Real-Time Water Quality Deployment Report

Lower Churchill River Network

September 15 to November 8, 2016

Newfoundland Labrador

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

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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 September 15th and 20th, 2016, real-time water quality monitoring instruments were deployed at all four stations on the Lower Churchill River for periods of 26-53 days.
- The above Muskrat Falls station was removed on October 11th as the station needed to be relocated before flooding of the Lower Churchill Project reservoir commenced.

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

	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 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 September 15 to November 8, 2016 are summarized in Table 2.

Table 2: Comparison rankings for Lower Churchill River stations September 15 to November 8, 2016

Churchill River Station and Instrument Number	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Grizzle Rapids (47384)	Sept. 15, 2016	Deployment	Excellent	Excellent	Excellent	Excellent	N/A
	Oct. 26, 2016	Removal	Excellent	Fair	Excellent	N/A	N/A
Above upper Muskrat Falls (47589)	Sept. 15, 2016	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	Oct. 11, 2016	Removal	Excellent	Good	Excellent	Excellent	N/A
Below Muskrat Falls (45708)	Sept. 15, 2016	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	Nov. 8, 2016	Removal	Good	Poor	Excellent	Good	Fair
At English Point (45709)	Sept. 20, 2016	Deployment	Good	Excellent	Good	Good	Fair
	Nov. 8, 2016	Removal	Good	Fair	Excellent	Excellent	Good

- Upon deployment at the station below Grizzle Rapids, temperature, pH, conductivity and dissolved oxygen all rank as 'excellent'. Upon removal, temperature and conductivity again ranked 'excellent', while pH ranked 'fair'. The field pH value was 7.09 while the QAQC pH value was 6.53. This discrepancy may be due to the QAQC sonde value being recorded before the sensor had acclimated. Dissolved oxygen could not be ranked upon removal as the DO sensor on the QAQC sonde was not functioning properly. The turbidity sensor was not ranked as turbidity data for the deployment was questionable and thus removed from the dataset.
- At the station above Muskrat Falls, temperature, conductivity, dissolved oxygen and turbidity all rank 'excellent' while pH ranked 'good' at deployment. Upon removal, temperature, conductivity and dissolved oxygen all ranked 'excellent' while pH ranked 'good'. The turbidity sensor could not be ranked upon removal as the sensor on the QAQC sonde was not functioning properly.
- Upon deployment at the below Muskrat Falls station, all sensors ranked 'excellent'. Upon removal, the conductivity sensor ranked 'excellent' while temperature and dissolved oxygen ranked 'good', turbidity ranked 'fair' and pH ranked 'poor'. The field turbidity value was 9.3NTU while the QAQC value was 4.3 NTU. This discrepancy is likely due to sediment being suspended around the field sonde while the value was recorded. The field pH value was 5.10, while the QAQC sonde measured 6.50. Analysis of the pH data indicates that the field sensor is likely inaccurate due to sensor drift.

- At the station at English Point, temperature, pH, conductivity and dissolved oxygen all rank as ‘excellent’ or ‘good’ upon deployment, while turbidity ranked as ‘fair’. The field turbidity reading was 18.7NTU, the QAQC reading was 13.5NTU and the grab sample value was 13.0NTU. This discrepancy is likely due to suspension of sediment around the field sonde when the value was being recorded. Upon removal, conductivity and dissolved oxygen ranked as ‘excellent’, temperature and turbidity ranked as ‘good’ and pH ranked as ‘fair’. The field pH reading was 6.71 and the QAQC reading was 6.13. The discrepancy between values is likely due to the QAQC sensor having not fully acclimated before the value was recorded.

Data Interpretation

- The following graphs and discussion illustrate water quality related events occurring from September 15 to November 8, 2016 on the Lower Churchill River Network. It should be noted for interpretation purposes that stations were removed from operation at different times throughout the deployment period, thus the graphs show different periods of time for the deployments and should be compared carefully as time periods differ between 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.
- Reservoir impoundment upstream of the Muskrat Falls dam commenced on November 5, 2016. At this time, only the below Lower Muskrat Falls and English Point instruments were deployed, both located downstream of the dam and reservoir. The below Grizzle Rapids station had been removed for the winter while the above Muskrat Falls station was removed before being relocated in preparation of impoundment as the station was in the inundation zone.

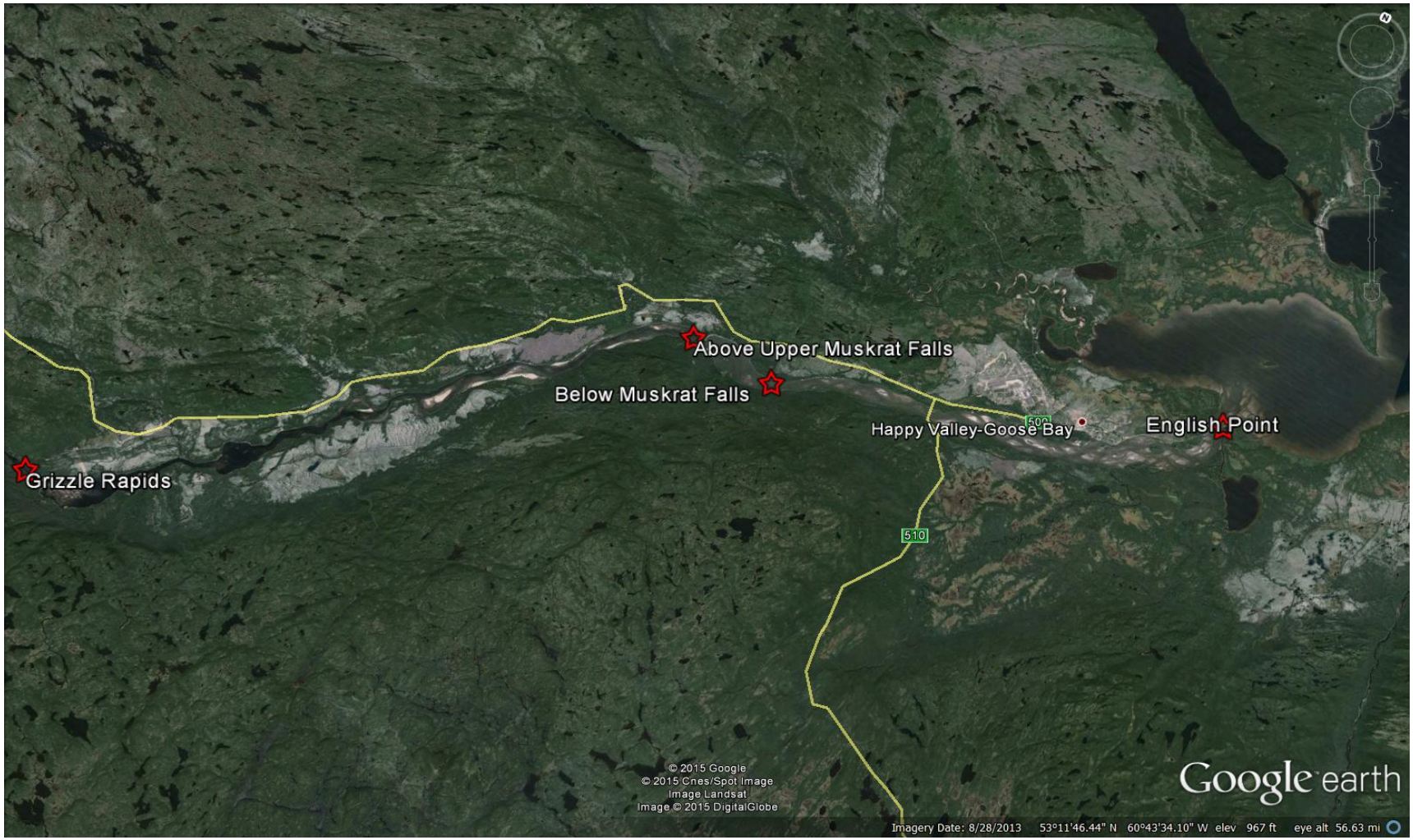

Figure 1: Lower Churchill Network- Station Locations

Churchill River below Grizzle Rapids

Water Temperature

- Water temperature ranges from 4.60°C to 13.00°C with a median value of 9.60°C (Figure 2).
- Water temperatures are gradually decreasing throughout the deployment period. This trend is expected as water temperatures continue to cool into the fall and winter months. This trend is mirrored by the average daily air temperature values.

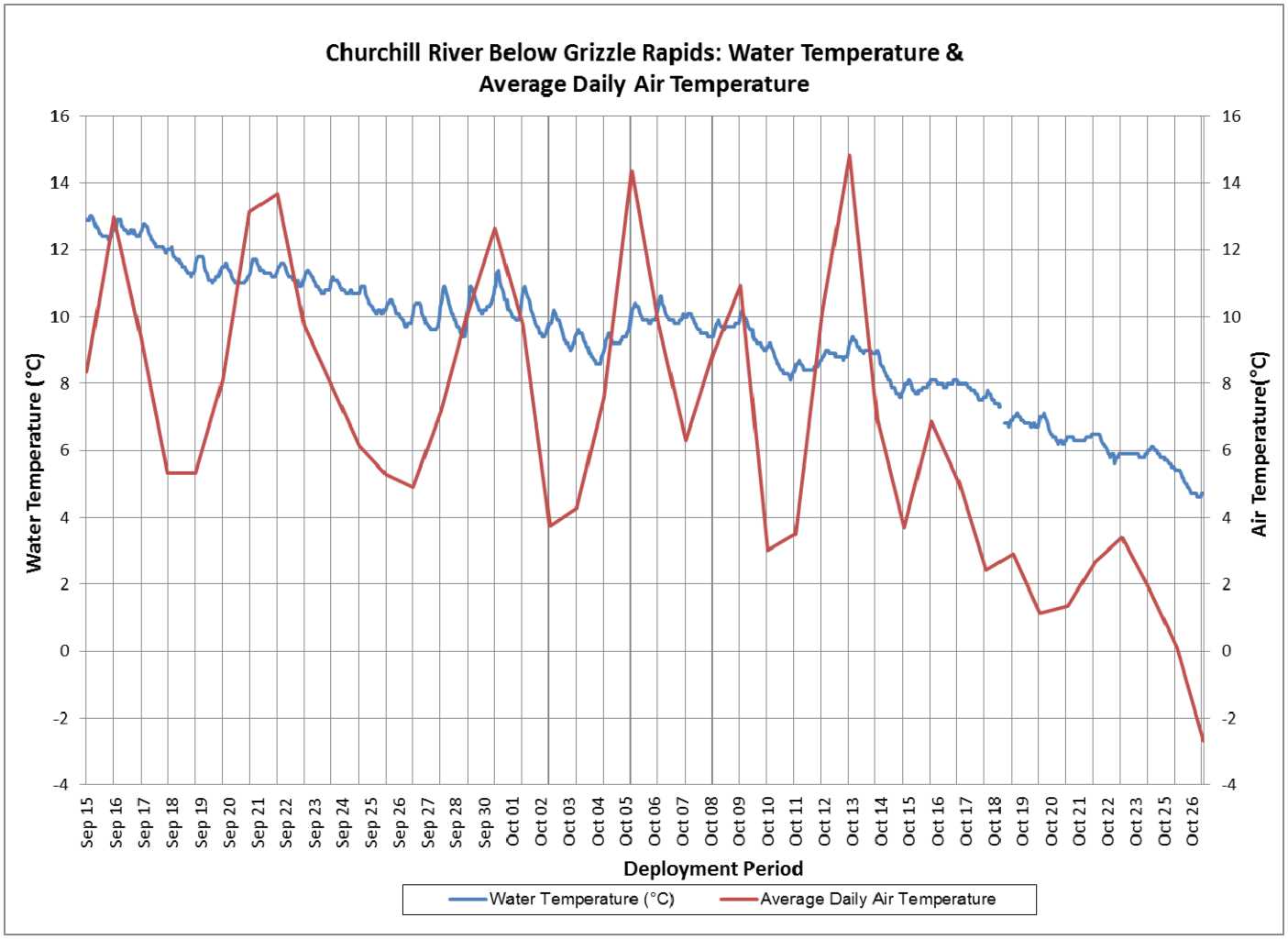

Figure 2: Water Temperature & Daily Average Air Temperature (Muskrat Falls Weather Station) at Churchill River below Grizzle Rapids

pH

- pH ranges between 7.06 and 7.43 pH units with a median value of 7.28 (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.

