

Real-Time Water Quality Deployment Report

Lower Churchill River Network

June 29 to August 3, 2016



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

Contents

Real Time Water Quality Monitoring.....	1
Quality Assurance and Quality Control.....	1
Data Interpretation.....	4
Churchill River below Grizzle Rapids.....	6
Churchill River above Upper Muskrat Falls.....	12
Churchill River below Muskrat Falls.....	19
Churchill River at English Point.....	26
Conclusions.....	32
References.....	33
APPENDIX A-Station Comparisons.....	34
APPENDIX B- Quality Assurance / Quality Control Procedures.....	38
APPENDIX C- Water Parameter Description.....	39
APPENDIX D-Grab Sample Results.....	40

Prepared by:

Kyla Brake – Environmental Scientist
Department of Environment and Climate Change
Water Resources Management Division
Phone: 709.729.3899
Fax: 709.729.0320
kbrake@gov.nl.ca

Real Time Water Quality Monitoring

- Staff of the Department of Environment and Climate Change monitor real-time water quality data on a regular basis.
- This deployment report discusses water quality related events occurring at four stations on the Lower Churchill River: below Grizzle Rapids, above and below Muskrat Falls and at English Point.
- On June 29/30, 2016, real-time water quality monitoring instruments were deployed at all four stations on the Lower Churchill River for periods of 33-34 days.

Quality Assurance and Quality Control

- As part of the Quality Assurance and Quality Control protocol (QAQC), an assessment of the reliability of data recorded by an instrument is made at the beginning and end of the deployment period. The procedure is based on the approach used by the United States Geological Survey.
- At deployment and removal, a QAQC Instrument is temporarily deployed alongside the Field Instrument. Values for temperature, pH, conductivity, dissolved oxygen and turbidity are compared between the two instruments. Based on the degree of difference between parameters recorded by the Field Instrument and QAQC Instrument at deployment and at removal, a qualitative statement is made on the data quality (Table 1).

Table 1: Instrument Performance Ranking classifications for deployment and removal

Parameter	Rank				
	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 dependent, temperature compensated and temperature independent. Because the temperature sensor is not isolated from the rest of the instrument, the entire instrument must be at the same temperature before the sensor will stabilize. The values may take some time to climb to the appropriate reading; if a reading is taken too soon it may not accurately portray the water body.
- Deployment and removal comparison rankings for the Lower Churchill River stations deployed from June 29/30, to August 3/4, 2016 are summarized in Table 2.

Table 2: Comparison rankings for Lower Churchill River stations June 29/30 to August 3/4, 2016

Churchill River Station and Instrument Number	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Grizzle Rapids (45699)	June 29, 2016	Deployment	Good	Fair	Excellent	Excellent	Excellent
	August 3, 2016	Removal	Good	Good	Excellent	Excellent	Excellent
Above upper Muskrat Falls (45708)	June 29, 2016	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	August 3, 2016	Removal	Excellent	Excellent	Excellent	Excellent	N/A
Below Muskrat Falls (47589)	June 30, 2016	Deployment	Excellent	Fair	Excellent	Excellent	Poor
	August 3, 2016	Removal	Good	Excellent	Excellent	Excellent	Good
At English Point (47384)	June 30, 2016	Deployment	Excellent	Fair	Excellent	Excellent	Marginal
	August 4, 2016	Removal	Excellent	Excellent	Excellent	Excellent	Good

- At the station below Grizzle Rapids, temperature, conductivity, dissolved oxygen, and turbidity all rank as 'good' or 'excellent' at deployment. pH ranks as 'fair'. The field pH value was 6.86 and the QA/QC value was 6.24, while the grab sample value was 6.95. The difference between the readings is likely due to the QA/QC sonde not being acclimated to the water conditions before the value was recorded. Upon removal, temperature, pH, conductivity, dissolved oxygen, and turbidity all rank as 'good' or 'excellent'.
- At the station above Muskrat Falls, temperature, pH, conductivity, turbidity and dissolved oxygen all rank 'excellent' at deployment. Upon removal, temperature, pH, conductivity and dissolved oxygen again rank as 'excellent'. The turbidity sensor could not be ranked as the QAQC turbidity sensor was not operational.
- Upon deployment at the below Muskrat Falls station, temperature, conductivity and dissolved oxygen ranked 'excellent' while pH ranked 'fair' and turbidity ranked 'poor'. The field pH value was 6.13, the QAQC value was 6.81, and the grab sample value was 6.97. The difference between readings is likely due to the field sonde not having fully acclimated to the environment before the value was read and recorded. Upon deployment, the field turbidity value was 24.0 NTU, the QAQC value was 46.9 NTU and the grab sample

value was 33.0 NTU. The discrepancy is likely due to sediment becoming suspended around the QAQC sonde as the value was recorded. Upon removal, all sensors ranked as 'good' or 'excellent'.

- At the station at English Point, temperature, conductivity, and dissolved oxygen all rank as 'excellent' while pH ranks as 'fair' and turbidity ranks as 'marginal' upon deployment. The field pH value was 6.02, the QAQC value was 6.73 and the grab sample value was 6.92. This discrepancy is likely due to the field sonde being slow to acclimate before the reading was recorded. The field turbidity value was 30.4NTU and the QA/QC value was 39.2NTU, while the grab sample value was 24.0NTU. This discrepancy is likely due to sediment being suspended and disturbed around the QAQC sonde as the value was being recorded. Upon removal, temperature, pH, conductivity, dissolved oxygen and turbidity all ranked as 'good' or 'excellent'.

Data Interpretation

- The following graphs and discussion illustrate water quality related events occurring from June 29/30 to August 3/4, 2016 on the Lower Churchill River Network.
- This is the second water quality deployment of 2016 for the above Upper Muskrat Falls and English Point stations. Due to accessibility issues during the May deployment attempt, this is the first water quality deployment of 2016 for the Grizzle Rapids and below Lower Muskrat Falls stations.
- With the exception of water quantity data (stage & flow), 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 experienced issues with sediment accumulation in 2014 and was only deployed for September in 2015. An attempt at deployment during May 2016 was not possible due to high water levels which prevented safe access to the station. The station was deployed June 30, 2016 but will be removed if sediment again accumulates and poses a threat to the instrumentation.



Figure 1: Lower Churchill Network- Station Locations

Churchill River below Grizzle Rapids

Water Temperature

- Water temperature ranges from 9.90°C to 20.00°C with a median value of 16.20°C (Figure 2).
- Water temperature gradually increases until July 18, a trend that is expected as air temperatures warm through the summer months. After July 18, water temperature decreases sharply for several days, a trend that is mirrored by the average daily air temperature values. Water temperatures are then relatively stable into August.

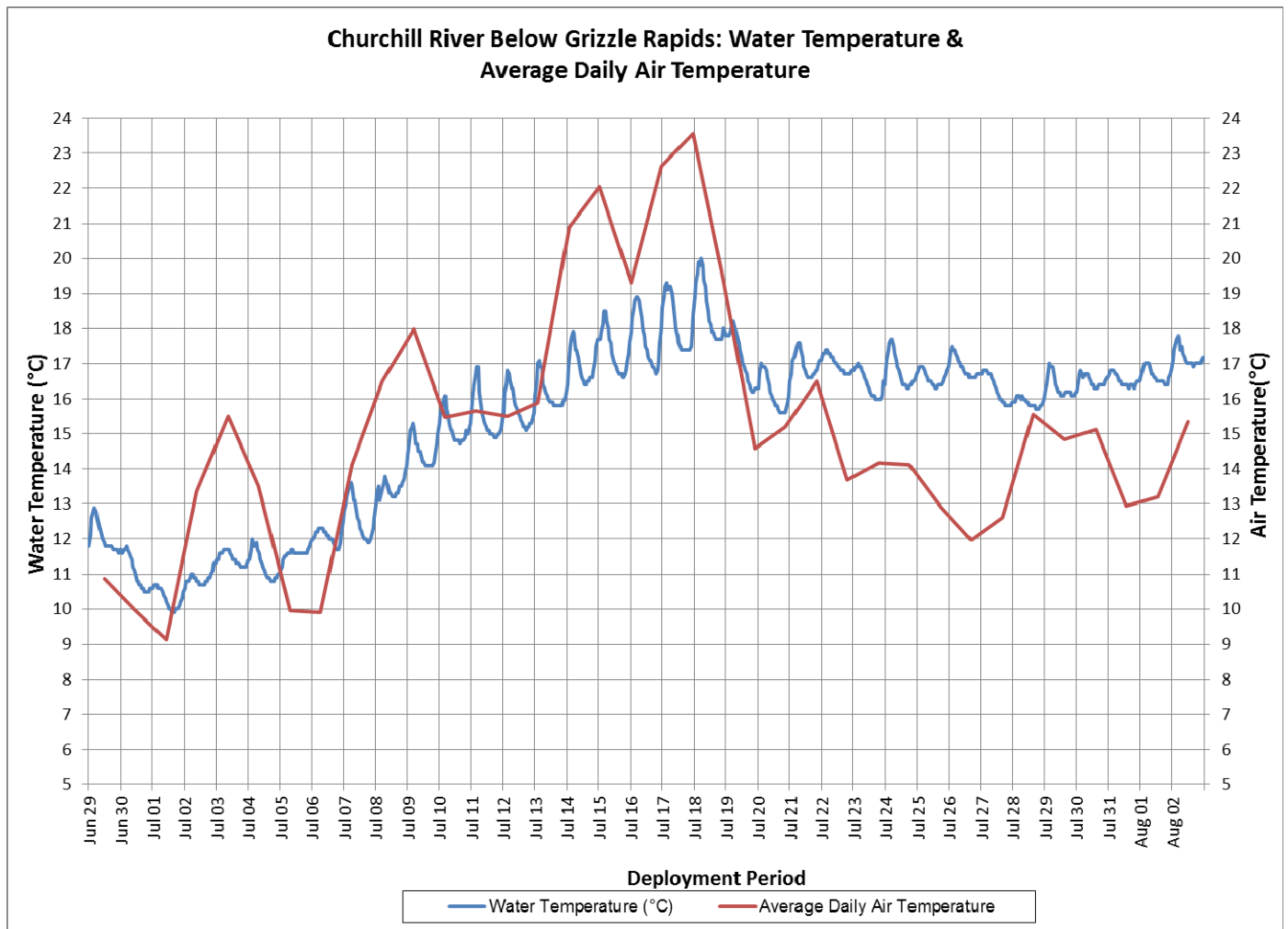


Figure 2: Water Temperature & Daily Average Air Temperature (Muskrat Falls Weather Station) at Churchill River below Grizzle Rapids

pH

- pH ranges between 6.78 and 7.20 pH units with a median value of 7.02 (Figure 3).
- pH values are stable and fall within the CCME Protection of Aquatic Life Guidelines.
- Photosynthesis uses up hydrogen molecules, which causes the concentration of hydrogen ions to decrease and therefore the pH to increase. For this reason, pH may be higher during daylight hours and during the growing season, when photosynthesis is at a maximum. This is illustrated by the diurnal fluctuations in Figure 3.

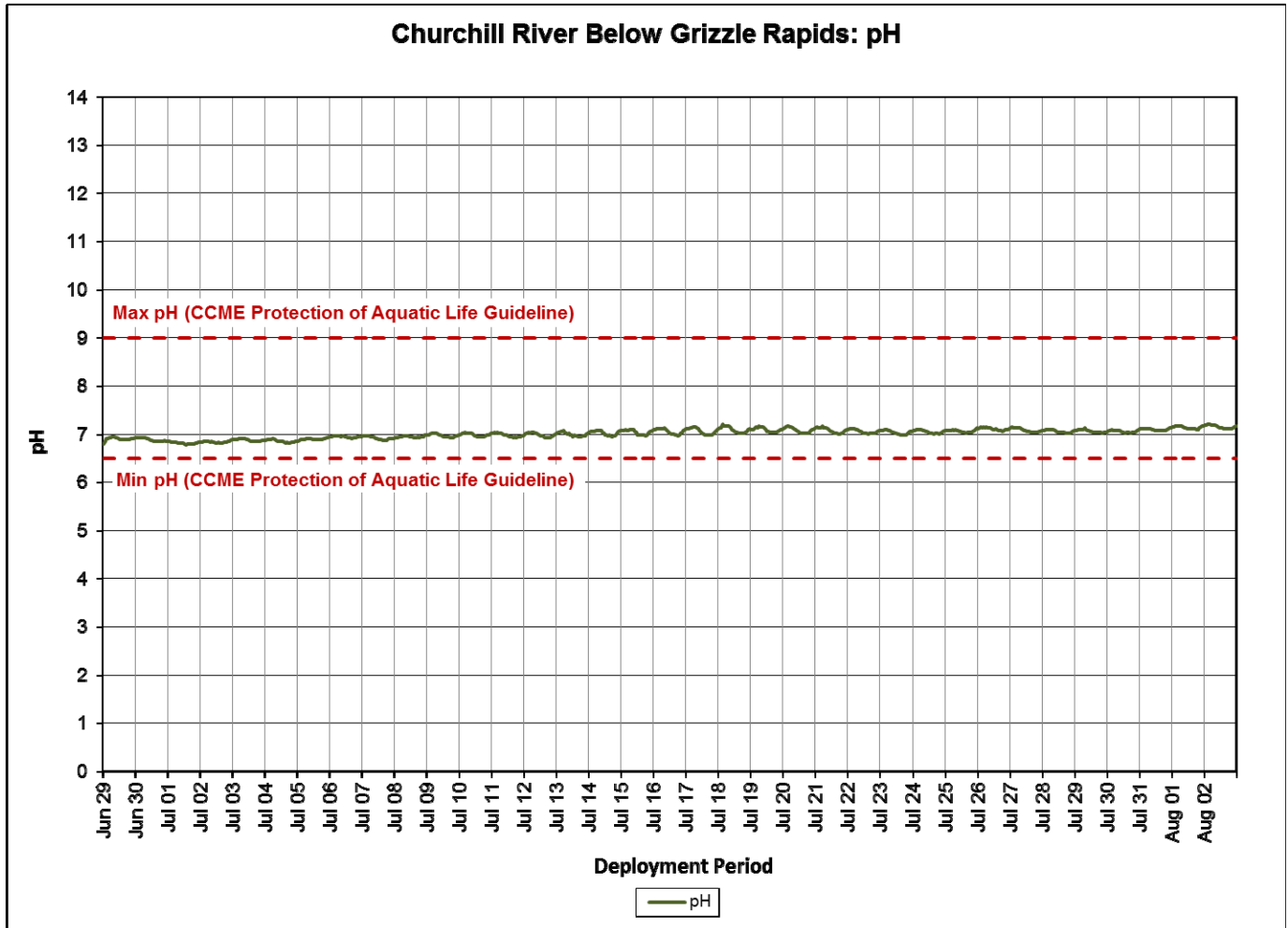


Figure 3: pH at Churchill River below Grizzle Rapids

Specific Conductivity, TDS and Stage

- Specific conductivity ranges from 13.7 μ S/cm to 18.6 μ S/cm with a median of 16.5 μ S/cm. (Figure 4).
- TDS (total dissolved solids) ranges from 0.0087 g/L to 0.0119 g/L with a median of 0.0105 g/L (Figure 4).
- Specific conductivity and TDS have a direct relationship but are two separate parameters. Specific conductivity is the ability of the water to conduct electricity. Therefore the value of TDS can be estimated by the conductivity of the water.
- The relationship between conductivity and stage are inversed. When stage level rises, the specific conductance levels drops in response as the increased amount of water in the river system dilutes the solids that are present. These parameters all remain relatively stable throughout the deployment period due to a stable stage level and minimal effects from precipitation events.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

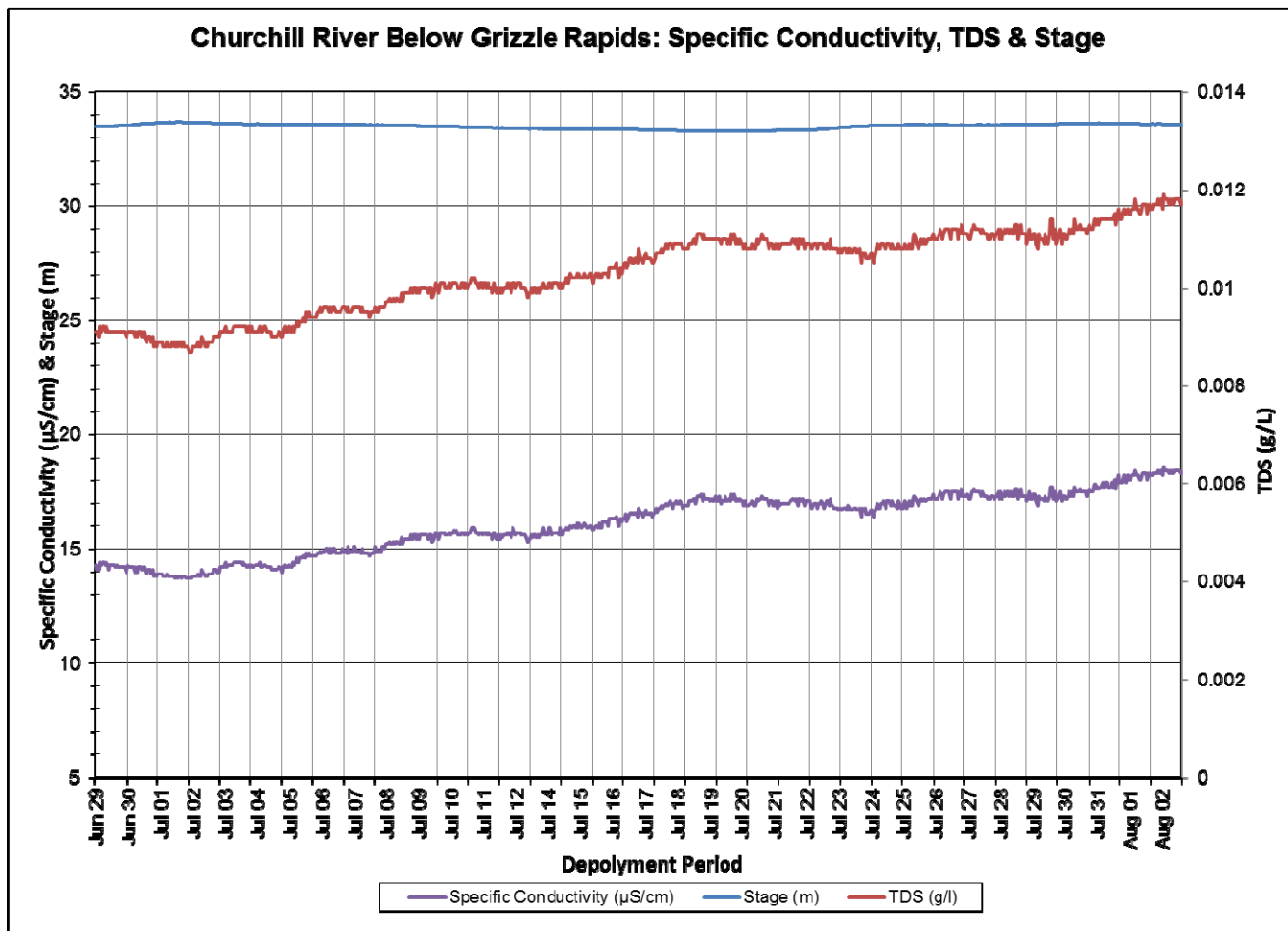


Figure 4: Specific Conductivity, TDS, and stage at Churchill River below Grizzle Rapids

Dissolved Oxygen

- Dissolved oxygen content ranges between 9.03mg/l and 10.93mg/l with a median value of 9.48mg/l. The saturation of dissolved oxygen ranges from 94.1% to 103.0% with a median value of 97.3% (Figure 5).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period, the dissolved oxygen levels are gradually falling as temperatures rise into the summer season. The dissolved oxygen also follows a diurnal pattern as the water temperature rises and falls under the influence of the ambient air temperature. Generally, there is more dissolved oxygen present in a waterbody during cooler temperatures.
- The dissolved oxygen levels remained above the CCME Guidelines for the Protection of Other Life Stages. However, the dissolved oxygen levels dipped slightly below the CCME Guideline for the Protection of Early Life Stages as water temperatures increased into the summer months.

