, dissolved oxygen and turbidity all ranked either 'good' or 'excellent' while pH ranked 'fair'.

  For pH, the field instrument read a value of 6.58 while the QAQC instrument read a value of 7.38, a difference of 1.2 pH units. The QAQC instrument is reading high for this station and read high for pH values collected the previous day (June 26). It is likely that the pH sensor on the QAQC instrument did not have sufficient time to stabilize to the environment or there was an error experienced during calibration.

  At removal, temperature, pH, specific conductivity and turbidity all ranked either 'good' or 'excellent'. Dissolved oxygen was not ranked due to an error with the dissolved oxygen sensor on the QAQC instrument (s/n: 47592).

Data Interpretation

- The following graphs and discussion illustrate water quality related events occurring between June 26/27 and August 8/9/13 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 11.70°C to 17.70°C during the deployment period (Figure 1).
- Water temperature is increasing throughout this part of the deployment period. This trend is expected due to the warming air temperatures in the summer season (Figure 2). Water temperature fluctuates diurnally.

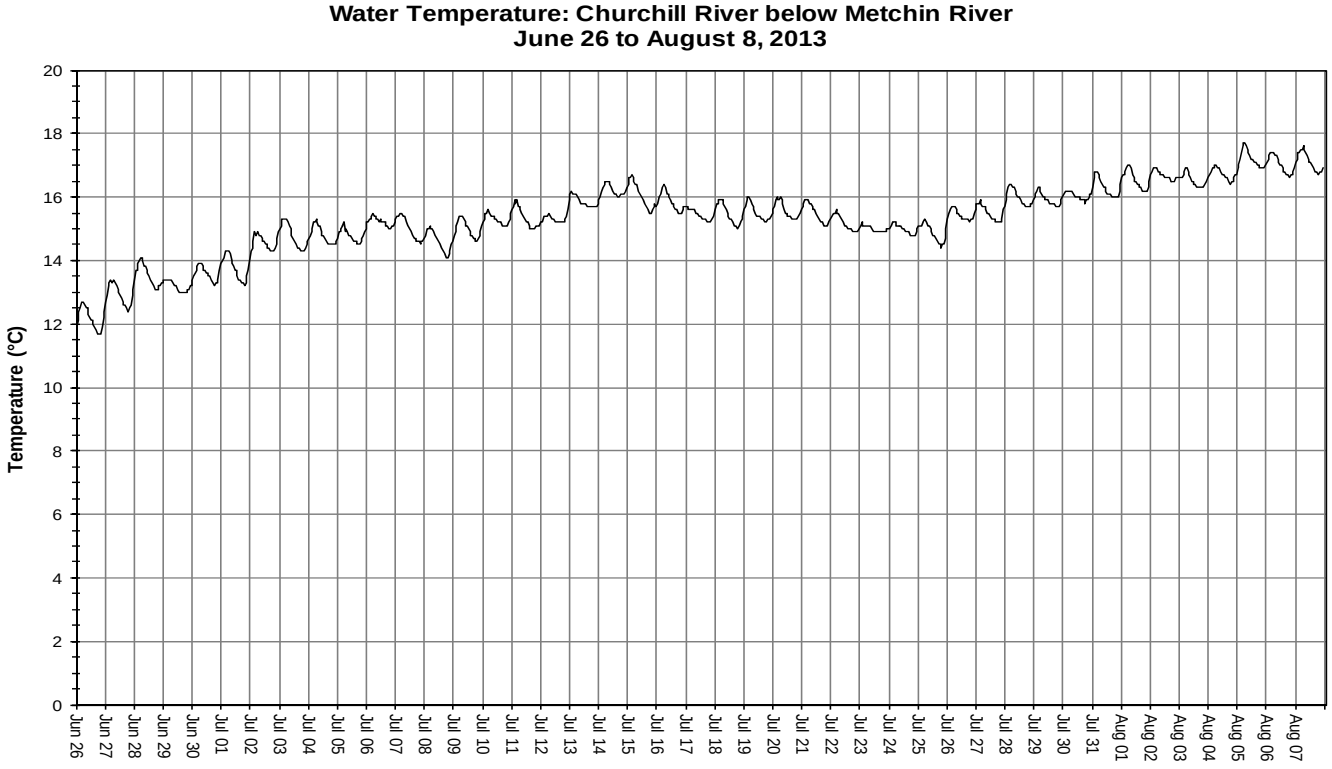


Figure 1: Water temperature at Churchill River below Metchin River

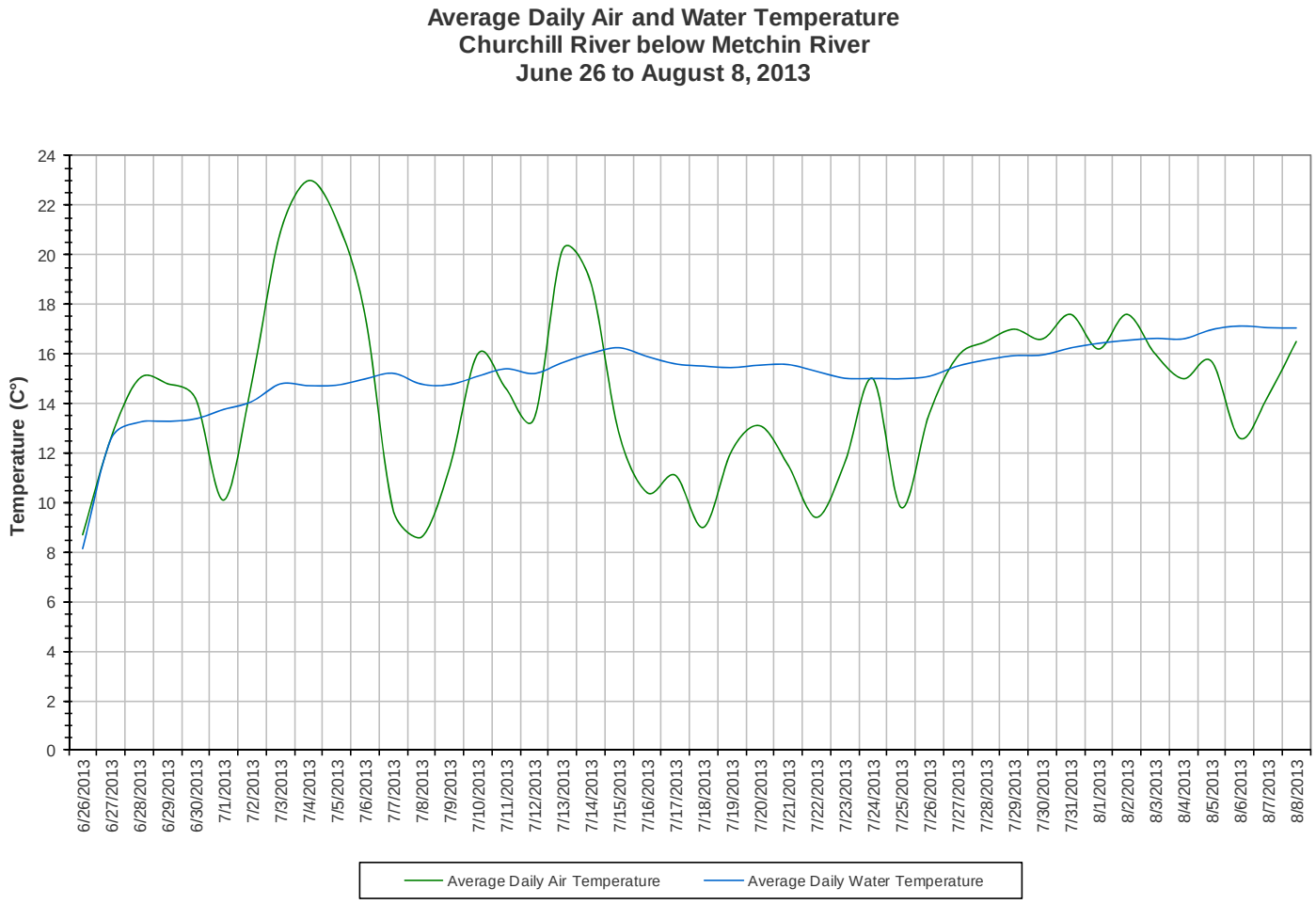


Figure 2: Average daily air and water temperature at Churchill River below Metchin River (weather data recorded at Churchill Falls, NL)

- pH ranges between 7.20 and 7.43 pH units and is very stable throughout the deployment period (Figure 3). pH values fluctuate slightly 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 3).

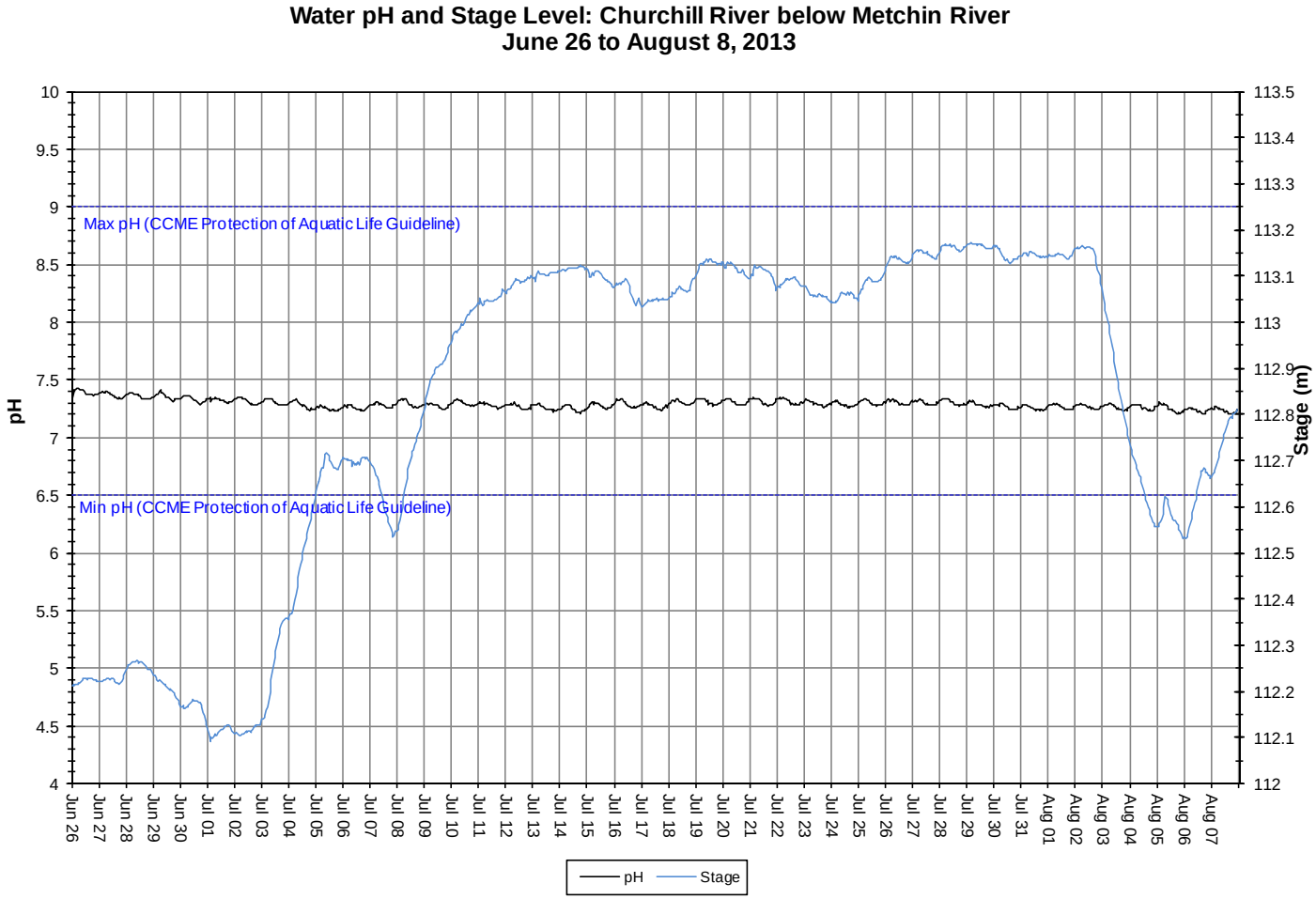


Figure 3: pH and stage level at Churchill River below Metchin River

- Specific conductivity ranges between 18.3µS/cm to 21.5µS/cm during the deployment period, averaging 19.8µS/cm (Figure 4).
- Specific conductivity is increasing slightly towards the end of the deployment period. Specific conductivity increases sharply from 19.4µS/cm to as high as 21.5µS/cm on July 8 for a period of 5 hours before returning to 19.4µS/cm. This increase does not correspond with a rainfall or weather related event, there is a sharp decrease in stage at the same time. Although this increase is notable on Figure 4, the increase of 2µS/cm is not substantial.
- Stage is included in Figure 4 to illustrate the inverse relationship between conductivity and water level. Stage is increasing throughout the first two weeks of the deployment period. Stage levels are stable for the following three weeks before decreasing in the final days before the instrument was retrieved. 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 clearly visible in the data collected during the deployment period. Specific conductivity is unusually stable during the changes in water level.

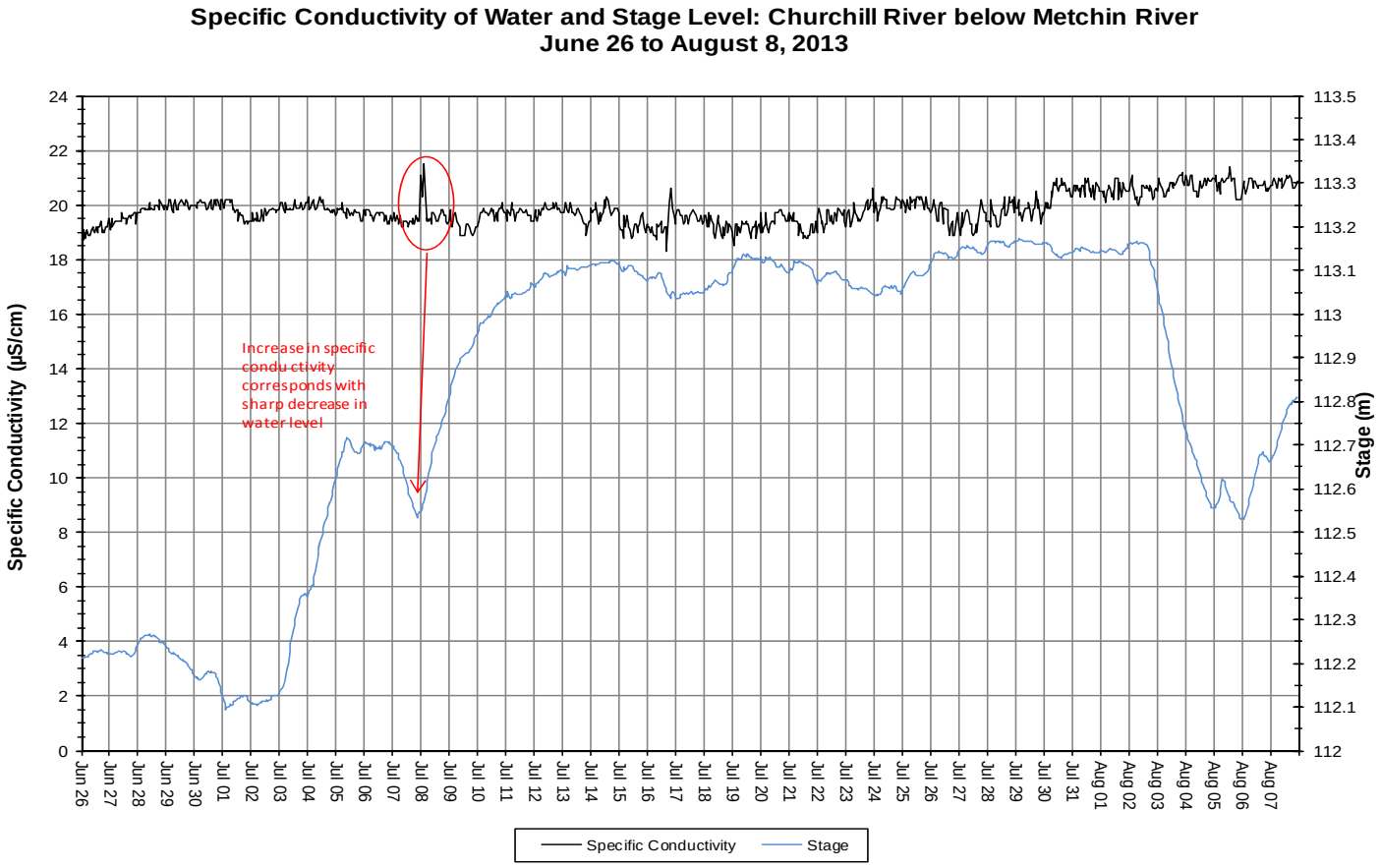


Figure 4: Specific conductivity and stage level at Churchill River below Metchin River

- Dissolved oxygen content ranges between 9.21mg/l and 10.82mg/l. The saturation of dissolved oxygen ranges from 92.7% to 102.7% (Figure 5).
- All values between June 26 and July 11 were above both the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages of 6.5mg/l and Early Life Stages of 9.5mg/l. The guidelines are indicated in blue on Figure 5. After July 11, dissolved oxygen content decreases to just below the guideline suggested by the CCME for Early Life Stages.
- Dissolved oxygen content is decreasing throughout the deployment period. This trend is expected given the warming air and water temperatures (Figure 2).

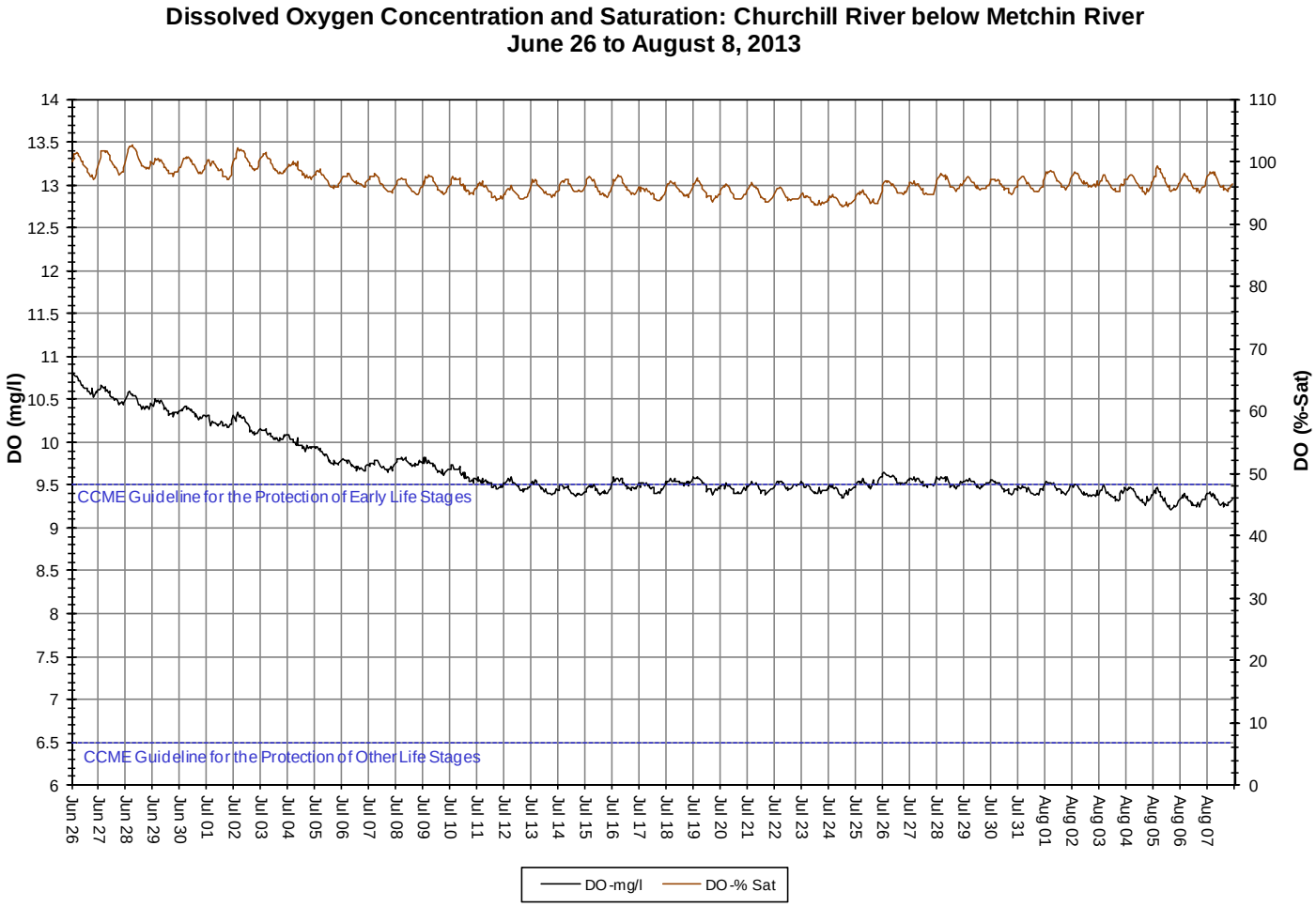


Figure 5: Dissolved oxygen and percent saturation at Churchill River below Metchin River

- 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 five instances when turbidity increases above 0NTU. These turbidity increases are relatively short-lived (1-2 hours) and low in magnitude (<30NTU). None of these events can be attributed directly to rainfall events. Precipitation records show some amount of rainfall occurred during 2/3 of the deployment period.