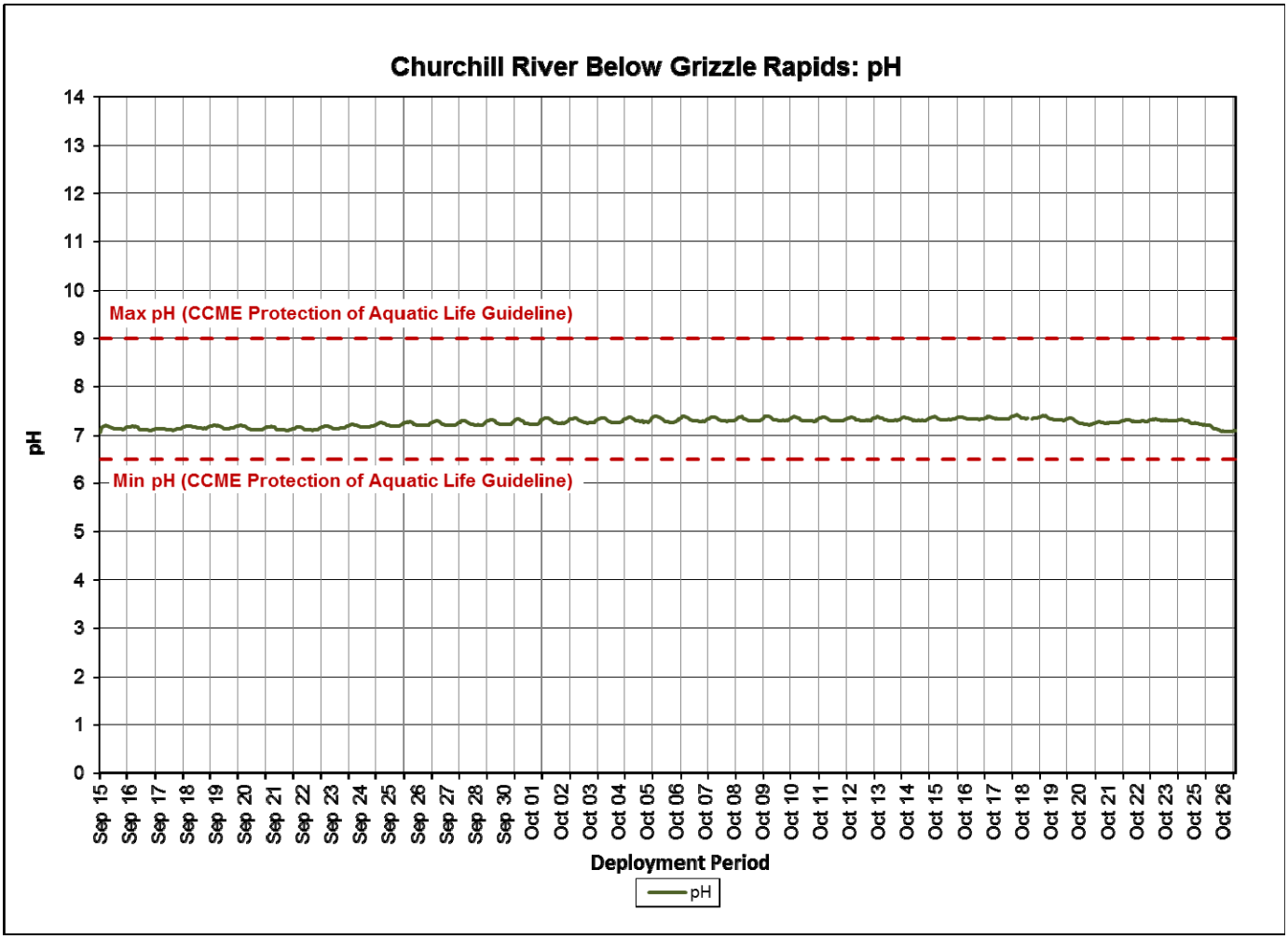

Figure 3: pH at Churchill River below Grizzle Rapids

Specific Conductivity, TDS and Stage

- Specific conductivity ranges from 16.1µS/cm to 21.9µS/cm with a median of 19.5µS/cm (Figure 4).
- TDS (total dissolved solids) ranges from 0.0103 g/L to 0.0140 g/L with a median of 0.0125 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 drop 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. Conductivity does drop at the end of the deployment, coinciding with precipitation and a rise in stage.
- 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.

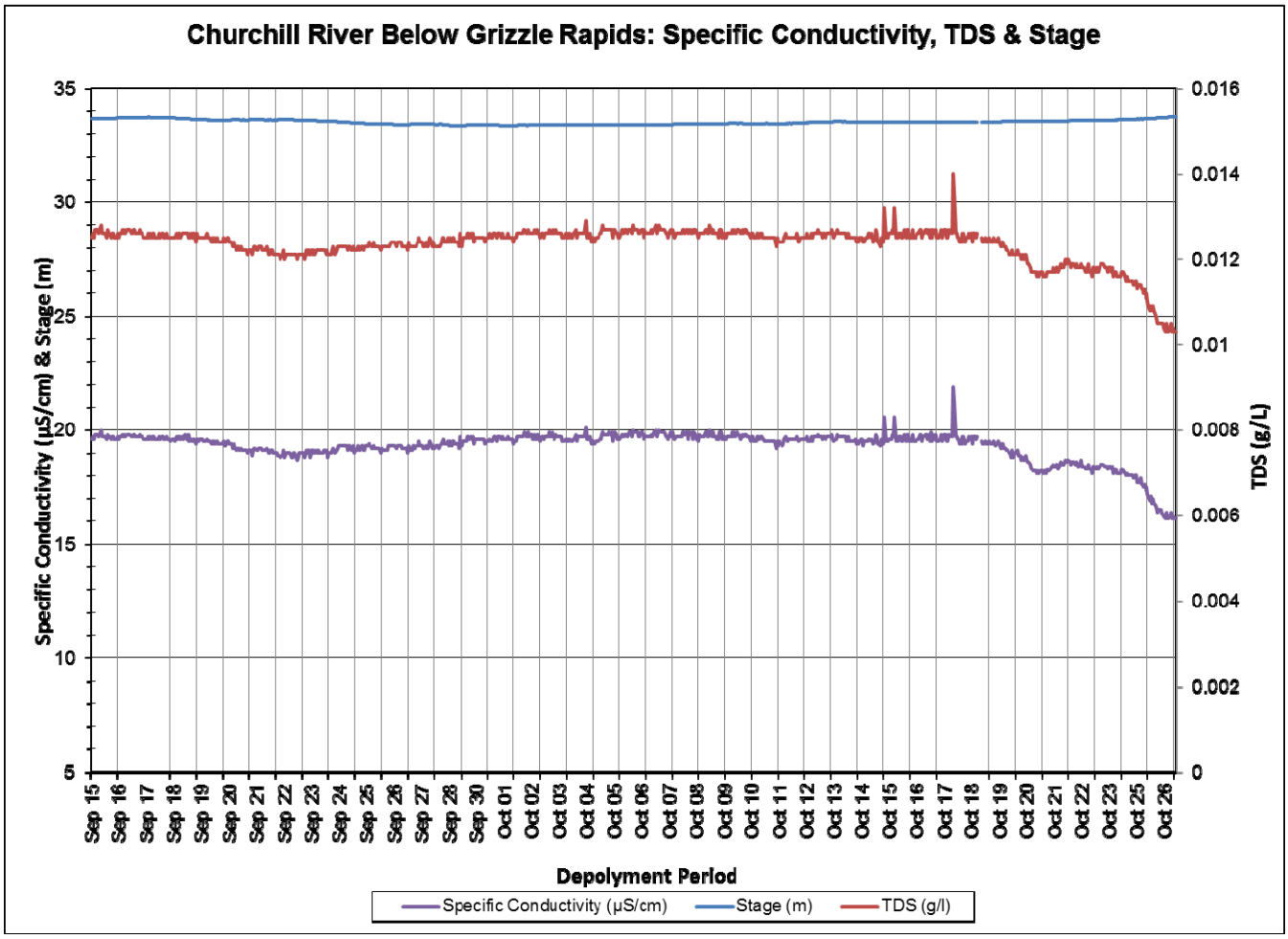

Figure 4: Specific Conductivity, TDS, and stage at Churchill River below Grizzle Rapids

Dissolved Oxygen

- Dissolved oxygen content ranges between 10.13mg/l and 11.91mg/l with a median value of 10.94mg/l. The saturation of dissolved oxygen ranges from 92.4% to 101.0% with a median value of 96.0% (Figure 5).
- There is an evident relationship between water temperature and dissolved oxygen. Throughout the deployment, dissolved oxygen is steadily increasing as water temperatures gradually decrease into the winter 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 Early and Other Life Stages throughout the deployment period.