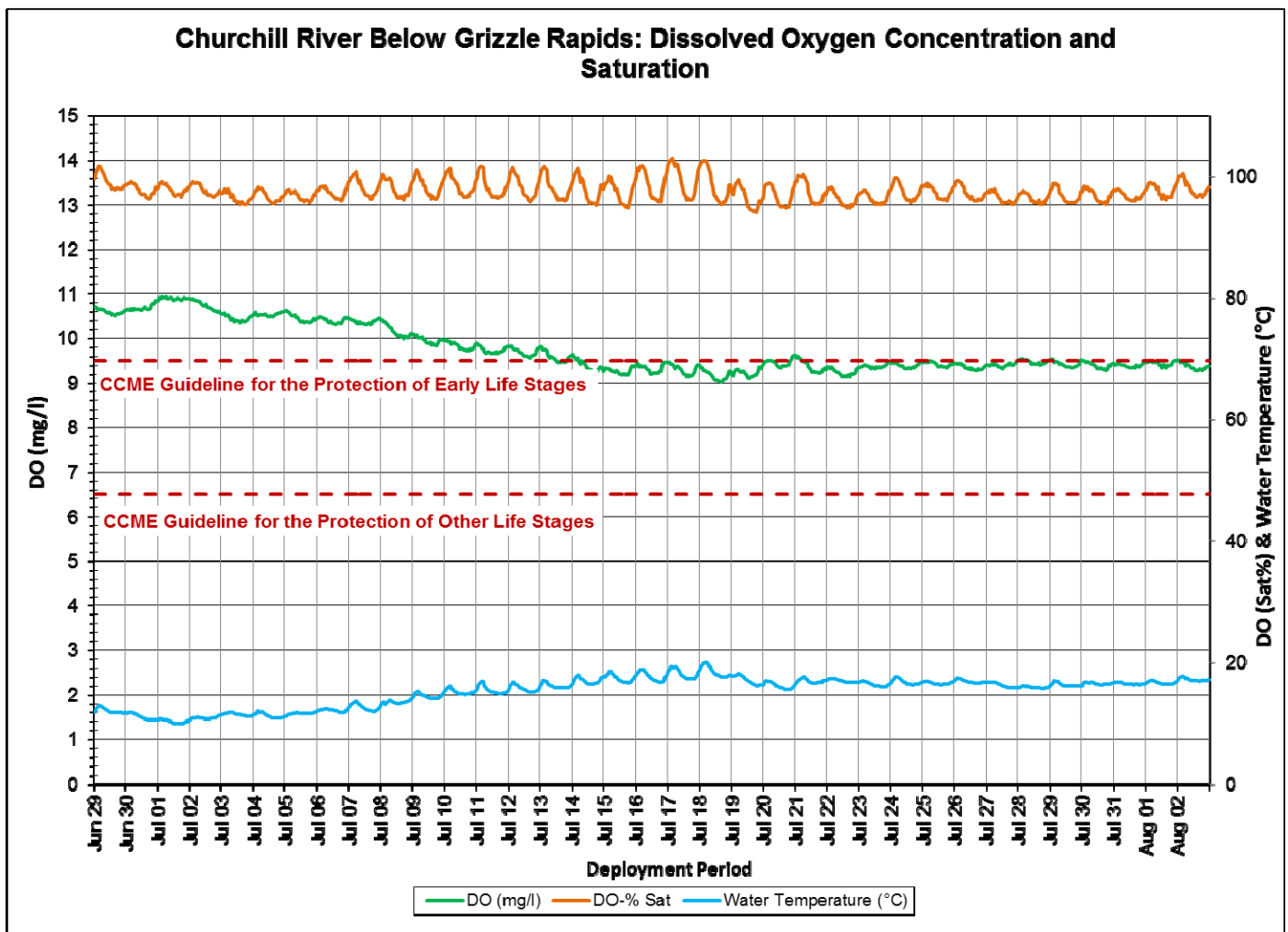


Figure 5: Dissolved Oxygen at Churchill River below Grizzle Rapids

Turbidity, Stage & Total Daily Precipitation

- Turbidity ranges between 0.0NTU and 26.5NTU with a median value of 4.1NTU (Figure 6).
- The majority of turbidity events in the deployment period correlate to larger precipitation events. Precipitation can increase the presence of suspended material in water. There is a period from July 24 to July 26th where turbidity increased for a few days before returning to around the median value for this deployment. This data was likely caused by sediment suspension as stage was increasing at the same time after a precipitation event (Figure 7).
- Stage ranges between 33.29m and 33.69m (Figure 6).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

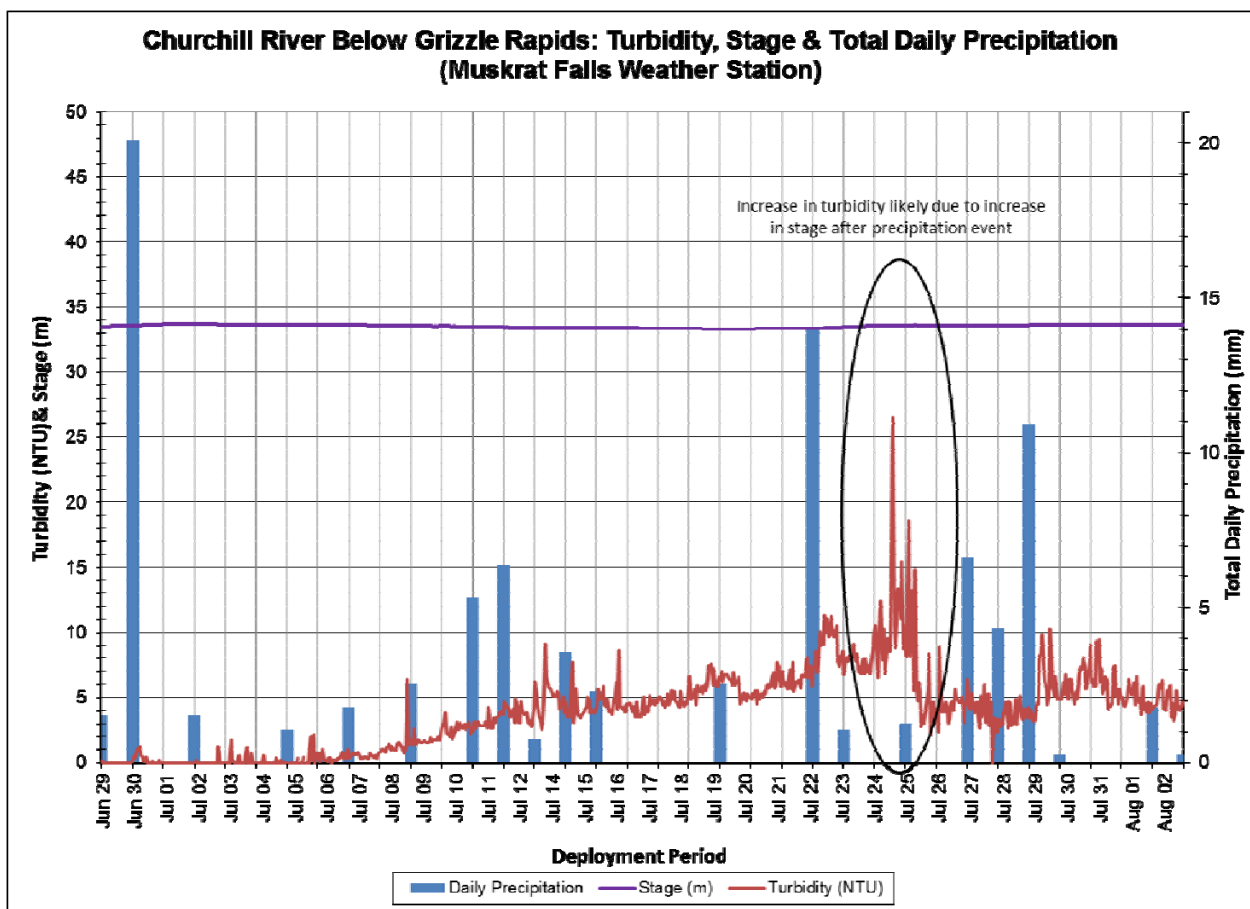


Figure 6: Turbidity, Stage, & Total Daily Precipitation (Muskrat Falls Weather Station) at Churchill River below Grizzle Rapids

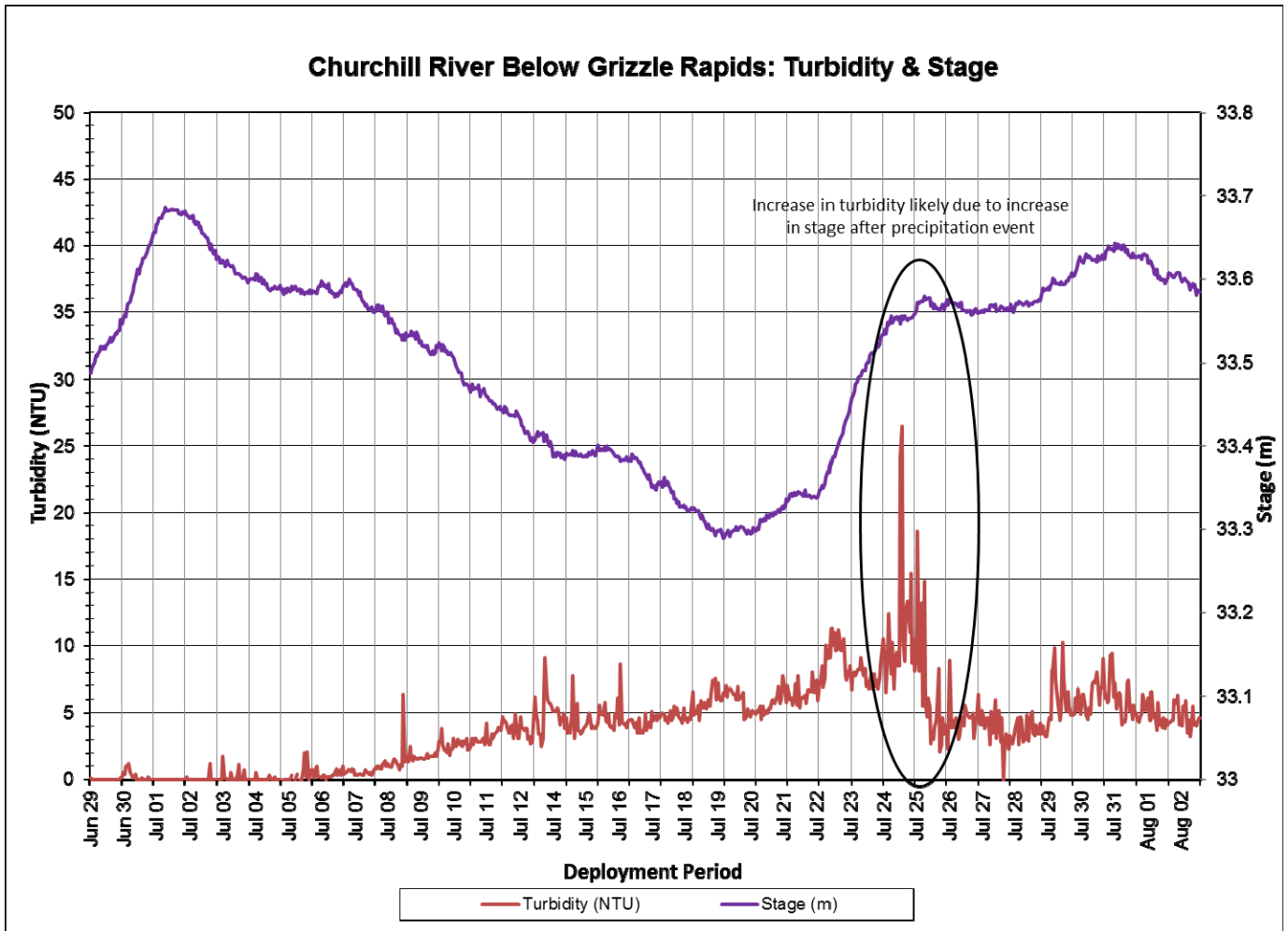


Figure 7: Turbidity & Stage at Churchill River below Grizzle Rapids

Churchill River above Upper Muskrat Falls

Water Temperature

- Water temperature ranges from 11.04°C to 20.08°C with a median value of 16.23°C (Figure 8).
- Water temperature gradually increases until July 18, a trend that is expected as air temperatures warm through the summer months. After July 18, water temperature decreases sharply for several days, a trend that is mirrored by the average daily air temperature values. Water temperatures are then relatively stable into August.

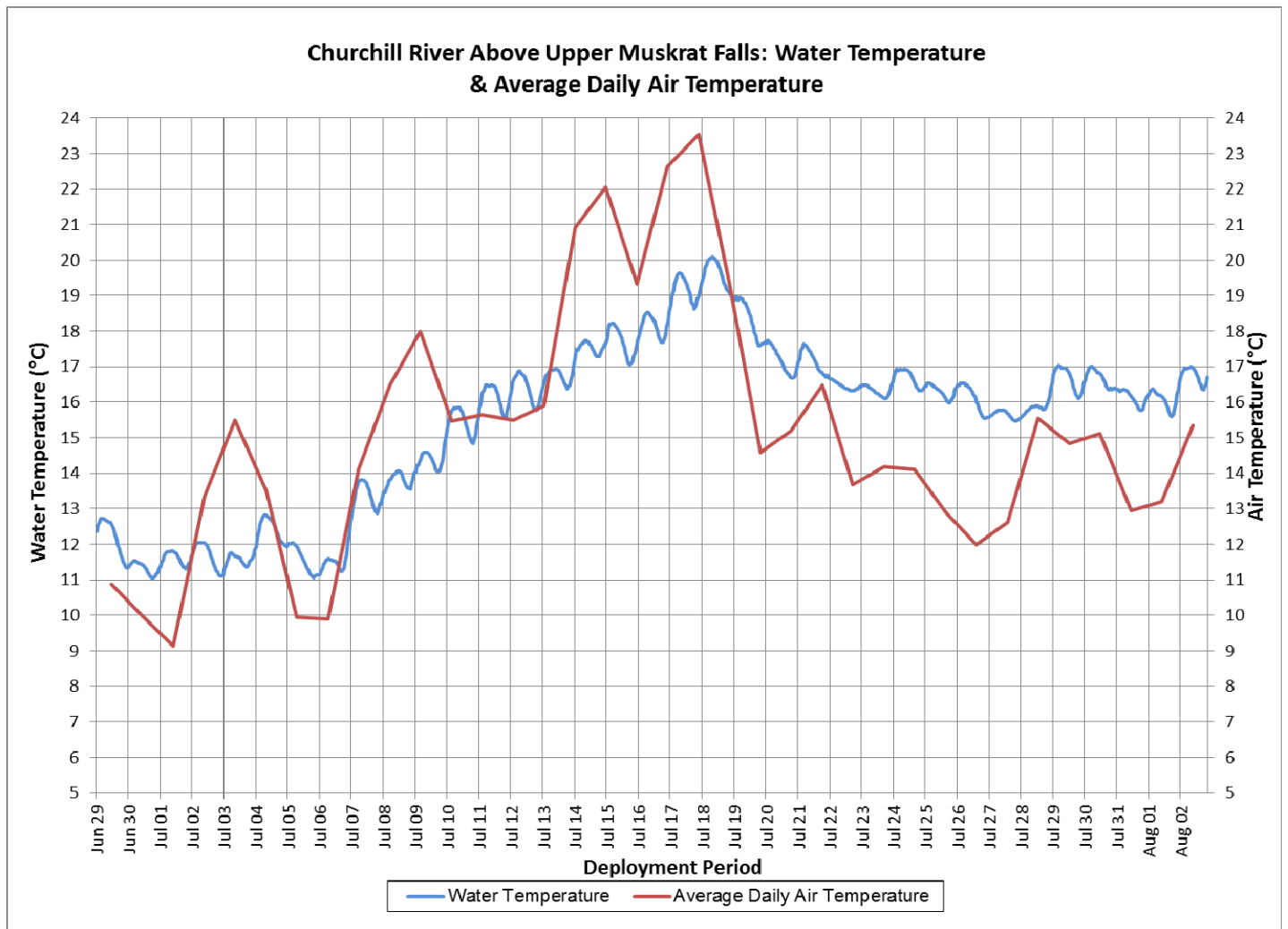


Figure 8: Water Temperature & Average Daily Air Temperature (Muskrat Falls Weather Station) at Churchill River above Upper Muskrat Falls

pH

- pH ranges between 6.54 and 6.79 pH units with a median value of 6.67 (Figure 9).
- pH values are relatively stable and fall within the CCME Protection of Aquatic Life Guidelines.

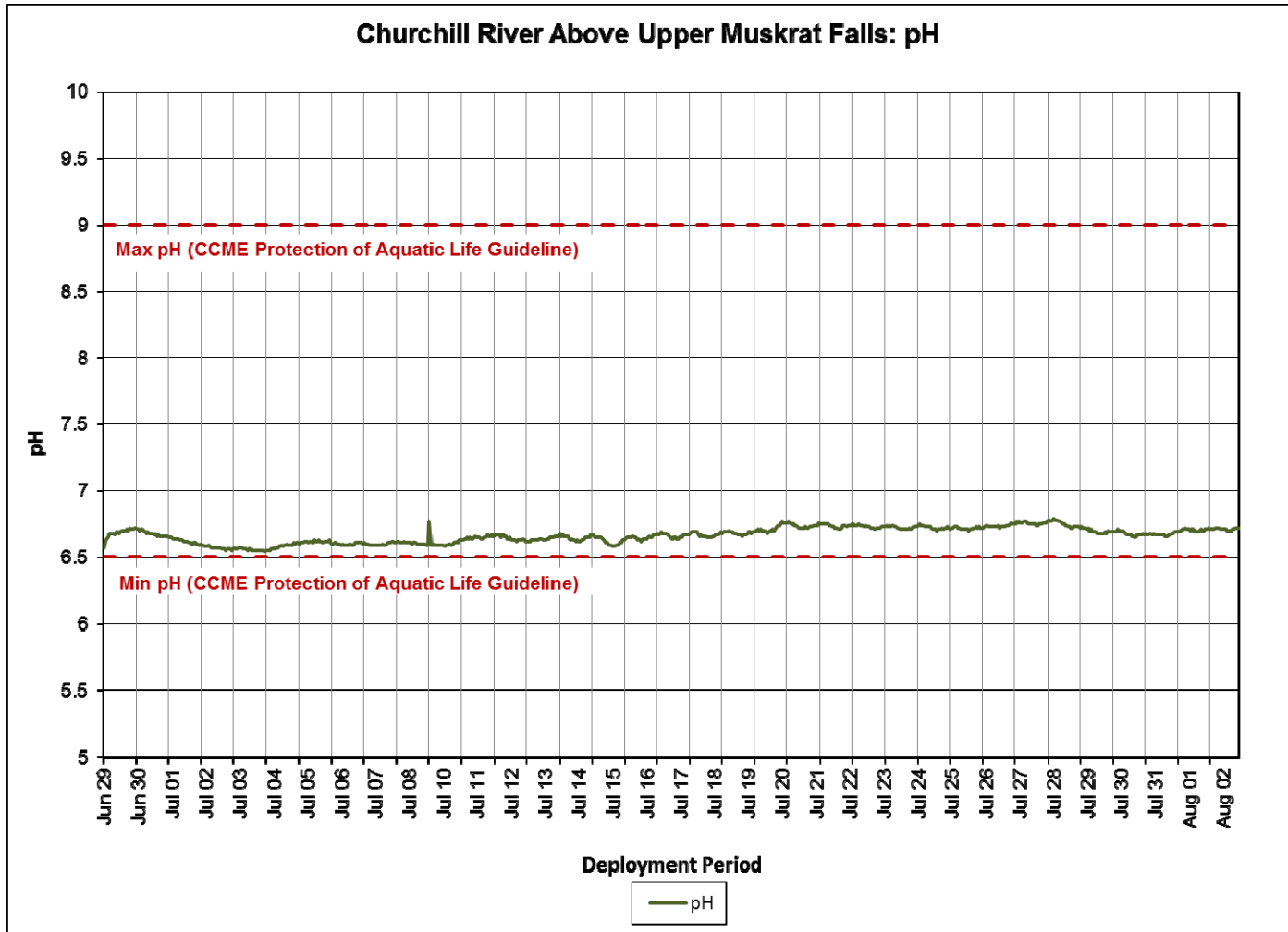


Figure 9: pH at Churchill River above Upper Muskrat Falls

Specific Conductivity, TDS and Stage

- Specific conductivity ranges from 13.7 μ S/cm to 18.1 μ S/cm with a median of 16.5 μ S/cm (Figure 10).
- TDS ranges from 0.0088 g/L to 0.0116 g/L with a median of 0.0106 g/L (Figure 10).
- Specific conductivity and TDS have a direct relationship but are two separate parameters. Specific conductivity is the ability of the water to conduct electricity. Therefore the value of TDS can be estimated by the conductivity of the water.
- The relationship between conductivity and stage are inverted. When stage level rises, the specific conductance levels drops in response as the increased amount of water in the river system dilutes the solids that are present. This trend is evident during stage increases around July 2nd and 25th.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