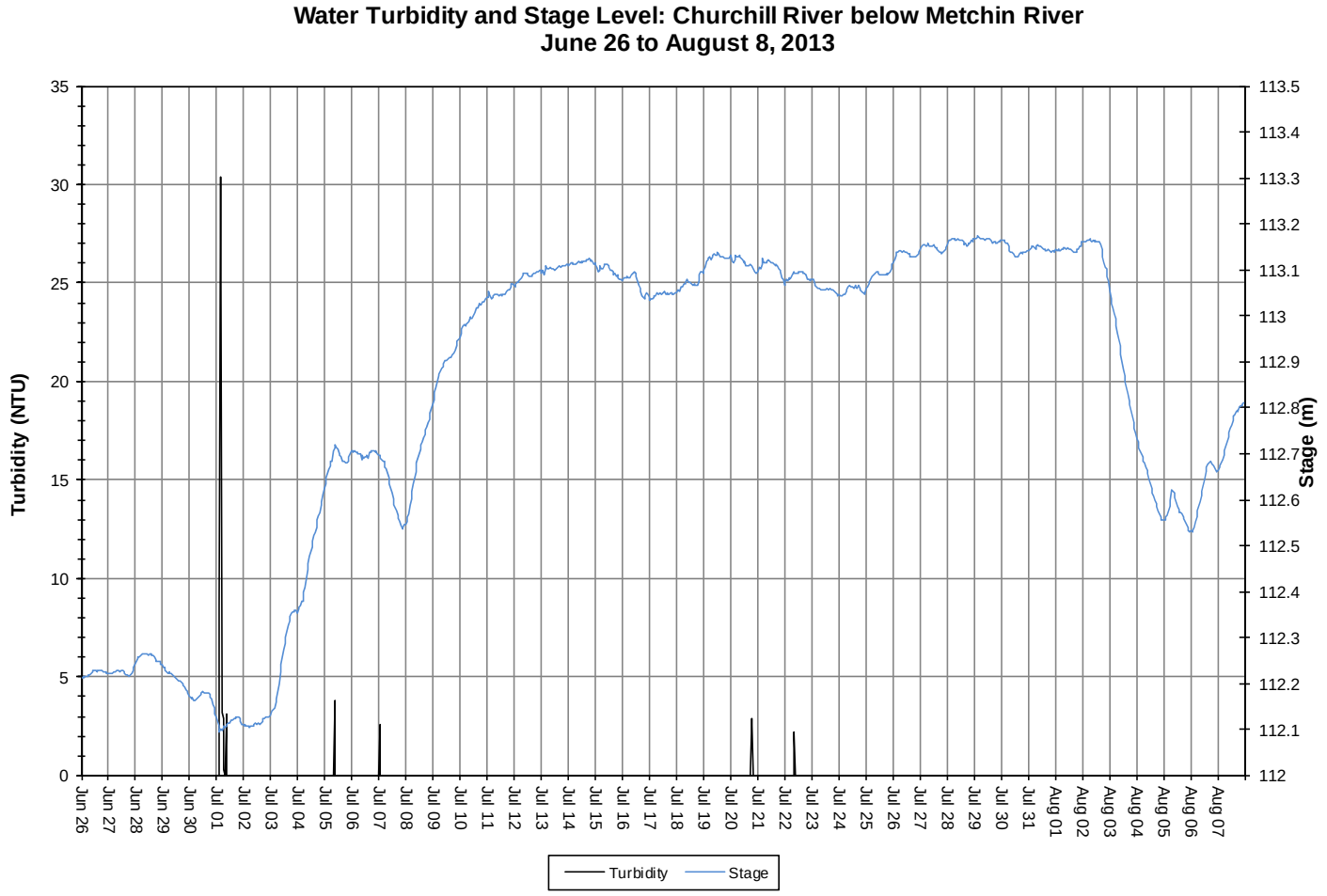


Figure 6: Turbidity and stage level at Churchill River below Metchin River

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 7). Stage is increasing in the beginning of the deployment period and decreasing near the end of the deployment period. Precipitation records are frequent but low in magnitude and do not contribute significantly to the changing water level. Stage ranges between 112.09m and 113.17m, a difference of 1.08m.

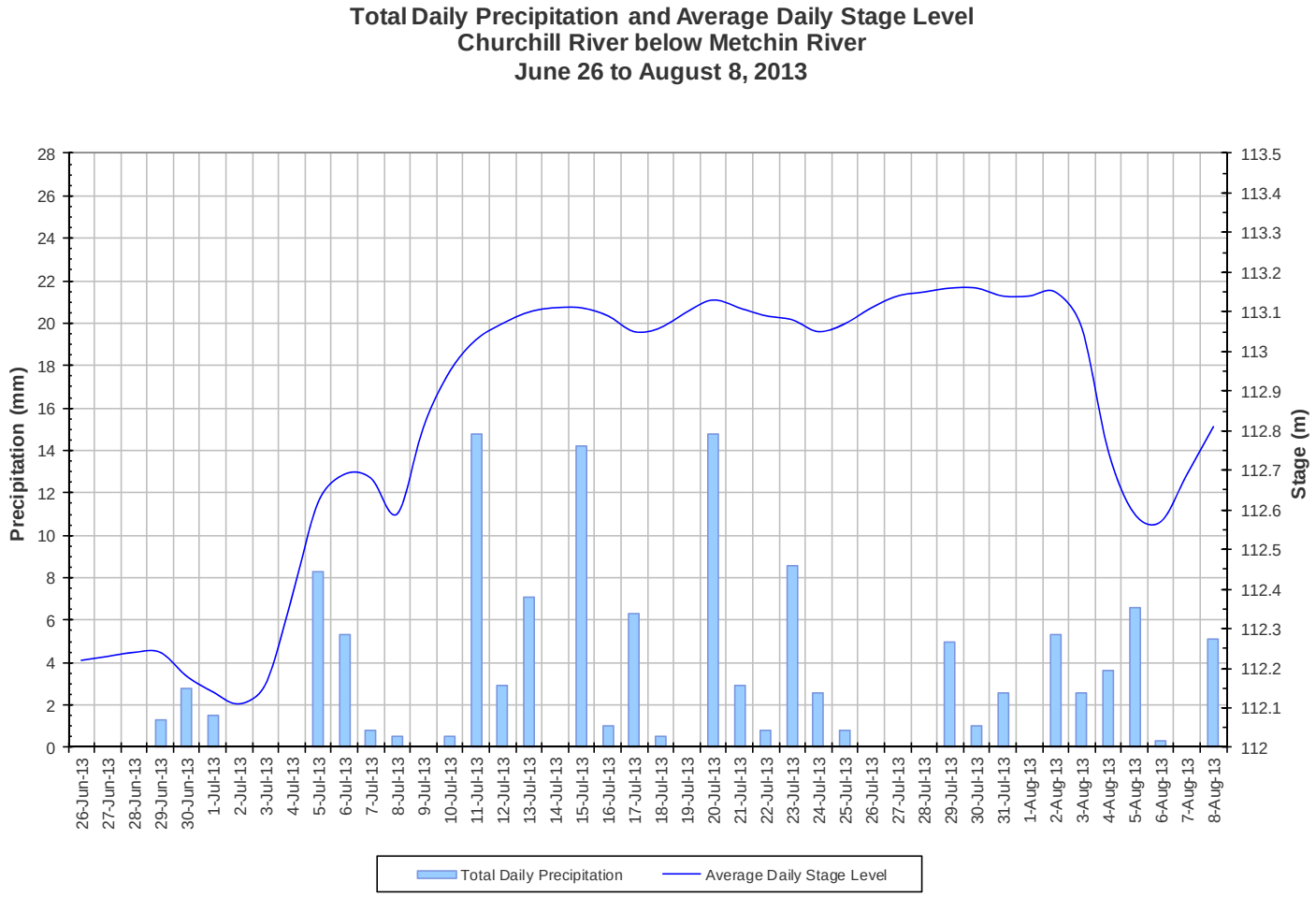


Figure 7: Daily precipitation and average daily stage level at Churchill River below Metchin River (weather data recorded at Churchill Falls)

Churchill River below Grizzle Rapids

- Water temperature ranges from 9.90°C to 18.10°C during the deployment period (Figure 8).
- Water temperature is increasing throughout the deployment period. This trend is expected due to the warming ambient air temperatures in the summer season (Figure 9). Water temperature fluctuates diurnally.

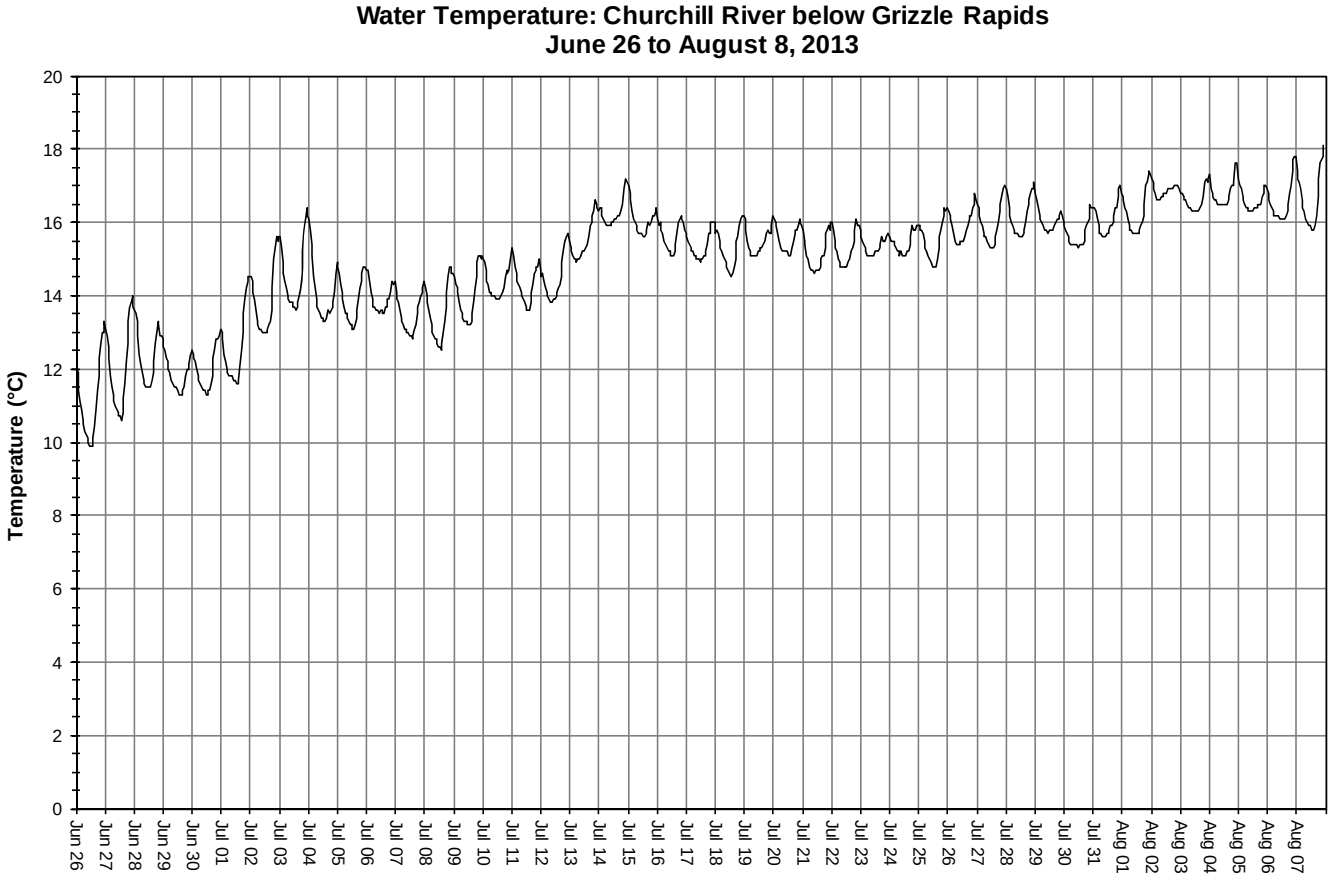


Figure 8: Water temperature at Churchill River below Grizzle Rapids

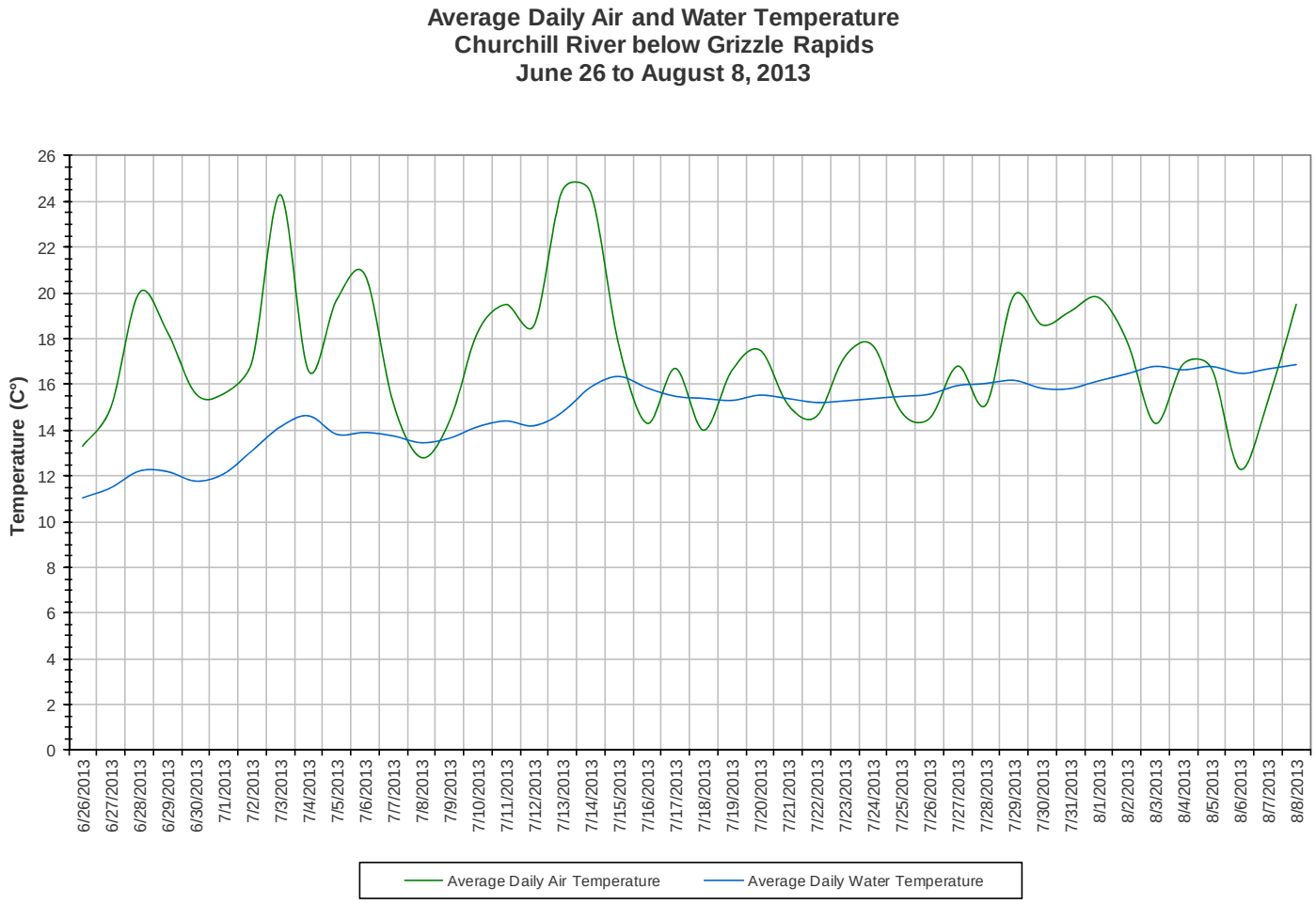


Figure 9: Average daily air and water temperature at Churchill River below Grizzle Rapids (weather data recorded at Goose Bay)

- pH ranges between 6.83 and 7.21 pH units (Figure 10).
- pH values are very stable throughout the deployment period. pH values fluctuate consistently 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).

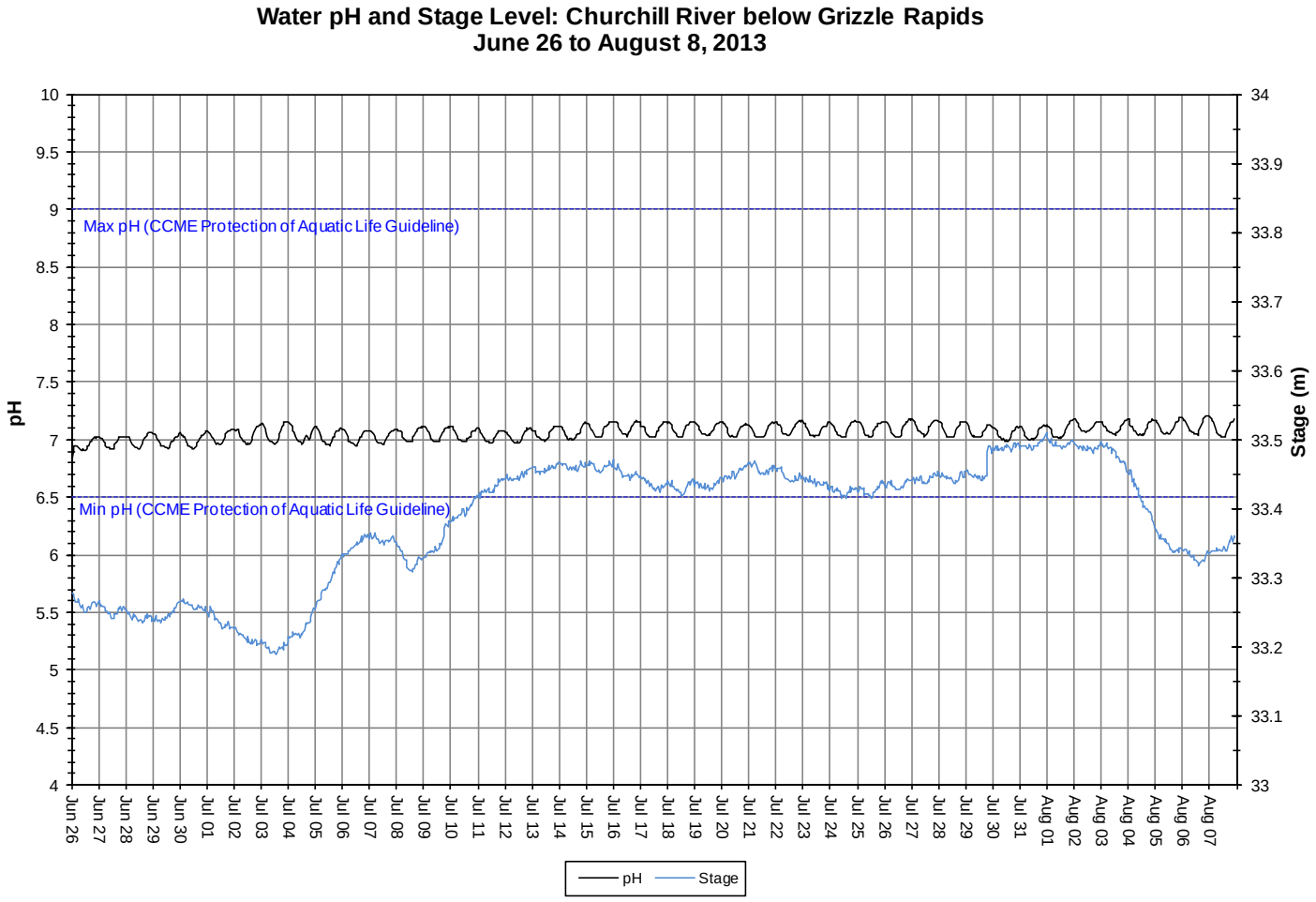


Figure 10: pH and stage level at Churchill River below Grizzle Rapids

- Specific conductivity ranges from 16.1µS/cm to 21.2µS/cm during the deployment period, averaging 18.6µS/cm (Figure 11).
- Specific conductance is increasing consistently throughout the deployment period.
- 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 minimal fluctuations. 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 not clearly visible in the data collected during the deployment period. Specific conductivity is increasing consistently during the changes in water level.