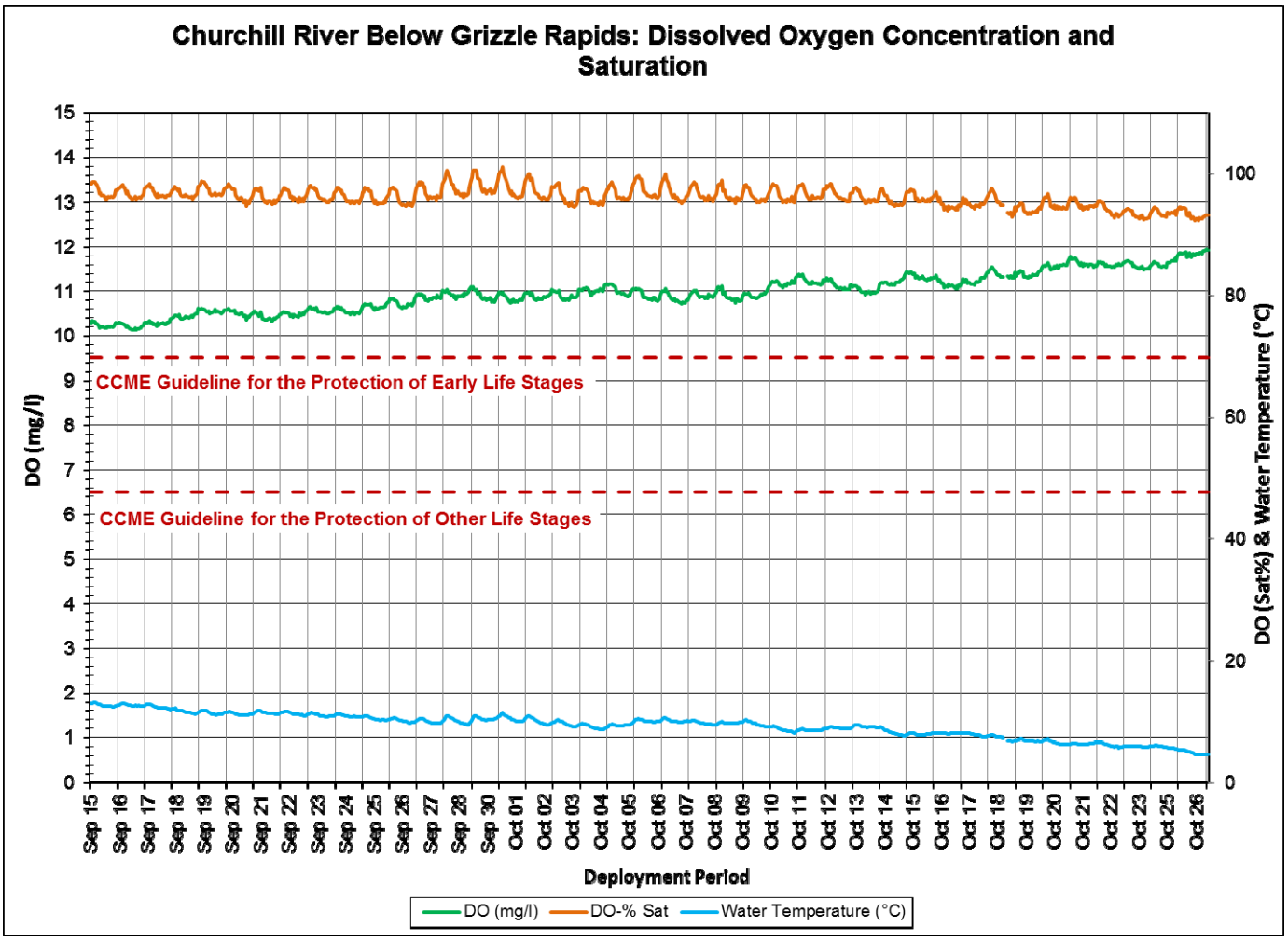

Figure 5: Dissolved Oxygen at Churchill River below Grizzle Rapids

Turbidity, Stage & Total Daily Precipitation

- Turbidity values recorded at this station were all 0.0NTU, indicating that there may have been an issue with the turbidity sensor. Values at this station typically have a median value near 0.0NTU, but normally show some variability throughout the deployment. As the values may be inaccurate, they have been removed from the dataset.
- Stage and precipitation (Muskrat Falls Weather Station) are graphed below to show the relationship between rainfall and water level (Figure 6). Overall, stage is relatively stable during the deployment period. Precipitation occurs on 23 of the days in the deployment period and amounts are generally low, with the exception of the largest event Oct 23/24 of 38.86mm.
- Stage ranged between 33.34m and 33.74m (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.

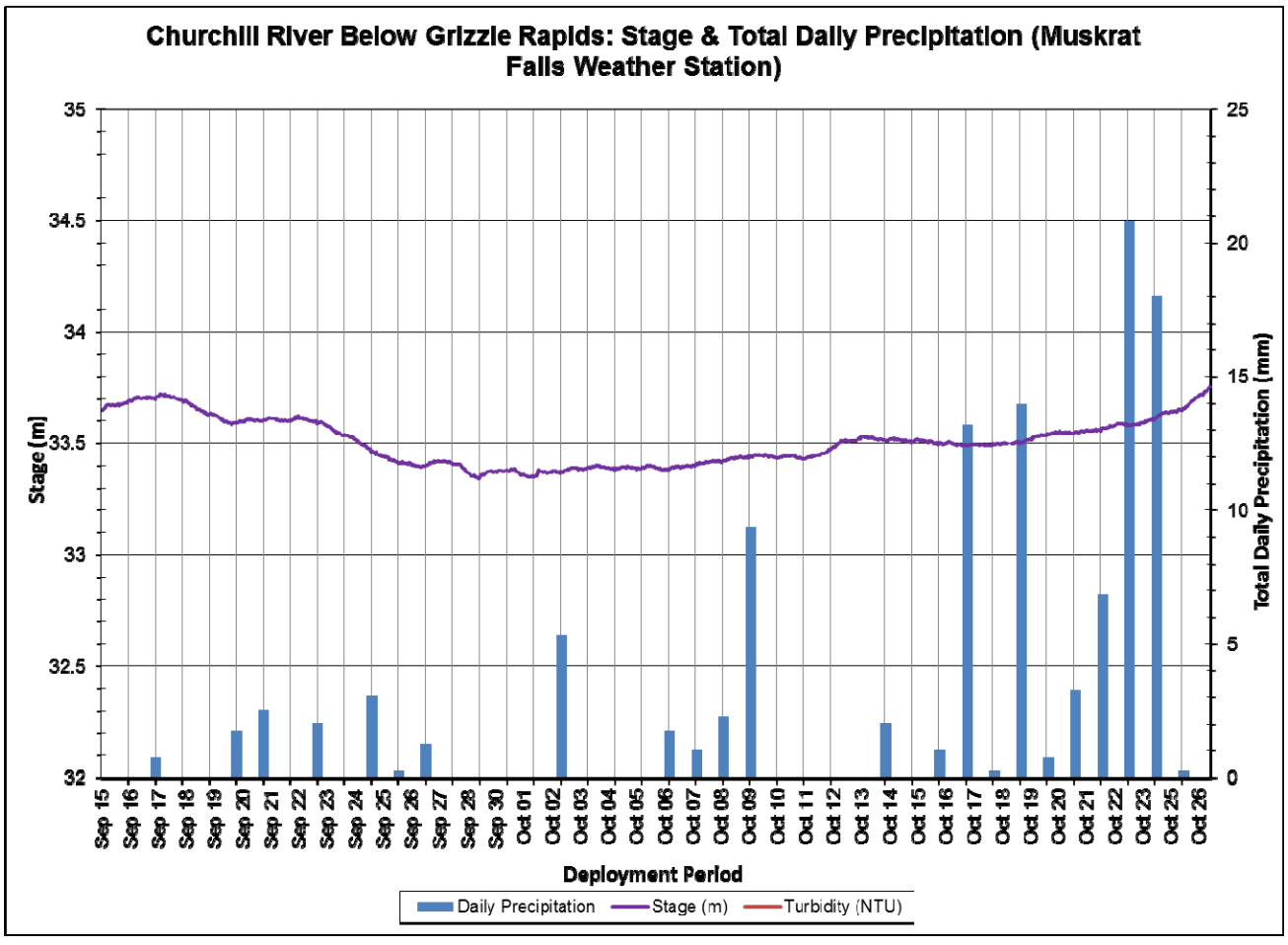

Figure 6: Stage & Total Daily Precipitation (Muskrat Falls Weather Station) at Churchill River below Grizzle Rapids

Churchill River above Upper Muskrat Falls

Water Temperature

- Water temperature ranges from 8.09°C to 12.79°C with a median value of 10.12°C (Figure 7).
- Water temperatures are generally decreasing into the fall and winter months. This trend is mirrored by the average daily air temperature values.

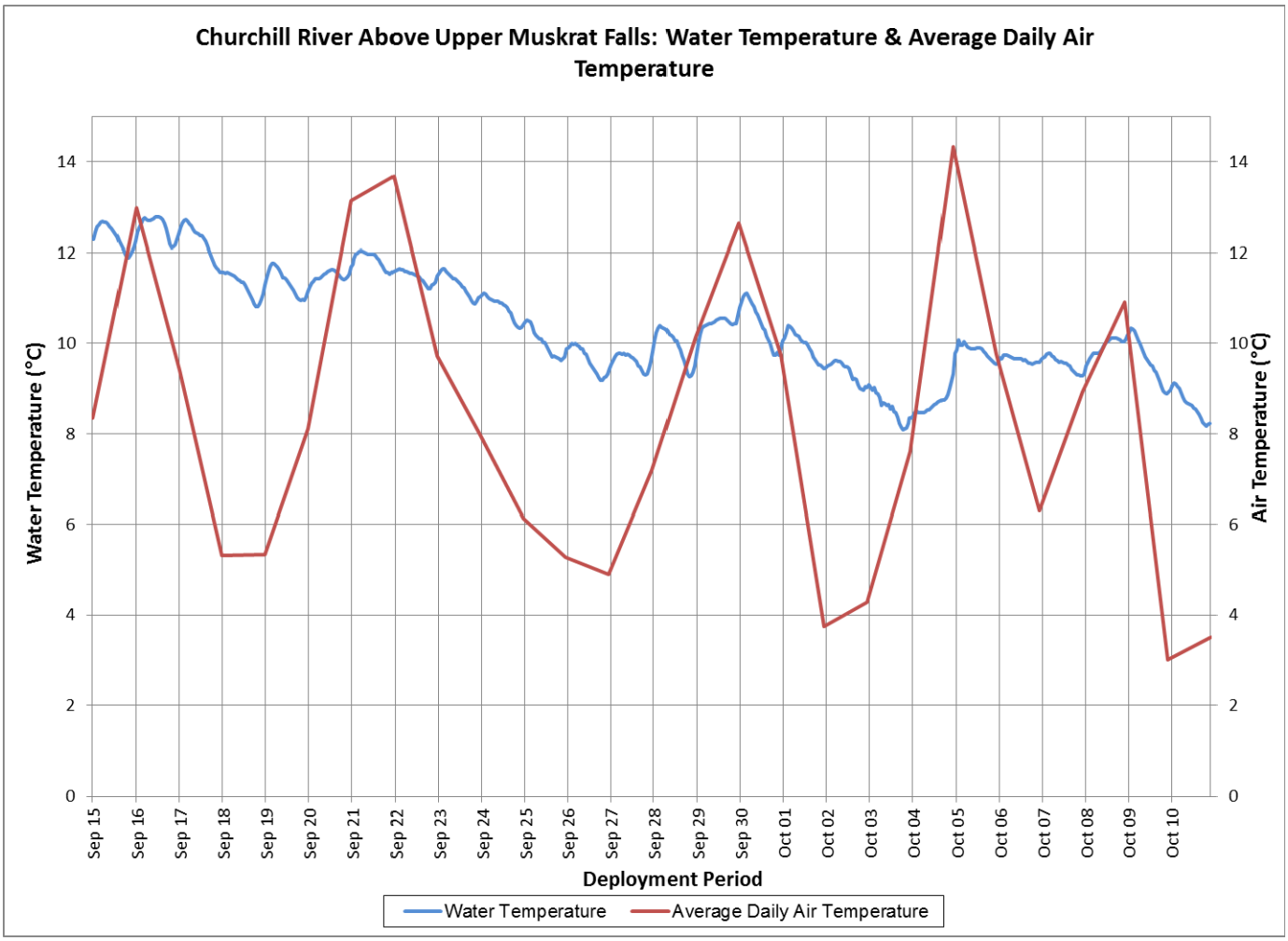

Figure 7: Water Temperature & Average Daily Air Temperature (Muskrat Falls Weather Station) at Churchill River above Upper Muskrat Falls

pH

- pH ranges between 6.79 and 6.97 pH units with a median value of 6.89 (Figure 8).
- pH values are relatively stable and fall within the CCME Protection of Aquatic Life Guidelines for the entirety of the deployment.