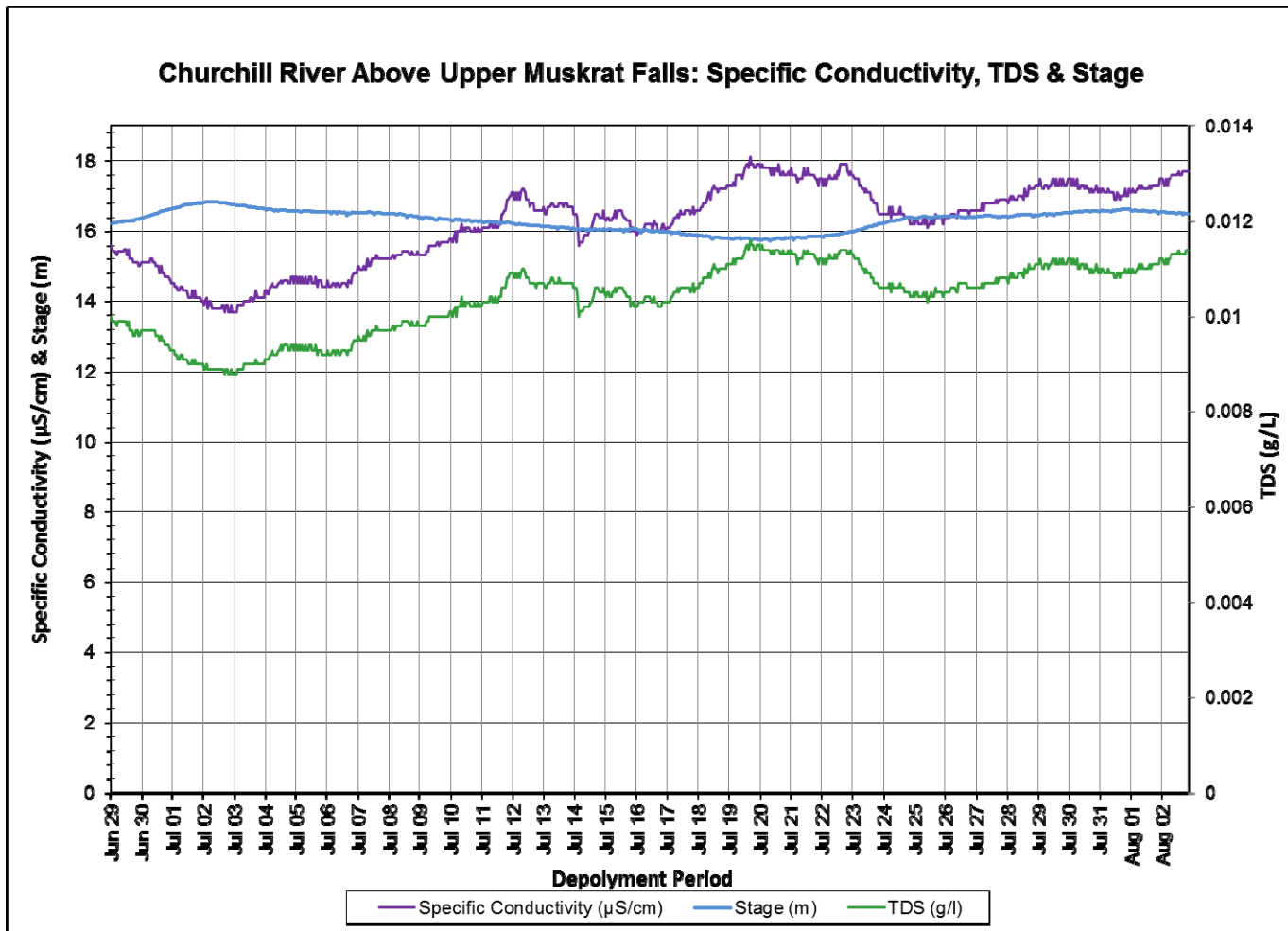


Figure 10: Specific Conductivity, TDS, and Stage at Churchill River above Upper Muskrat Falls

Dissolved Oxygen

- Dissolved oxygen content ranges between 9.04mg/l and 10.85mg/l with a median value of 9.62mg/l. The saturation of dissolved oxygen ranges from 95.8% to 102.8% with a median value of 98.9% (Figure 11).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period the dissolved oxygen levels are slowly falling as temperatures rise into the summer season. The dissolved oxygen also follows a diurnal pattern as the water temperature rises and falls under the influence of the ambient air temperature. Generally, there is more dissolved oxygen present in a waterbody during cooler temperatures.
- The dissolved oxygen levels remained above the CCME Guidelines for the Protection of Other Life Stages. However, the dissolved oxygen levels dipped slightly below the CCME Guideline for the Protection of Early Stages mid-July when water temperatures were at their highest.

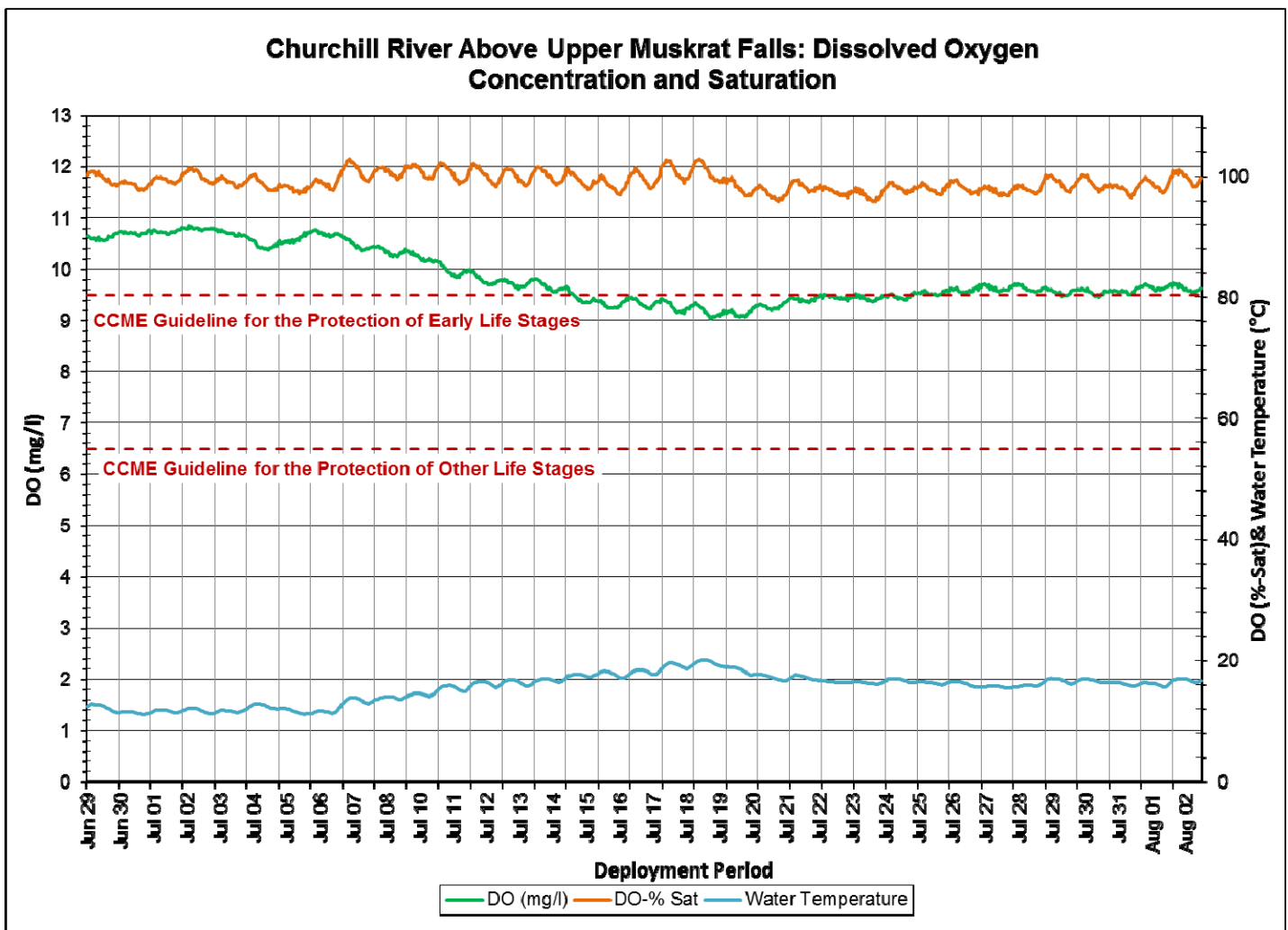


Figure 11: Dissolved oxygen at Churchill River above Upper Muskrat Falls

Chlorophyll

- Chlorophyll ranges between 5.1ug/L and 12.0ug/L, with a median value of 7.3ug/L (Figure 12). The values were relatively stable throughout the deployment.
- Chlorophyll is found within living cells of photosynthetic organisms like phytoplankton and cyanobacteria. The amount of chlorophyll found in water can be used to understand the general biological health of an ecosystem. Chlorophyll can also be used to identify algal bloom events and is an indicator of nutrient loading in ecosystems.

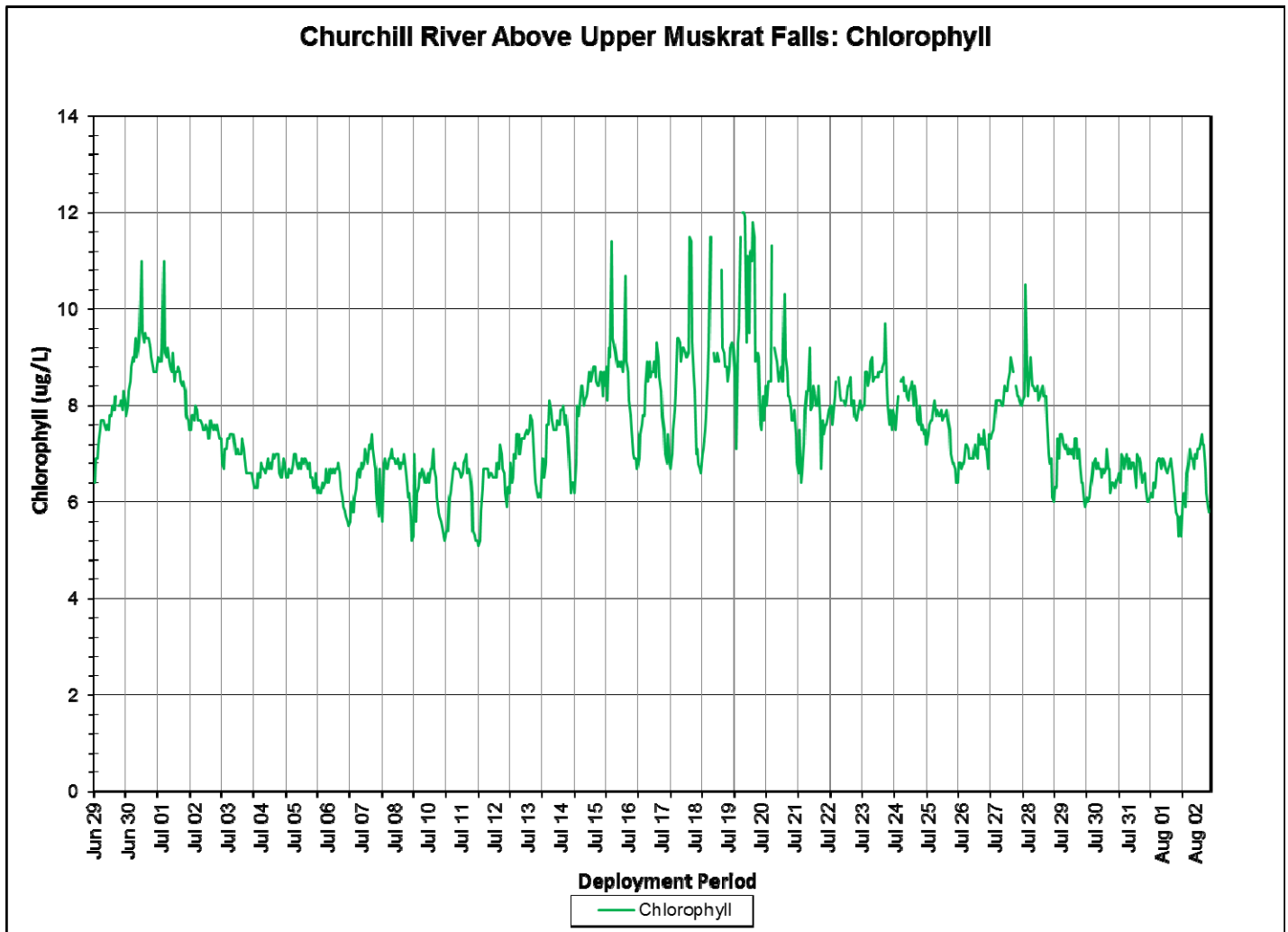


Figure 12: Chlorophyll at Churchill River above Upper Muskrat Falls

Stage, Flow, Turbidity and Precipitation

- Turbidity ranges between 3.9NTU and 86.6NTU with a median value of 7.6NTU (Figure 13).
- The majority of turbidity events in the deployment period correlate with increases in stage and precipitation events. Precipitation can increase the presence of suspended material in water.
- Precipitation occurs on 22 of the days in the deployment period and amounts are generally low, with the exception of June 30 which received a total of 20.07mm.
- Stage ranges between 15.74m and 16.83m, and streamflow ranges from 1179.57m³/s to 1792.08 m³/s (Figure 14).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

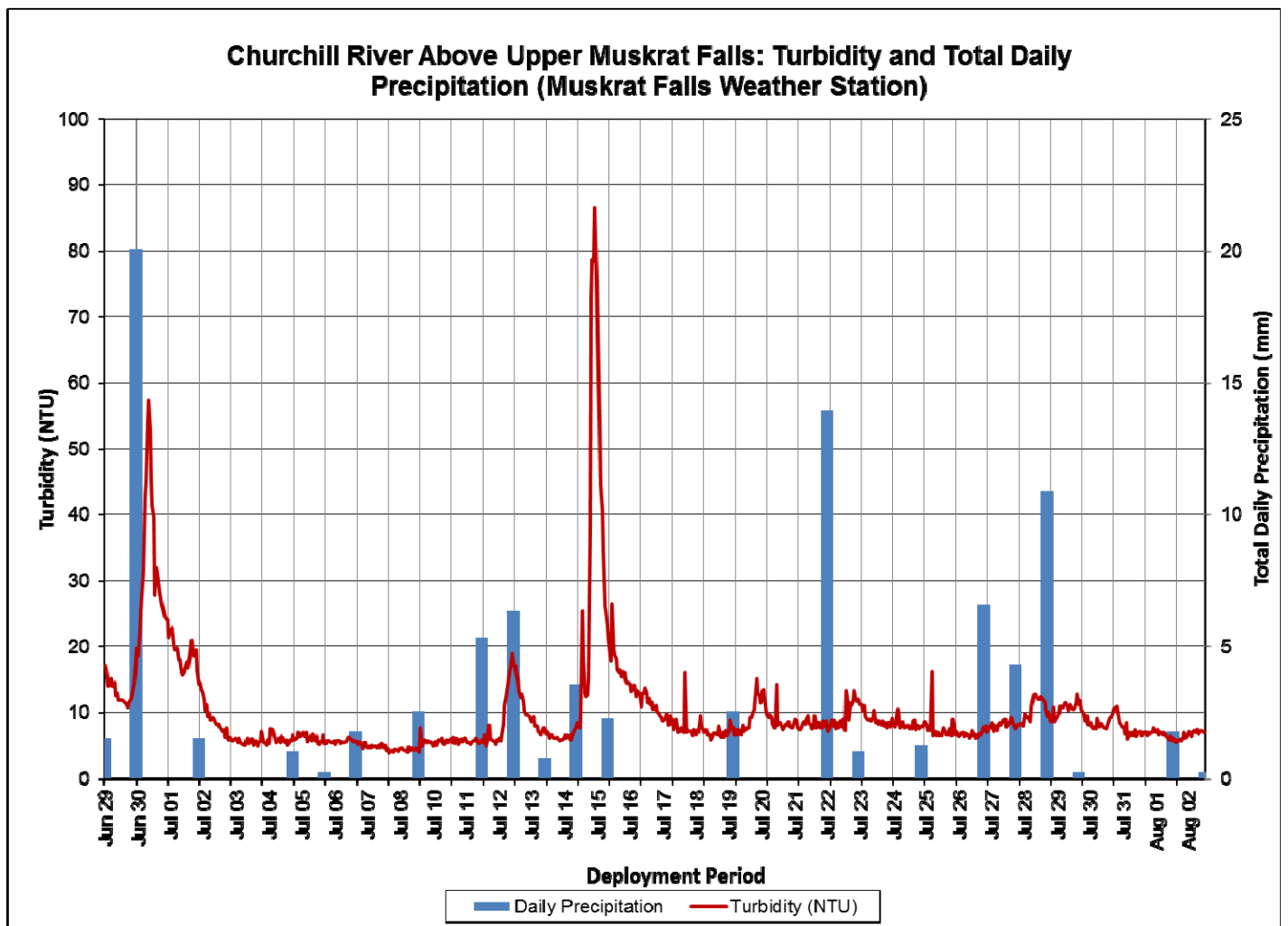


Figure 13: Turbidity and Total Daily Precipitation (Muskrat Falls Weather Station) at Churchill River above Upper Muskrat Falls