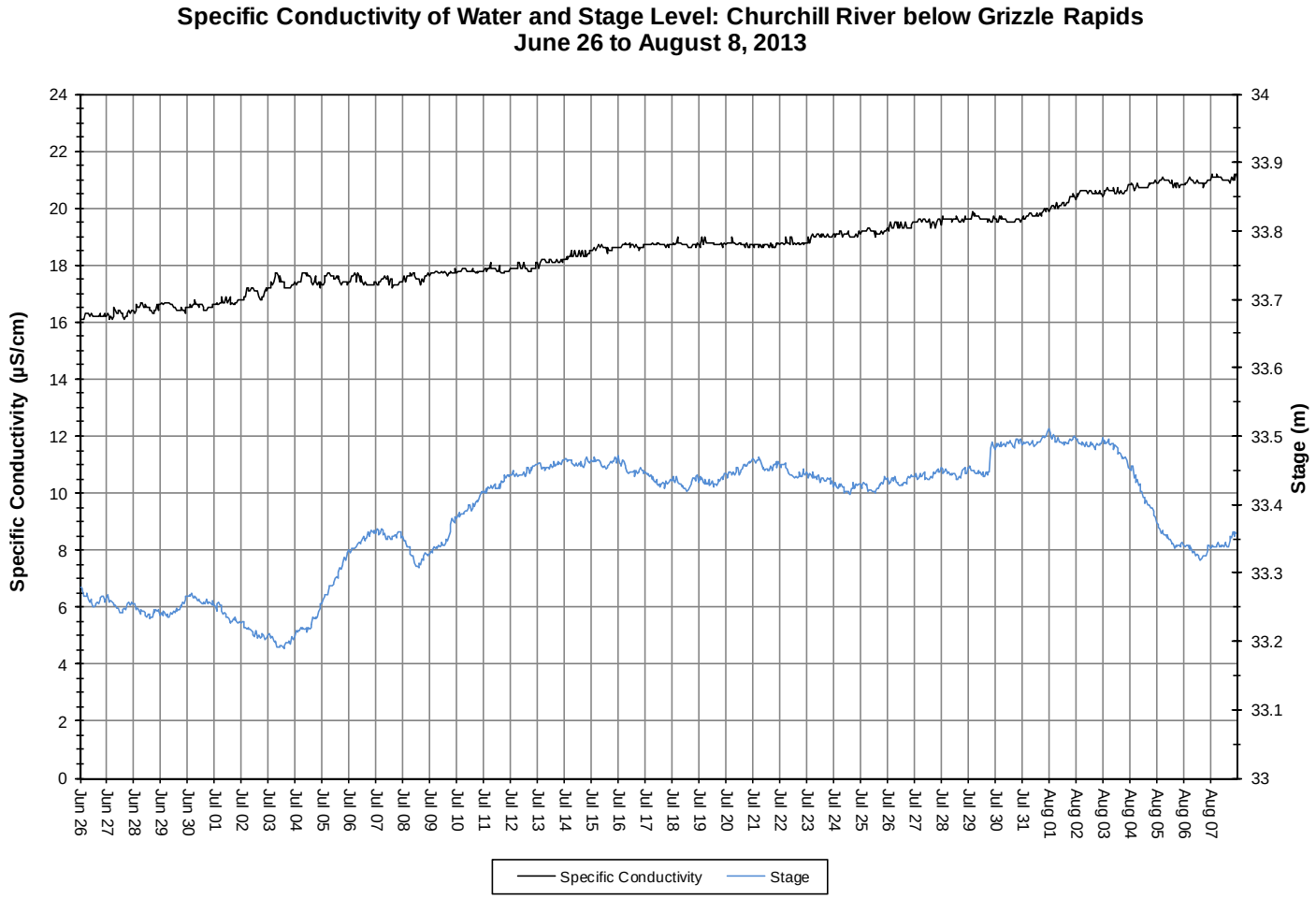


Figure 11: Specific conductivity and stage level at Churchill River below Grizzle Rapids

- Dissolved oxygen content ranges between 9.33mg/l and 11.17mg/l. The saturation of dissolved oxygen ranges from 95.5% to 105.2% (Figure 12).
- Most values were above both the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages of 6.5mg/l and Early Life Stages of 9.5mg/l. The guidelines are indicated in blue on Figure 12. In the final days of the deployment period, dissolved oxygen drops to just below the minimum CCME Guideline for the Protection of Aquatic life at Early Life Stages.
- Dissolved oxygen content is decreasing throughout the deployment period. This trend is expected given the warming air and water temperatures (Figure 9). Dissolved oxygen content increases during the warm days and decreases during the cool nights.

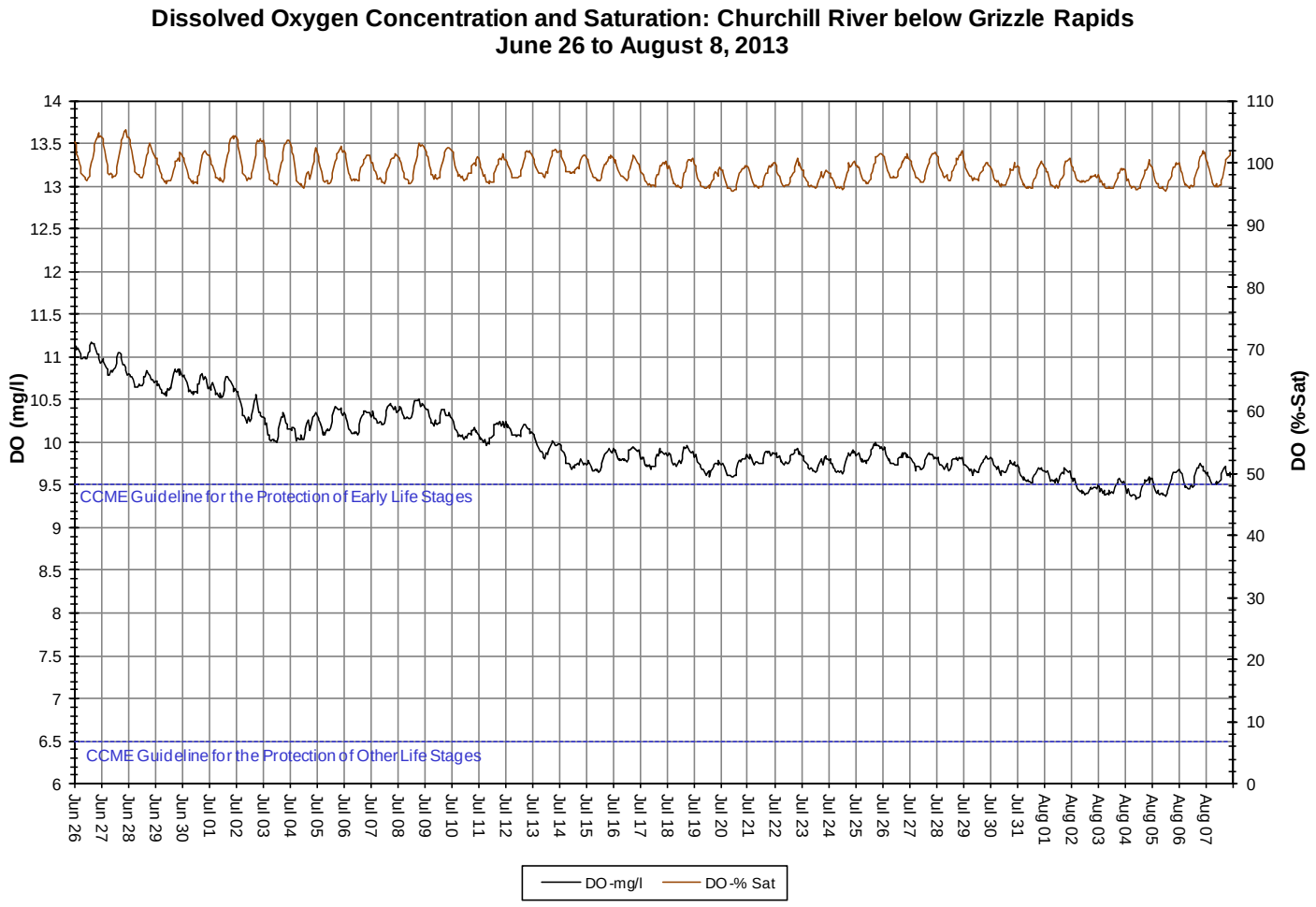


Figure 12: Dissolved oxygen and percent saturation at Churchill River below Grizzle Rapids

- 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 are a couple of instances when turbidity values are recorded as high as 15.4NTU. These increases are short lived (1-4 hours) and not significant. The increase in turbidity on July 30, corresponds with a visit to the station by Environment Canada. The increase in turbidity may have been caused by Environment Canada staff disturbing the instrument while working on site near the shoreline. Stage level was corrected at the same time the turbidity increase was recorded.

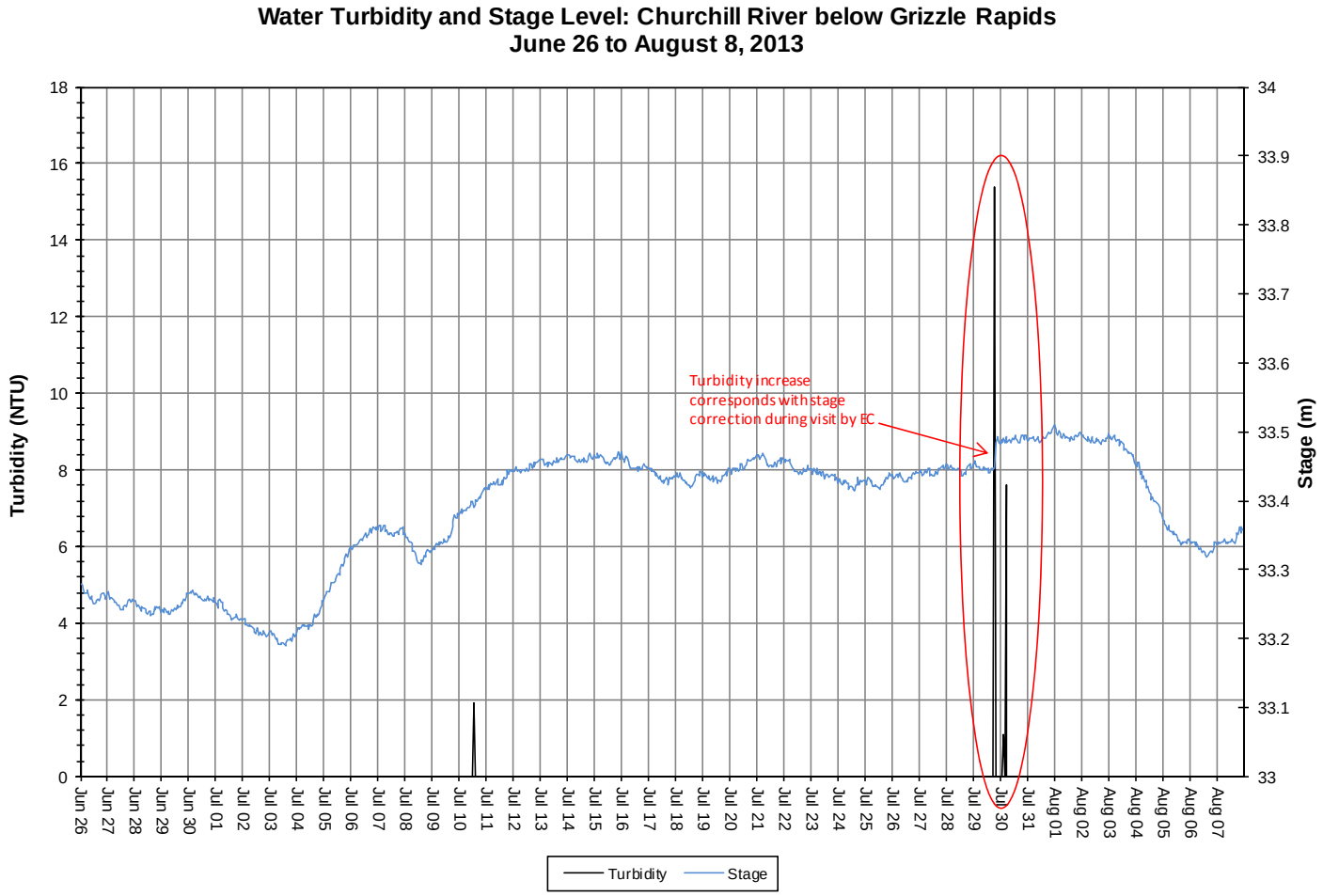


Figure 13: Turbidity and stage level at Churchill River below Grizzle Rapids

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 14). Stage is increasing at the beginning of the deployment period and is relatively stable for the last three weeks of the deployment period. Precipitation amounts are high in frequency and low in magnitude. Stage ranges between 33.19m and 33.51m, a difference of 0.32m.

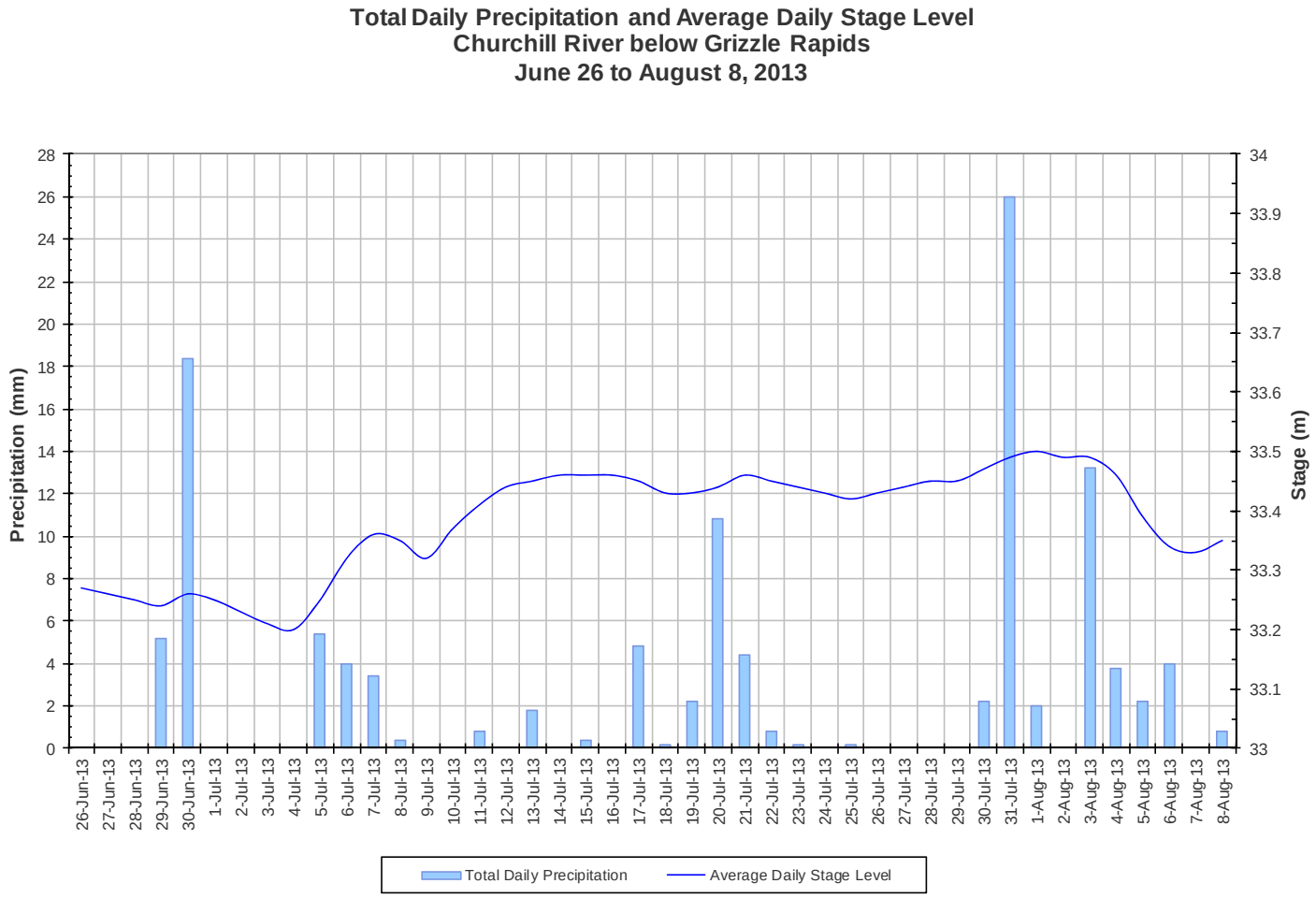


Figure 14: Daily precipitation and average daily stage level at Churchill River below Grizzle Rapids (weather data recorded at Goose Bay)

Churchill River above Muskrat Falls

- Water temperature ranges from 11.93°C to 17.92°C during the deployment period (Figure 15).
- Water temperature is increasing throughout the deployment period. This trend is expected given the warming ambient air temperatures in the summer season (Figure 16). Water temperature fluctuates diurnally.