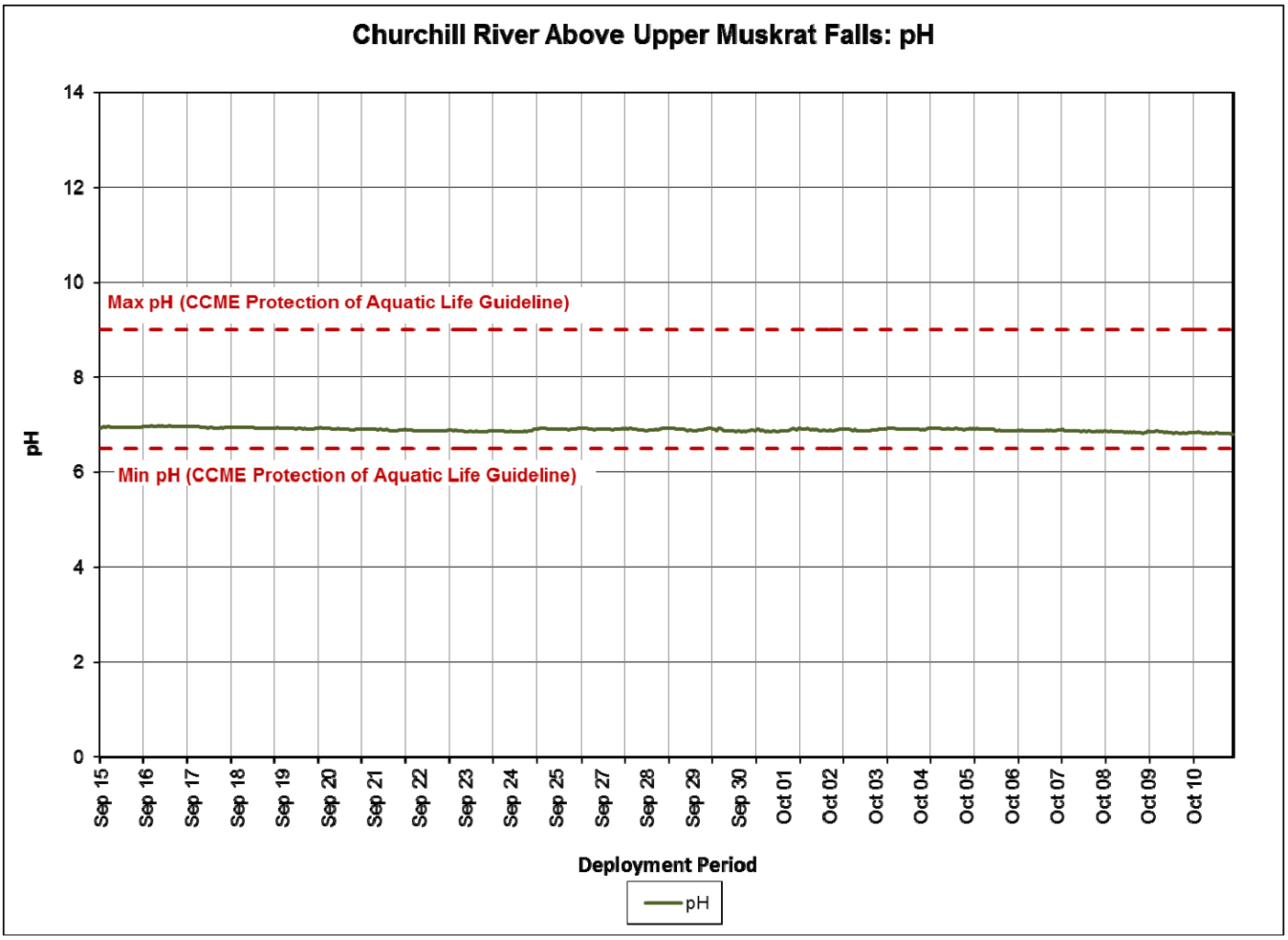

Figure 8: pH at Churchill River above Upper Muskrat Falls

Specific Conductivity, TDS and Stage

- Specific conductivity ranges from 19.4µS/cm to 22.9µS/cm with a median of 21.0µS/cm (Figure 9).
- TDS ranges from 0.0124 g/L to 0.0146 g/L with a median of 0.0134 g/L (Figure 9).
- 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. This is evident around September 22/23 when a small increase in stage was mirrored by a small decrease in conductivity.
- 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.

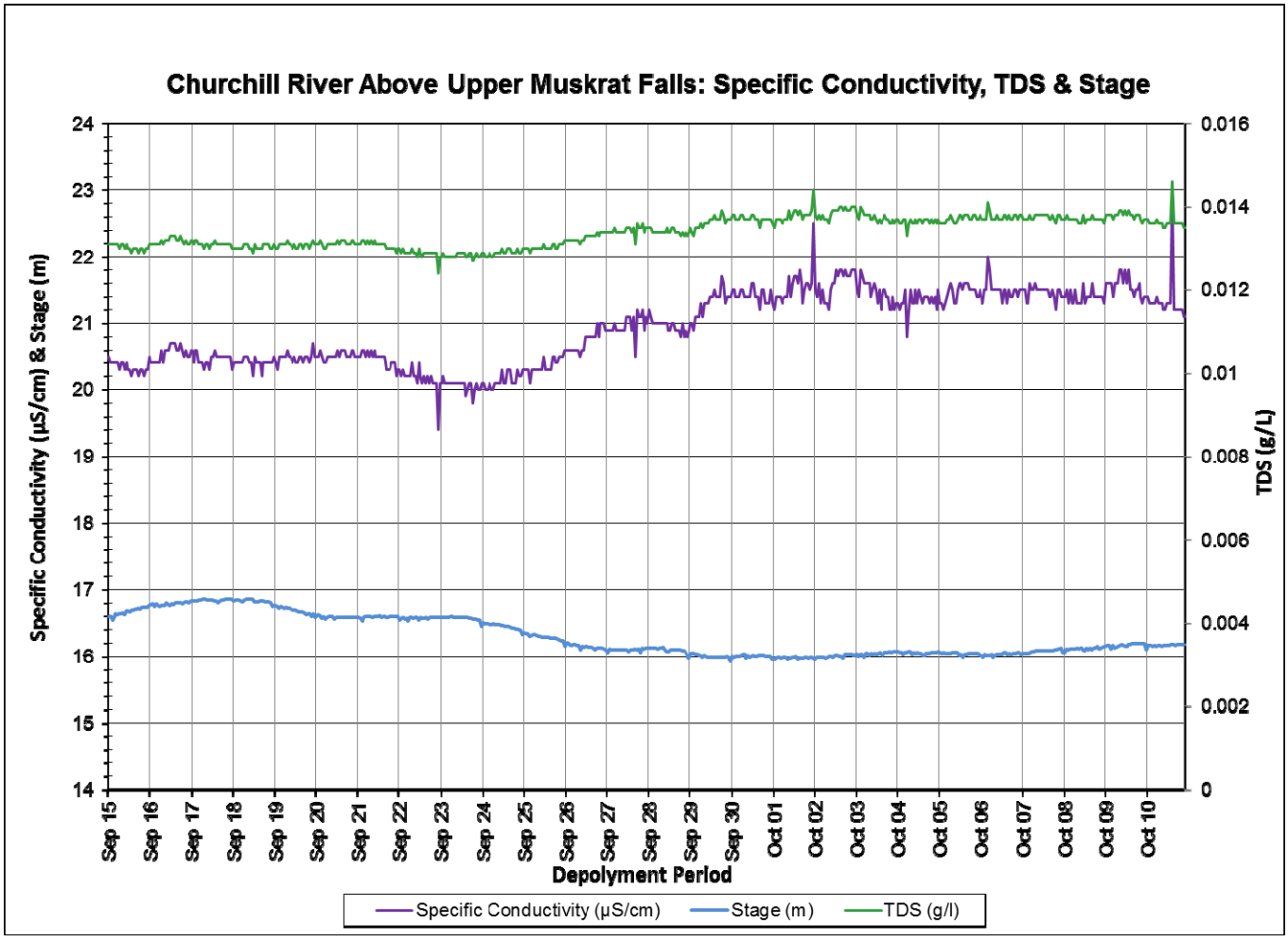

Figure 9: Specific Conductivity, TDS, and Stage at Churchill River above Upper Muskrat Falls

Dissolved Oxygen

- Dissolved oxygen content ranges between 10.27mg/l and 11.31mg/l with a median value of 10.90mg/l. The saturation of dissolved oxygen ranges from 94.5% to 101.1% with a median value of 97.2% (Figure 10).
- There is an evident relationship between water temperature and dissolved oxygen. Throughout the deployment, as water temperatures are slowly decreasing into the fall and winter season, dissolved oxygen levels are increasing steadily. Generally, there is more dissolved oxygen present in a waterbody during cooler temperatures. The dissolved oxygen also follows a diurnal pattern as the water temperature rises and falls under the influence of the ambient air temperature.
- The dissolved oxygen levels remained above the CCME Guidelines for the Protection of Early and Other Life Stages throughout the deployment period.

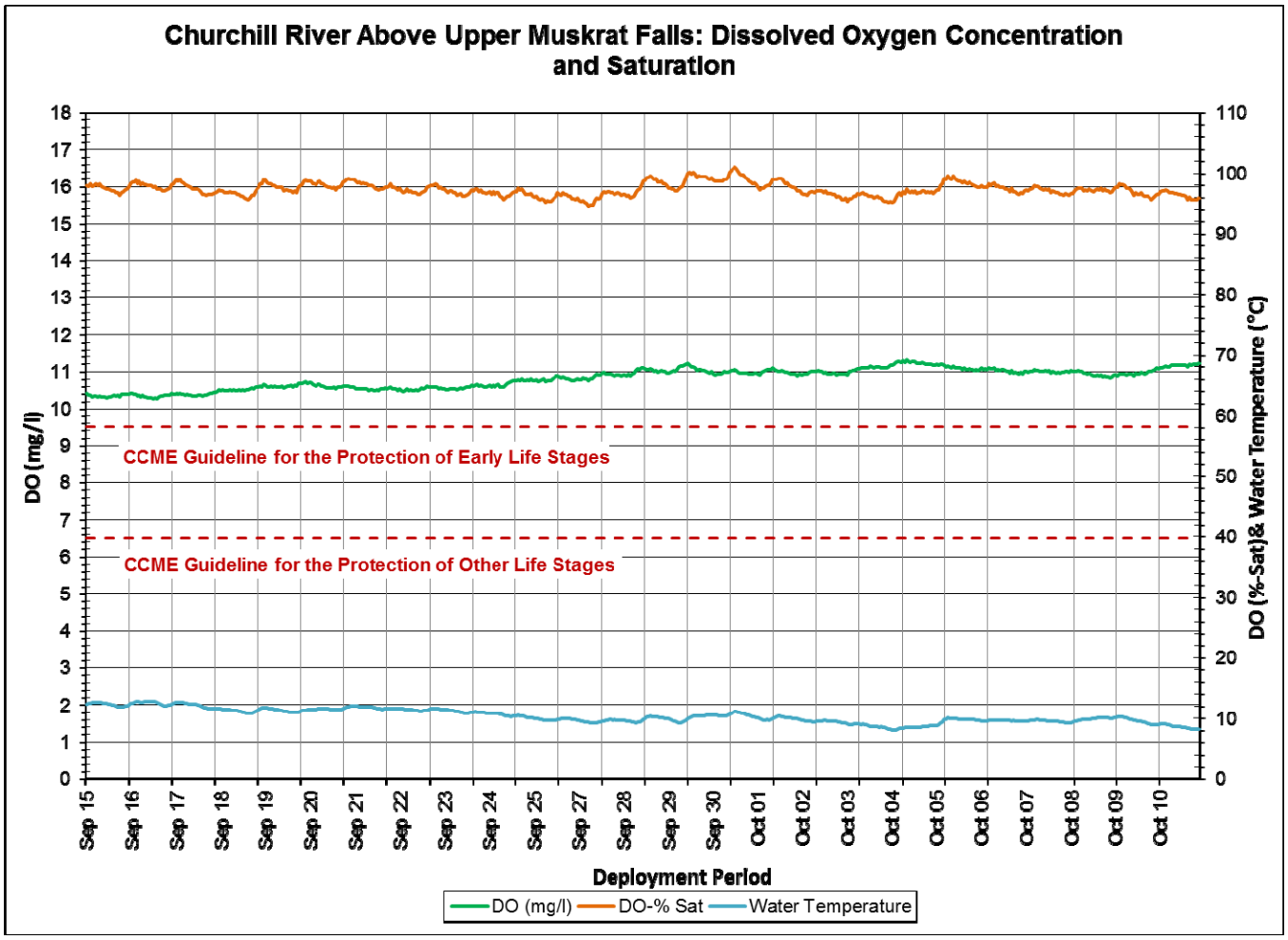

Figure 10: Dissolved oxygen at Churchill River above Upper Muskrat Falls

Chlorophyll

- Chlorophyll ranges between 3.8ug/L and 16.0ug/L, with a median value of 5.5ug/L (Figure 11).
- 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.