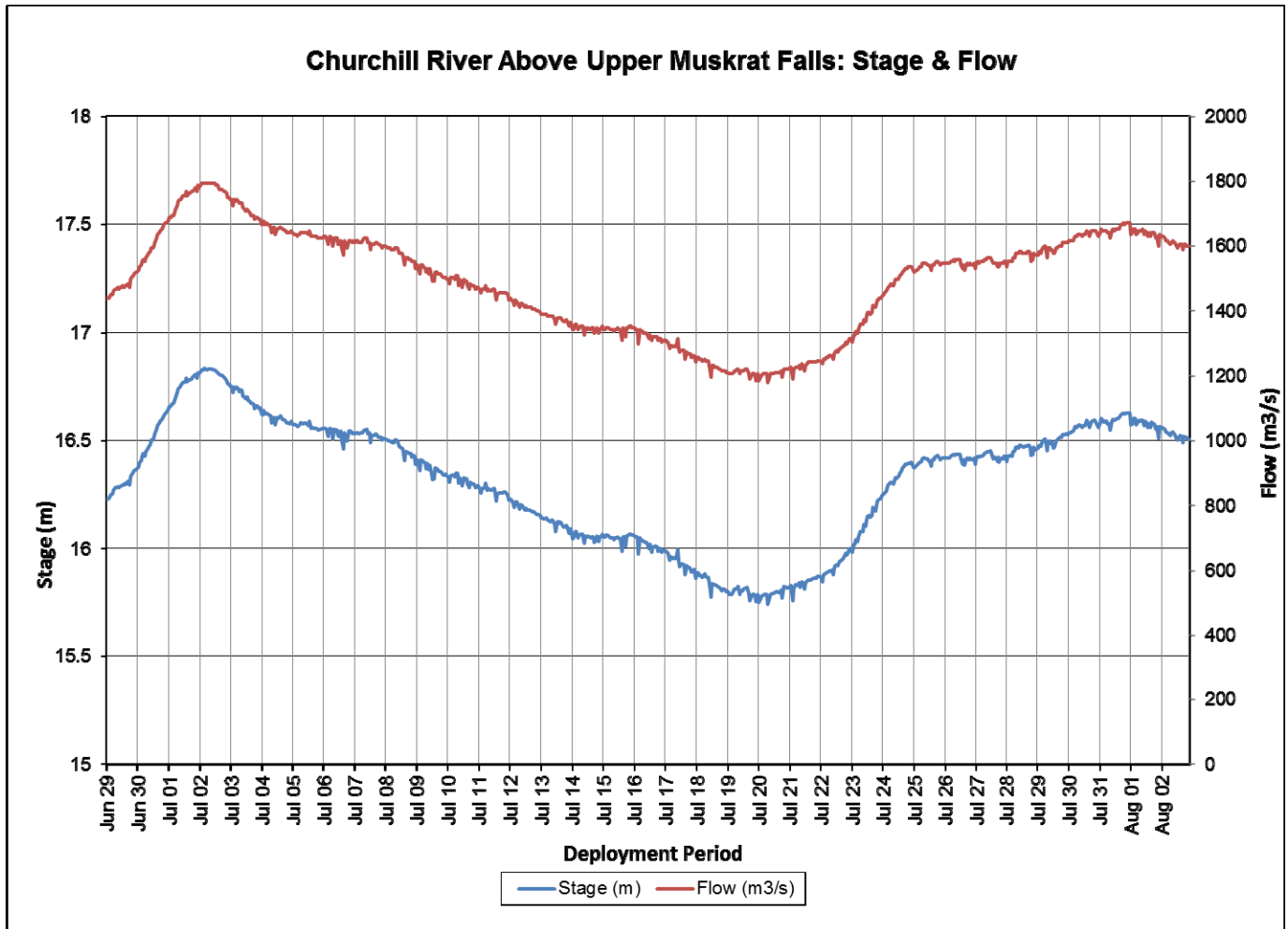


Figure 14: Stage and Flow at Churchill River above Upper Muskrat Falls

Churchill River below Muskrat Falls

- The sonde located at this station was repeatedly buried in sand during the 2014 season. The decision to not redeploy the sonde until sand conditions in the area improve was made in August 2014. The station was deployed June 30, 2016, but will be removed if conditions deteriorate or there is a potential for damage to instrumentation.

Water Temperature

- Water temperature ranges from 11.30°C to 19.90°C with a median value of 16.30°C (Figure 15).
- Water temperature gradually increases until July 18, a trend that is expected as air temperatures warm through the summer months. After July 18, water temperature decreases sharply for several days, a trend that is mirrored by the average daily air temperatures values. Water temperatures were then relatively stable into August.

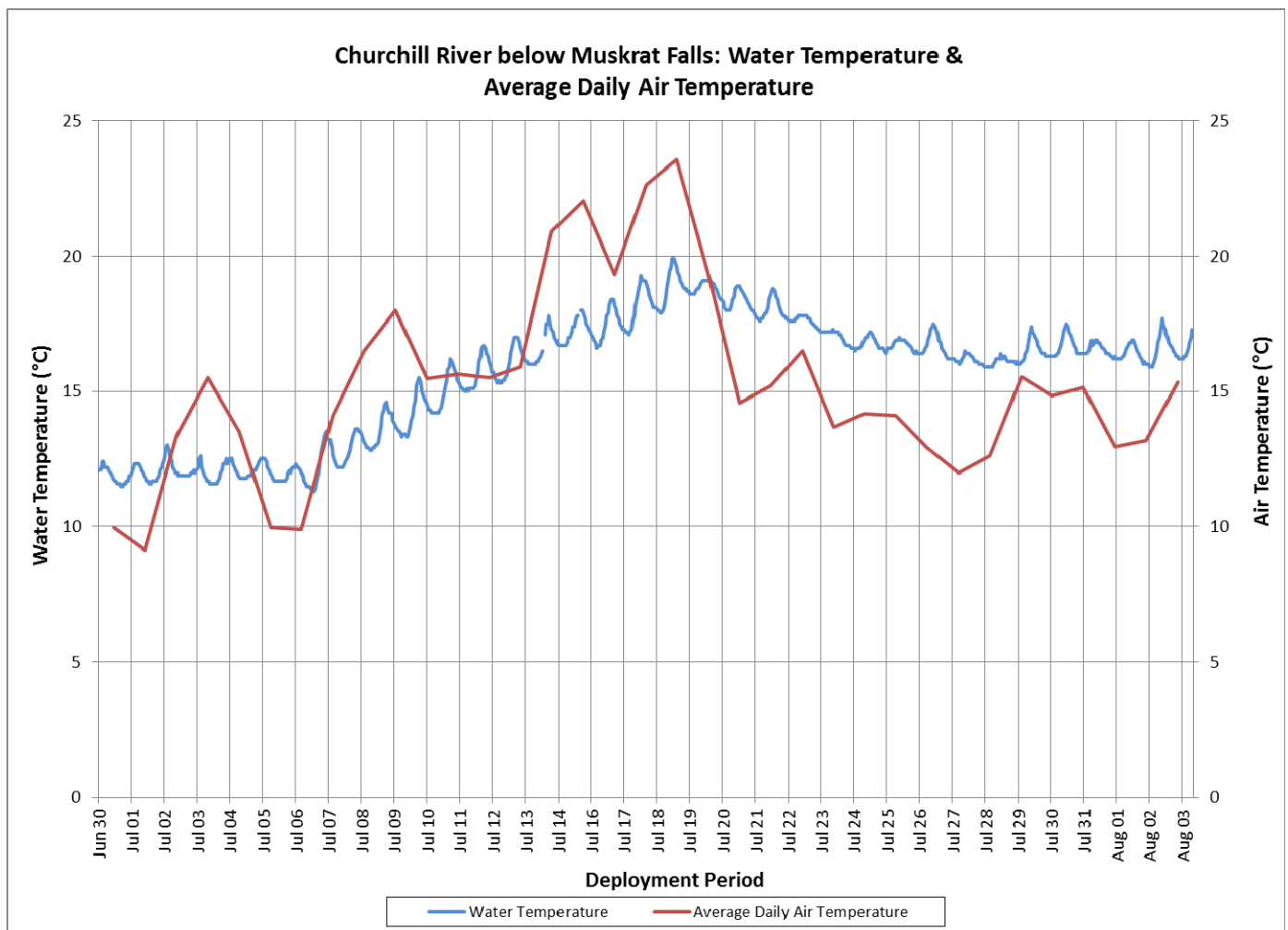


Figure 15: Water Temperature & Daily Average Air Temperature (Muskrat Falls Weather Station) at Churchill River below Muskrat Falls

pH

- pH ranges between 6.47 and 6.78 pH units with a median value of 6.64 (Figure 16).
- All pH values recorded during this deployment period hover around the minimum CCME protection of Aquatic Life Guideline of 6.5.

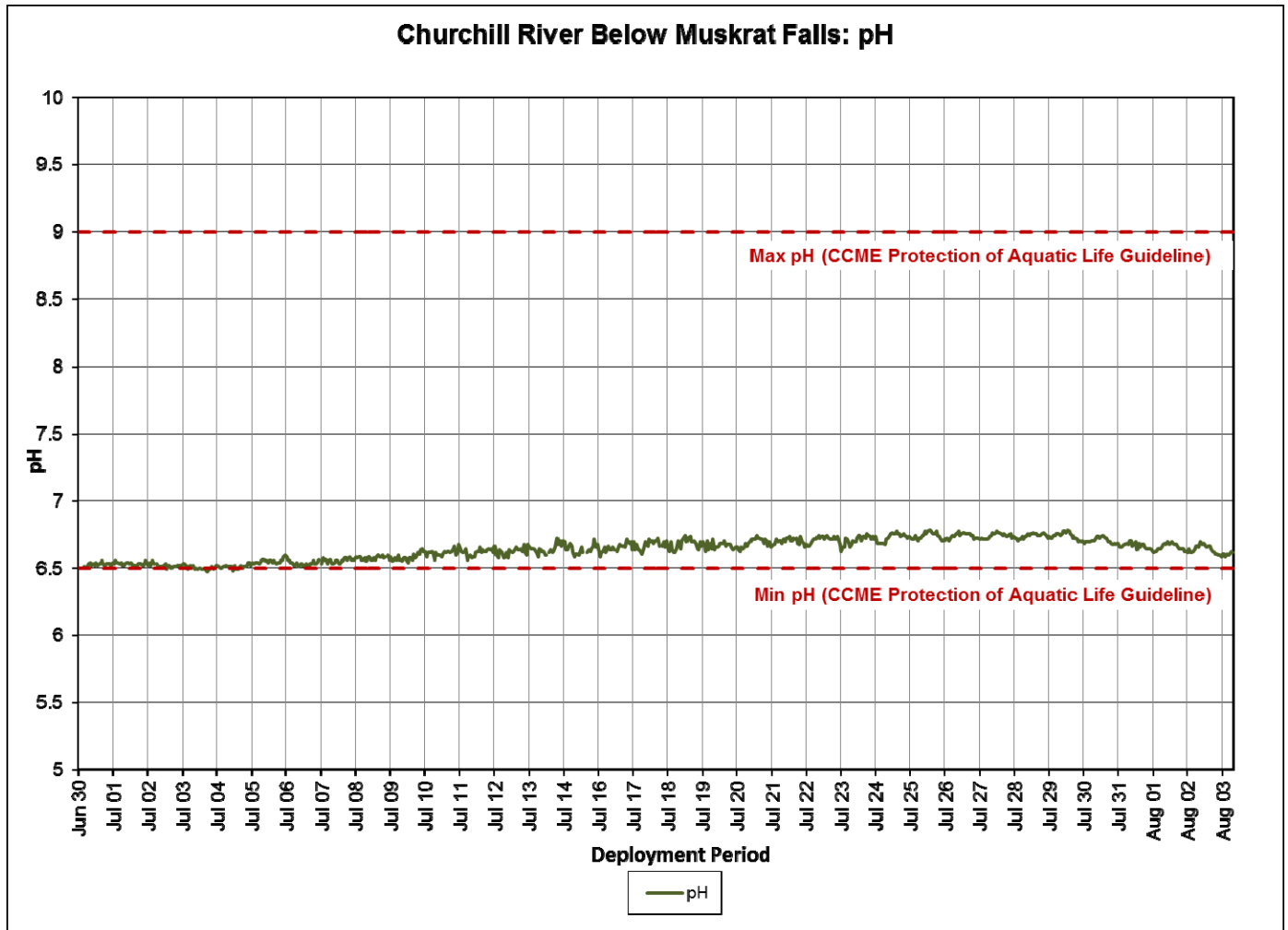


Figure 16: pH at Churchill River below Muskrat Falls

Specific Conductivity, TDS & Stage

- Specific conductance ranges between 14.0 μ S/cm and 18.6 μ S/cm during the deployment period, with a median of 16.5 μ S/cm (Figure 17). These values are nearly identical to those of the below Grizzle Rapids and above Upper Muskrat Falls stations for the same time period.
- TDS ranges between 0.0089 g/mL to 0.0119 g/mL during the deployment period, with a median of 0.0105 g/mL (Figure 17).
- Specific conductivity and TDS have a direct relationship but are two separate parameters. Specific conductivity is the ability of the water to conduct electricity. Therefore the value of TDS can be estimated by the conductivity of the water.
- The relationship between conductivity and stage are inversed. When stage level rises, the specific conductance levels drop in response as the increased amount of water in the river system dilutes the solids that are present.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

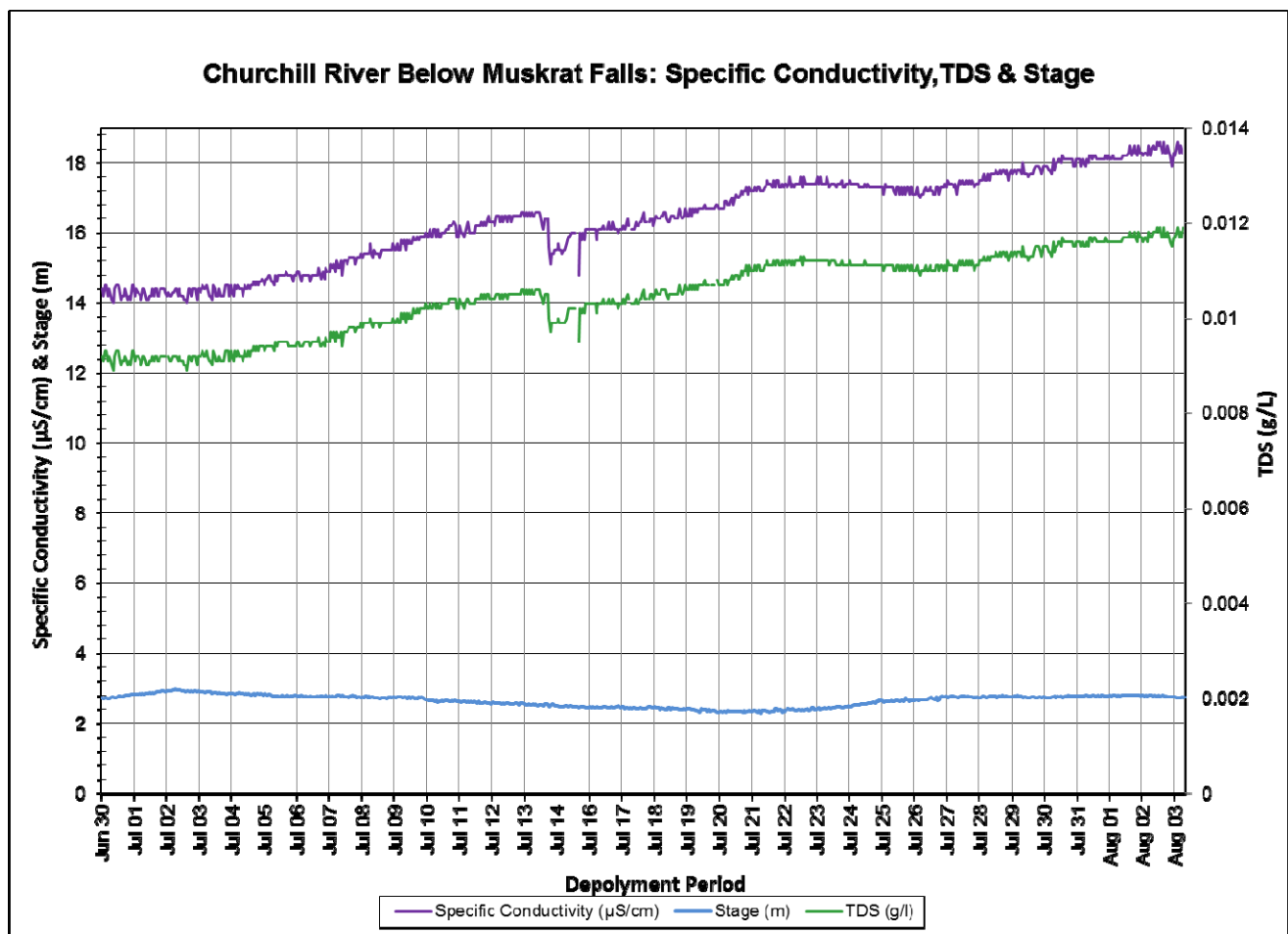


Figure 17: Specific Conductivity, TDS & Stage at Churchill River below Muskrat Falls

Dissolved Oxygen

- Dissolved oxygen content ranges between 9.78mg/l and 11.97mg/l with a median value of 10.67mg/l. The saturation of dissolved oxygen ranges from 104.0% to 115.3% with a median value of 109.4% (Figure 18).
- 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 18)
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period the dissolved oxygen levels are slowly falling as temperatures rise into the summer season. The dissolved oxygen also follows a diurnal pattern as the water temperature rises and falls under the influence of ambient air temperature. Generally, there is more dissolved oxygen present in a waterbody during cooler temperatures.
- The dissolved oxygen levels remained above the CCME Guidelines for the Protection of Other Life Stages and Early Life Stages throughout the deployment.

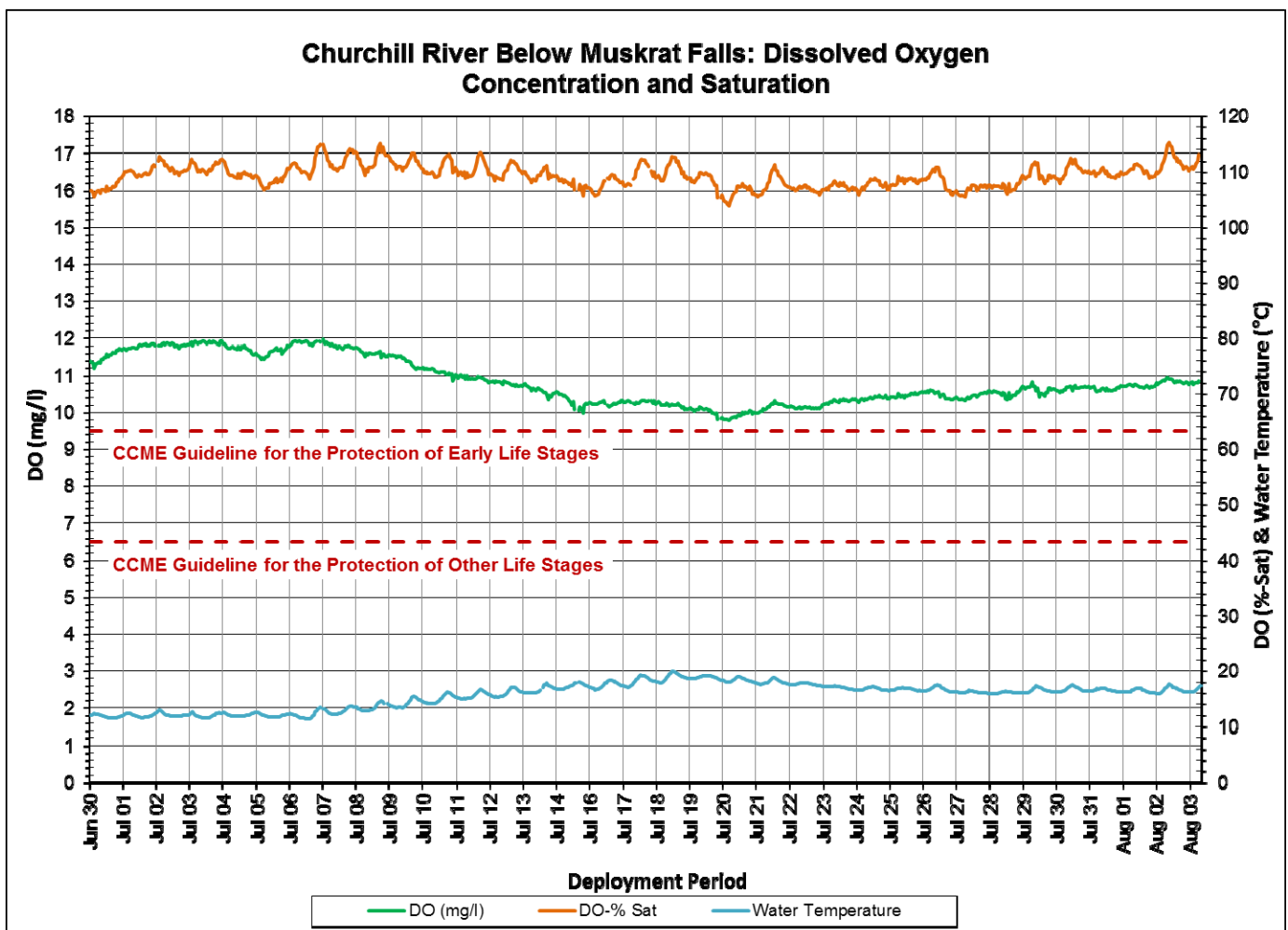


Figure 18: Dissolved Oxygen & Stage at Churchill River below Muskrat Falls

Chlorophyll

- Chlorophyll ranges between 4.8ug/L and 114.0ug/L, with a median value of 9.08ug/L (Figure 19).
- Chlorophyll is found within living cells of photosynthetic organisms like phytoplankton and cyanobacteria. The amount of chlorophyll found in water can be used to understand the general biological health of an ecosystem. Chlorophyll can also be used to identify algal bloom events and is an indicator of nutrient loading in ecosystems.