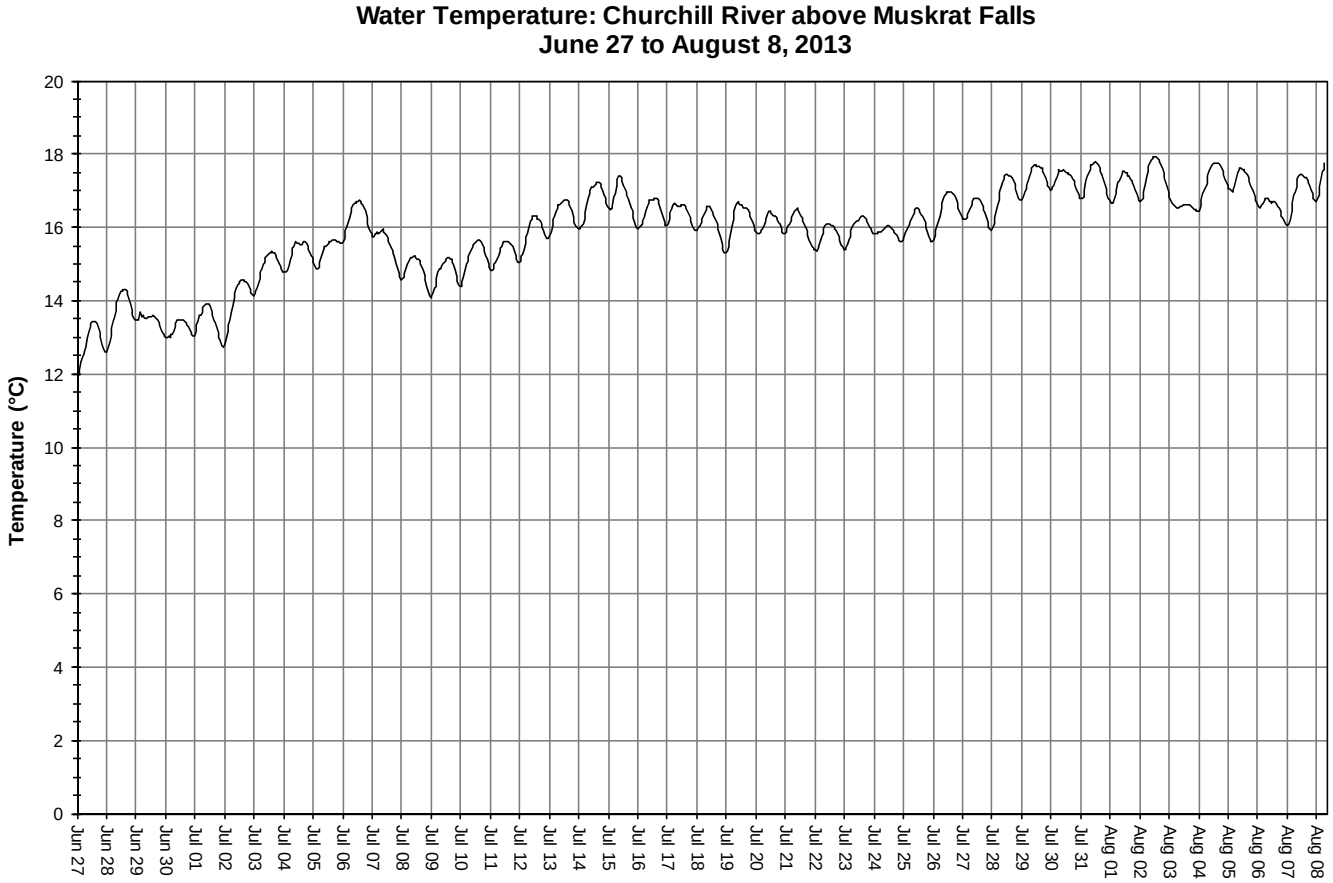


Figure 15: Water temperature at Churchill River above Muskrat Falls

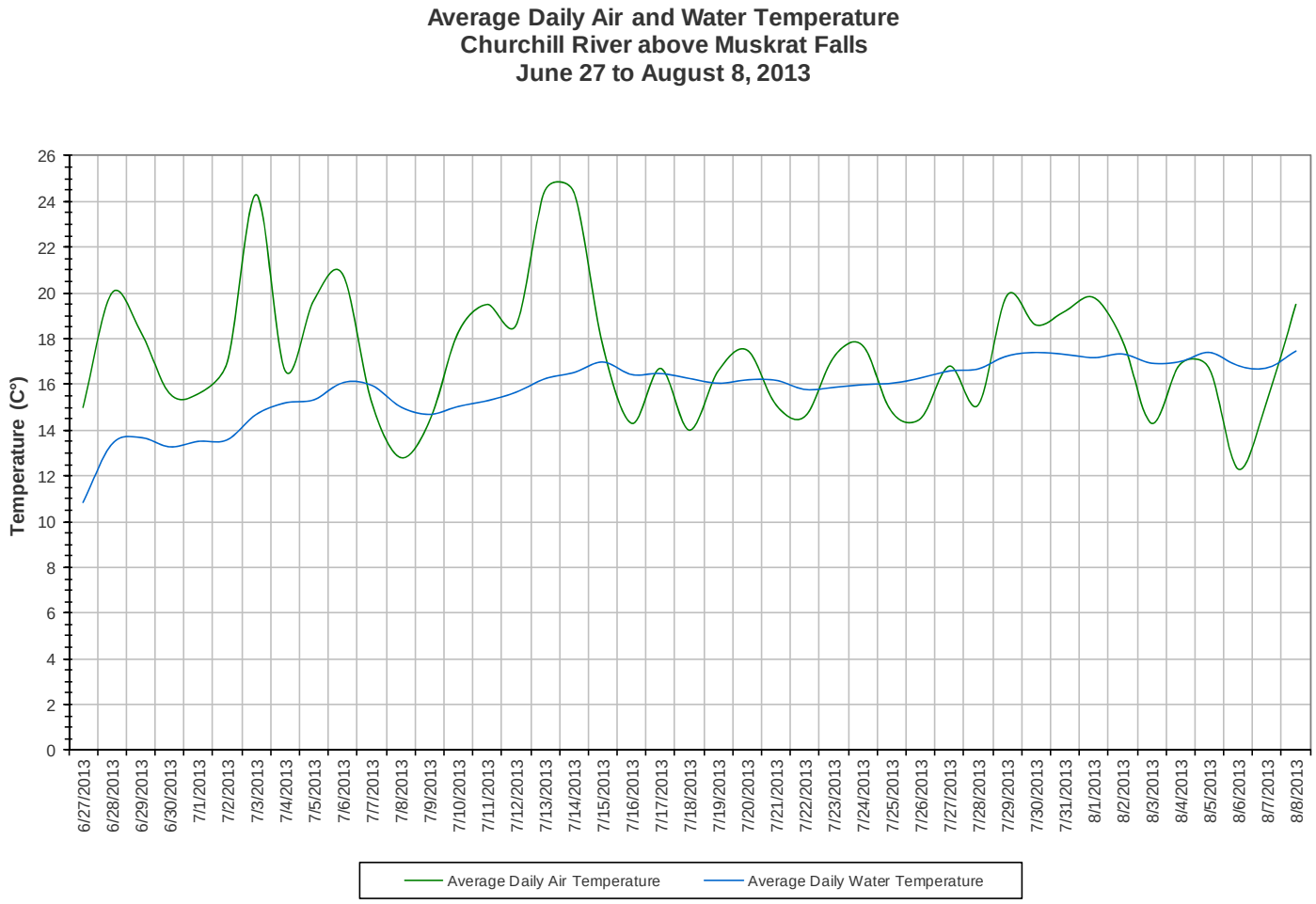


Figure 16: Average daily air and water temperature at Churchill River above Muskrat Falls (weather data recorded at Goose Bay)

- pH ranges between 6.52 and 7.30 pH units (Figure 17). pH values are increasing consistently throughout the deployment period.
- All pH values recorded are within the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 17).

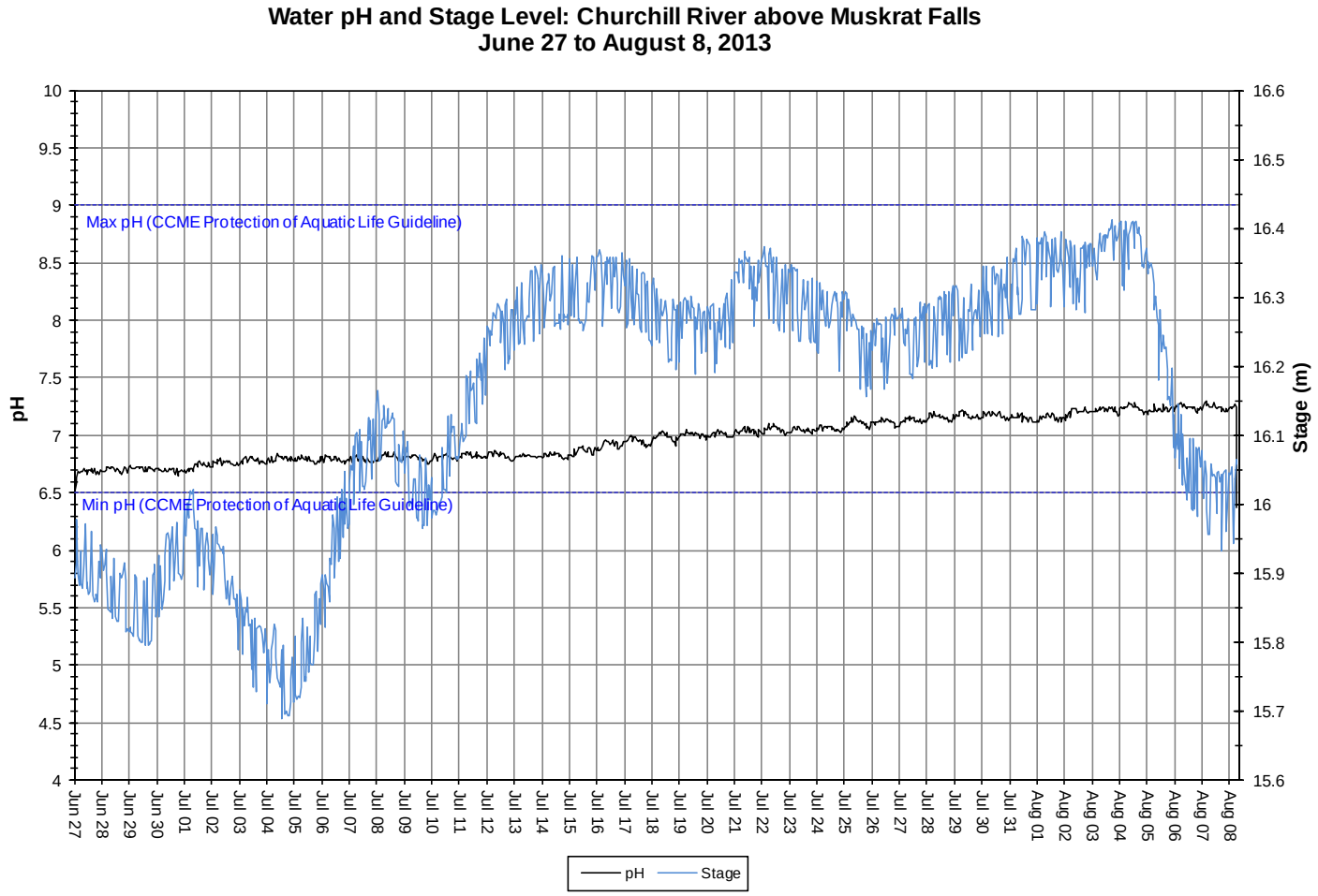


Figure 17: pH and stage at Churchill River above Muskrat Falls

- Specific conductivity ranges from 17.0µS/cm to 22.4µS/cm during the deployment period, averaging 19.5µS/cm. (Figure 18).
- Specific conductance is increasing consistently throughout the deployment period.
- 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 not clearly visible in the data collected during the deployment period. Specific conductivity is increasing consistently during the changes in water level.

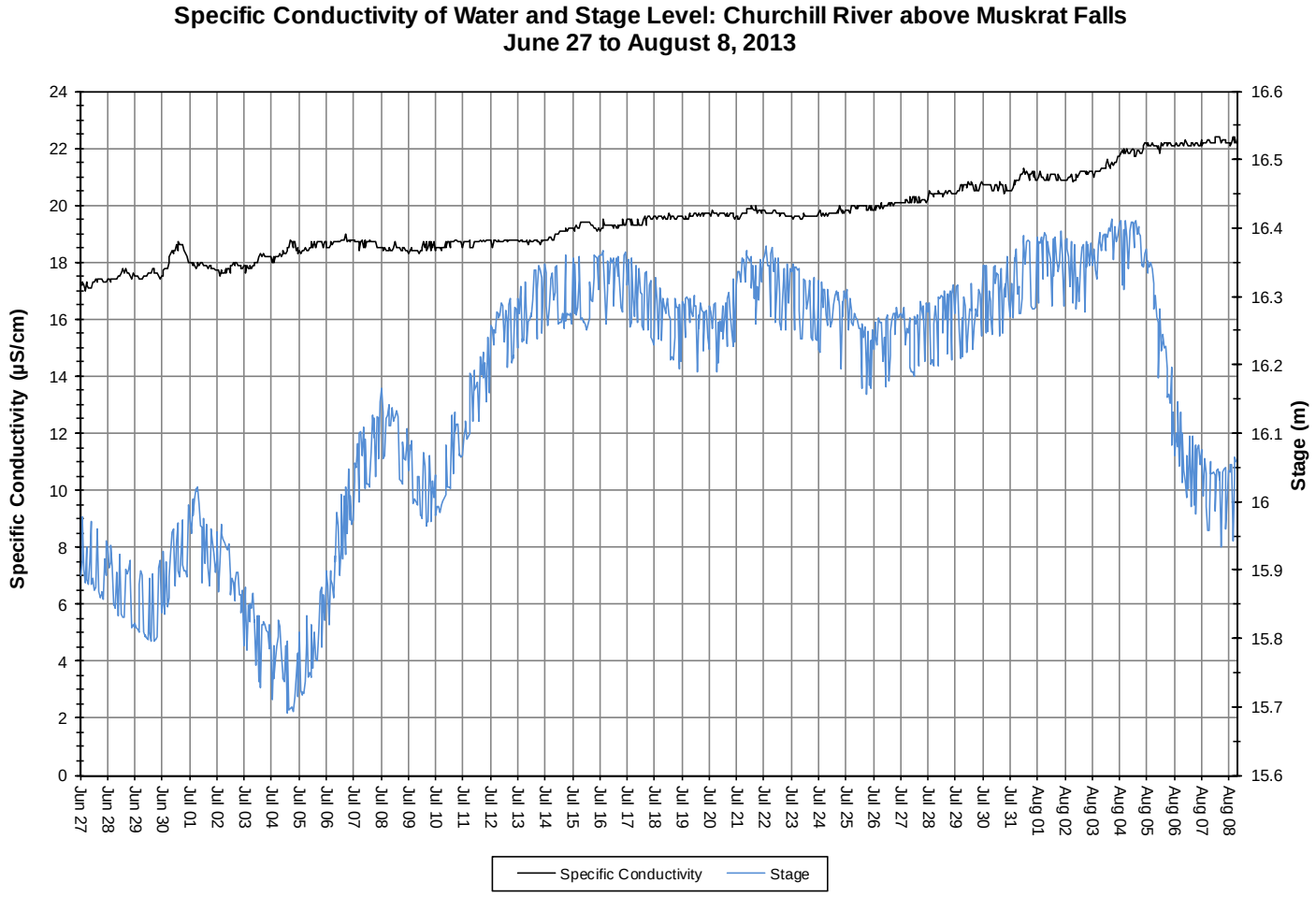


Figure 18: Specific conductivity and stage level at Churchill River above Muskrat Falls

- Dissolved oxygen content ranges between 9.19mg/l and 10.78mg/l. The saturation of dissolved oxygen ranges from 95.4% to 103.4% (Figure 19).
- All values were above the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages of 6.5mg/l. Most values were above the minimum CCME Guideline for the Protection of Cold Water Biota at Early Life Stages of 9.5mg/l. The guidelines are indicated in blue on Figure 19. Near the end of the deployment period when the water temperatures are at seasonal highs, dissolved oxygen content is just below the minimum guideline suggested by the CCME for Early Life Stages.
- Dissolved oxygen content is decreasing throughout the deployment period. This trend is expected given the warming air and water temperatures (Figure 16).

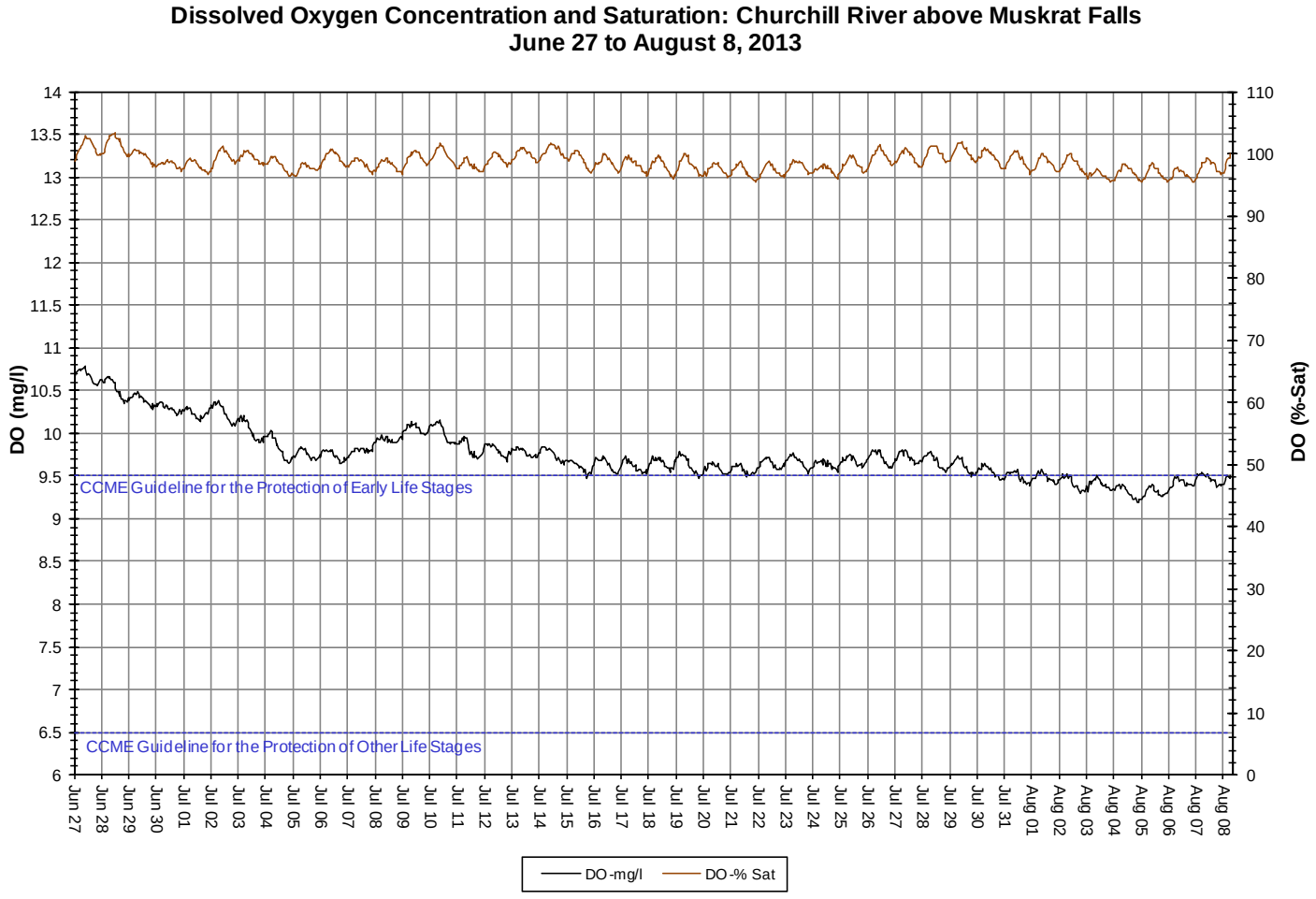


Figure 19: Dissolved oxygen and percent saturation at Churchill River above Muskrat Falls

- Turbidity generally ranges between 0NTU and 25NTU, averaging ~2.5NTU (Figure 20). A median value of 2.9NTU during the first half of the deployment period indicates there is a consistent natural background turbidity value. This trend is typical at this station. However, during the second half of the deployment period, the median value drops to 0NTU. This trend is not usually experienced at this station. The turbidity sensor continues to catch turbidity events but no background turbidity value is recorded.
- There are a number of increases in turbidity throughout the deployment period. Rainfall events recorded in the area on June 29-30, totaling 23mm may have in part caused a turbidity increase from June 30 to July 2. Similarly, a heavy rainfall event totaling 26mm on July 31 likely caused an increase in turbidity on August 1 while rainfall amounts up to 18mm on August 3-5, likely caused an increase in turbidity on August 5-6. There is no corresponding rainfall event for the increase in turbidity experienced on July 18. Turbidity increases to 1554NTU for a period of one hour. This event is an isolated occurrence and is not considered a water quality event. These events are indicated in red on figure 20.

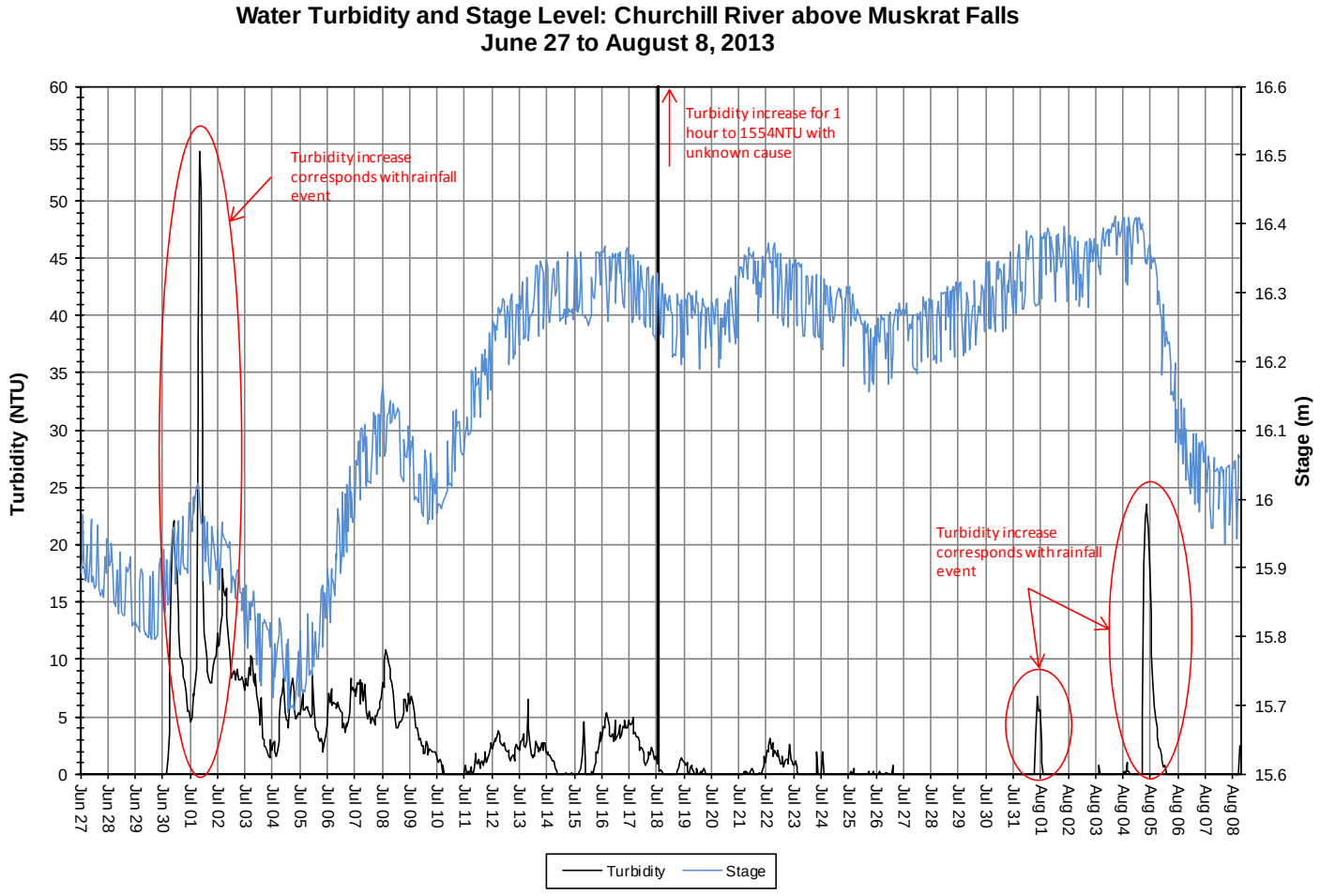


Figure 20: Turbidity and stage level at Churchill River above Muskrat Falls

- Chlorophyll is now being measured at the station above Muskrat Falls (Figure 21). The sensor is undergoing testing and is currently not functioning. The sensor may require additional calibration by an instrument technician. The values collected for the deployment period are inaccurate and have been removed from the data set.