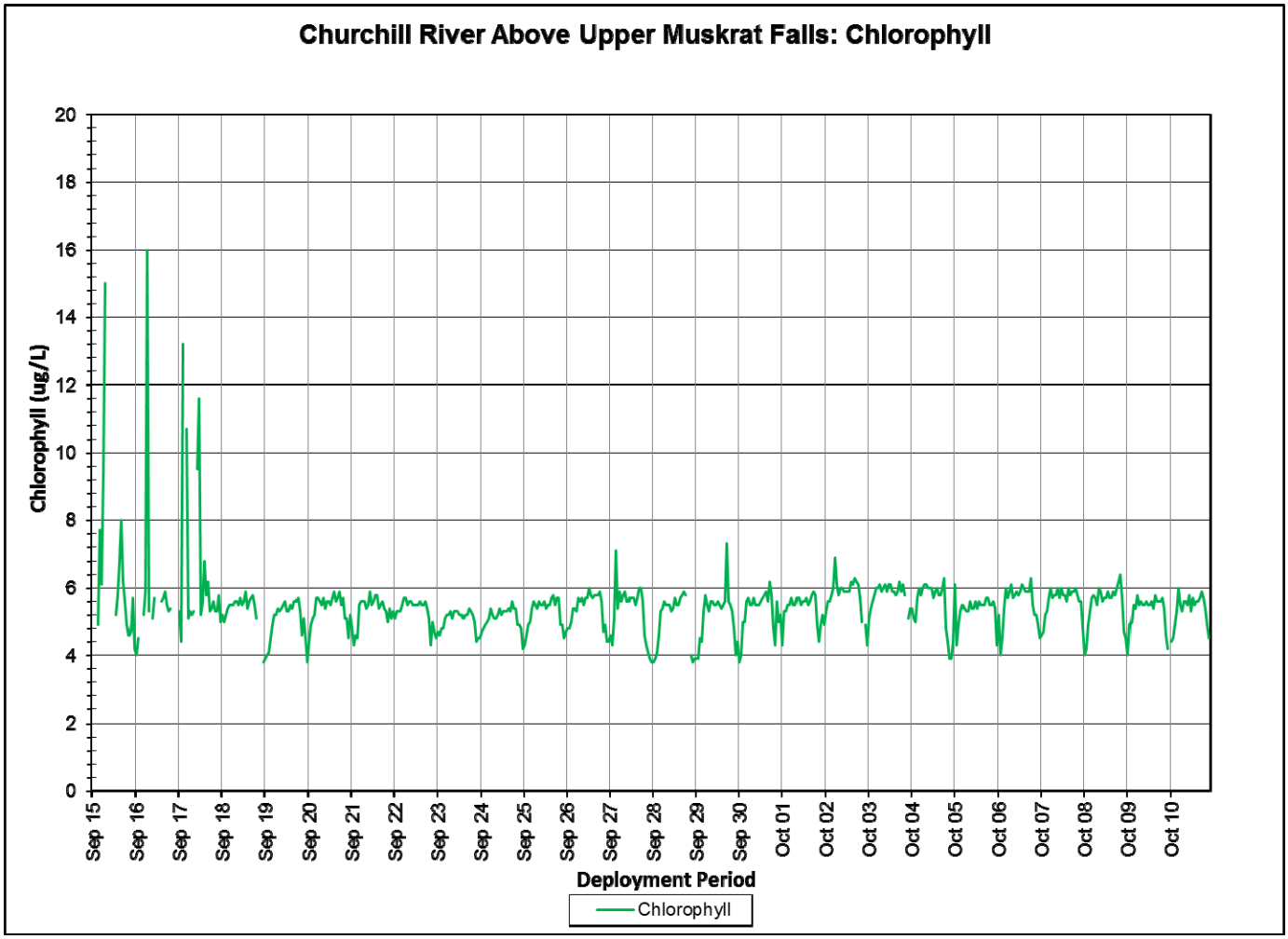

Figure 11: Chlorophyll at Churchill River above Upper Muskrat Falls

Stage, Flow, Turbidity and Precipitation

- Turbidity ranges between 0.0 NTU and 92.8 NTU with a median value of 1.1 NTU (Figure 12).
- Numerous 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 12 of the days in the deployment period and amounts are generally low. The largest precipitation event was on October 9th with a total of 9.4 mm. A significant increase in turbidity is noticeable at this time.
- Other spikes in turbidity may be natural background variation, debris passing the sensor, or turbidity may have been affected by an unknown cause. A notable series of spikes occurred October 5, which is not associated with precipitation and occurred at the same time as increases at the below Muskrat Falls station. The cause of these increases is not evident.
- Stage ranges between 15.92m and 16.86m, and streamflow ranges from 1272.00m^3/s to 1810.73 m^3/s (Figure 13).
- 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.

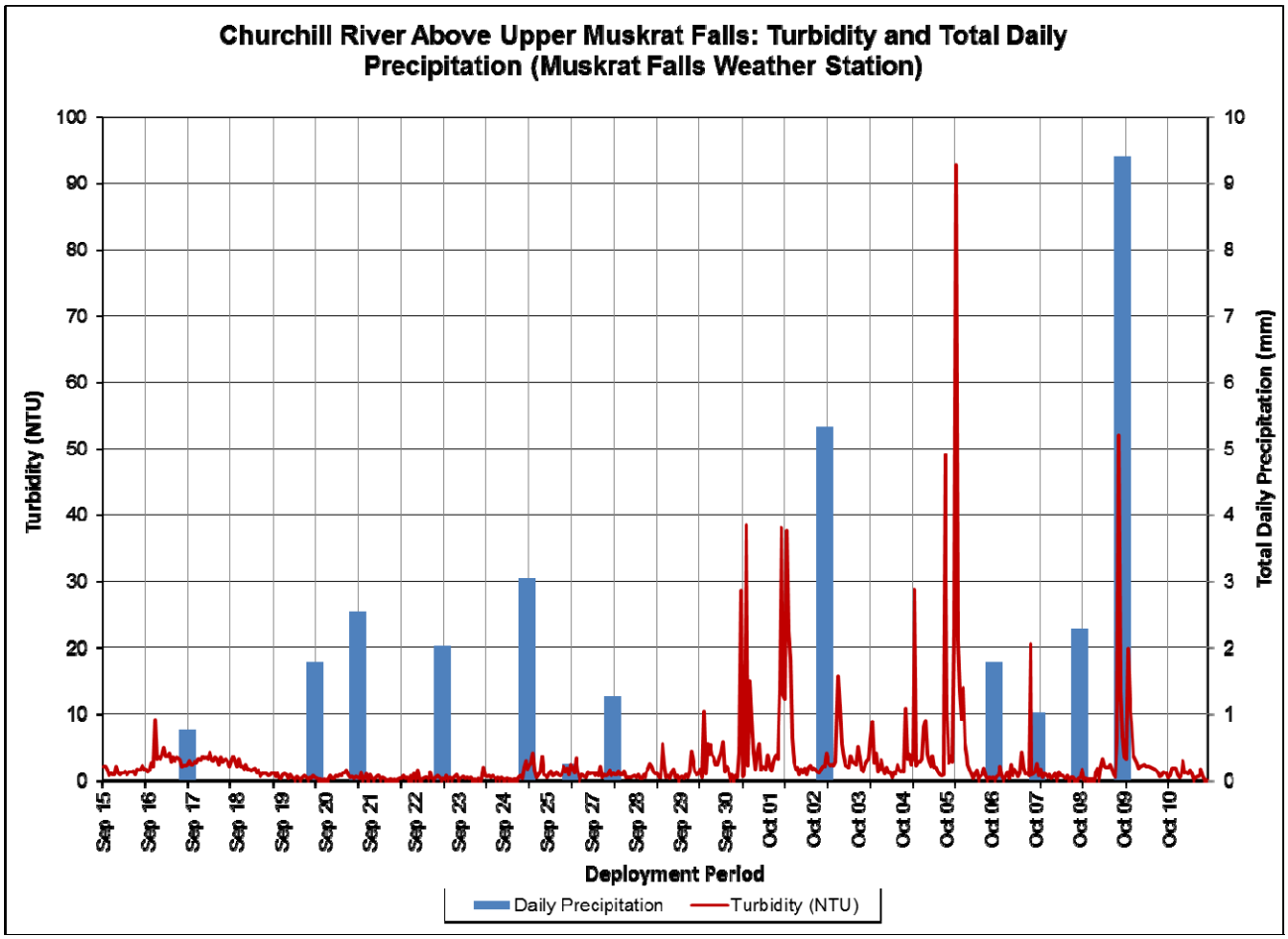

Figure 12: Turbidity and Total Daily Precipitation (Muskrat Falls Weather Station) at Churchill River above Upper Muskrat Falls

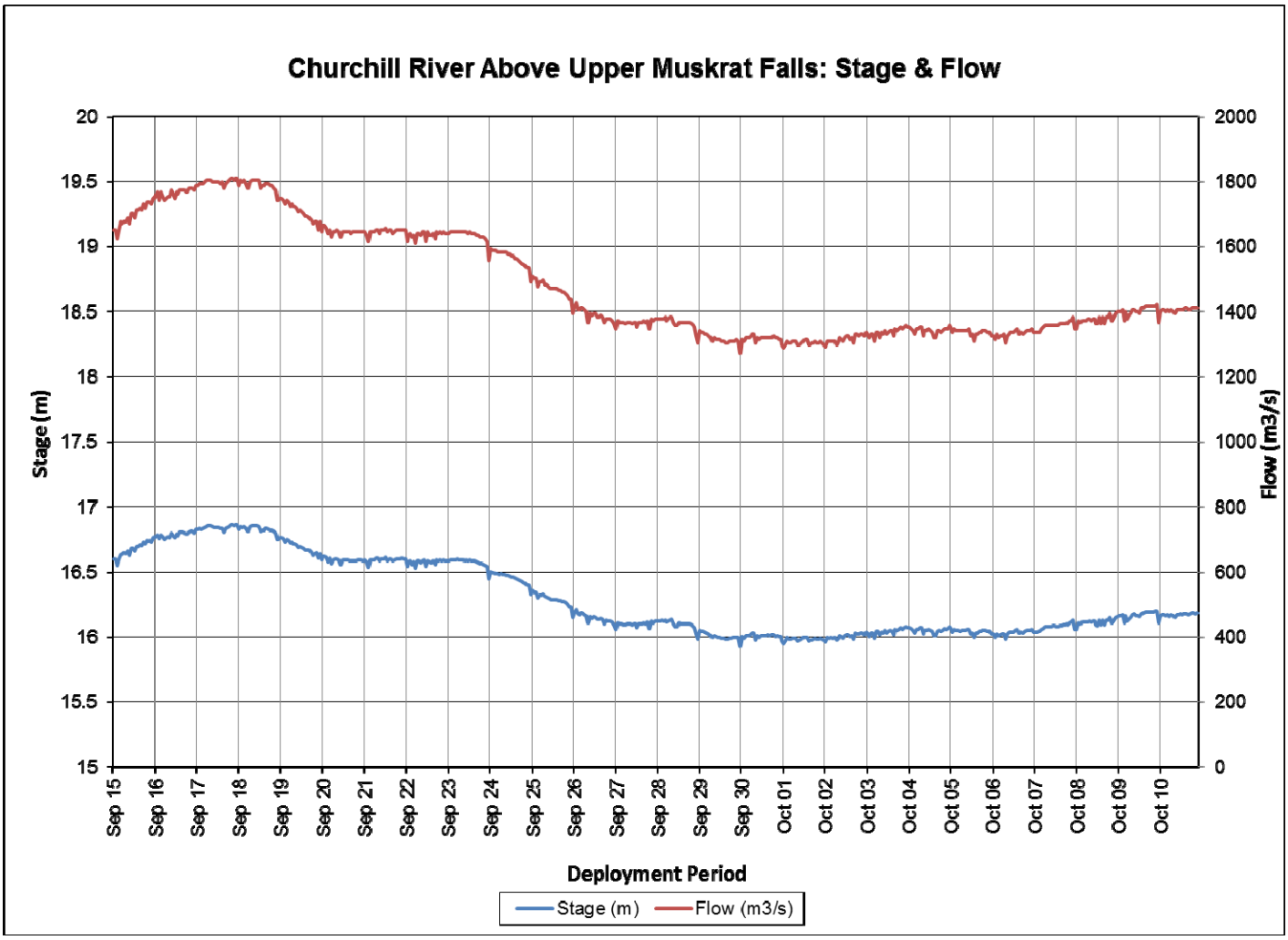

Figure 13: Stage and Flow at Churchill River above Upper Muskrat Falls

Churchill River below Muskrat Falls

Water Temperature

- Water temperature ranges from 2.90°C to 13.30°C with a median value of 8.70°C (Figure 14).
- Water temperatures are generally decreasing into the fall and winter months. This trend is mirrored by the average daily air temperature values.