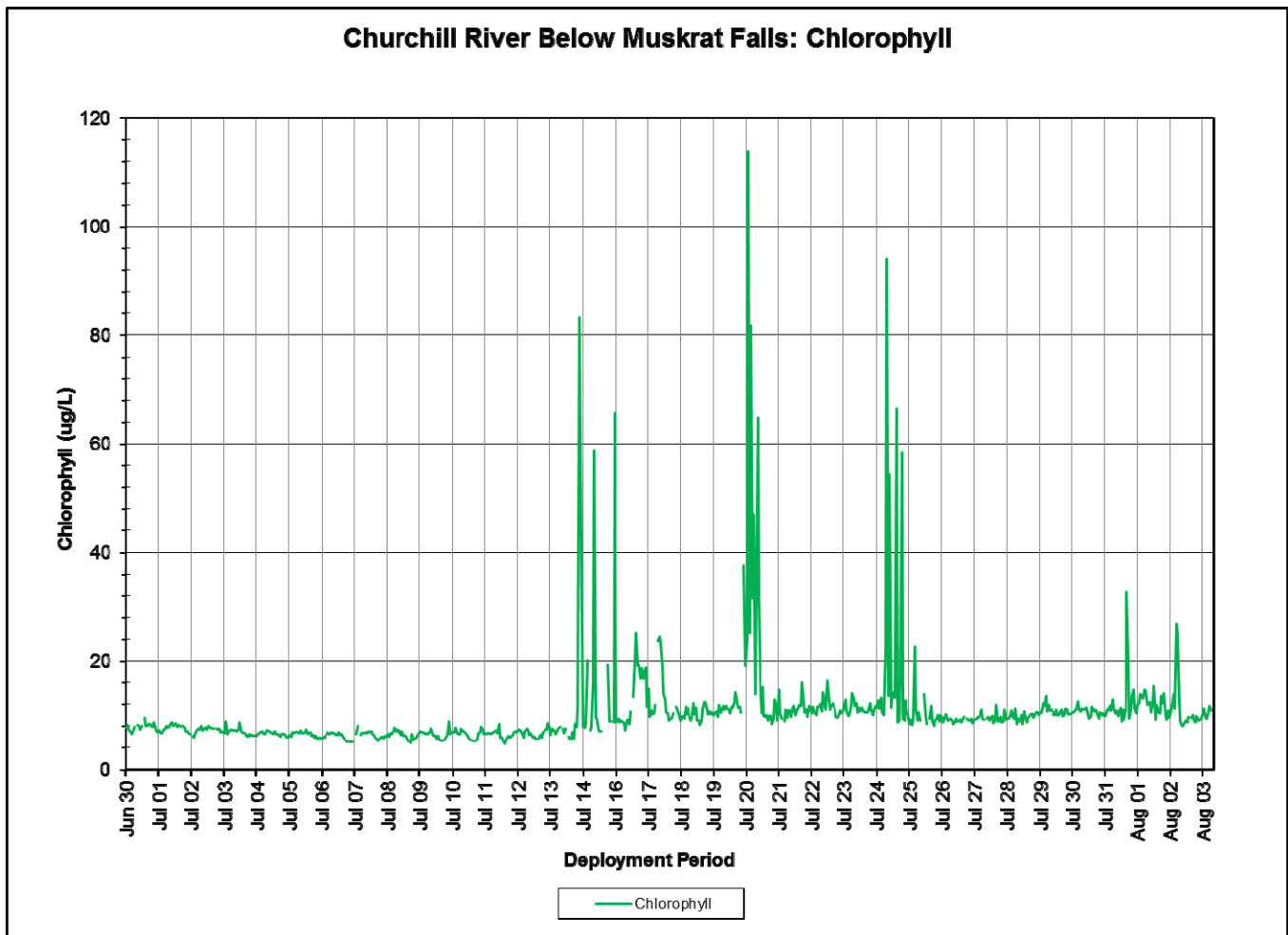


Figure 19: Chlorophyll at Churchill River below Muskrat Falls

Turbidity, Stage & Precipitation

- Turbidity ranges between 0.6NTU and 41.0NTU with a median value of 4.6NTU (Figure 20).
- The majority of turbidity events in the deployment period correlate to precipitation events. Precipitation can increase the presence of suspended material in water.
- Precipitation occurs on 21 days during the deployment period and amounts are generally small in magnitude, with the largest on June 30 at 20.07 mm.
- Stage ranges between 2.29m and 2.98m (Figure 21).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

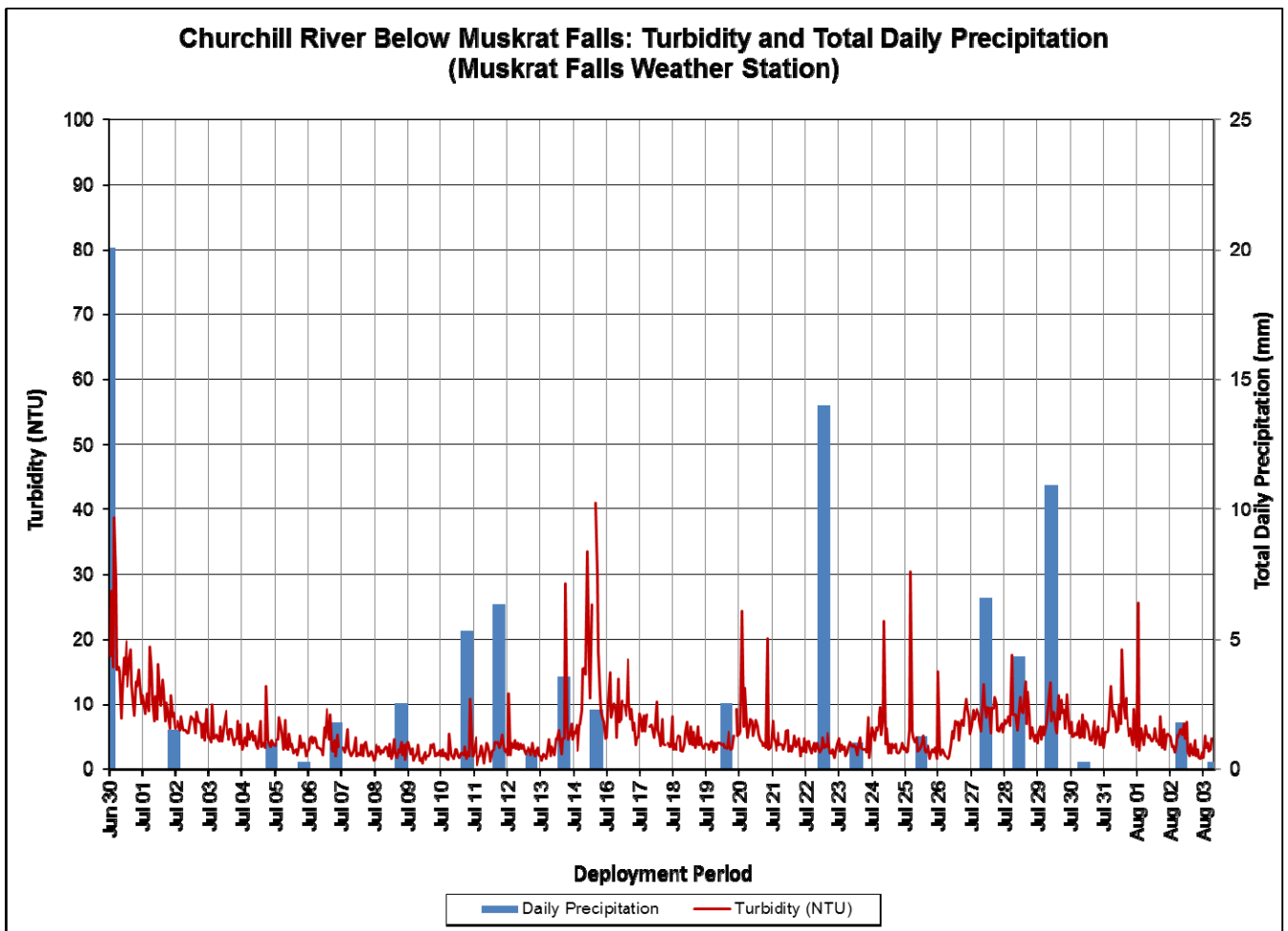


Figure 20: Turbidity & Total Daily Precipitation (Muskrat Falls Weather Station) at Churchill River below Muskrat Falls

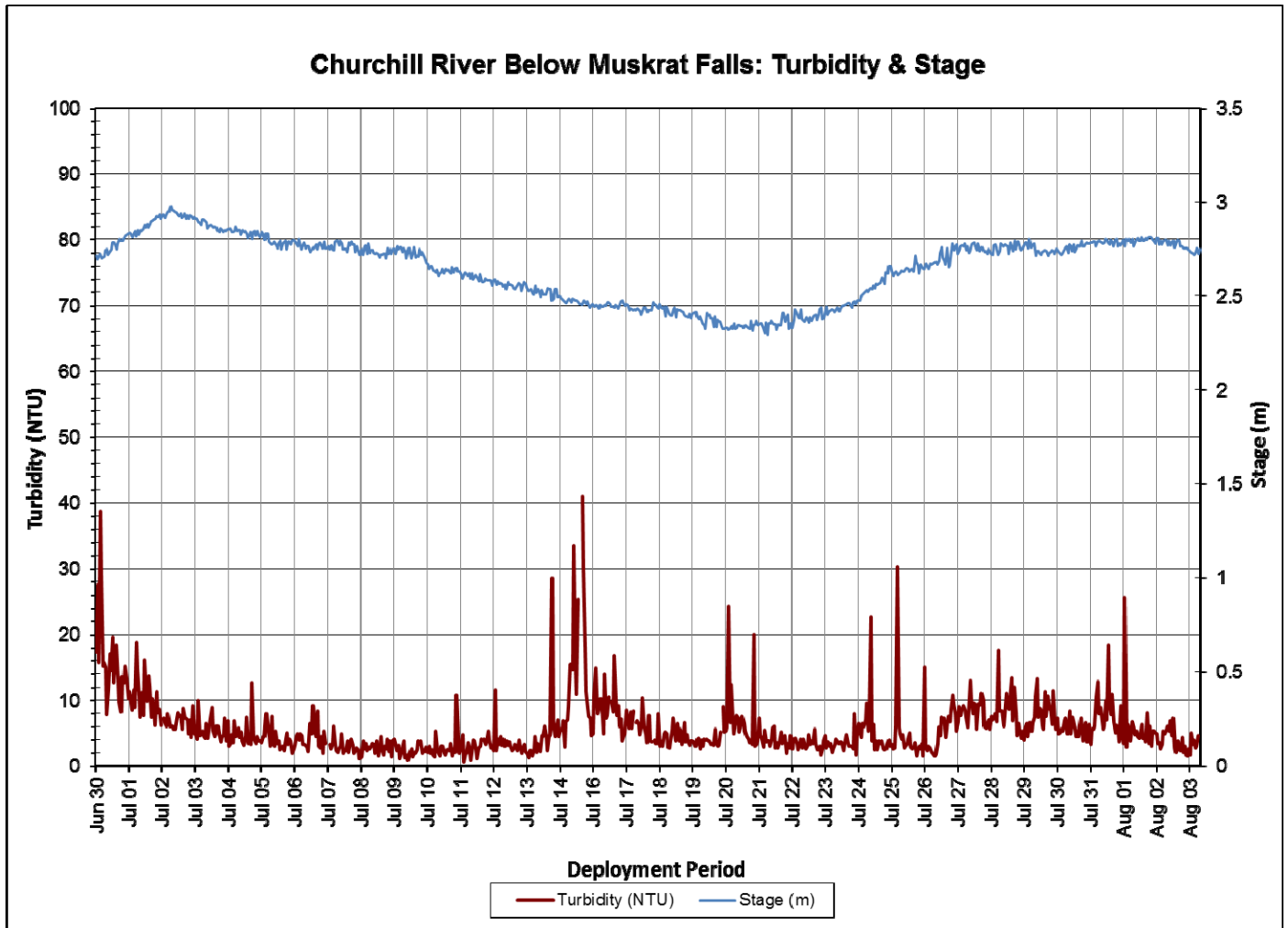


Figure 21: Turbidity & Stage at Churchill River below Muskrat Falls

Churchill River at English Point

Water Temperature

- Water temperature ranges from 11.20°C to 21.70°C with a median value of 16.20°C (Figure 22).
- Water temperature gradually increases until July 18, a trend that is expected as air temperatures warm through the summer months. After July 18, water temperature decreases sharply for several days, a trend that is mirrored by the average daily air temperatures values. Water temperatures are then relatively stable into August.

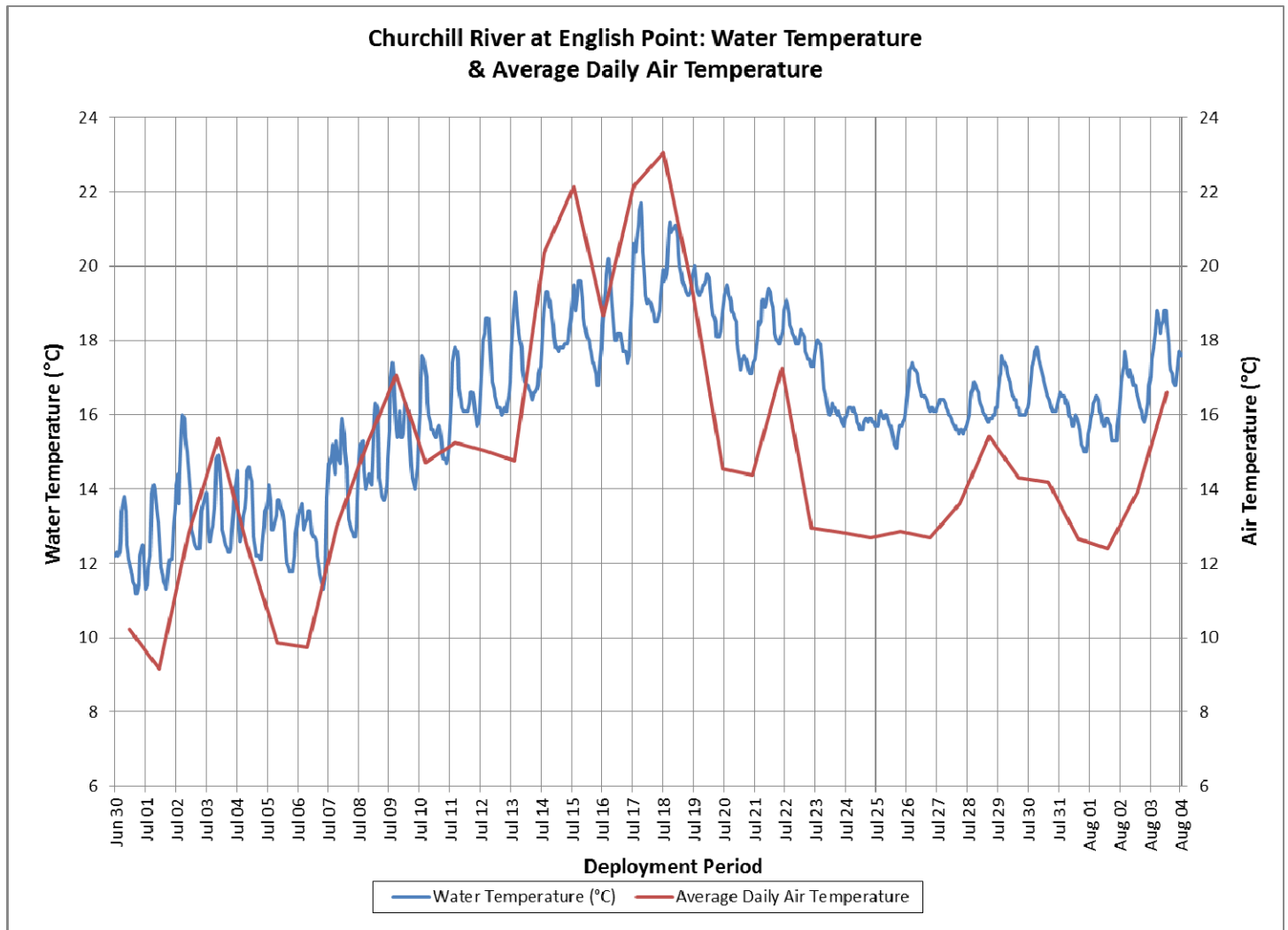


Figure 22: Water Temperature & Daily Average Air Temperature (Mud Lake Weather Station) at Churchill River at English Point

pH

- pH ranges between 6.20 and 7.08 pH units with a median value of 6.62 (Figure 23).
- pH values recorded during the first half of the deployment hover around the minimum CCME Guideline for Protection of Aquatic Life. This is likely due to the large influx of freshwater from the combination of the spring melt and the large precipitation event that occurred on June 30th. pH values during the second half of the deployment remained above the minimum Protection of Aquatic Life guideline.