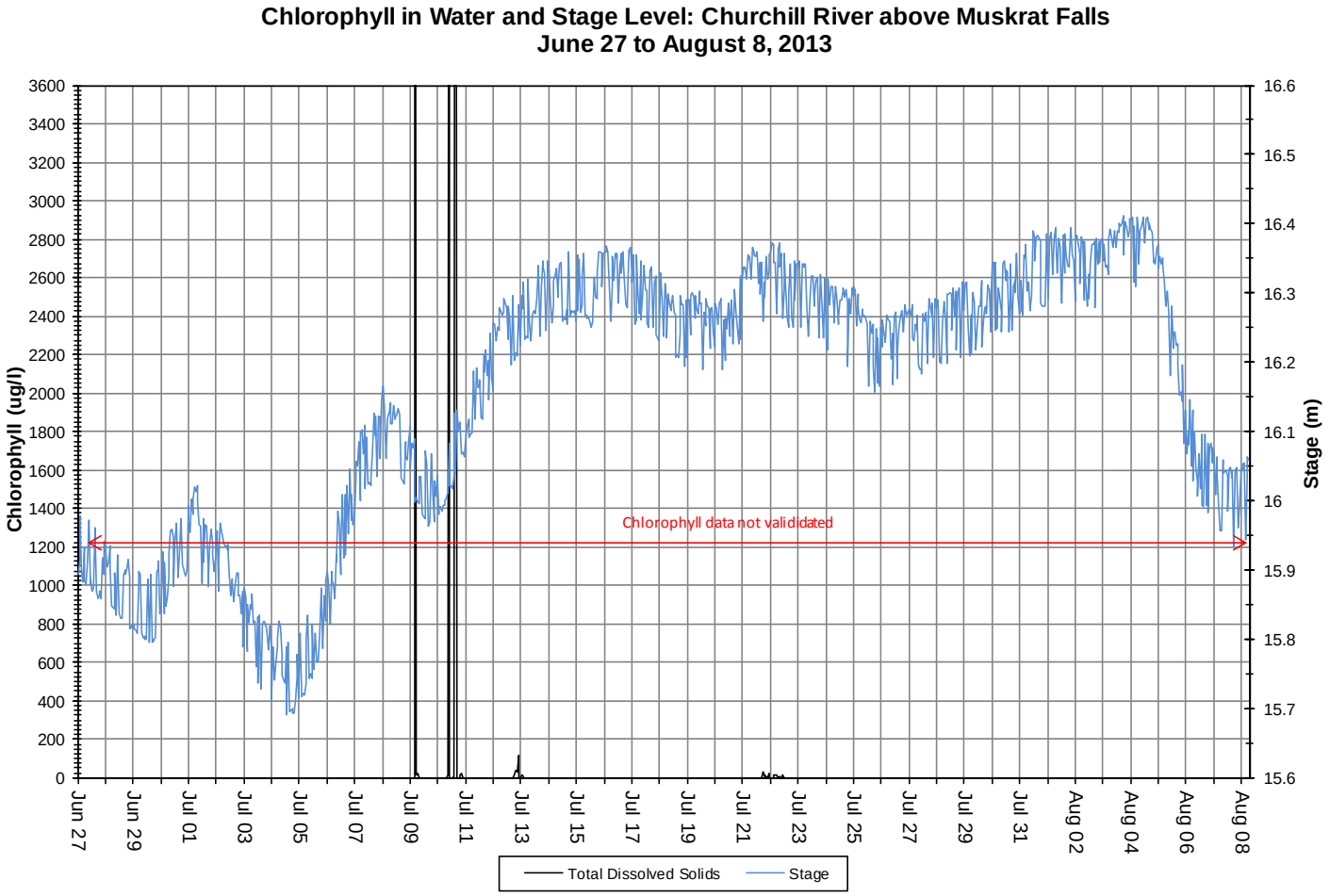


Figure 21: Chlorophyll and stage level at Churchill River above Muskrat Falls

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 22). Stage is increasing in the beginning of the deployment period and is stable for much of the remainder of the deployment period. Precipitation records are generally low in magnitude but high in frequency. Stage ranges between 15.69m and 16.41m, a difference of 0.72m. Discharge ranges from 1120 m^3/s to 1490m^3/s.

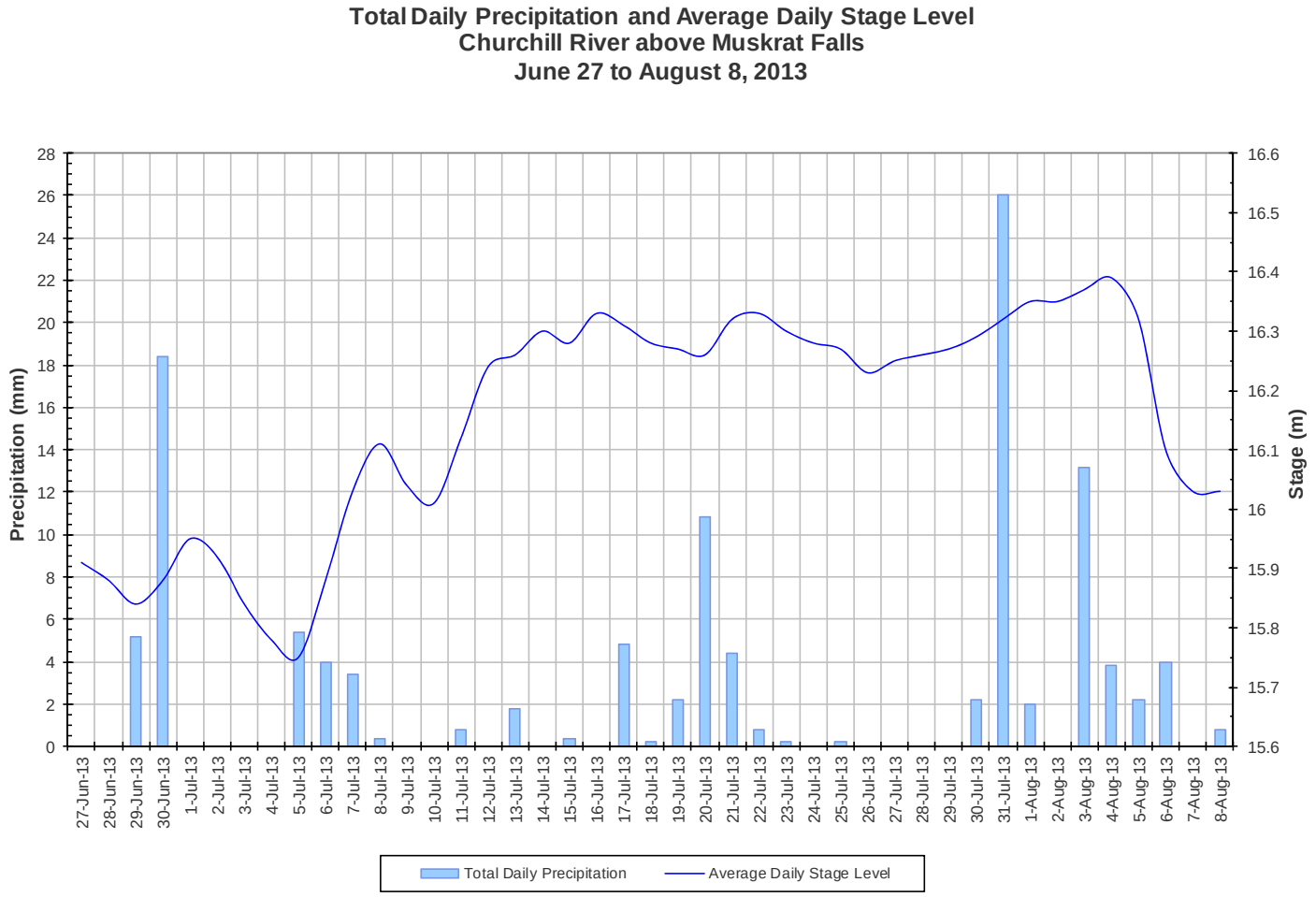


Figure 22: Daily precipitation and average daily stage level at Churchill River above Muskrat Falls (weather data recorded at Goose Bay)

Churchill River below Muskrat Falls

- Water temperature ranges from 11.90°C to 17.90°C during the deployment period (Figure 23).
- Water temperature is increasing throughout the deployment period. This trend is expected given the warming ambient air temperatures in the summer season (Figure 24). Water temperature fluctuates consistently each 24 hour period.

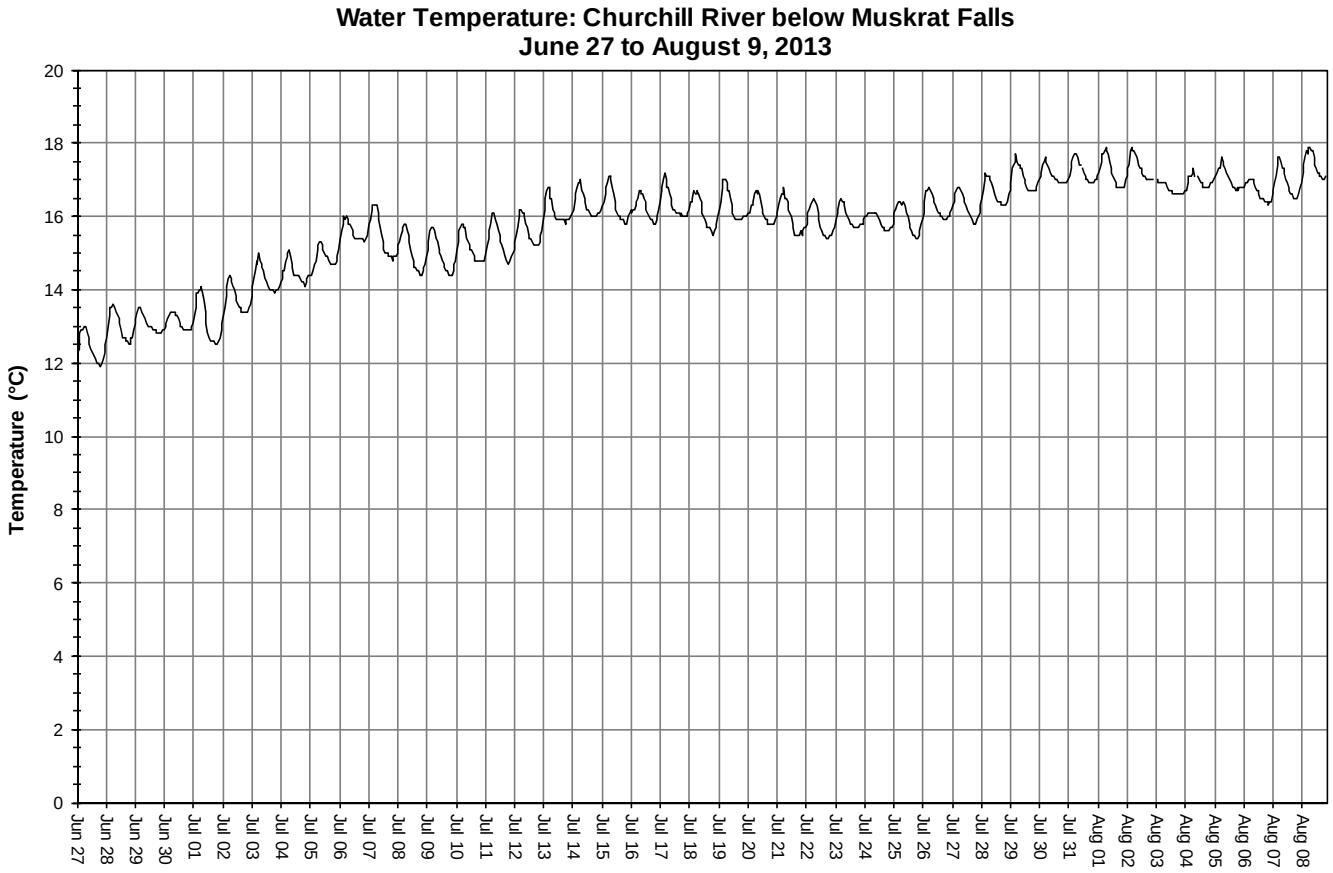


Figure 23: Water temperature at Churchill River below Muskrat Falls

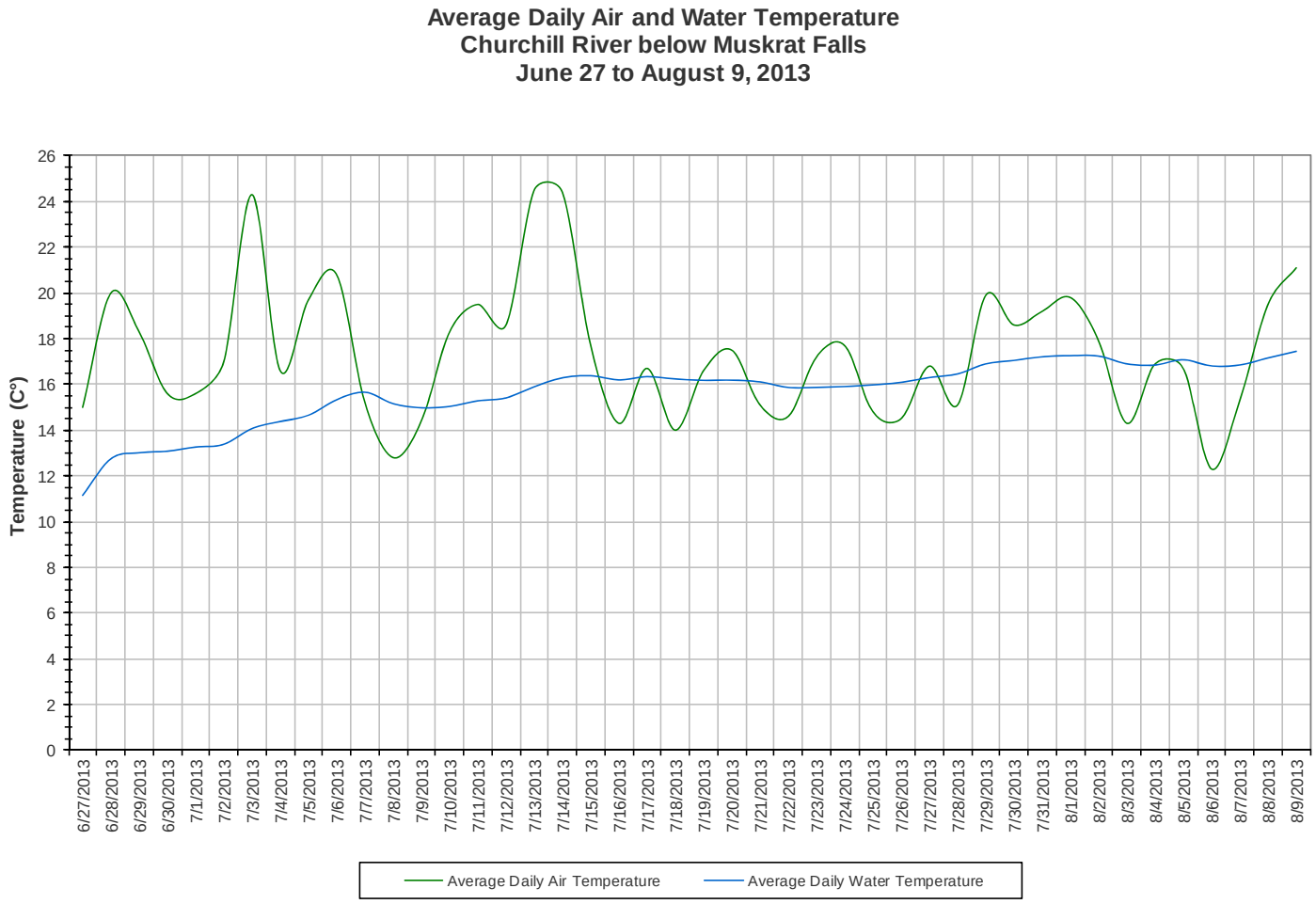


Figure 24: Average daily air and water temperature at Churchill River below Muskrat Falls

(weather data recorded at Goose Bay)

- pH ranges between 6.64 and 7.10 pH units (Figure 25). pH is generally stable at this station.
- All values during the deployment are within of below the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 25).
- pH fluctuates each day, increasingly so towards the end of the deployment period.

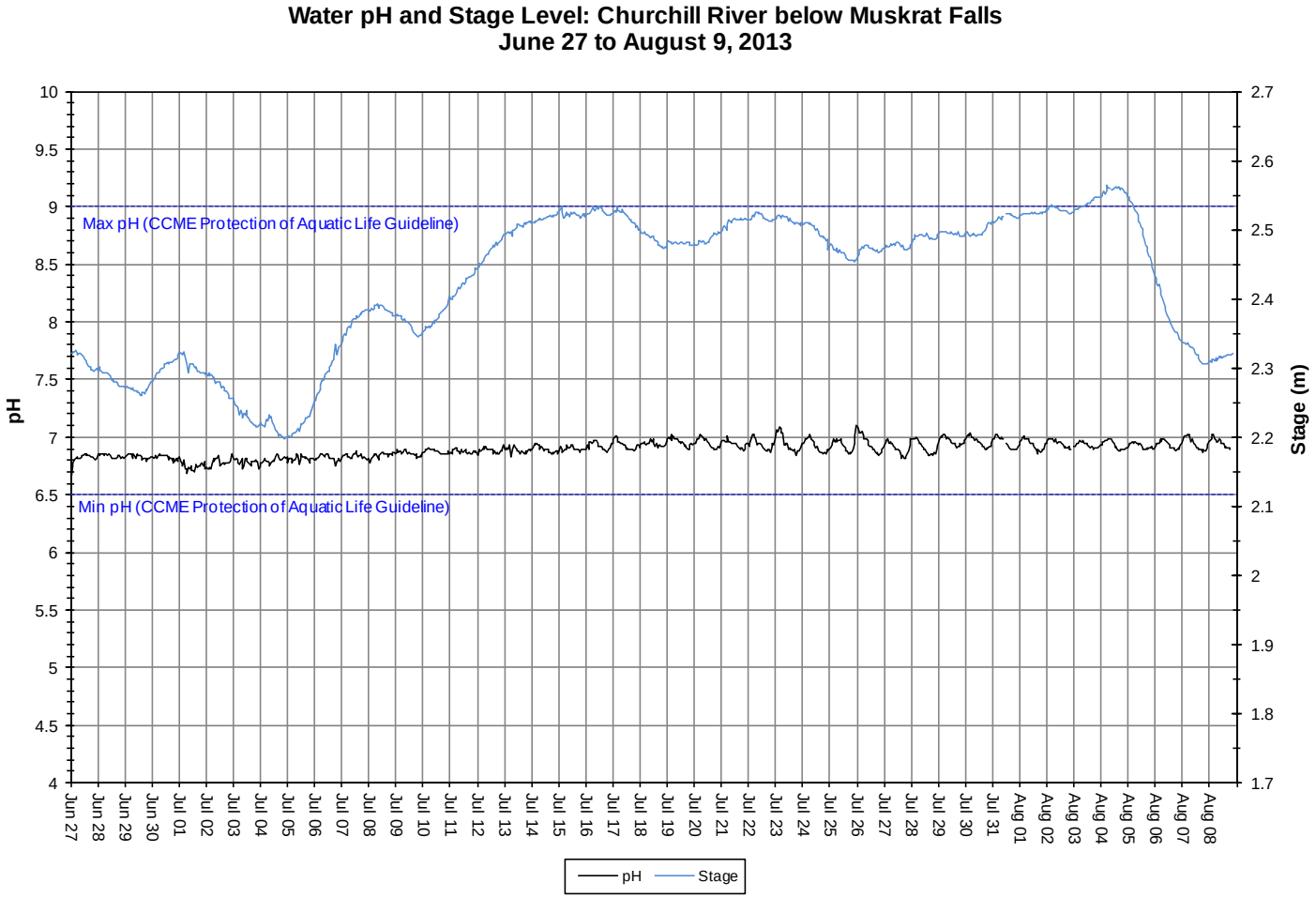


Figure 25: pH and stage level at Churchill River below Muskrat Falls

- Specific conductance ranges between 14.1µS/cm and 21.5µS/cm during the deployment period, averaging 17.8µS/cm (Figure 26).
- Specific conductivity is increasing consistently throughout the deployment period.
- Stage is included in Figure 26 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 not clearly visible in the data collected during the deployment period. Specific conductivity is increasing consistently during the changes in water level.