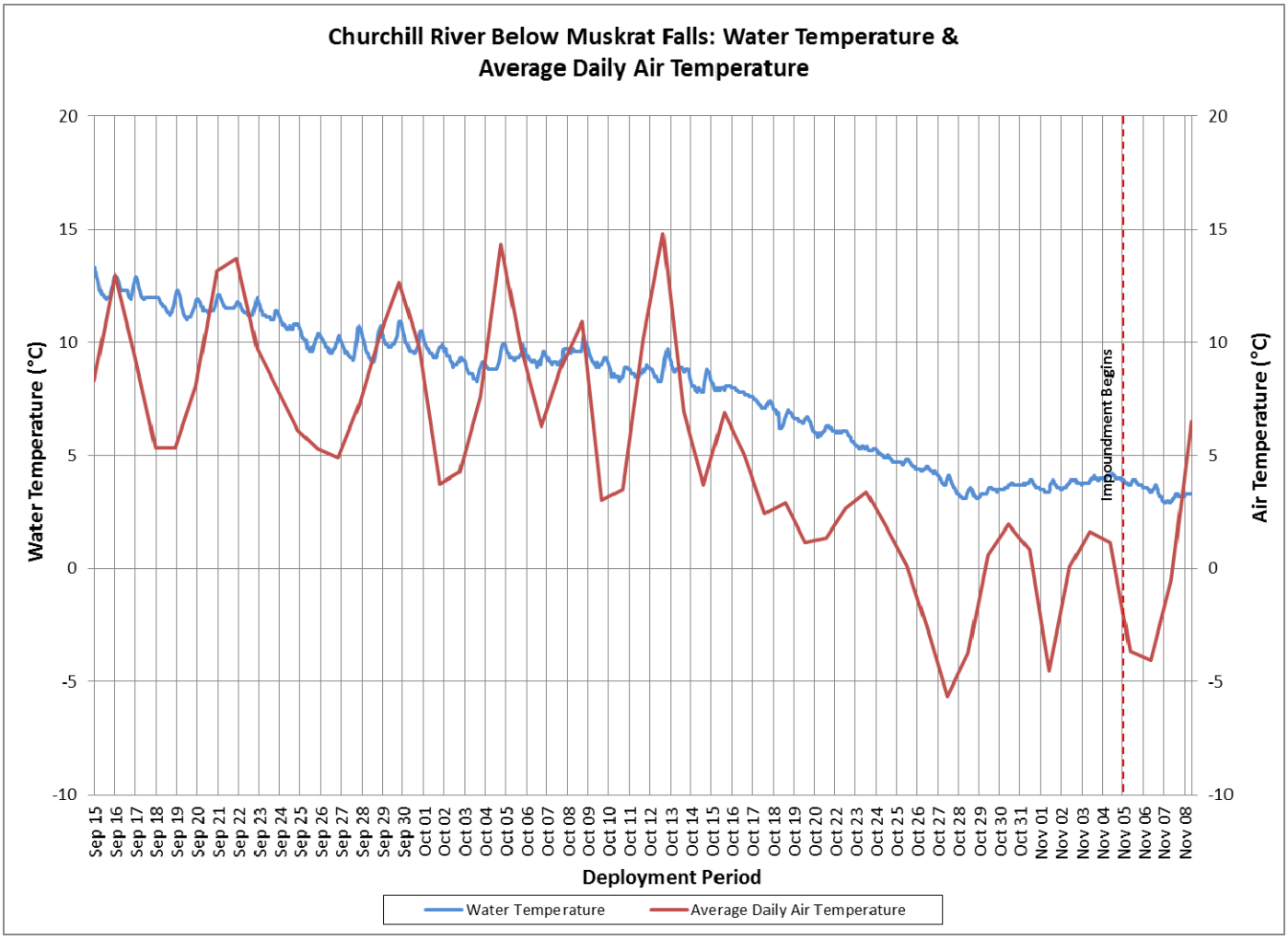

Figure 14: Water Temperature & Daily Average Air Temperature (Muskrat Falls Weather Station) at Churchill River below Muskrat Falls

pH

- pH ranges between 5.08 and 7.26 pH units with a median value of 6.83 (Figure 15).
- Between September 15 and October 16, pH values were generally stable and fell within the CCME Guidelines for the Protection of Aquatic Life. After October 16th, the pH values begin to steadily drift downward, falling below the minimum guideline October 22 and remaining below until the end of deployment. The 'poor' ranking of this sensor upon on removal after deployment and the consistent downward trend of pH indicates that October 16 to November 8 may have been subject to sensor drift.

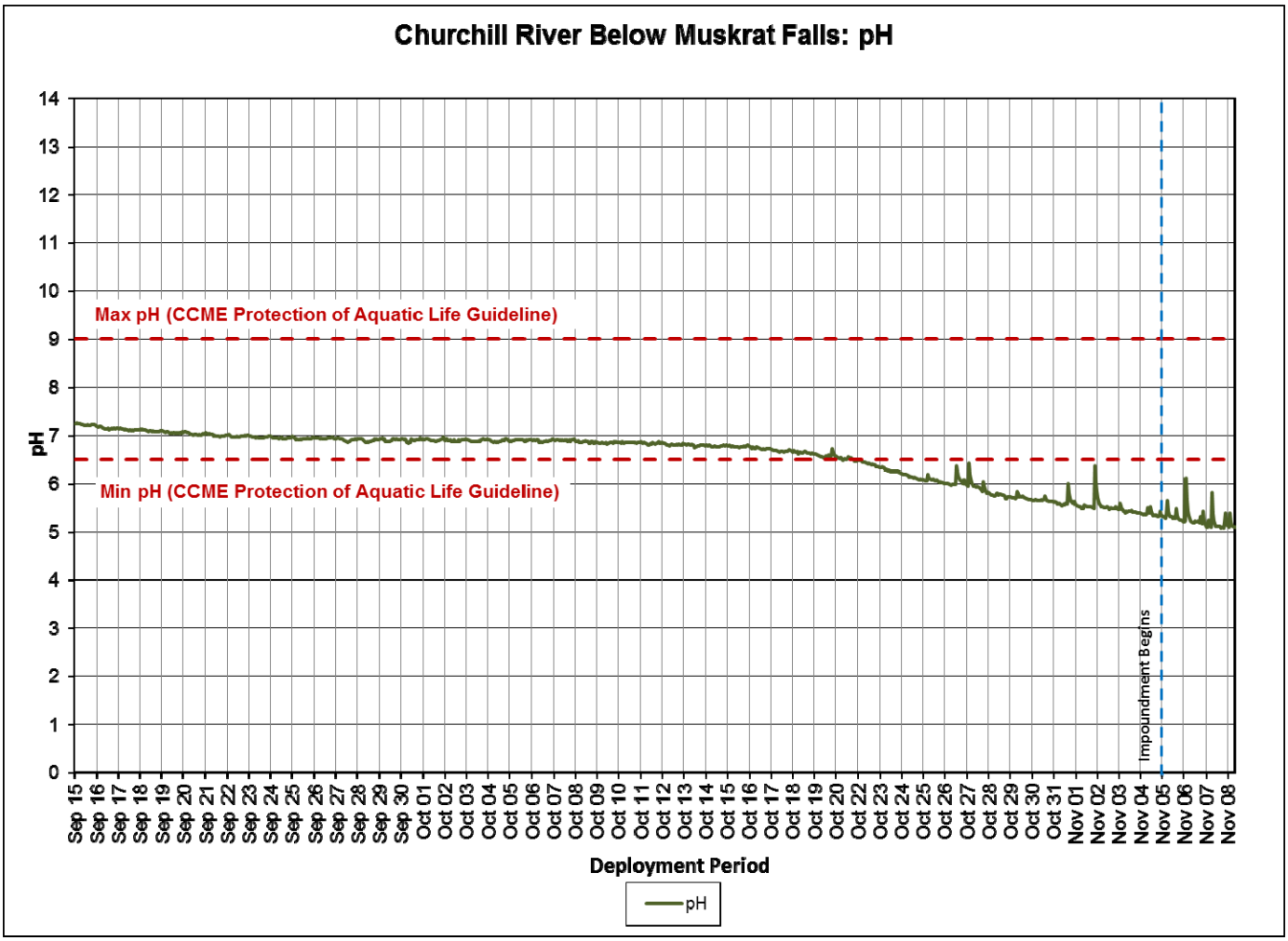

Figure 15: pH at Churchill River below Muskrat Falls

Specific Conductivity, TDS & Stage

- Specific conductance ranges between 14.7µS/cm and 20.7µs/cm during the deployment period, with a median of 20.0µS/cm (Figure 16).
- TDS ranges between 0.0094 g/mL to 0.0133 g/mL during the deployment period, with a median of 0.0128 g/mL (Figure 16).
- 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. This is evident in Figure 16 on October 24 after 38.86mm of rain fell in the preceding two days, increasing stage and decreasing conductivity.
- 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.

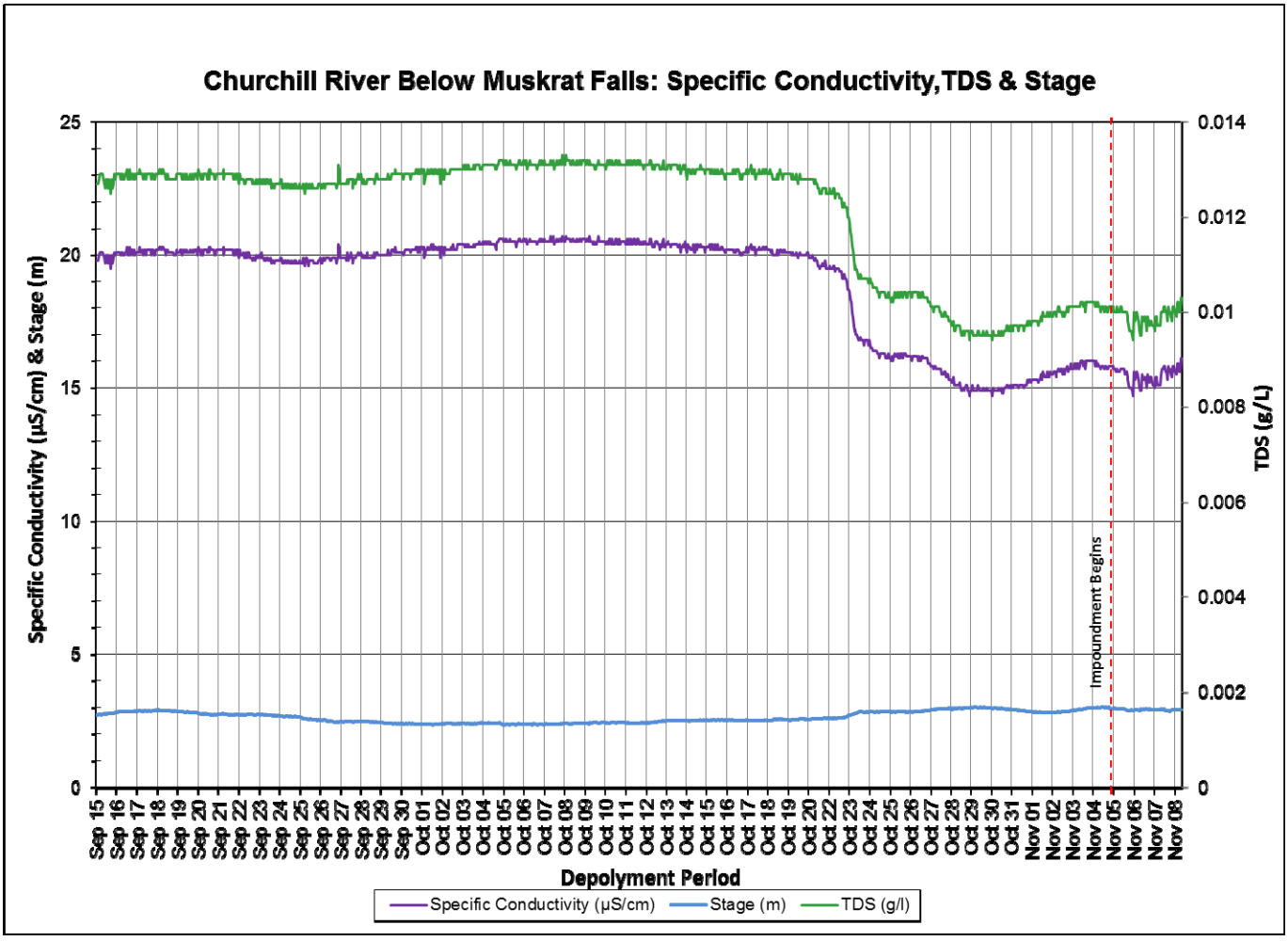

Figure 16: Specific Conductivity, TDS & Stage at Churchill River below Muskrat Falls