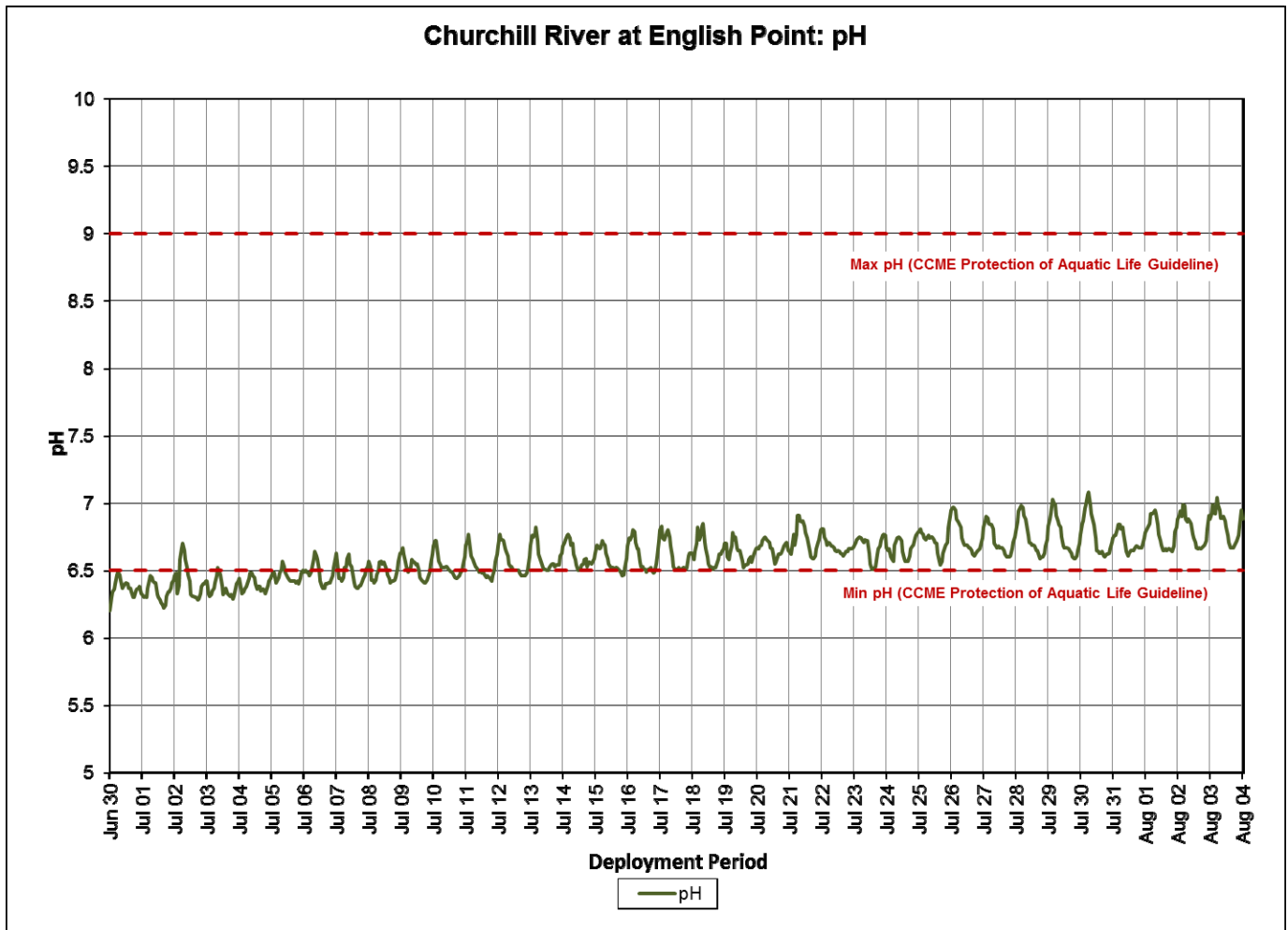


Figure 23: pH at Churchill River at English Point Station

Specific Conductivity and TDS

- Specific conductance ranges between 16.2 μ S/cm and 66.6 μ S/cm during the deployment period, with a median of 30.9 μ S/cm (Figure 24).
- TDS ranges between 0.0104 g/mL to 0.0426 g/mL during the deployment period, with a median of 0.0197 g/mL (Figure 24).
- Specific conductivity fluctuates considerably at this location due to the tidal influences of the Atlantic Ocean on Lake Melville. 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 24).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

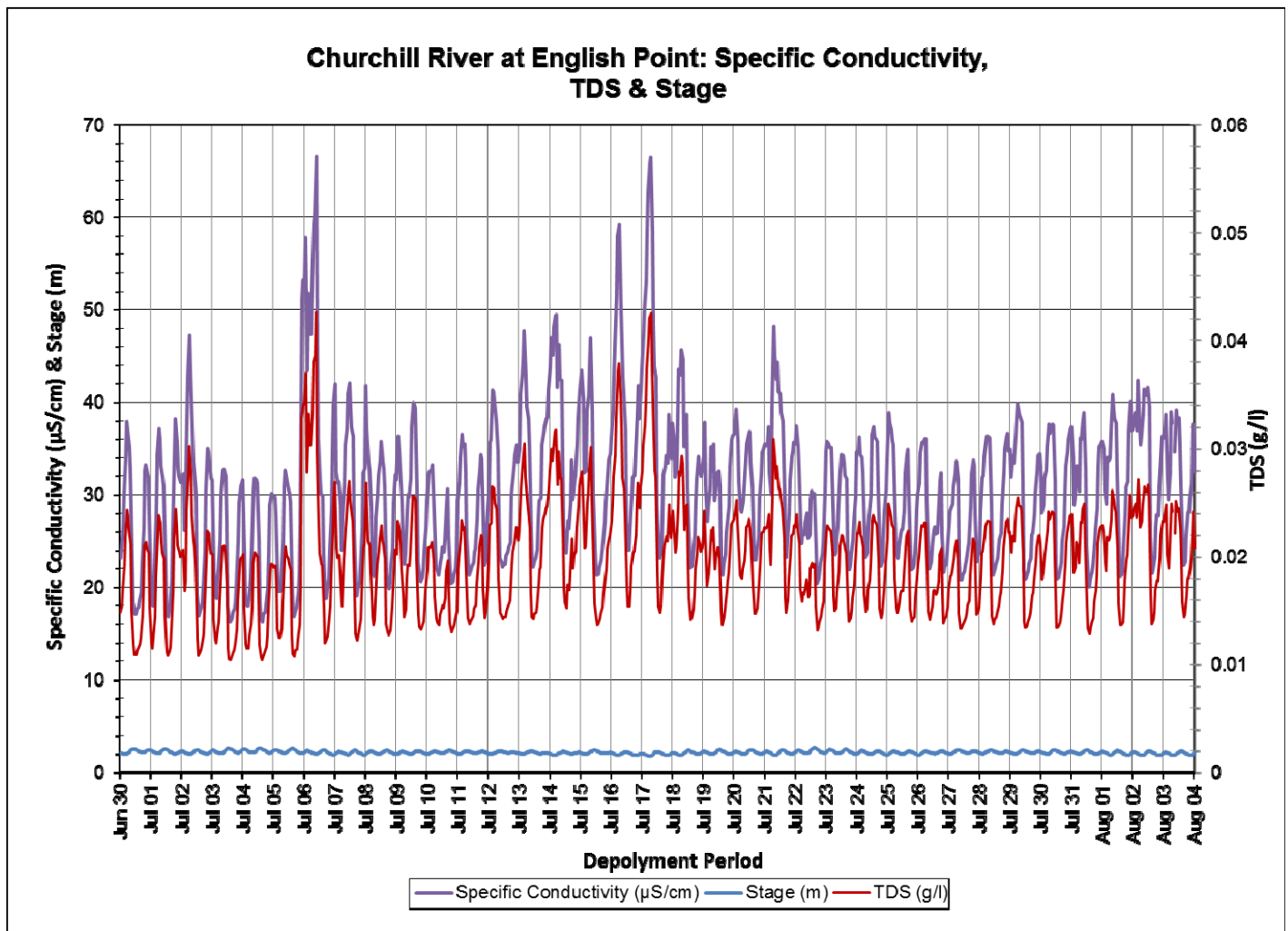


Figure 24: Specific Conductivity & TDS at Churchill River at English Point Station

Dissolved Oxygen

- Dissolved oxygen content ranged between 9.05mg/l and 11.28mg/l during the deployment period with a median value of 10.01mg/L. The saturation of dissolved oxygen ranged from 92.5% to 114.3% with a median value of 102.9% (Figure 25).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period the dissolved oxygen levels are falling as temperatures rise into the summer season. The dissolved oxygen also follows a diurnal pattern as the water temperature rises and falls under the influence of the ambient air temperature. Generally, there is more dissolved oxygen present in a waterbody during cooler temperatures.
- The dissolved oxygen levels remained above the CCME Guidelines for the Protection of Other Life Stages (Figure 25). However, the dissolved oxygen levels dipped slightly below the CCME Guideline for the Protection of Early Life Stages during mid-July when water temperatures were highest before rising again when water temperatures cooled at the end of July.

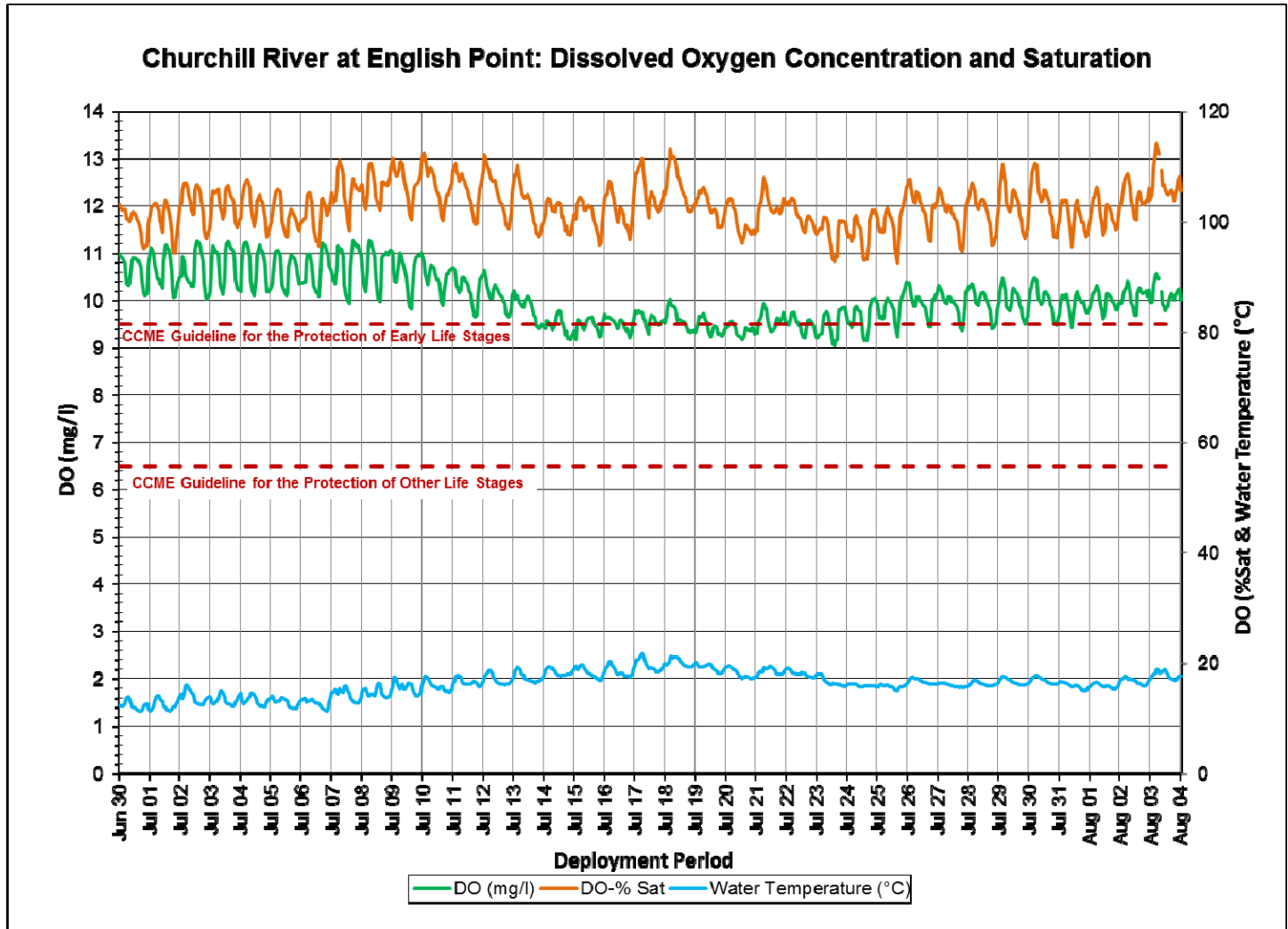


Figure 25: Dissolved Oxygen at Churchill River at English Point Station

Stage, Flow, Turbidity & Precipitation

- Turbidity ranges from 0.0NTU to 114.9NTU during the deployment period, with a median value of 0.0NTU (Figure 26).
- The majority of turbidity events in the deployment period correlate with increases in stage and precipitation events. Precipitation can increase the presence of suspended material in water (Figure 26).
- Precipitation occurs on 19 of the days in the deployment period and amounts are generally low, with the exception of the 21.34mm of precipitation on June 30th (Figure 26).
- Stage fluctuates considerably at this location due to the tidal influences of the Atlantic Ocean. As the tide comes in, the stage level increases causing tide related turbidity events, and vice versa as the tide goes out. This pattern is generally consistent throughout the deployment period (Figure 27). Tidal action may also suspend material into the water column, causing spikes in turbidity.
- Stage ranges between 1.78m and 2.62m, with a median value of 2.12m (Figure 27).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

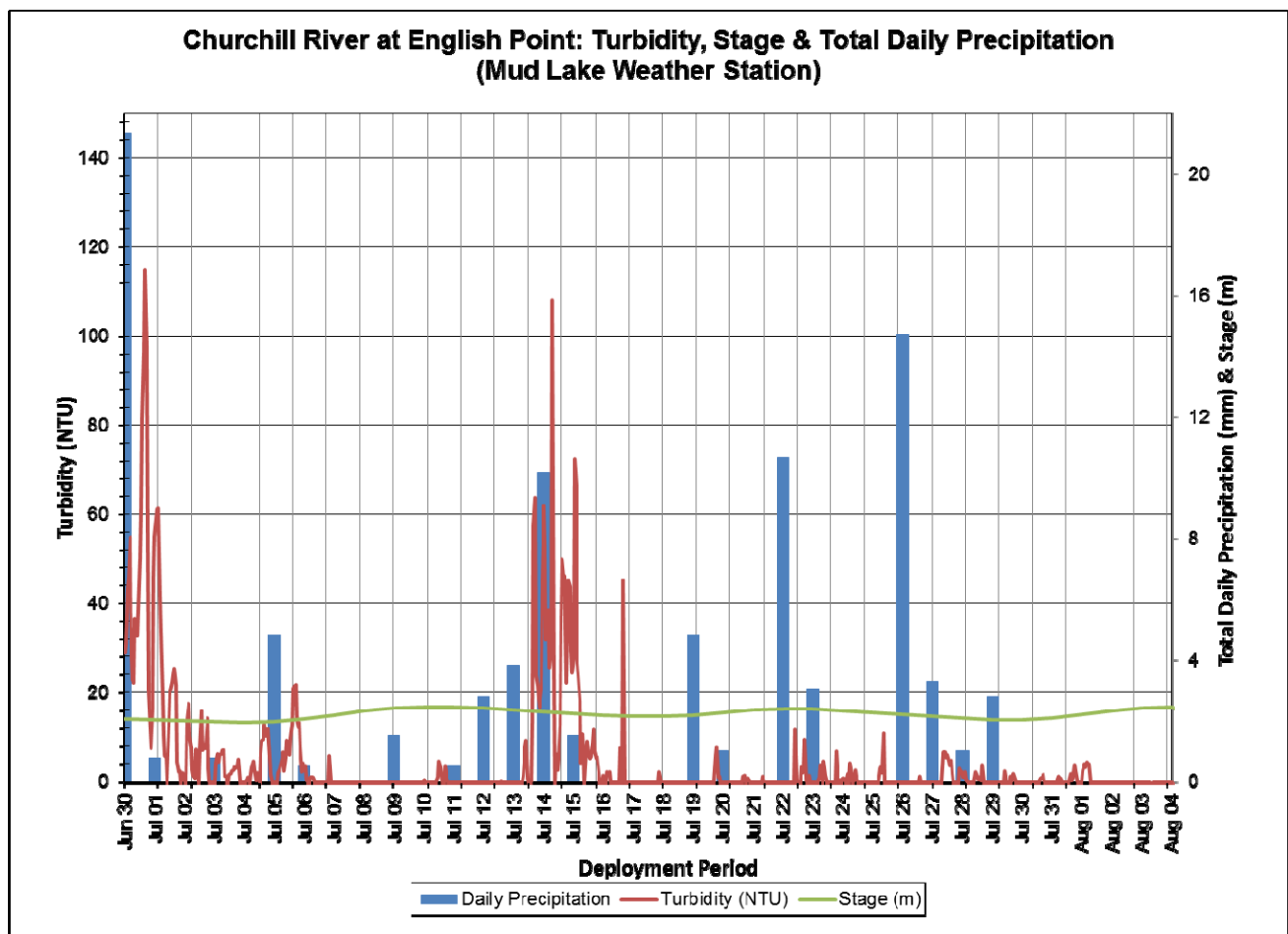


Figure 26: Turbidity, Stage & Total Precipitation (Mud Lake Weather Station) at Churchill River at English Point Station

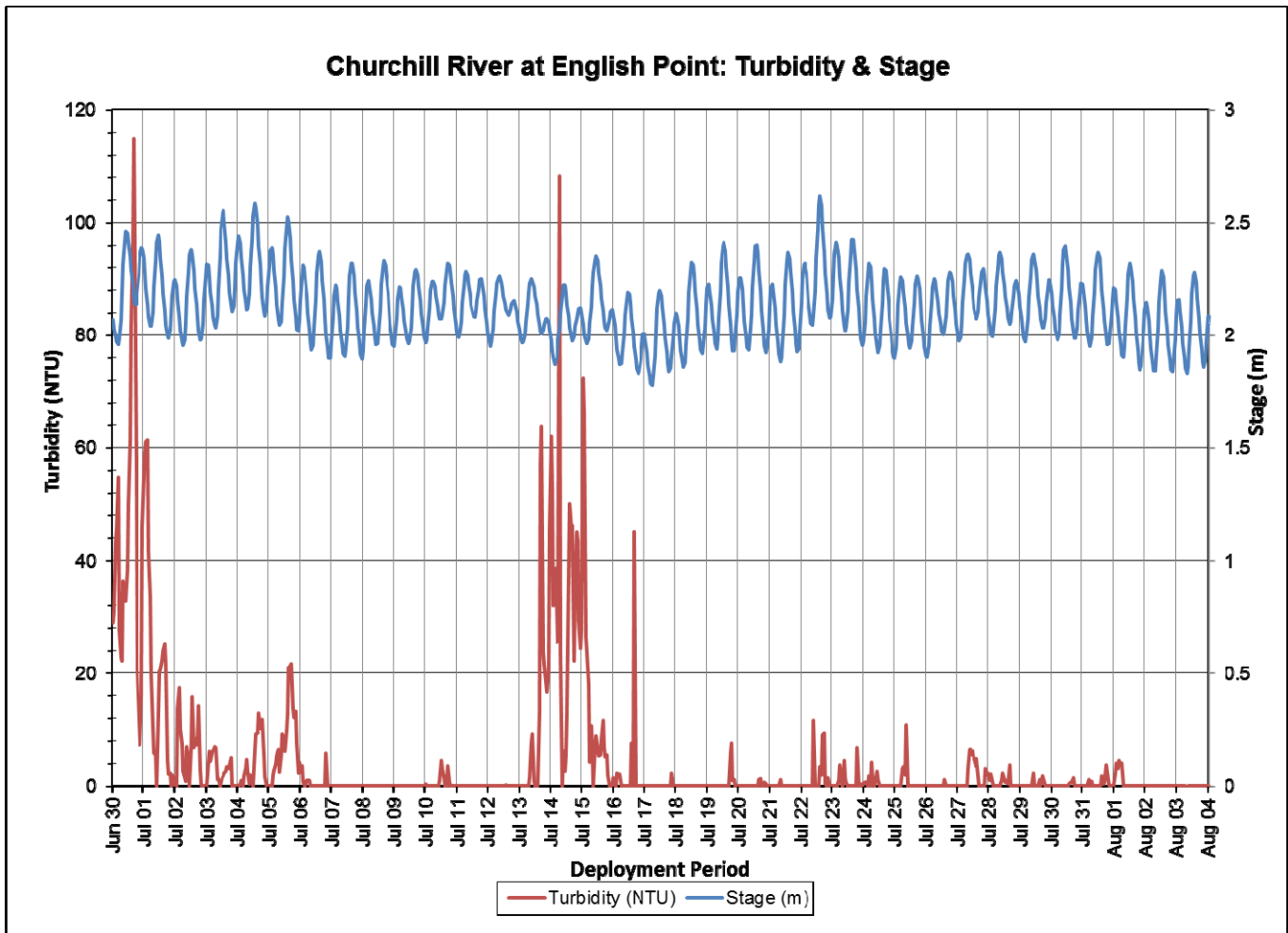


Figure 27: Turbidity & Stage at Churchill River at English Point Station

Conclusions

- Instruments at four water quality monitoring stations on the Lower Churchill River were deployed from June 29/30 to August 3/4 for periods of 33-34 days.
- Stage levels are generally stable at all stations during the summer months. Water level changes at each of the stations ranged between 0.4m and 1.09m.
- Water temperature was increasing at all stations throughout the deployment period due to the increasing ambient air temperatures in the region during the summer months. A drop in water and air temperature was noted at all stations July 18th. Water temperature typically ranged between 9.90°C and 21.70°C.
- pH is generally neutral and stable at stations along the Lower Churchill River ranging between 6.20 and 7.20 pH units. Generally, the pH values at all stations were within the recommended CCME Guidelines for the Protection of Aquatic Life for the majority of the time, except at English Point during the first half of deployment.
- Specific conductivity was relatively stable at the stations below Grizzle Rapids, above upper Muskrat Falls and below Muskrat Falls regardless of the fluctuating stage levels, ranging 13.7 to 18.6 $\mu\text{S}/\text{cm}$. All stations showed little variation in values except at English Point, which is influenced by the tides in Lake Melville. Specific conductivity values at the station at English Point ranged higher at 16.2 $\mu\text{S}/\text{cm}$ to 66.6 $\mu\text{S}/\text{cm}$. This is comparable to other deployments at this location.
- Dissolved oxygen was generally decreasing slightly throughout the deployment period at all stations as water temperatures warmed into the summer and could hold less oxygen. Values ranged between 9.03mg/l and 11.97mg/l.
- Turbidity events occurred at all stations and were mainly related to precipitation events. At all stations, the median turbidity ranged from 0.0NTU to 7.6NTU, which indicates a low background turbidity. Turbidity at all stations ranged from 0.0 to 114.9NTU.