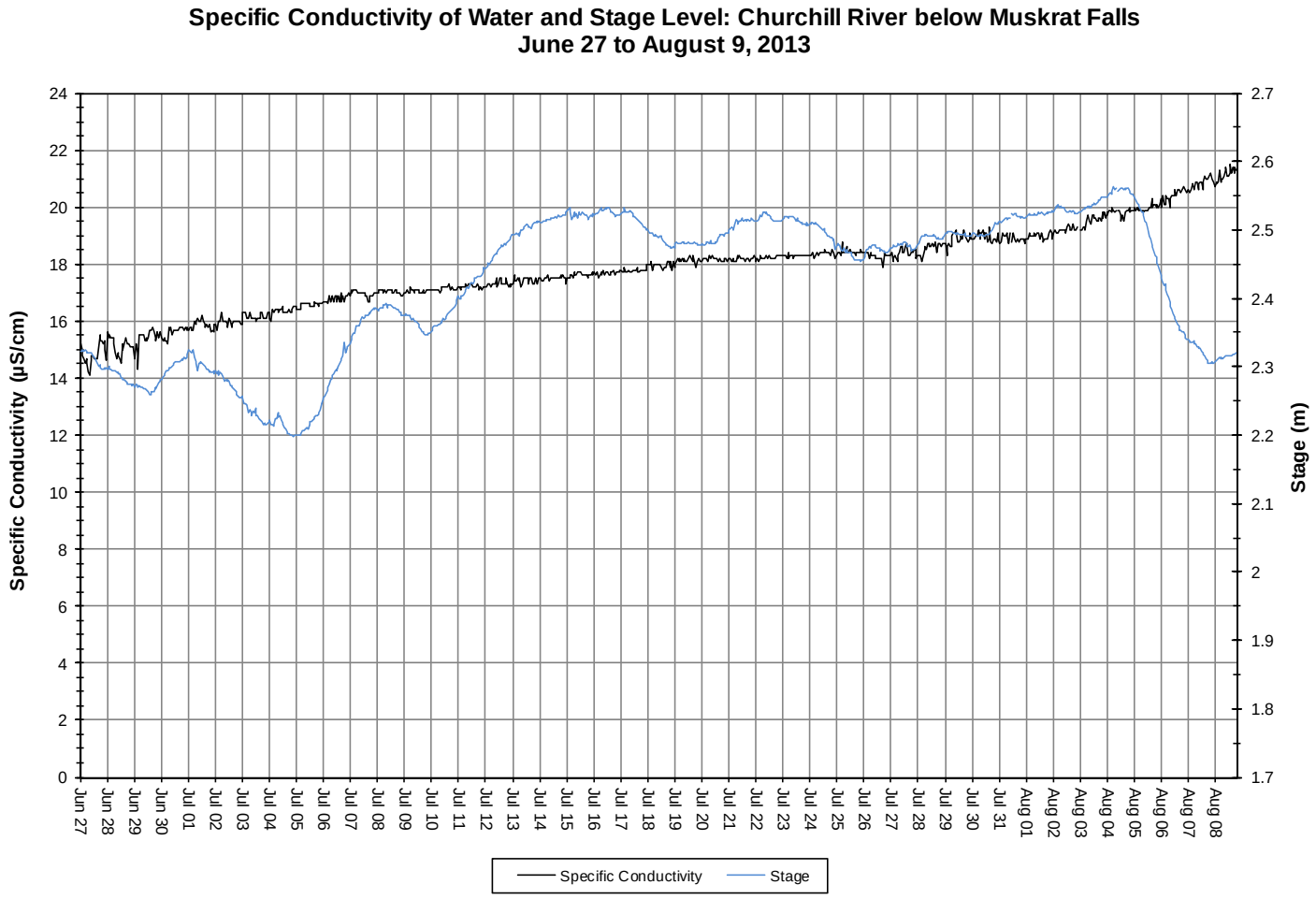


Figure 26: Specific conductivity and stage level at Churchill River below Muskrat Falls

- Dissolved oxygen content ranges between 9.90mg/l and 11.52mg/l. The saturation of dissolved oxygen ranges from 101.0% to 113.5% (Figure 27).
- All 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 27.
- Dissolved oxygen content is decreasing throughout the deployment period. This trend is expected given the warming air and water temperatures (Figure 24). 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.

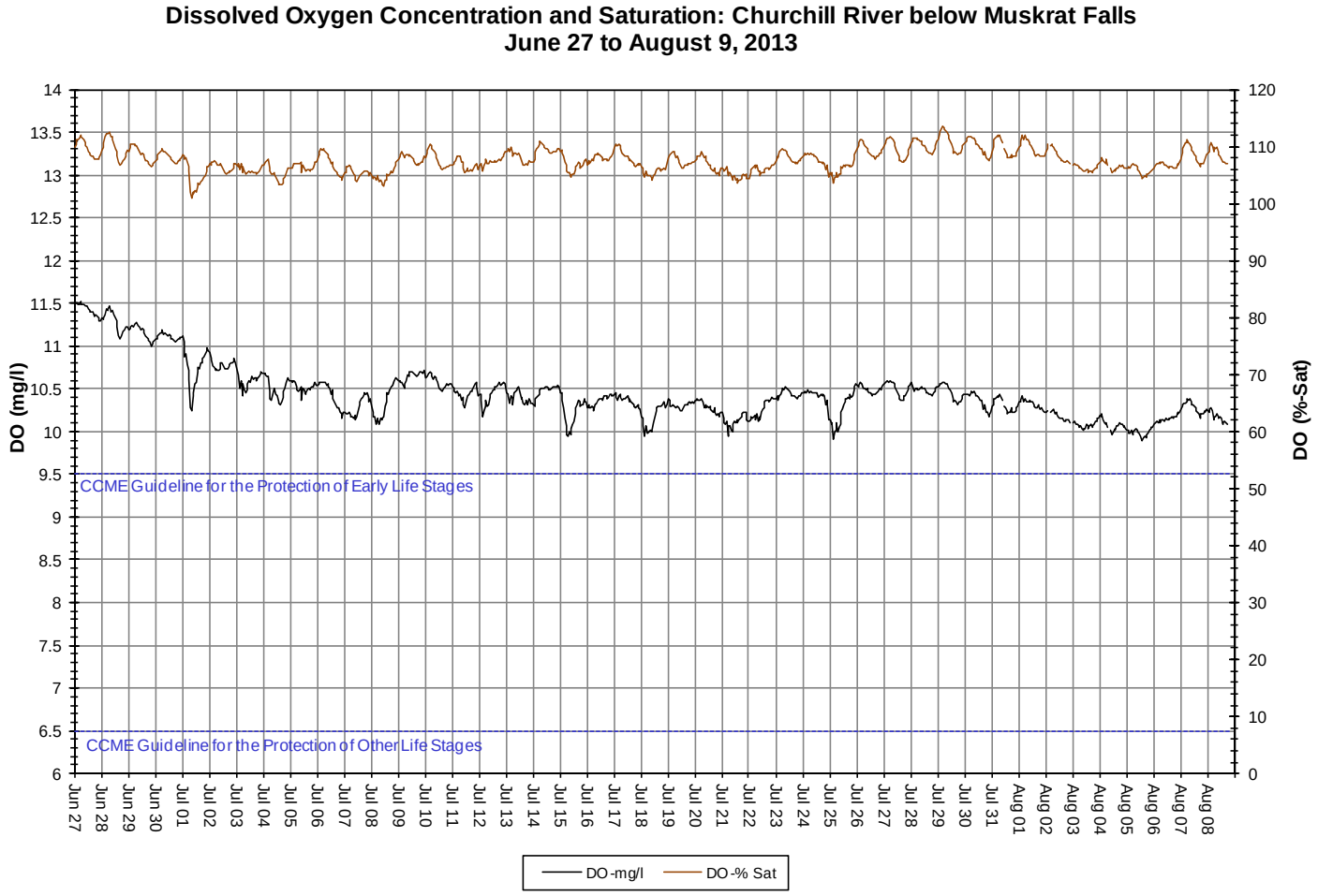


Figure 27: Dissolved oxygen and percent saturation at Churchill River below Muskrat Falls

- Turbidity data for this station is displayed on 2 graphs to show the scale of the data collected. Figure 28a shows the data on a scale from 1 to 1000NTU in order to view all the events captured. Figure 28b is a closer look at the background data displayed on a scale from 1 to 100NTU.
- Turbidity typically ranges between 3.7NTU and 70NTU throughout the deployment period with the exception of some extreme events (Figure 28). A median value of 17.4NTU indicates there is a consistent natural background turbidity value at this station. While it is typical for this station to see a natural background turbidity value greater than 0NTU, 17.4 NTU is high for this station at this time of year.
- Turbidity events up to July 26 appear normal for this station even considering a number of short lasting sharp increases. The median value for background turbidity in the first half of the deployment period until July 26 is 12NTU.These short lasting extreme turbidity events include one 7 hour event on June 29 where turbidity values up to 2600NTU were recorded. On June 30, July 2, and 4, turbidity values up to 650NTU are recorded; however, events last for only 1-2 hours each time. Rainfall events recorded on June 29-30, may have contributed to these increases.

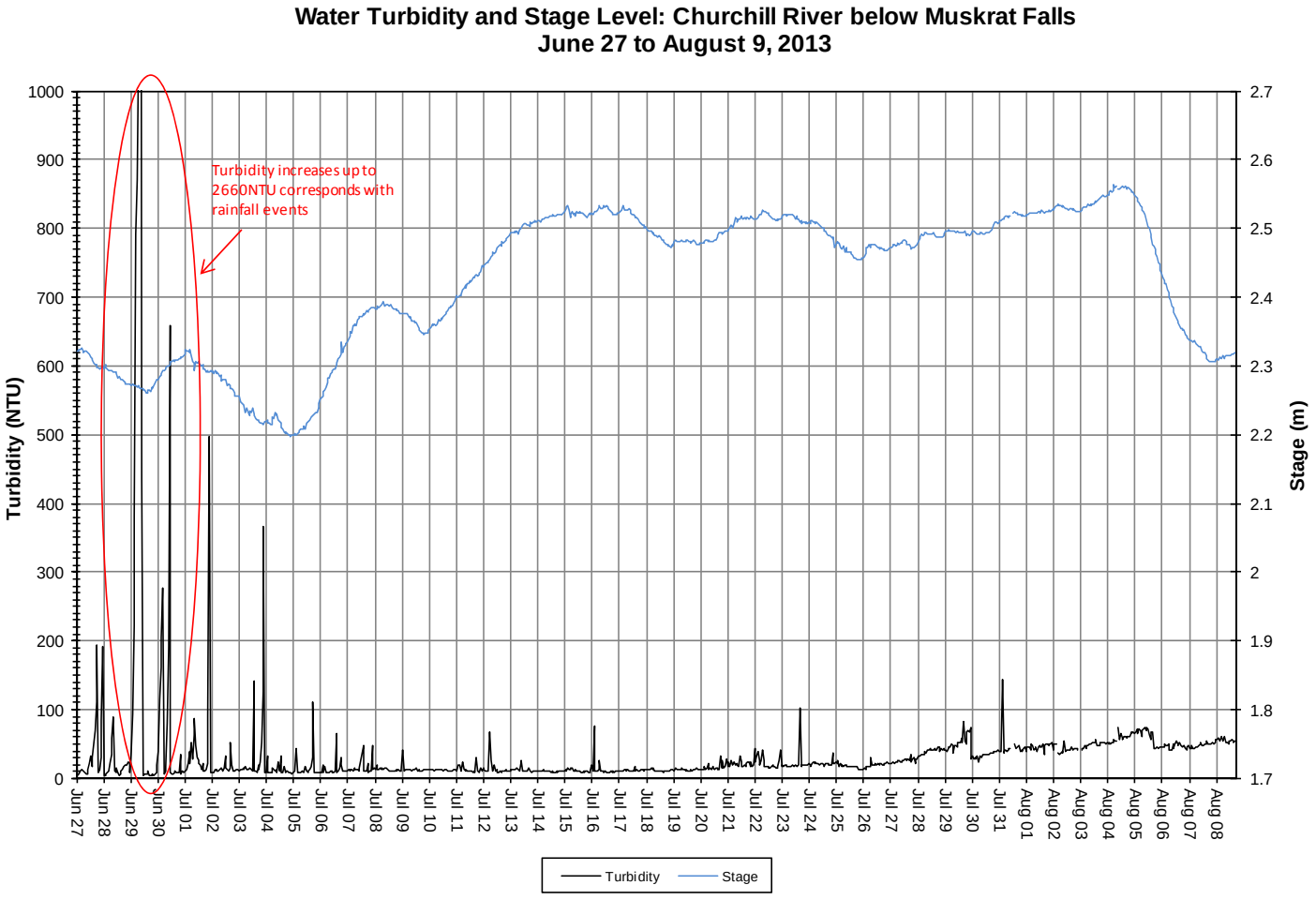


Figure 28a: Turbidity and stage level at Churchill River below Muskrat Falls

- After July 26, background turbidity values begin to increase consistently almost for the entire remainder of the deployment period. The median value for background turbidity from July 26 to the end of the deployment period is 45NTU. While turbidity events are still captured, it is unusual to see such a steady increase in background turbidity values as well. A significant rainfall event on July 31 of 26mm corresponds with an increase in turbidity from 38NTU to 144NTU however only for a period of one hour.

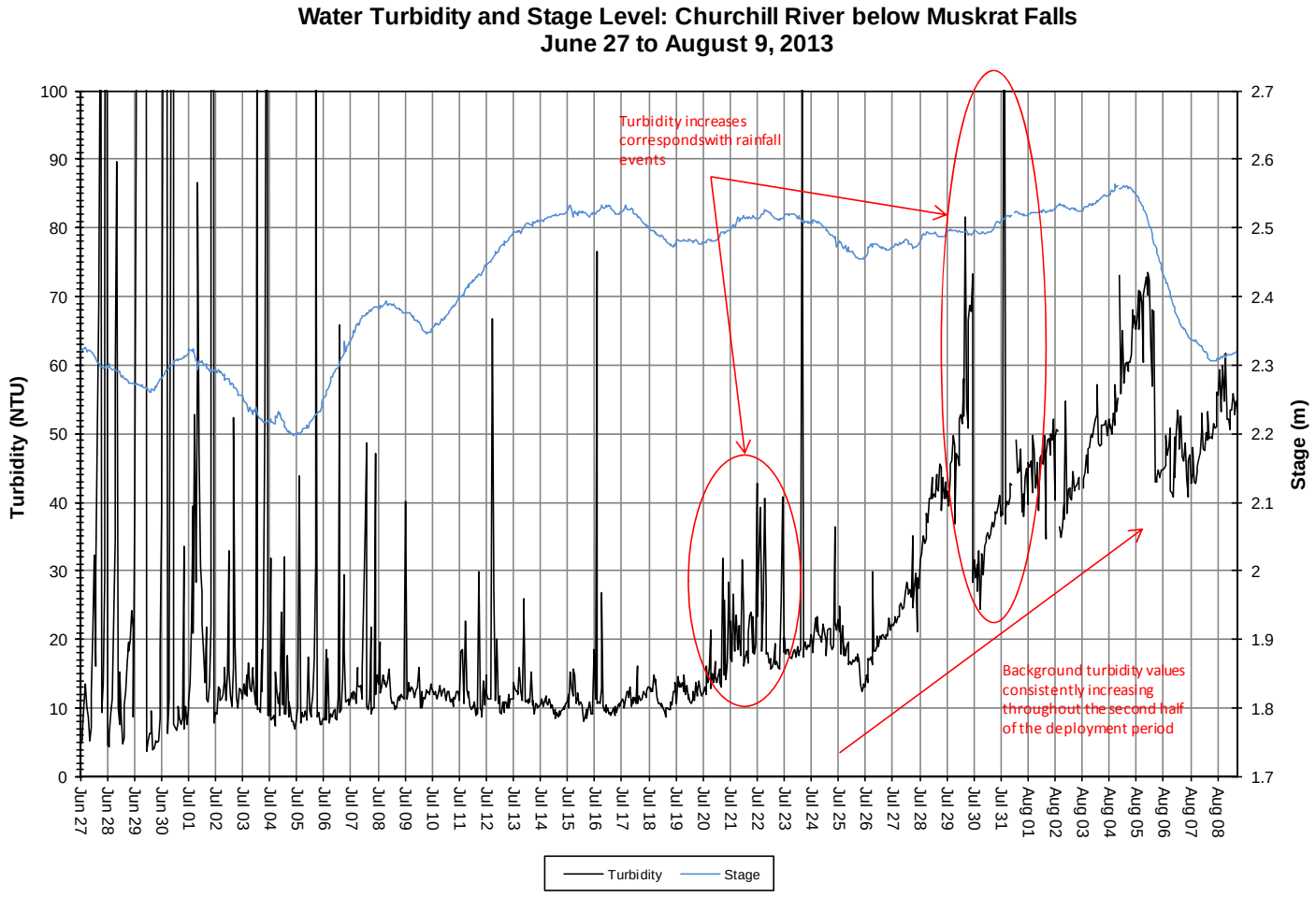


Figure 28b: Turbidity and stage level at Churchill River below Muskrat Falls

- Chlorophyll is now being measured at the station below Muskrat Falls (Figure 29). The sensor is undergoing testing and data cannot be validated until further testing is completed. The sensor may require additional calibration by an instrument technician.