Dissolved Oxygen

- Dissolved oxygen content ranges between 11.59mg/l and 14.99mg/l with a median value of 13.08mg/l. The saturation of dissolved oxygen ranges from 102.9% to 120.1% with a median value of 112.2% (Figure 17).
- 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 17)
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period the dissolved oxygen levels are slowly rising as temperatures fall into the winter season. Generally, there is more dissolved oxygen present in a waterbody during cooler temperatures. The dissolved oxygen also follows a diurnal pattern as the water temperature rises and falls under the influence of the ambient air temperature.
- The dissolved oxygen levels remained above the CCME Guidelines for the Protection of Other Life Stages and Early Life Stages throughout the deployment.

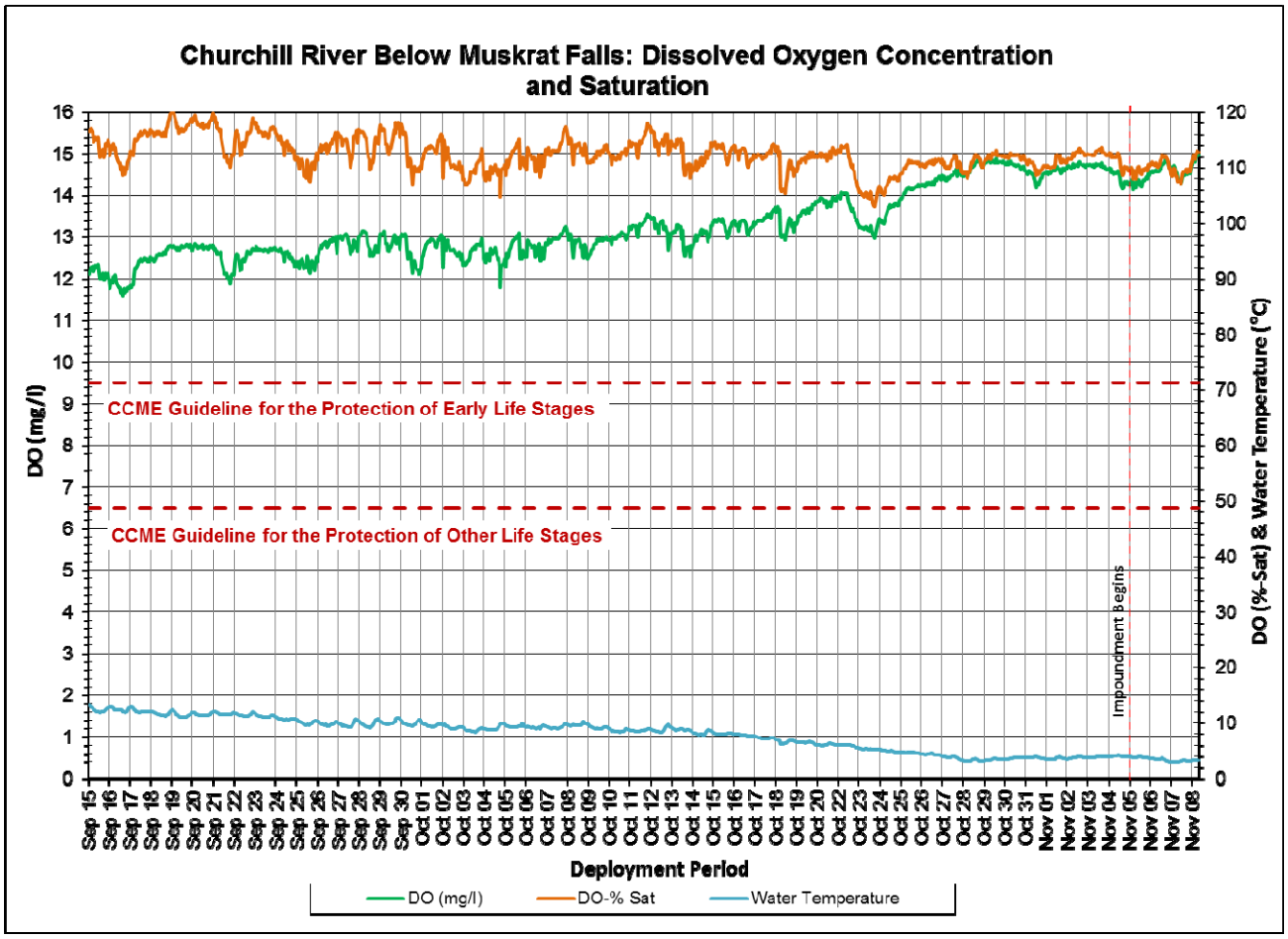

Figure 17: Dissolved Oxygen & Stage at Churchill River below Muskrat Falls

Turbidity, Stage & Precipitation

- Turbidity ranges between 0.0NTU and 241.7NTU with a median value of 4.1NTU (Figure 18).
- Precipitation occurs on 26 days during the deployment period and amounts are generally small in magnitude, with the largest event dropping a total of 38.86mm over the two day period of October 23-24.
- Numerous turbidity events in the deployment period correlate to precipitation events. Precipitation can increase the presence of suspended material in water.
- Other spikes in turbidity may be natural background variation, debris passing the sensor, or turbidity may have been affected by an unknown cause. A notable series of spikes occurred October 5, which is not associated with precipitation and occurred at the same time as increases at the above Upper Muskrat Falls station. The cause of these increases is not evident.
- Stage ranges between 2.34m and 3.01m (Figure 19).
- 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.

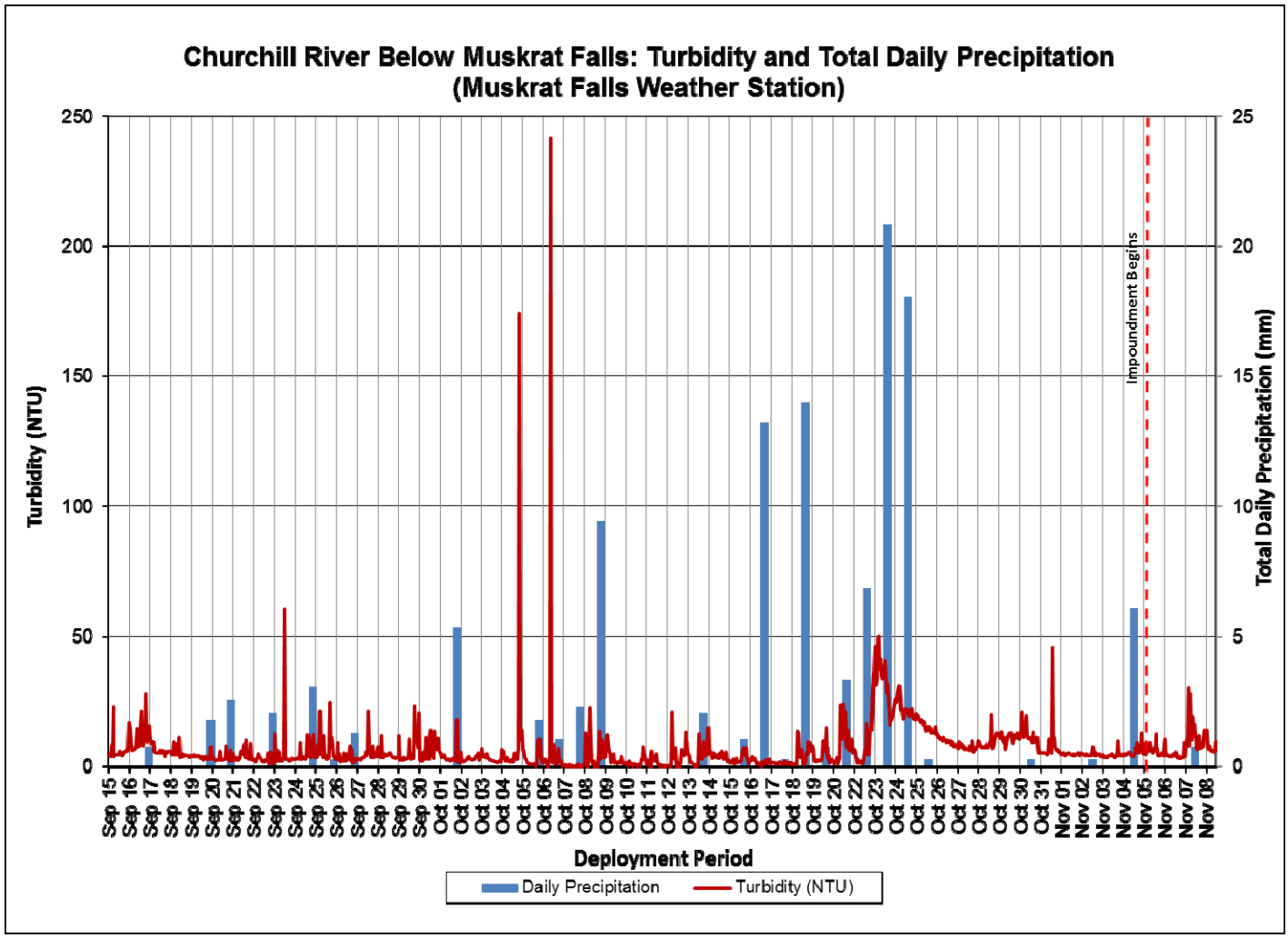

Figure 18: Turbidity & Total Daily Precipitation (Muskrat Falls Weather Station) at Churchill River below Muskrat Falls