References

- Canadian Council of Ministers of the Environment. 2007. Canadian water quality guidelines for the protection of aquatic life: Summary table. Updated December, 2007. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.
 - Online: <http://st-ts.ccme.ca/en/index.html?chems=154,162&chapters=1>
 - Swanson, H.A., and Baldwin, H.L., 1965. A Primer on Water Quality, U.S. Geological Survey.
 - Online: <http://ga.water.usgs.gov/edu/characteristics.html>
 - YSI a Xylem Brand. The Basics of Chlorophyll Measurement. Accessed December 9, 2015.
 - Online: <https://www.y.si.com/File%20Library/Documents/Technical%20Notes/T606-The-Basics-of-Chlorophyll-Measurement.pdf>
 - An Introduction to Algae Measurements Using In Vivo Fluoresces. Accessed December 9, 2015.\ul style="list-style-type: none;"> - Online: <http://www.ott.com/download/fluorescence-white-paper/>
- Environment Canada. Water Quality. Fresh Water Quality Monitoring Date modified: 2015-11-26
 - Online: <https://www.ec.gc.ca/eaudouce-freshwater/default.asp?lang=En&n=8C50C138-1&printfullpage=true#wsA92C85CB>
- Volunteers Contributing to Our Understanding of Water Quality. Trophic State Equations
 - Online: <http://www.secchidipin.org/index.php/monitoring-methods/trophic-state-equations/>

APPENDIX A-Station Comparisons

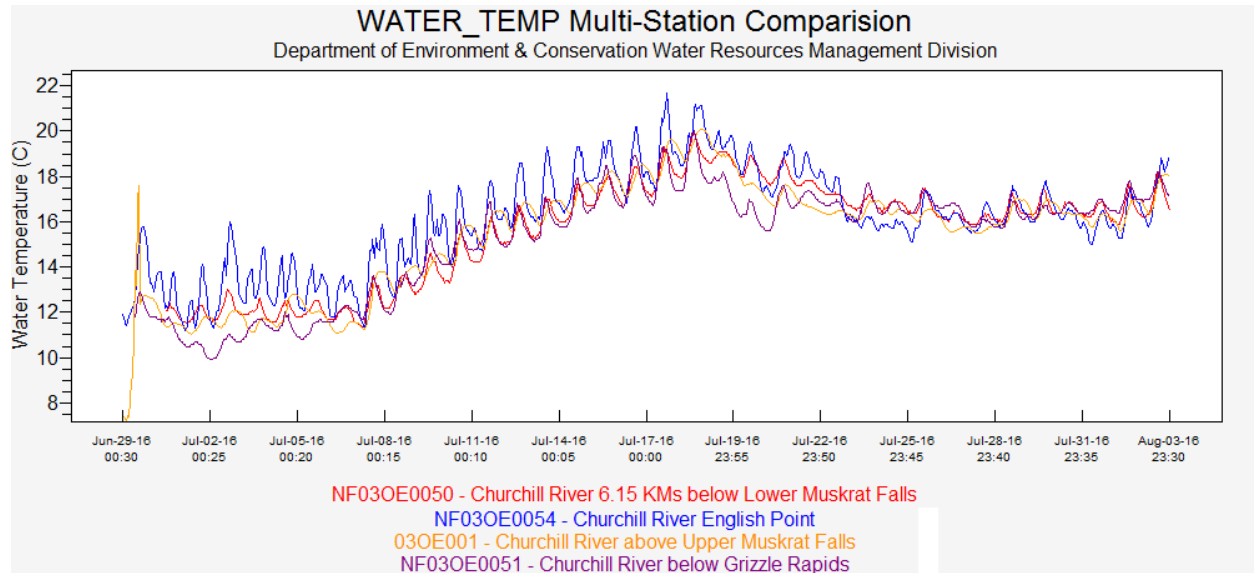


Figure A1: Comparison of Water Temperature at the Real-Time Stations on Churchill River

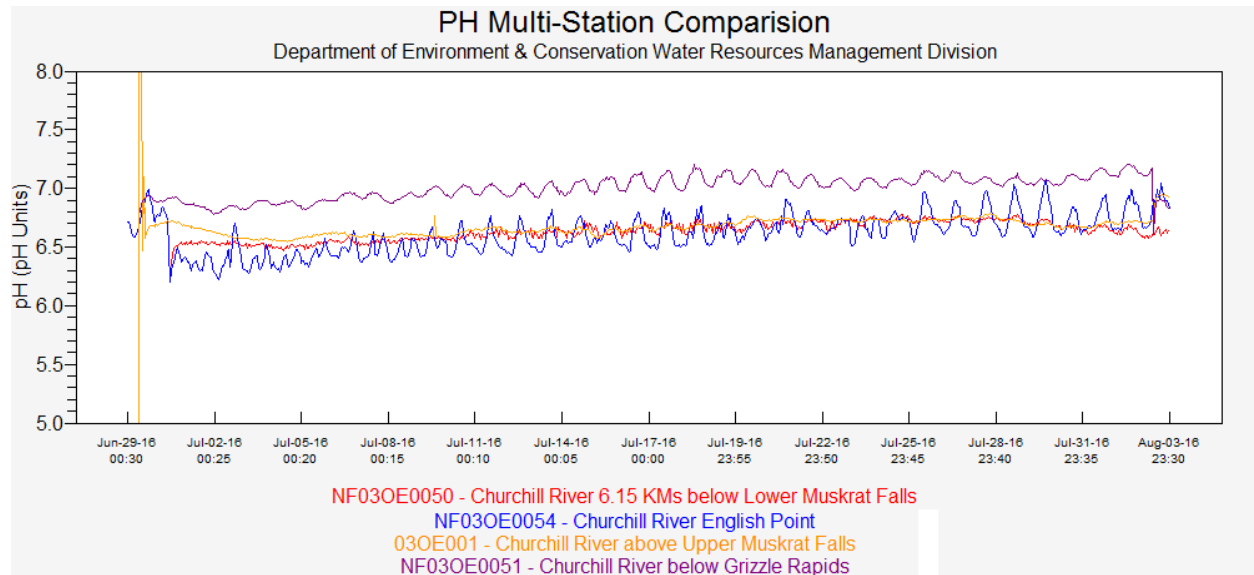


Figure A2: Comparison of pH at the Real-Time Stations on Churchill River

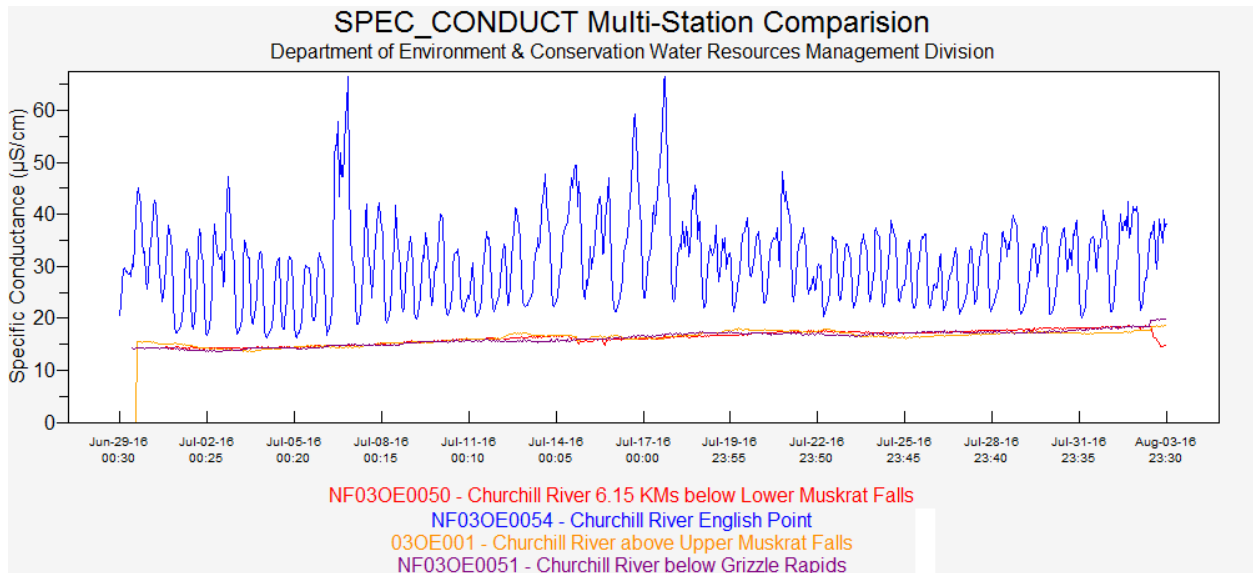


Figure A3: Comparison of Specific Conductivity at the Real-Time Stations on Churchill River

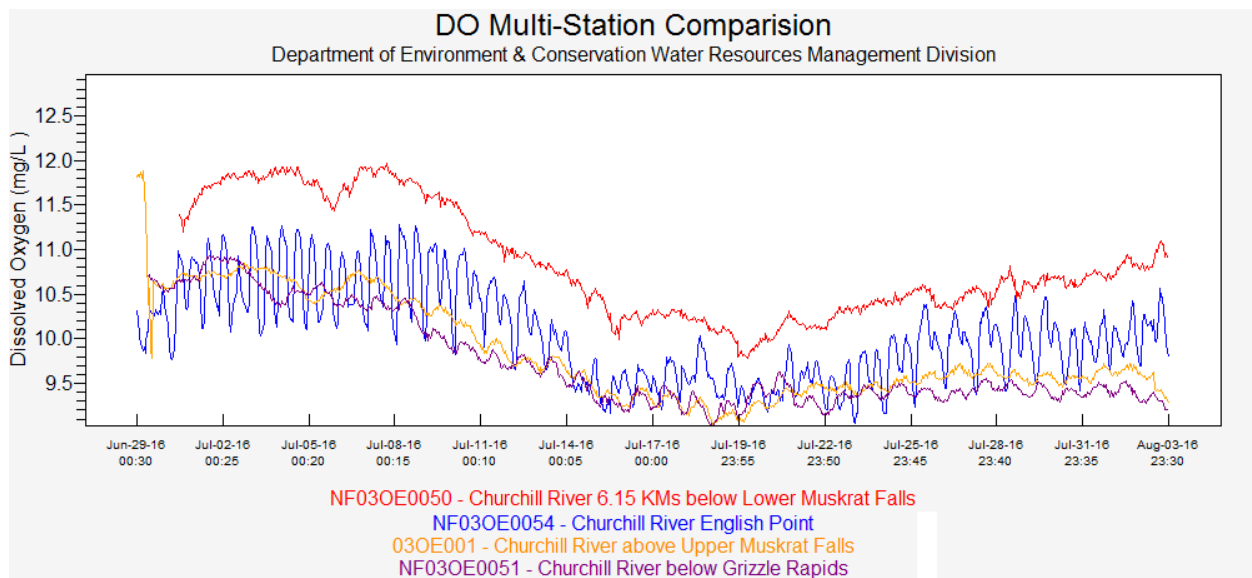


Figure A4: Comparison of Dissolved Oxygen at the Real-Time Stations on Churchill River

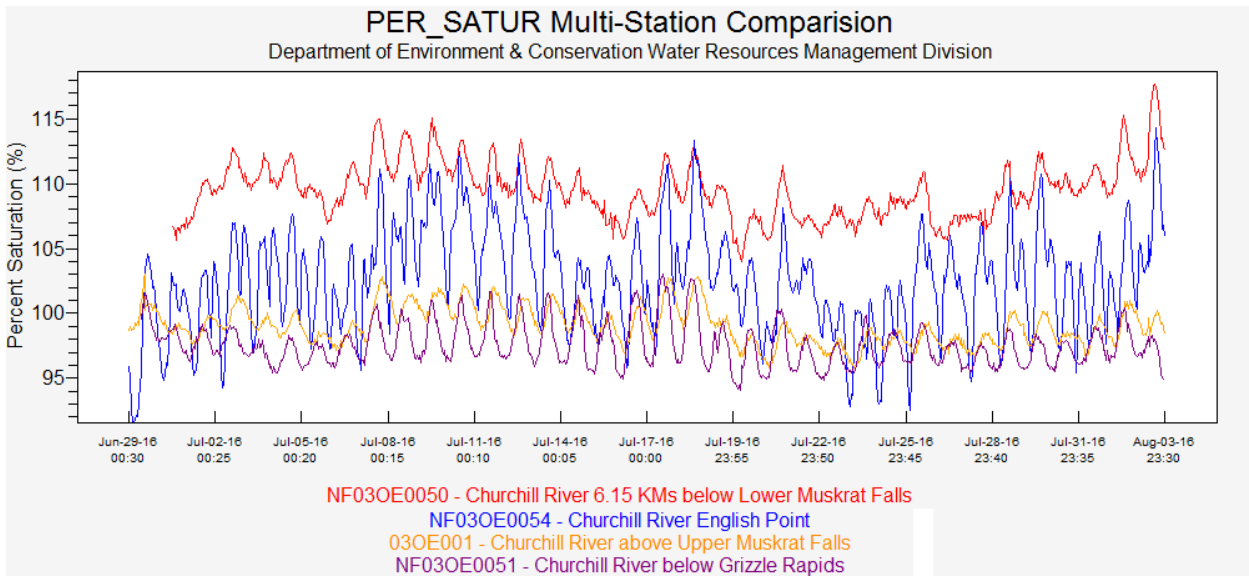


Figure A5: Comparison of Dissolved Oxygen (% Sat) at the Real-Time Stations on Churchill River

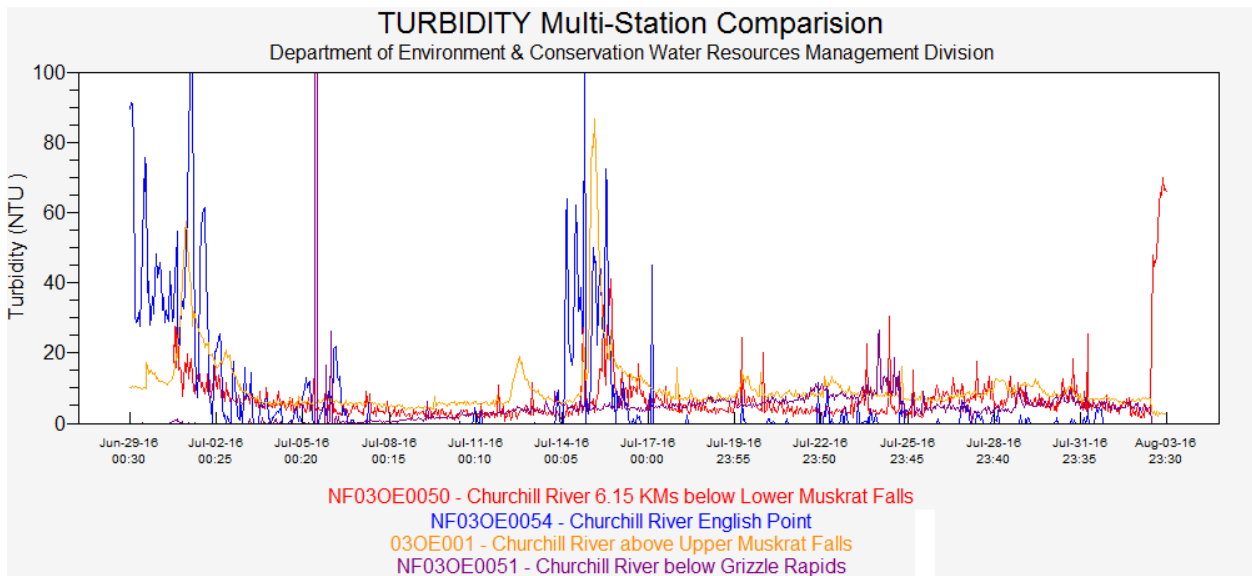


Figure A6: Comparison of Turbidity at the Real-Time Stations on Churchill River

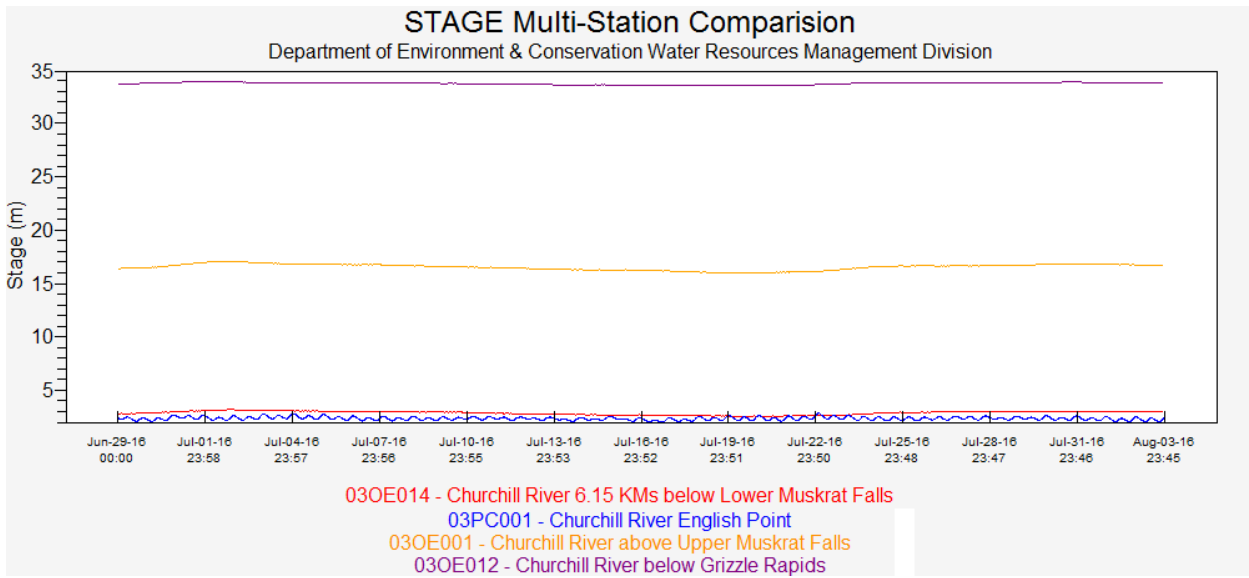


Figure A7: Comparison of Stage at the Real-Time Stations on Churchill River

APPENDIX B- Quality Assurance / Quality Control Procedures

- As part of the Quality Assurance / Quality Control (QA/QC) protocol, the performance of a station's water quality instrument (i.e., Field Sonde) is rated at the beginning and end of its deployment period. The procedure is based on the approach used by the United States Geological Survey (Wagner *et al.* 2006)¹.
- At the beginning of the deployment period, a newly calibrated QA/QC water quality instrument (i.e., QA/QC Sonde) is temporarily deployed *in-situ* and alongside the newly calibrated Field Sonde. A grab sample is also taken from the water body at this time and sent away to a laboratory for analysis. Field Sonde performance ratings for *temperature (°C)* and *Dissolved Oxygen (% saturation)* are based on differences recorded by the Field Sonde and QA/QC Sonde. Field Sonde performance ratings for *specific conductivity (µS/cm)*, *pH (unit)* and *turbidity (NTU)* are based on differences between Field Sonde readings and grab sample results.
- At the end of the deployment period, water quality parameters are recorded by the Field Sonde before and after a thorough cleaning of its probes. Error caused by *bio-fouling* (E_f) is assessed by comparing these readings with readings made by a newly calibrated QA/QC Sonde, which is temporarily deployed *in-situ* and alongside the Field Sonde. An assessment of *instrument drift error* (E_d) is made during laboratory calibration of the Field Sonde, and the two error values are added to give an estimate of total error ($E_t = E_f + E_d$). If E_t exceeds a predetermined data correction criterion, a correction factor is applied to the dataset based on linear interpolation of E_t . The Field Sonde performance is also rated at the end of the deployment period, based on the E_t value.
- Performance ratings are based on differences listed in the table below.