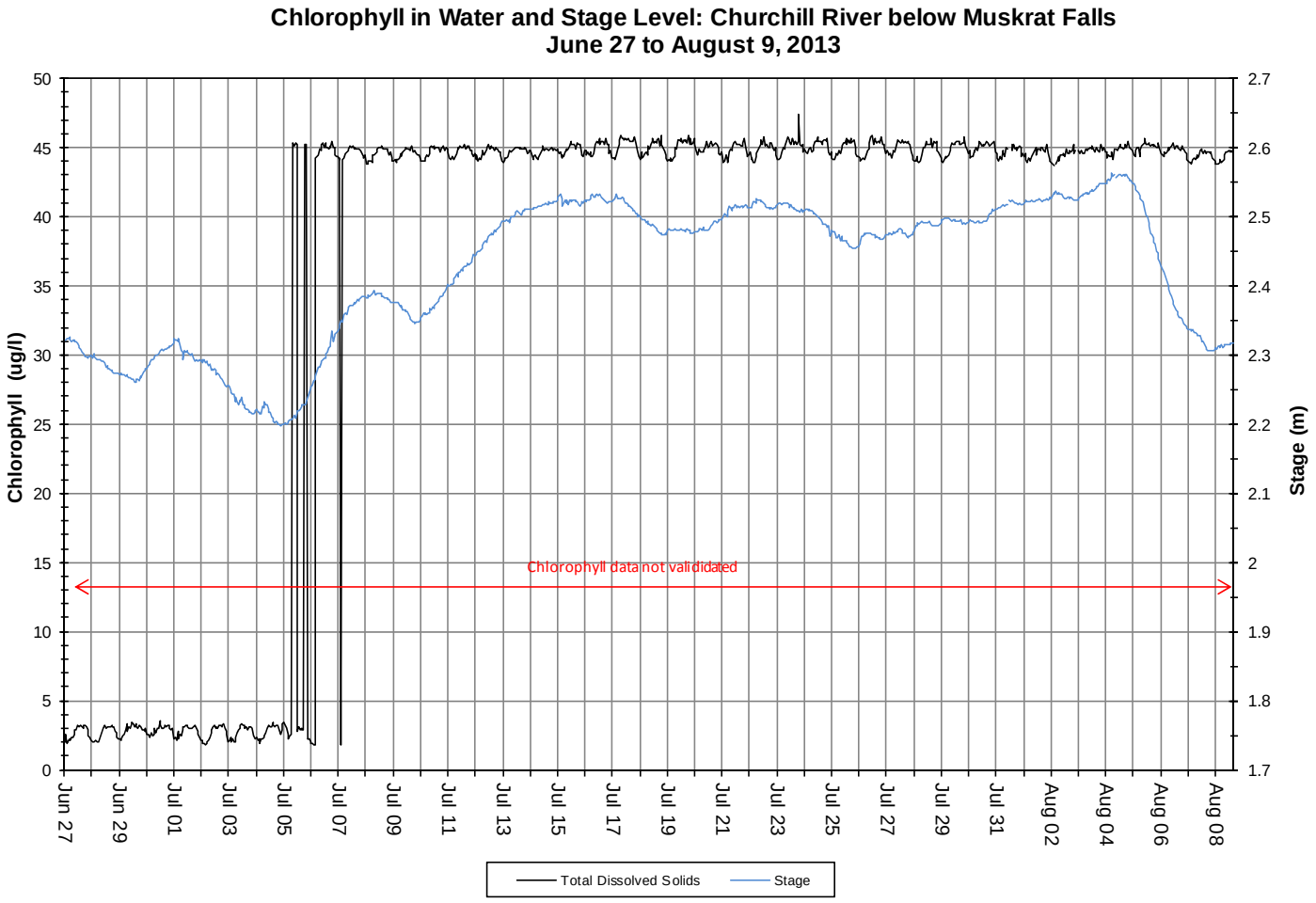


Figure 29: Chlorophyll and stage level at Churchill River below Muskrat Falls

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 30). Stage is increasing in the beginning of the deployment period and then stabilizes for the remainder of the deployment period. Precipitation events are high in frequency and low in magnitude. Stage ranges between 2.20m and 2.56m, a difference of 0.36m.

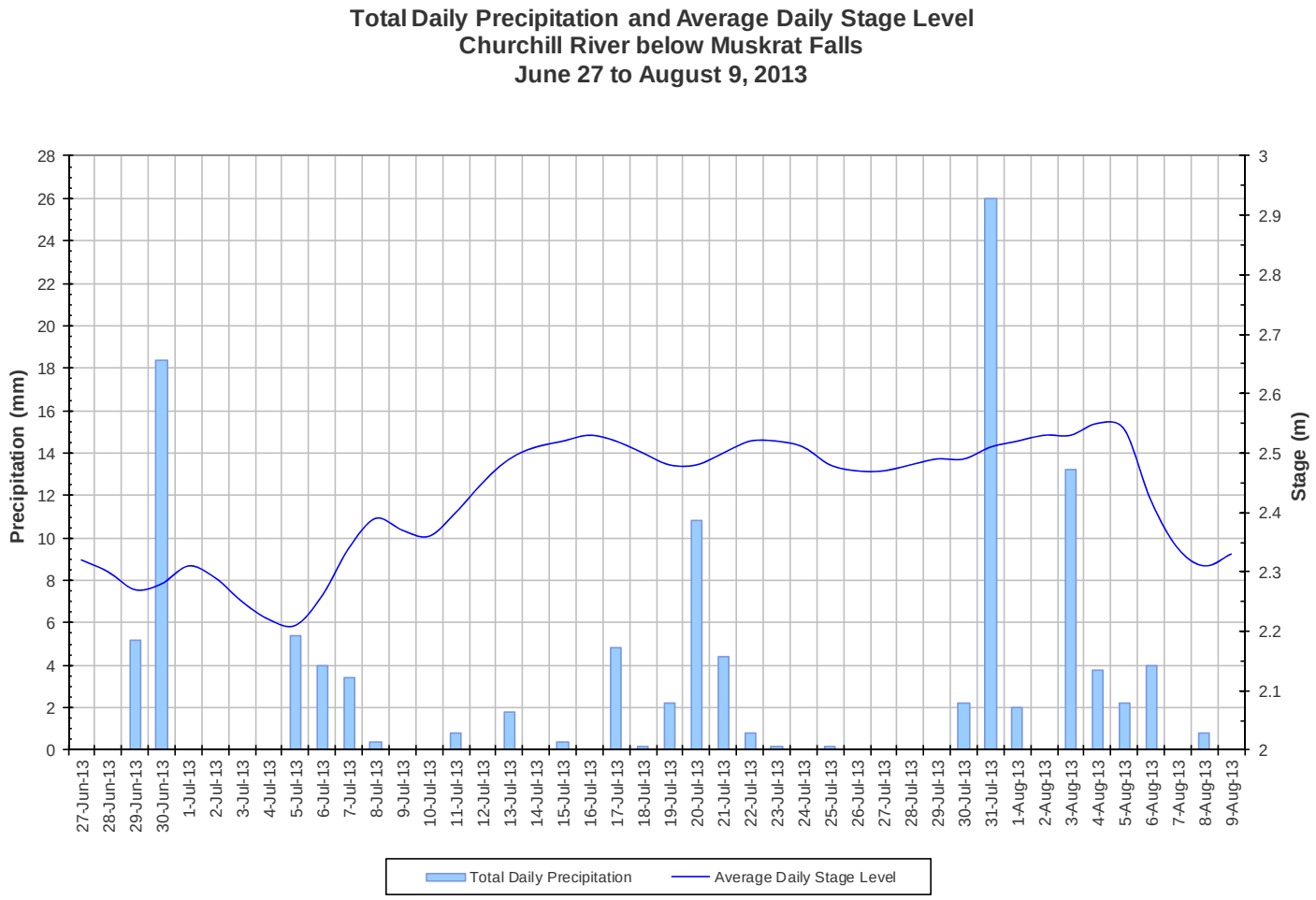


Figure 30: Daily precipitation and average daily stage level at Churchill River below Muskrat Falls

(weather data recorded at Goose Bay)

Churchill River at English Point

- This station experienced a transmission error from July 11-23. Log file data from the instrument internal memory was retrieved on August 13 at removal and used to supplement the transmitted data available from the Automatic Data Retrieval System. Stage data and daily averages for this time remain unavailable.
- Water temperature ranges from 11.30°C to 20.60°C during the deployment period (Figure 31).
- Water temperature is increasing slightly throughout the deployment period. This trend is expected given the warming ambient air temperatures in the summer season (Figure 32). Water temperature fluctuates diurnally.

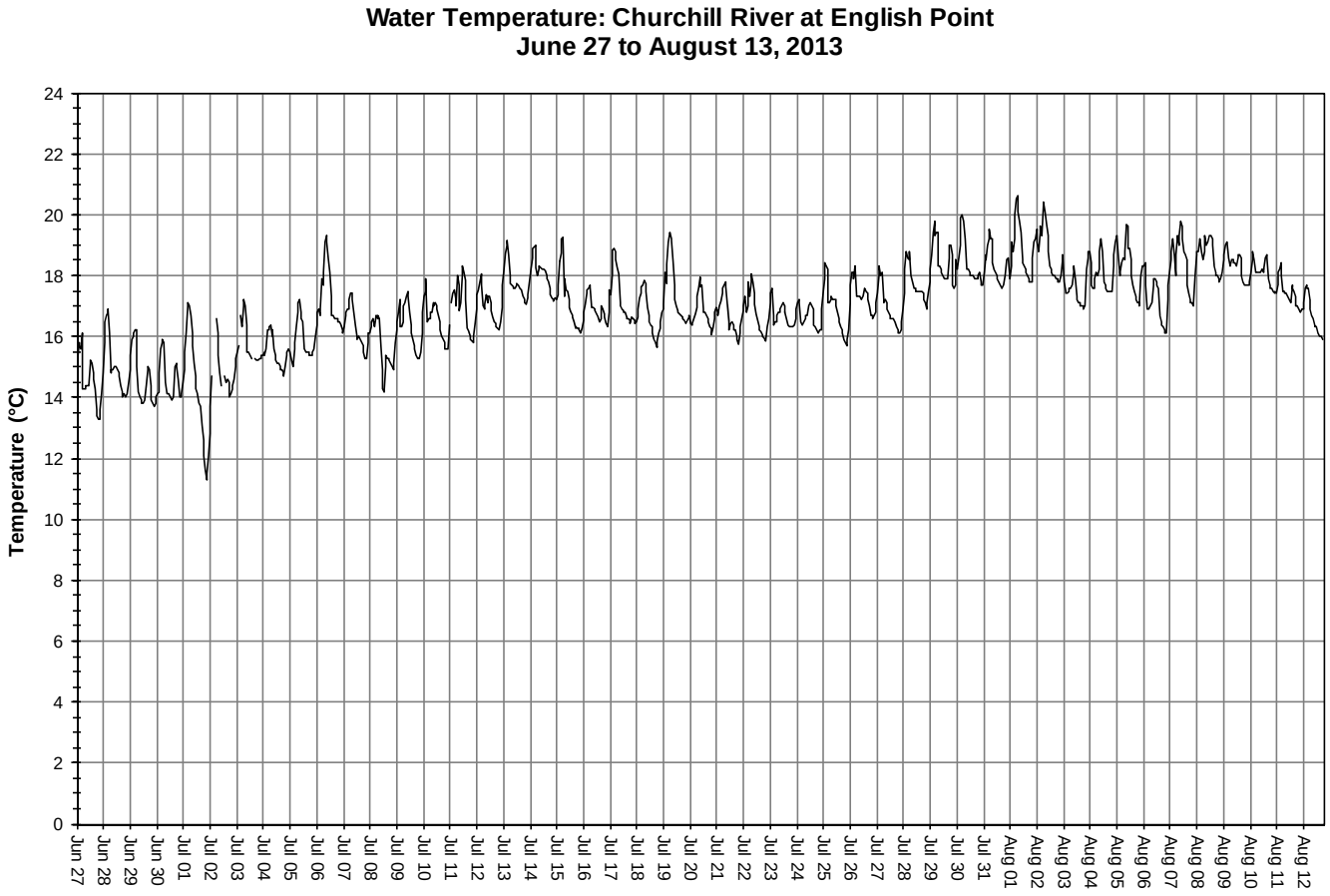


Figure 31: Water temperature at Churchill River at English Point

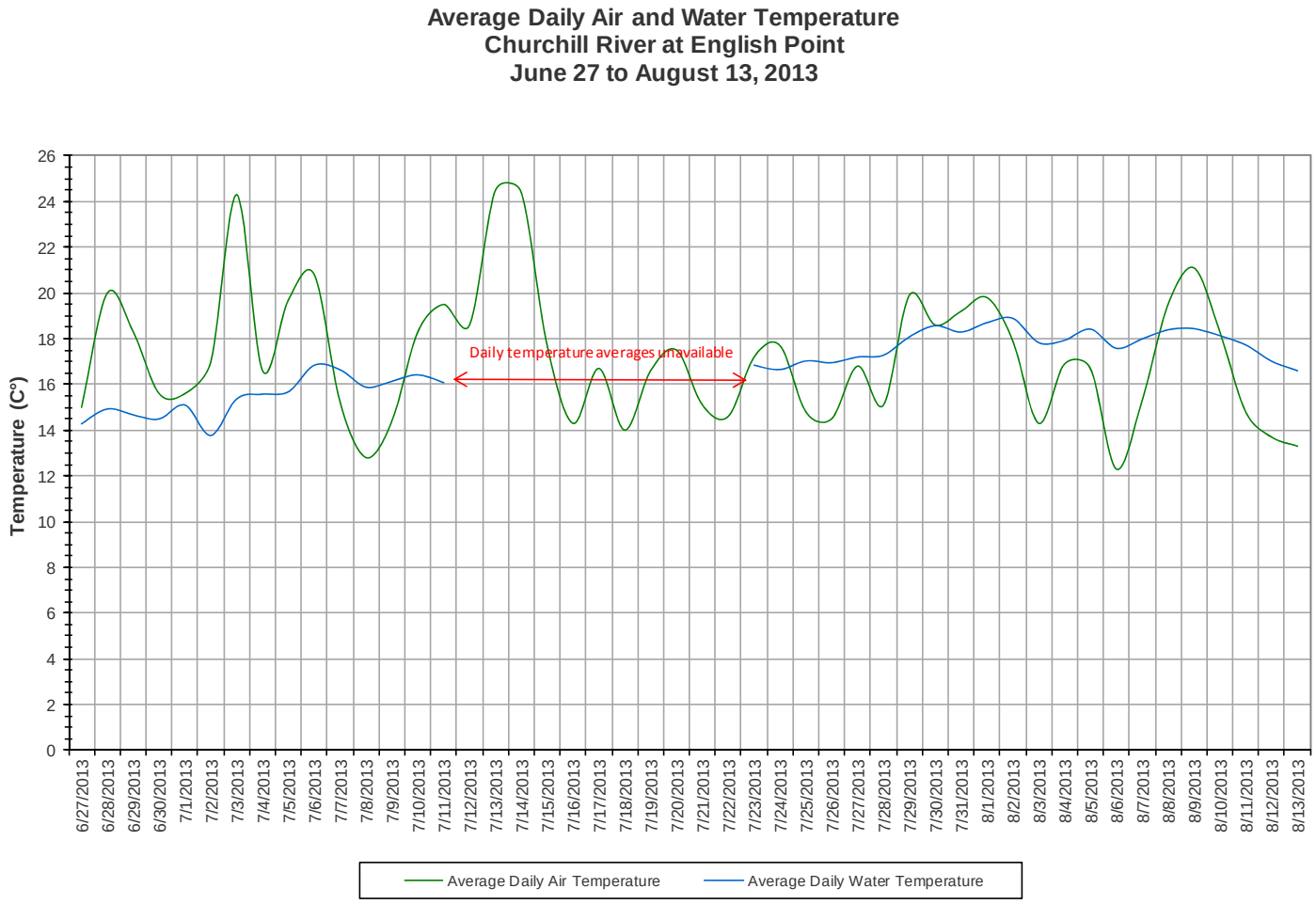


Figure 32: Average daily air and water temperature at Churchill River at English Point

(weather data recorded at Goose Bay)

- pH ranges between 6.34 and 7.40 pH units (Figure 33). pH fluctuates on a daily basis.
- All values during the deployment are within or just barely outside the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 33).

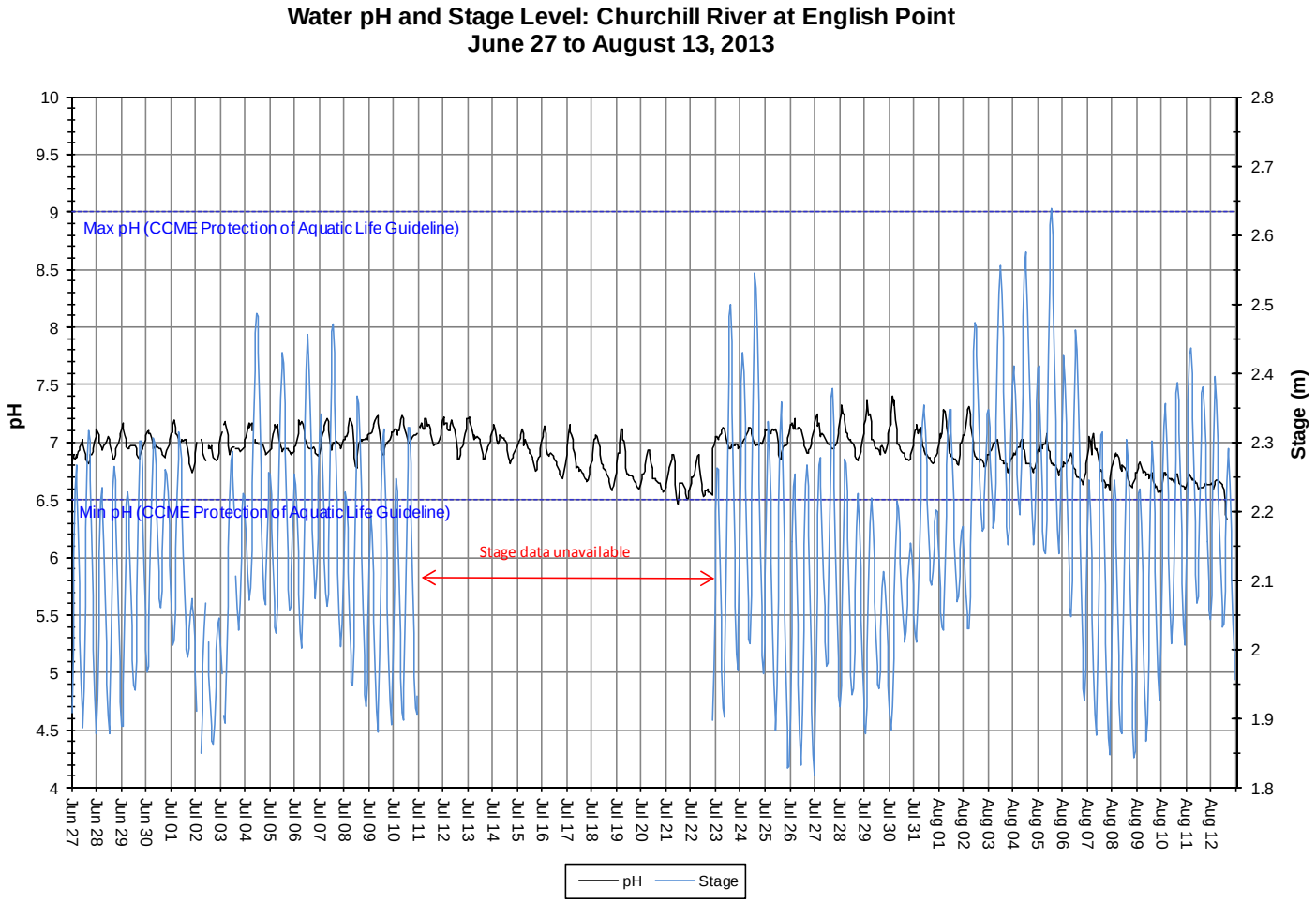


Figure 33: pH and stage level at Churchill River at English Point

- Specific conductance typically ranges between 20.8µS/cm and 53.6µS/cm during the deployment period, averaging 31.5µS/cm (Figure 34).
- On July 1 for a period of one hour, specific conductivity increases to 91µS/cm. It is unknown was caused this increase however it is not considered significant due to the short one hour timeframe.
- 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.