Parameter	Rating				
	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

■ _____

¹ Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51 p. + 8 attachments; accessed April 10, 2006, at <http://pubs.water.usgs.gov/tm1d3>

APPENDIX C- Water Parameter Description

- **Dissolved Oxygen** - The amount of Dissolved Oxygen (DO) (mg/l or % saturation) in the water is vital to aquatic organisms for their survival. The concentration of DO is affected by such things as water temperature, water depth and flow (e.g., aeration by rapids, riffles etc.), consumption by aerobic organisms, consumption by inorganic chemical reactions, consumption by plants during darkness, and production by plants during the daylight (Allan 2010).
- **Flow** – Flow (m³/s) is a measure of how quickly a volume of water is displaced in streams, rivers, and other channels.
- **pH** - pH is the measure of hydrogen ion activity and affects: (i) the availability of nutrients to aquatic life; (ii) the concentration of biochemical substances dissolved in water; (iii) the efficiency of hemoglobin in the blood of vertebrates; and (iv) the toxicity of pollutants. Changes in pH can be attributed to industrial effluence, saline inflows or aquatic organisms involved in the photosynthetic cycling of CO₂ (Allan 2010).
- **Specific conductivity** - Specific conductivity (µS/cm) is a measure of water's ability to conduct electricity, with values normalized to a water temperature of 25°C. Specific conductance indicates the concentration of dissolved solids (such as salts) in the water, which can affect the growth and reproduction of aquatic life. Specific conductivity is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).
- **Stage** – Stage (m) is the elevation of the water surface and is often used as a surrogate for the more difficult to measure flow.
- **Temperature** - Essential to the measurement of most water quality parameters, temperature (°C) controls most processes and dynamics of limnology. Water temperature is influenced by such things as ambient air temperature, solar radiation, meteorological events, industrial effluence, wastewater, inflowing tributaries, as well as water body size and depth (Allan 2010; Hach 2006).
- **Total Dissolved Solids** - Total Dissolved Solids (TDS) (g/l) is a measure of alkaline salts dissolved in water or in fine suspension and can affect the growth and reproduction of aquatic life. It is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).
- **Turbidity** - Turbidity (NTU) is a measure of the translucence of water and indicates the amount of suspended material in the water. Turbidity is caused by any substance that makes water cloudy (e.g., soil erosion, micro-organisms, vegetation, chemicals, etc.) and can correspond to precipitation events, high stage, and floating debris near the sensor (Allan 2010; Hach 2006; Swanson and Baldwin 1965)

APPENDIX D-Grab Sample Results



Success Through Science®

Maxxam Job #: B6E0324
Report Date: 2016/07/14

Department of Environment & Conservation
Site Location: CHURCHILL RIVER, GOOSE BAY, NL
Your P.O. #: 215062145-2

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CQZ708 CR below GR								
Sampling Date	2016/06/29 10:00							
Matrix	W							
Sample #	2016-6307-00-SI-SP							
Registration #	WS-S-0000							
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	12	1.0	mg/L	N/A	2016/07/13	2016/07/13		4570151
Hardness (CaCO3)	7.1	1.0	mg/L	N/A	2016/07/12	2016/07/12		4570144
Nitrate (N)	ND	0.050	mg/L	N/A	2016/07/13	2016/07/13		4570147
Inorganics								
Conductivity	15	1.0	uS/cm	N/A	2016/07/12	2016/07/12	JMV	4573983
Bromide (Br-)	ND	1.0	mg/L	N/A	2016/07/11	2016/07/11	FD	4572058
Total Alkalinity (Total as CaCO3)	7.1	5.0	mg/L	N/A	2016/07/12	2016/07/12	NRG	4574251
Dissolved Chloride (Cl)	1.5	1.0	mg/L	N/A	2016/07/13	2016/07/13	NRG	4574258
Colour	34	5.0	TCU	N/A	2016/07/13	2016/07/13	NRG	4574263
Dissolved Fluoride (F-)	ND	0.10	mg/L	N/A	2016/07/12	2016/07/12	JMV	4573984
Total Kjeldahl Nitrogen (TKN)	0.12	0.10	mg/L	+/- <RDL	2016/07/11	2016/07/11	AAY	4572942
Nitrite (N)	ND	0.010	mg/L	N/A	2016/07/13	2016/07/13	NRG	4574269
Nitrogen (Ammonia Nitrogen)	ND	0.050	mg/L	N/A	2016/07/12	2016/07/12	NRG	4572815
Dissolved Organic Carbon (C)	4.3	0.50	mg/L	N/A	2016/07/11	2016/07/11	SMT	4572530
Total Organic Carbon (C)	4.3	0.50	mg/L	N/A	2016/07/12	2016/07/12	SMT	4574036
pH	6.95	N/A	pH	N/A	2016/07/12	2016/07/12	JMV	4573982
Total Phosphorus	ND	0.004	mg/L	N/A	2016/07/12	2016/07/12	SNR	4574240
Dissolved Sulphate (SO4)	ND	2.0	mg/L	N/A	2016/07/12	2016/07/12	NRG	4574260
Turbidity	1.1	0.10	NTU	N/A	2016/07/11	2016/07/11	JMV	4572486
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	ND	0.000013	mg/L	N/A	2016/07/13	2016/07/13	ARS	4575885
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	0.084	0.0050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Antimony (Sb)	ND	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Arsenic (As)	ND	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Barium (Ba)	0.0069	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Boron (B)	ND	0.050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Cadmium (Cd)	ND	0.000010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Calcium (Ca)	1.8	0.10	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Chromium (Cr)	ND	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Copper (Cu)	ND	0.0020	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Iron (Fe)	0.15	0.050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Lead (Pb)	ND	0.00050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Magnesium (Mg)	0.61	0.10	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Manganese (Mn)	0.0069	0.0020	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Nickel (Ni)	ND	0.0020	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Potassium (K)	0.26	0.10	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Selenium (Se)	ND	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Sodium (Na)	0.56	0.10	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Strontium (Sr)	0.010	0.0020	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Uranium (U)	ND	0.00010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Zinc (Zn)	0.0066	0.0050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399



Success Through Science®

Maxxam Job #: B6D8171
Report Date: 2016/07/12

Department of Environment & Conservation
Client Project #: TSS ANALYSIS
Site Location: CHURCHILL RIVER, GOOSE BAY, NL
Your P.O. #: 216009736

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CQP211 CR below GR								
Sampling Date 2016/06/29 10:00								
Matrix W								
Sample # 2016-6307-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Inorganics								
Total Suspended Solids	ND	1.0	mg/L	N/A	2016/07/08	2016/07/12	LPW	4566703



Success Through Science®

Maxxam Job #: B6E0324
Report Date: 2016/07/14

Department of Environment & Conservation
Site Location: CHURCHILL RIVER, GOOSE BAY, NL
Your P.O. #: 215062145-2

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
Sample Details/Parameters								
CQZ709 CR @ upper MF								
Sampling Date	2016/06/29 14:00							
Matrix	W							
Sample #	2016-6308-00-SI-SP							
Registration #	WS-5-0000							
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	14	1.0	mg/L	N/A	2016/07/13	2016/07/13		4570151
Hardness (CaCO3)	8.6	1.0	mg/L	N/A	2016/07/12	2016/07/12		4570144
Nitrate (N)	ND	0.050	mg/L	N/A	2016/07/13	2016/07/13		4570147
Inorganics								
Conductivity	17	1.0	uS/cm	N/A	2016/07/12	2016/07/12	JMV	4573983
Bromide (Br-)	ND	1.0	mg/L	N/A	2016/07/11	2016/07/11	FD	4572058
Total Alkalinity (Total as CaCO3)	7.0	5.0	mg/L	N/A	2016/07/12	2016/07/12	NRG	4574251
Dissolved Chloride (Cl)	1.8	1.0	mg/L	N/A	2016/07/13	2016/07/13	NRG	4574258
Colour	36	5.0	TCU	N/A	2016/07/13	2016/07/13	NRG	4574263
Dissolved Fluoride (F-)	ND	0.10	mg/L	N/A	2016/07/12	2016/07/12	JMV	4573984
Total Kjeldahl Nitrogen (TKN)	0.10	0.10	mg/L	N/A	2016/07/11	2016/07/11	AAY	4572942
Nitrite (N)	ND	0.010	mg/L	N/A	2016/07/13	2016/07/13	NRG	4574269
Nitrogen (Ammonia Nitrogen)	ND	0.050	mg/L	N/A	2016/07/12	2016/07/12	NRG	4572815
Dissolved Organic Carbon (C)	4.4	0.50	mg/L	N/A	2016/07/11	2016/07/11	SMT	4572530
Total Organic Carbon (C)	4.5	0.50	mg/L	N/A	2016/07/12	2016/07/12	SMT	4574036
pH	7.01	N/A	pH	N/A	2016/07/12	2016/07/12	JMV	4573982
Total Phosphorus	0.035	0.004	mg/L	+/- 0.006	2016/07/12	2016/07/12	SNR	4574240
Dissolved Sulphate (SO4)	ND	2.0	mg/L	N/A	2016/07/12	2016/07/12	NRG	457426^
Turbidity	11	0.10	NTU	N/A	2016/07/11	2016/07/11	JMV	4572-
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	ND	0.000013	mg/L	N/A	2016/07/13	2016/07/13	ARS	4575885
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	0.57	0.0050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Antimony (Sb)	ND	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Arsenic (As)	ND	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Barium (Ba)	0.012	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Boron (B)	ND	0.050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Cadmium (Cd)	ND	0.000010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Calcium (Ca)	2.0	0.10	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Chromium (Cr)	0.0014	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Copper (Cu)	ND	0.0020	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Iron (Fe)	0.66	0.050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Lead (Pb)	ND	0.00050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Magnesium (Mg)	0.89	0.10	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Manganese (Mn)	0.021	0.0020	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Nickel (Ni)	ND	0.0020	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Potassium (K)	0.47	0.10	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Selenium (Se)	ND	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Sodium (Na)	0.84	0.10	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Strontium (Sr)	0.013	0.0020	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Uranium (U)	0.00012	0.00010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Zinc (Zn)	ND	0.0050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399



Success Through Science®

Maxxam Job #: B6D8171
Report Date: 2016/07/12

Department of Environment & Conservation
Client Project #: TSS ANALYSIS
Site Location: CHURCHILL RIVER, GOOSE BAY, NL
Your P.O. #: 216009736

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CQP212 CR @ upper MF								
Sampling Date 2016/06/29 14:00								
Matrix W								
Sample # 2016-6308-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Inorganics								
Total Suspended Solids	15	1.0	mg/L	N/A	2016/07/08	2016/07/12	LPW	4566703



Success Through Science™

Maxxam Job #: B6E0324
Report Date: 2016/07/14

Department of Environment & Conservation
Site Location: CHURCHILL RIVER, GOOSE BAY, NL
Your P.O. #: 215062145-2

Sample Details/Parameters	Result	RD L	UNITS	MU	Extracted	Analyzed	By	Batch
Sample Details/Parameters								
CQZ710 CR below MF								
Sampling Date	2016/06/30 12:30							
Matrix	W							
Sample #	2016-6309-00-SI-SP							
Registration #	WS-5-0000							
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	16	1.0	mg/L	N/A	2016/07/13	2016/07/13		4570151
Hardness (CaCO3)	12	1.0	mg/L	N/A	2016/07/12	2016/07/12		4570144
Nitrate (N)	ND	0.050	mg/L	N/A	2016/07/13	2016/07/13		4570147
Inorganics								
Conductivity	15	1.0	uS/cm	N/A	2016/07/12	2016/07/12	JMV	4573983
Bromide (Br-)	ND	1.0	mg/L	N/A	2016/07/11	2016/07/11	FD	4572058
Total Alkalinity (Total as CaCO3)	6.8	5.0	mg/L	N/A	2016/07/12	2016/07/12	NRG	4574251
Dissolved Chloride (Cl)	1.8	1.0	mg/L	N/A	2016/07/13	2016/07/13	NRG	4574258
Colour	37	5.0	TCU	N/A	2016/07/13	2016/07/13	NRG	4574263
Dissolved Fluoride (F-)	ND	0.10	mg/L	N/A	2016/07/12	2016/07/12	JMV	4573984
Total Kjeldahl Nitrogen (TKN)	0.10	0.10	mg/L	N/A	2016/07/11	2016/07/11	AAV	4572942
Nitrite (N)	ND	0.010	mg/L	N/A	2016/07/13	2016/07/13	NRG	4574269
Nitrogen (Ammonia Nitrogen)	ND	0.050	mg/L	N/A	2016/07/12	2016/07/12	NRG	4572815
Dissolved Organic Carbon (C)	4.6	0.50	mg/L	N/A	2016/07/11	2016/07/11	SMT	4572530
Total Organic Carbon (C)	4.4	0.50	mg/L	N/A	2016/07/12	2016/07/12	SMT	4574036
pH	6.97	N/A	pH	N/A	2016/07/12	2016/07/12	JMV	4573982
Total Phosphorus	0.064	0.004	mg/L	+/- 0.009	2016/07/12	2016/07/12	SNR	4574240
Dissolved Sulphate (SO4)	ND	2.0	mg/L	N/A	2016/07/12	2016/07/12	NRG	4574260
Turbidity	33	0.10	NTU	N/A	2016/07/11	2016/07/11	JMV	4572486
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	ND	0.000013	mg/L	N/A	2016/07/13	2016/07/13	ARS	4575885
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	1.8	0.0050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Antimony (Sb)	ND	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Arsenic (As)	ND	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Barium (Ba)	0.026	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Boron (B)	ND	0.050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Cadmium (Cd)	0.000028	0.000010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Calcium (Ca)	2.3	0.10	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Chromium (Cr)	0.0036	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Copper (Cu)	0.0032	0.0020	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Iron (Fe)	1.8	0.050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Lead (Pb)	0.00061	0.00050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Magnesium (Mg)	1.6	0.10	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Manganese (Mn)	0.056	0.0020	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Nickel (Ni)	0.0028	0.0020	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Potassium (K)	0.94	0.10	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Selenium (Se)	ND	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Sodium (Na)	0.83	0.10	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Strontium (Sr)	0.015	0.0020	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Uranium (U)	0.00011	0.00010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Zinc (Zn)	0.0075	0.0050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399



Success Through Science®

Maxxam Job #: B6D8171
Report Date: 2016/07/12

Department of Environment & Conservation
Client Project #: TSS ANALYSIS
Site Location: CHURCHILL RIVER, GOOSE BAY, NL
Your P.O. #: 216009736

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CQP213 CR below MF								
Sampling Date 2016/06/30 12:30								
Matrix W								
Sample # 2016-6309-00-SI-SP								
Registration # WS-5-0000								
RESULTS OF ANALYSES OF WATER								
Inorganics								
Total Suspended Solids	54	2.0	mg/L	N/A	2016/07/07	2016/07/08	LPW	4568304



Success Through Science®

Maxxam Job #: B6E0324
Report Date: 2016/07/14

Department of Environment & Conservation
Site Location: CHURCHILL RIVER, GOOSE BAY, NL
Your P.O. #: 215062145-2

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CQ2712 CR @ English Point								
Sampling Date	2016/06/30 10:50							
Matrix	W							
Sample #	2016-6311-00-SI-SP							
Registration #	WS-S-0000							
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	23	1.0	mg/L	N/A	2016/07/14	2016/07/14		4570151
Hardness (CaCO3)	12	1.0	mg/L	N/A	2016/07/12	2016/07/12		4570144
Nitrate (N)	ND	0.050	mg/L	N/A	2016/07/13	2016/07/13		4570147
Inorganics								
Conductivity	28	1.0	uS/cm	N/A	2016/07/12	2016/07/12	JMV	4573983
Bromide (Br-)	ND	1.0	mg/L	N/A	2016/07/11	2016/07/11	FD	4572058
Total Alkalinity (Total as CaCO3)	7.5	5.0	mg/L	N/A	2016/07/12	2016/07/12	MCN	4574278
Dissolved Chloride (Cl)	4.3	1.0	mg/L	N/A	2016/07/13	2016/07/13	MCN	4574285
Colour	52	25	TCU	N/A	2016/07/13	2016/07/13	MCN	4574291
Dissolved Fluoride (F-)	ND	0.10	mg/L	N/A	2016/07/12	2016/07/12	JMV	4573984
Total Kjeldahl Nitrogen (TKN)	0.10	0.10	mg/L	N/A	2016/07/11	2016/07/11	AAY	4572942
Nitrite (N)	ND	0.010	mg/L	N/A	2016/07/13	2016/07/13	MCN	4574299
Nitrogen (Ammonia Nitrogen)	ND	0.050	mg/L	N/A	2016/07/13	2016/07/13	NRG	4574970
Dissolved Organic Carbon (C)	5.6	0.50	mg/L	N/A	2016/07/11	2016/07/11	SMT	4572530
Total Organic Carbon (C)	6.1	0.50	mg/L	N/A	2016/07/12	2016/07/12	SMT	4574036
pH	6.92	N/A	pH	N/A	2016/07/12	2016/07/12	JMV	4573982
Total Phosphorus	0.093	0.004	mg/L	+/- 0.013	2016/07/12	2016/07/12	SNR	4574240
Dissolved Sulphate (SO4)	ND	2.0	mg/L	N/A	2016/07/12	2016/07/12	MCN	4574286
Turbidity	24	0.10	NTU	N/A	2016/07/11	2016/07/11	JMV	4572486
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	ND	0.000013	mg/L	N/A	2016/07/13	2016/07/13	ARS	4575885
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	1.5	0.0050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Antimony (Sb)	ND	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Arsenic (As)	ND	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Barium (Ba)	0.022	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Boron (B)	ND	0.050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Cadmium (Cd)	0.000025	0.000010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Calcium (Ca)	2.3	0.10	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Chromium (Cr)	0.0032	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Copper (Cu)	0.0028	0.0020	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Iron (Fe)	1.8	0.050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Lead (Pb)	0.00054	0.00050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Magnesium (Mg)	1.6	0.10	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Manganese (Mn)	0.049	0.0020	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Nickel (Ni)	0.0023	0.0020	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Potassium (K)	0.96	0.10	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Selenium (Se)	ND	0.0010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Sodium (Na)	3.4	0.10	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Strontium (Sr)	0.019	0.0020	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Uranium (U)	0.00011	0.00010	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399
Total Zinc (Zn)	0.0071	0.0050	mg/L	N/A	2016/07/12	2016/07/12	BAN	4574399



Success Through Science®

Maxxam Job #: B6D8171
Report Date: 2016/07/12

Department of Environment & Conservation
Client Project #: TSS ANALYSIS
Site Location: CHURCHILL RIVER, GOOSE BAY, NL
Your P.O. #: 216009736

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CQP215 CR @ English Point								
Sampling Date 2016/06/30 10:50								
Matrix W								
Sample # 2016-6311-00-SI-SP								
Registration # WS-5-0000								
RESULTS OF ANALYSES OF WATER								
Inorganics								
Total Suspended Solids	48	2.0	mg/L	N/A	2016/07/07	2016/07/08	LPW	4568304