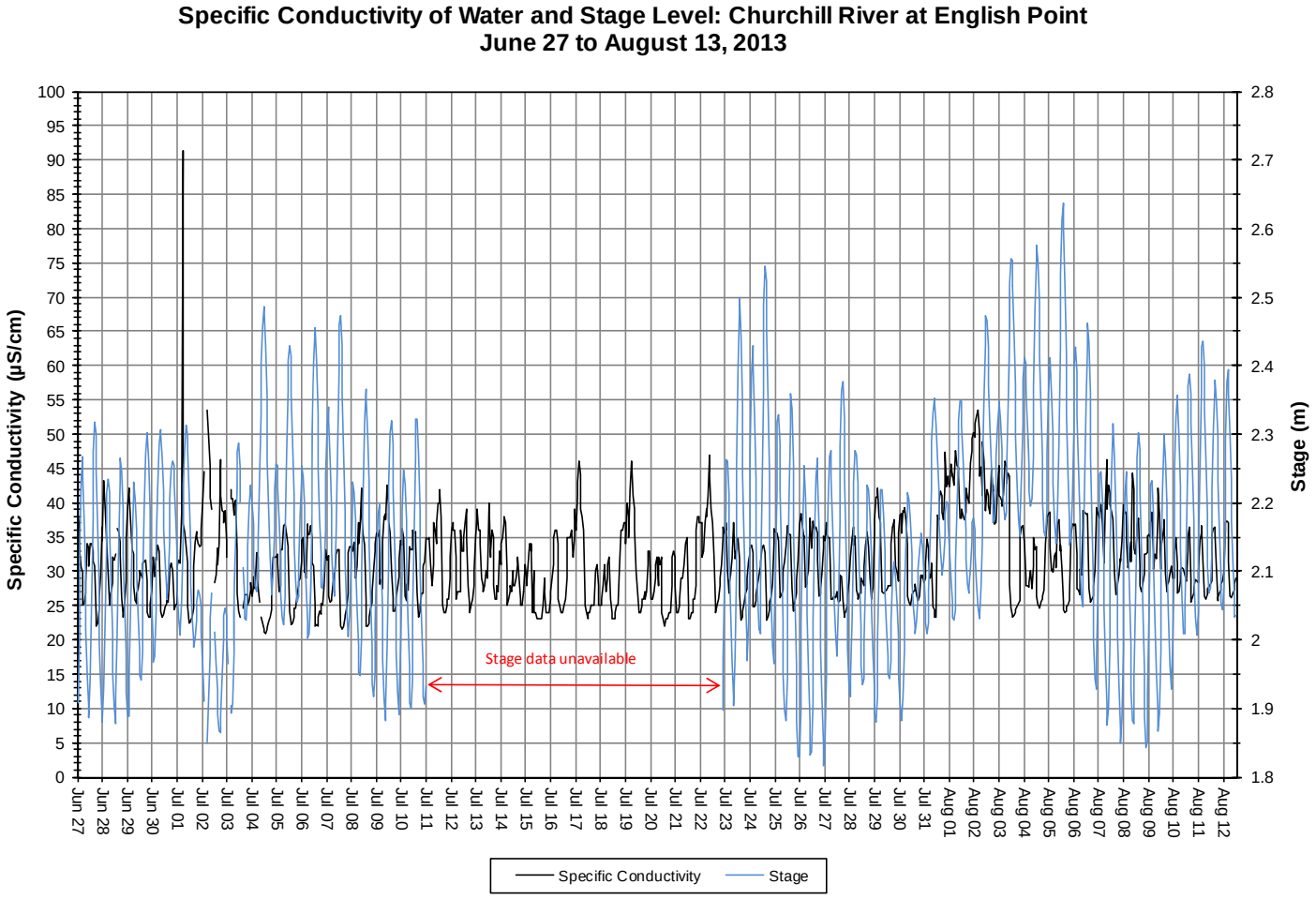


Figure 34: Specific conductivity and stage level at Churchill River at English Point

- Dissolved oxygen content ranges between 8.81mg/l and 11.12mg/l. The saturation of dissolved oxygen ranges from 89.6% to 110.8% (Figure 35).
- All values were above the minimum CCME Guidelines for the Protection of Cold Water Biota at Other Life Stage of 6.5mg/l. For the majority of the deployment period, dissolved oxygen content is below the CCME Guideline for the Protection of Aquatic Life at Early Life Stages of 9.5mg/l for some period of time each day, usually in the afternoon and evenings when the water temperature is the greatest. The guidelines are indicated in blue on Figure 35.
- Dissolved oxygen content is decreasing slightly throughout the deployment period. This trend is expected given the warming air and water temperatures (Figure 32).

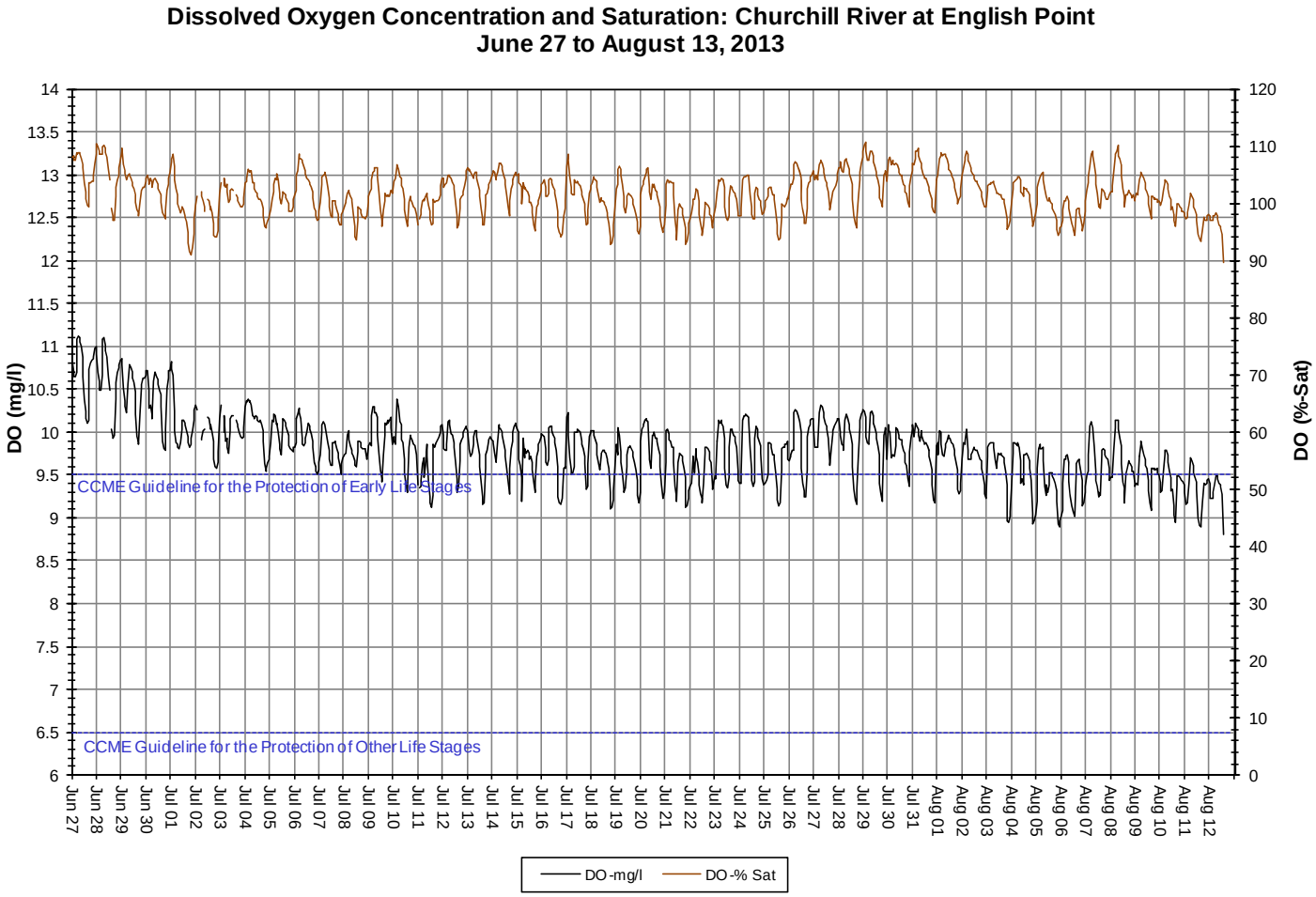


Figure 35: Dissolved oxygen and percent saturation at Churchill River at English Point

- Turbidity ranges between 1NTU and 181NTU throughout the deployment period (Figure 36). A median value of 11.0NTU indicates there is a consistent natural background turbidity value at this station. This trend is typical at this station.
- There are a number of instances when turbidity increases well above the background turbidity value. On June 28, turbidity increases as high as 181NTU on two separate occasions in the same day. There is no corresponding rainfall event with this turbidity increase and the cause is unknown. Each event last between 2-3 hours. There are also no corresponding rainfall events for turbidity increases experienced on July 11, 24, or 25.
- There are corresponding rainfall events on the previous or same day as turbidity events occurring on July 19, 22, and August 6. Oddly, there is no corresponding turbidity increase for a significant rainfall event of 26mm on July 31. These events are indicated in red on Figure 36.

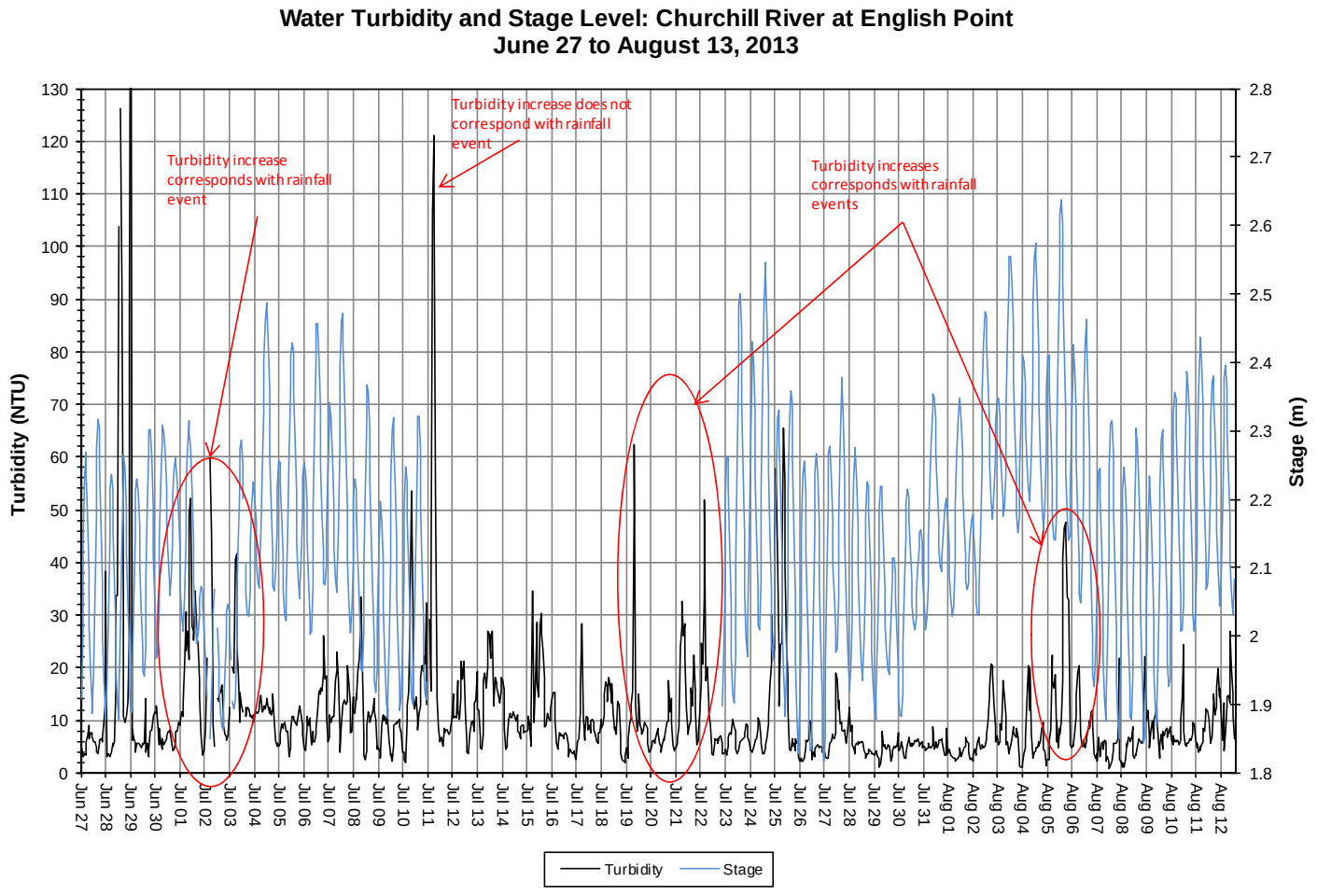


Figure 36: Turbidity and stage level at Churchill River at English Point

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 37). Stage is generally stable with minor fluctuations throughout the deployment period. Stage data is unavailable from July 10-23 due to a transmission error. Precipitation events are high in frequency and low in magnitude. Stage ranges between 1.82m and 2.55m, a difference of 0.73m.

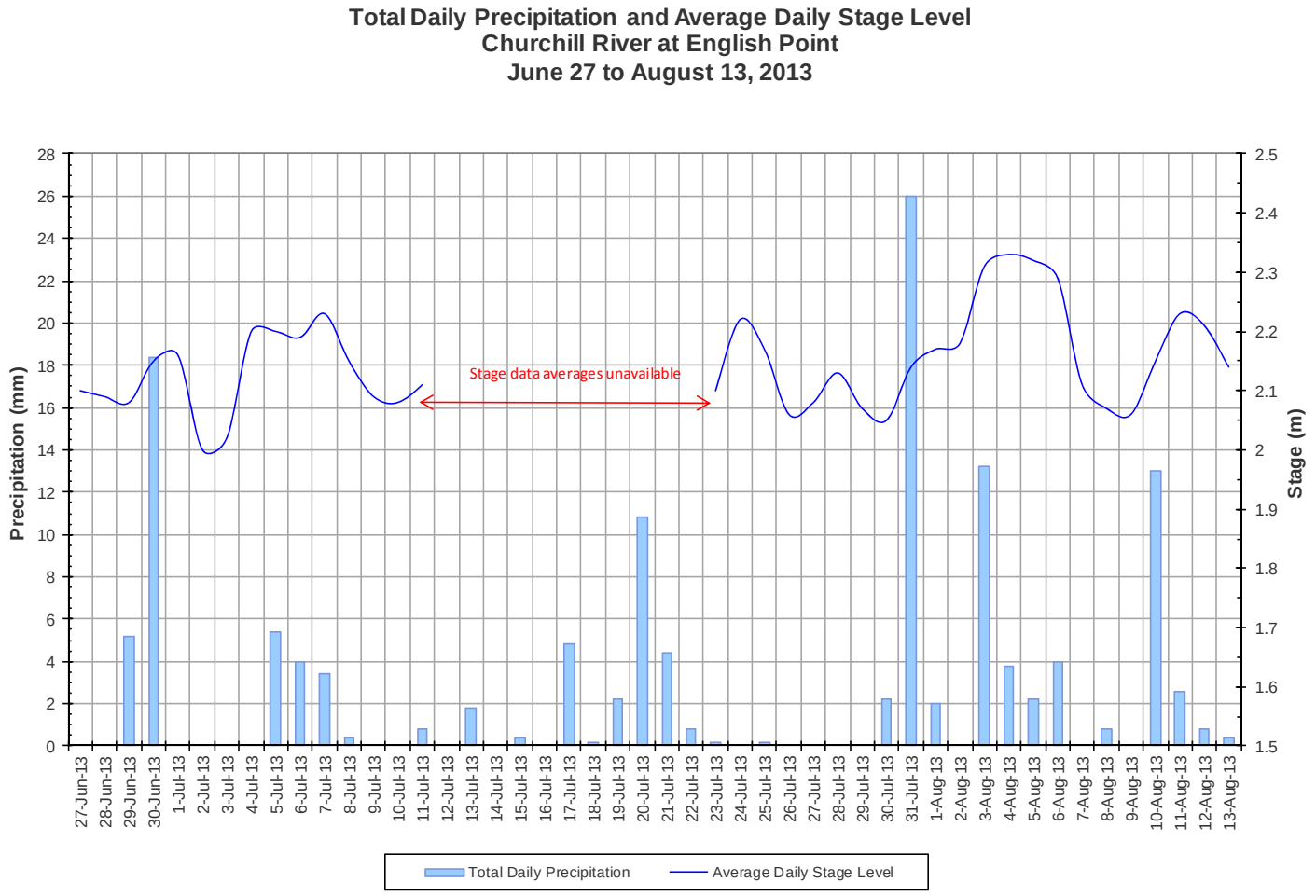
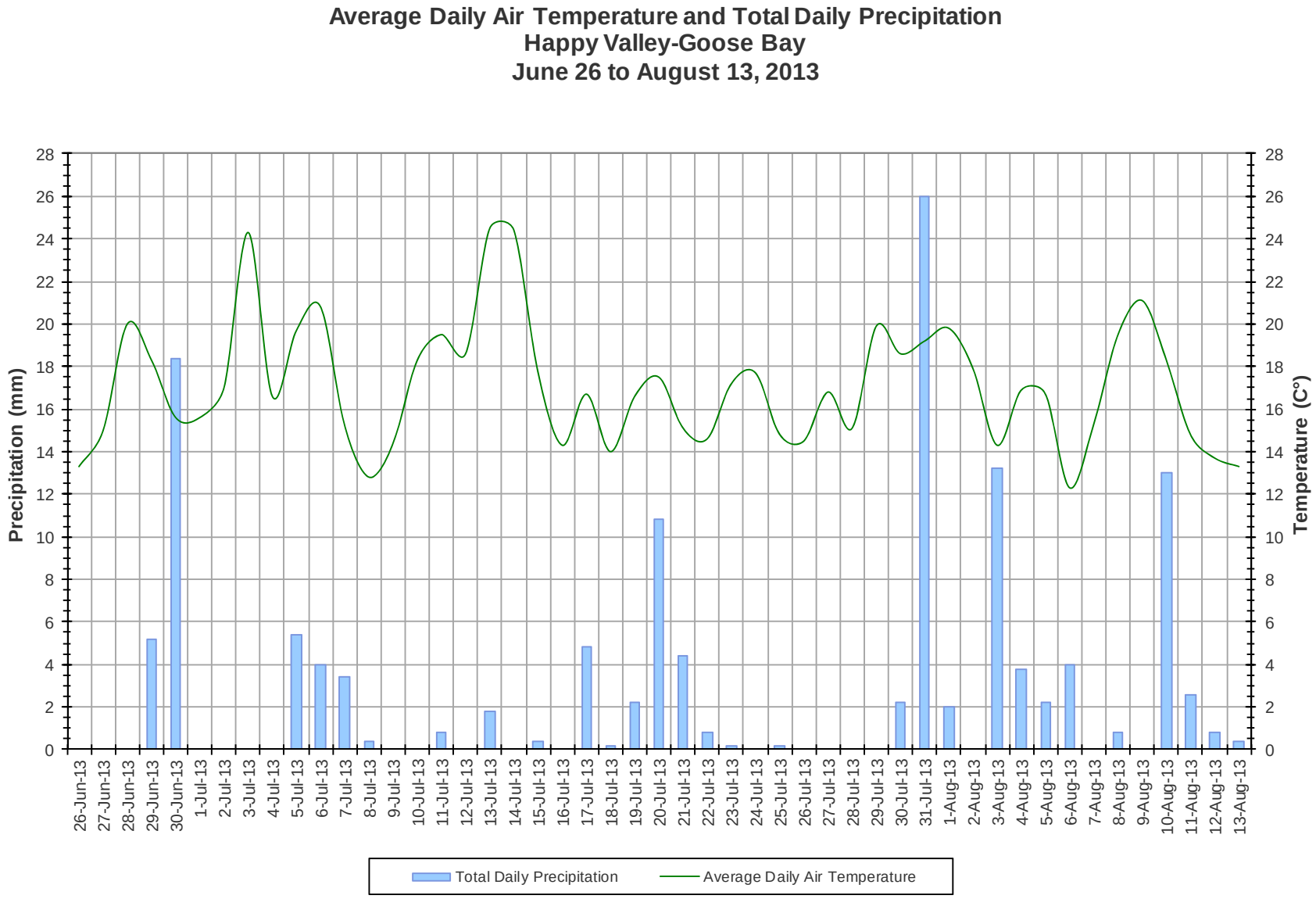


Figure 37: Daily precipitation and average daily stage level at Churchill River at English Point (weather data recorded at Goose Bay)

Conclusions

- Instruments at five water quality monitoring stations on the Lower Churchill River were deployed from June 26/27 to August 8/9/13, 2013.
- Stage levels decreased at all stations increased for the first week of the deployment period. The following three weeks were generally stable in terms of water level throughout the Lower Churchill River. In the final week of the deployment, stage level was decreasing throughout the network. Water level changes at the each of the stations ranged between 0.32m and 1.08m.
- Water temperature was increasing at all stations throughout the deployment period due to the warming ambient air temperatures in the region in the summer season. Water temperature typically ranged between 10°C and 18°C.
- pH is generally neutral and stable at all stations along the Lower Churchill River ranging between 6.34 and 7.43 pH units. pH values were generally within the recommended CCME Guidelines for the Protection of Aquatic Life and consistent at all stations. At the station at English Point, pH values were either just above or just below the lower recommended values for pH as suggested by the guidelines.
- Specific conductivity was consistently increasing at all stations regardless of the fluctuating stage levels. While this trend is not normally experienced, for this deployment period, the trend was similar throughout the network with the exception of the station at English Point which is influenced by the tides in Lake Melville. Specific conductivity typically averaged between 18µS/cm and 20µS/cm at the stations below Metchin River, below Grizzle Rapids and above and below Muskrat Falls. The station at English Point experiences averaged higher at 31µS/cm.
- Dissolved oxygen content was decreasing throughout the deployment period as it is inversely related to water temperature. Values ranged between 8.81mg/l and 11.52mg/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. Most values were above or just below the CCME Guideline for the Protection of Aquatic Life at 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. All values recorded at this station were greater than 9.5mg/l.
- 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. Turbidity values at the station above Muskrat Falls were atypical for the station, reporting a 0NTU background values for the latter half of the deployment period. Conversely, background turbidity values were upwards of 45NTU at the station just 6km below Muskrat Falls during the same time period. Turbidity values at the station at English Point were typical of the station, with an 11NTU background value. There were turbidity increases above the background values at all stations. Some of these increases correspond with rainfall events.

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



Average Daily Air Temperature and Total Daily Precipitation
Churchill Falls
June 26 to August 13, 2013