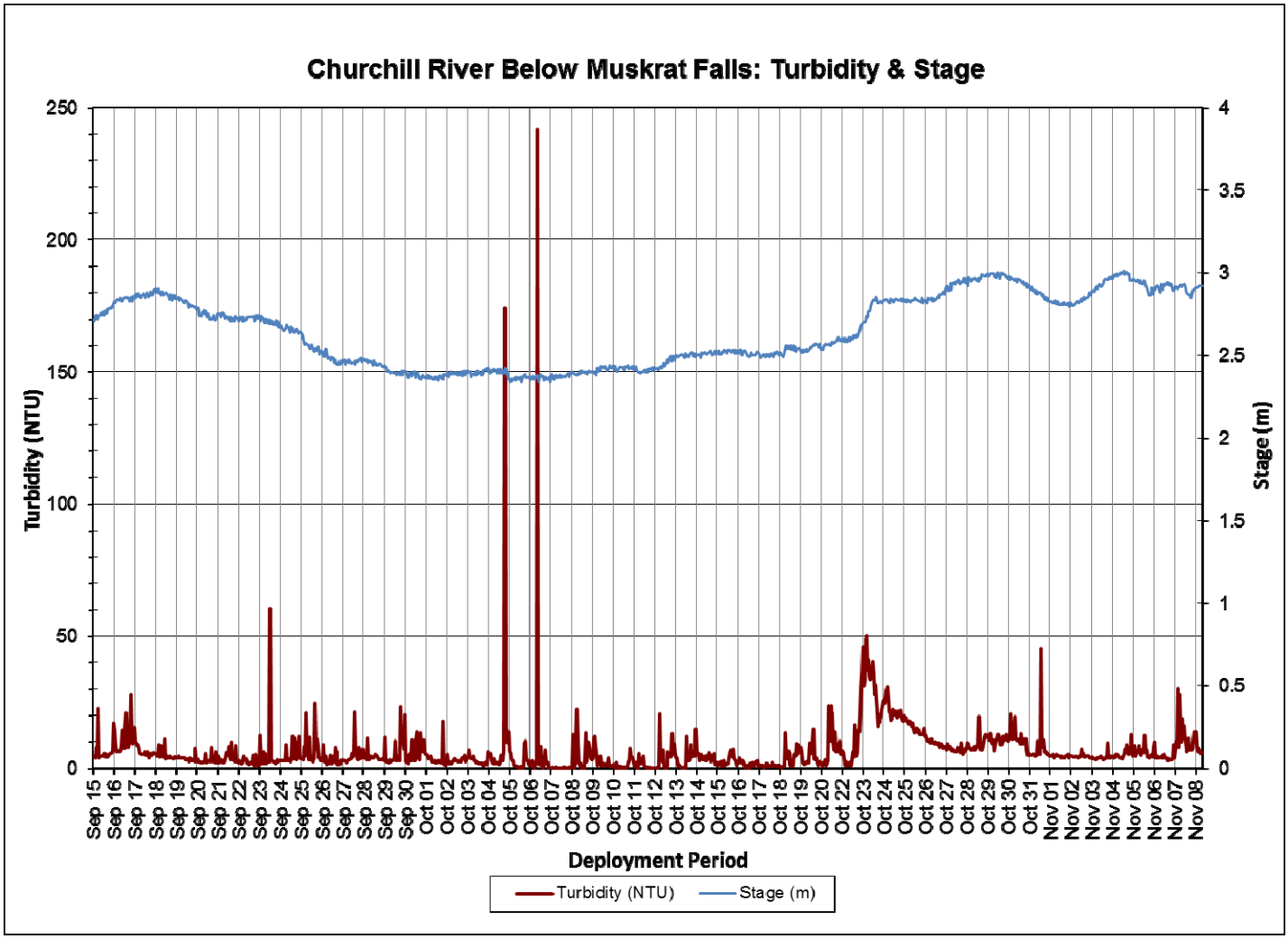

Figure 19: Turbidity & Stage at Churchill River below Muskrat Falls

Churchill River at English Point

This station suffered significant transmission losses which resulted in data gaps for this deployment period.

Water Temperature

- Water temperature ranges from 1.70°C to 12.70°C with a median value of 8.10°C (Figure 20).
- Water temperatures are generally decreasing into the fall and winter months. This trend is mirrored by the average daily air temperature values.

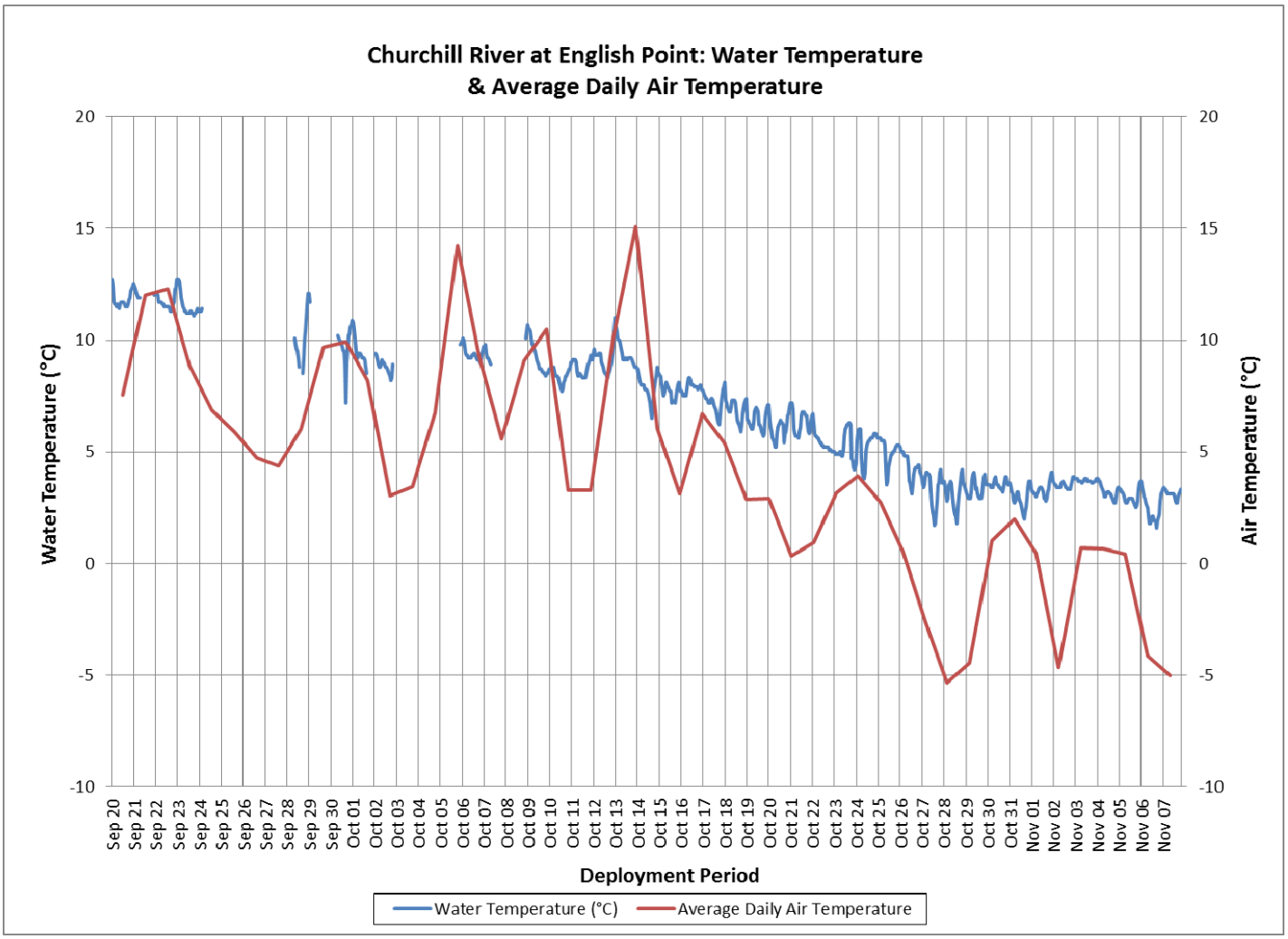

Figure 20: Water Temperature & Daily Average Air Temperature (Mud Lake Weather Station) at Churchill River at English Point

pH

- pH ranges between 6.29 and 7.32 pH units with a median value of 6.90 (Figure 21).
- The majority of pH values recorded during this deployment are above the minimum CCME Guideline for Protection of Aquatic Life. Values dip slightly below the guideline October 24 to November 8, likely due to the large influx of freshwater from large precipitation events on October 23/24 which brought over 36mm to the area (Mud Lake Weather Station). Large amounts of precipitation, which is generally more acidic, can decrease pH at a station.

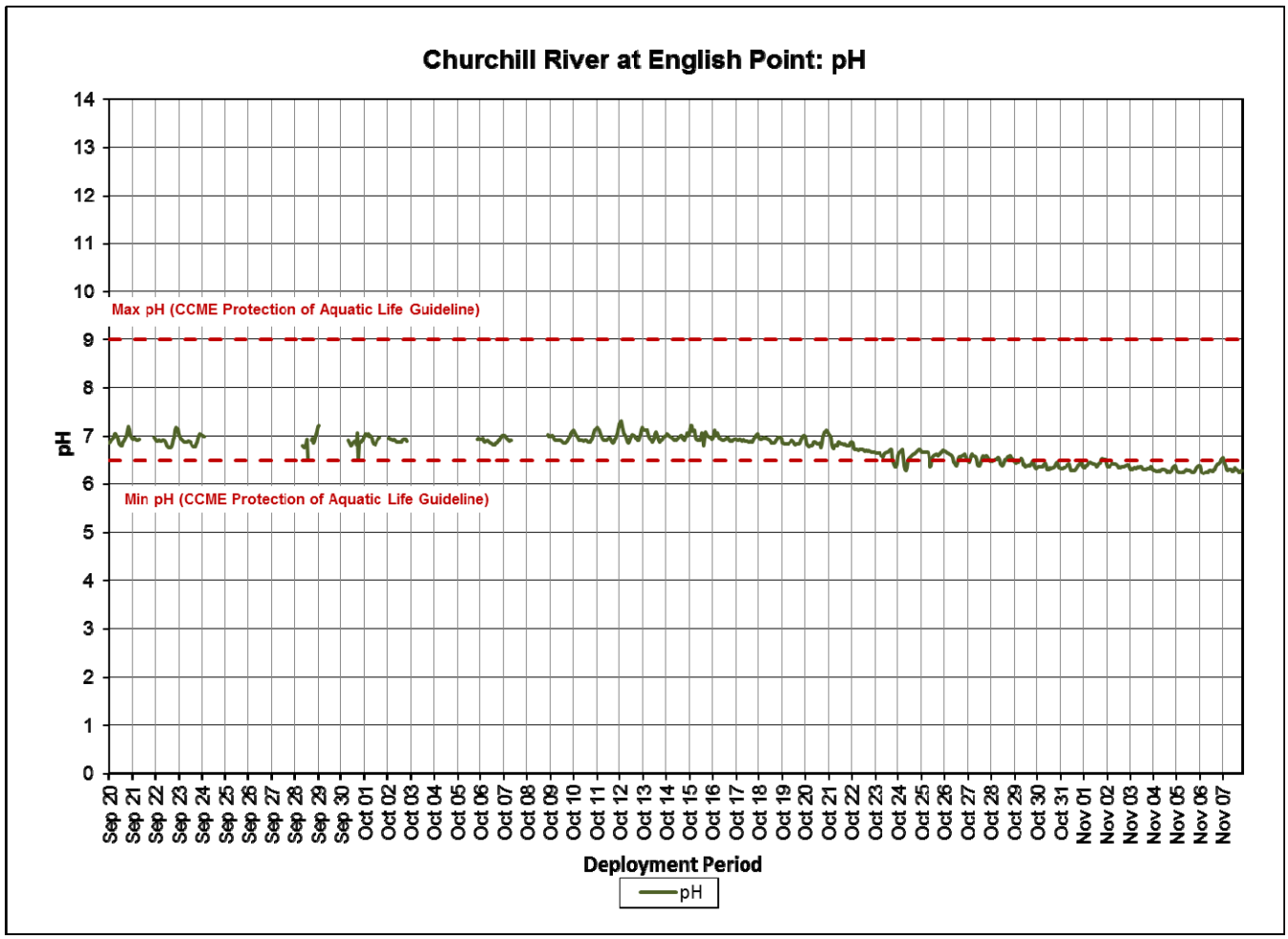

Figure 21: pH at Churchill River at English Point Station

Specific Conductivity and TDS

- Specific conductance ranges between 18.6µS/cm and 67.8µs/cm during the deployment period, with a median of 36.1µS/cm (Figure 22).
- TDS ranges between 0.0119 g/mL to 0.0434 g/mL during the deployment period, with a median of 0.0231 g/mL (Figure 22).
- 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 22). A variation in this pattern exists October 22-23, when significant precipitation was added to the system.
- 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.

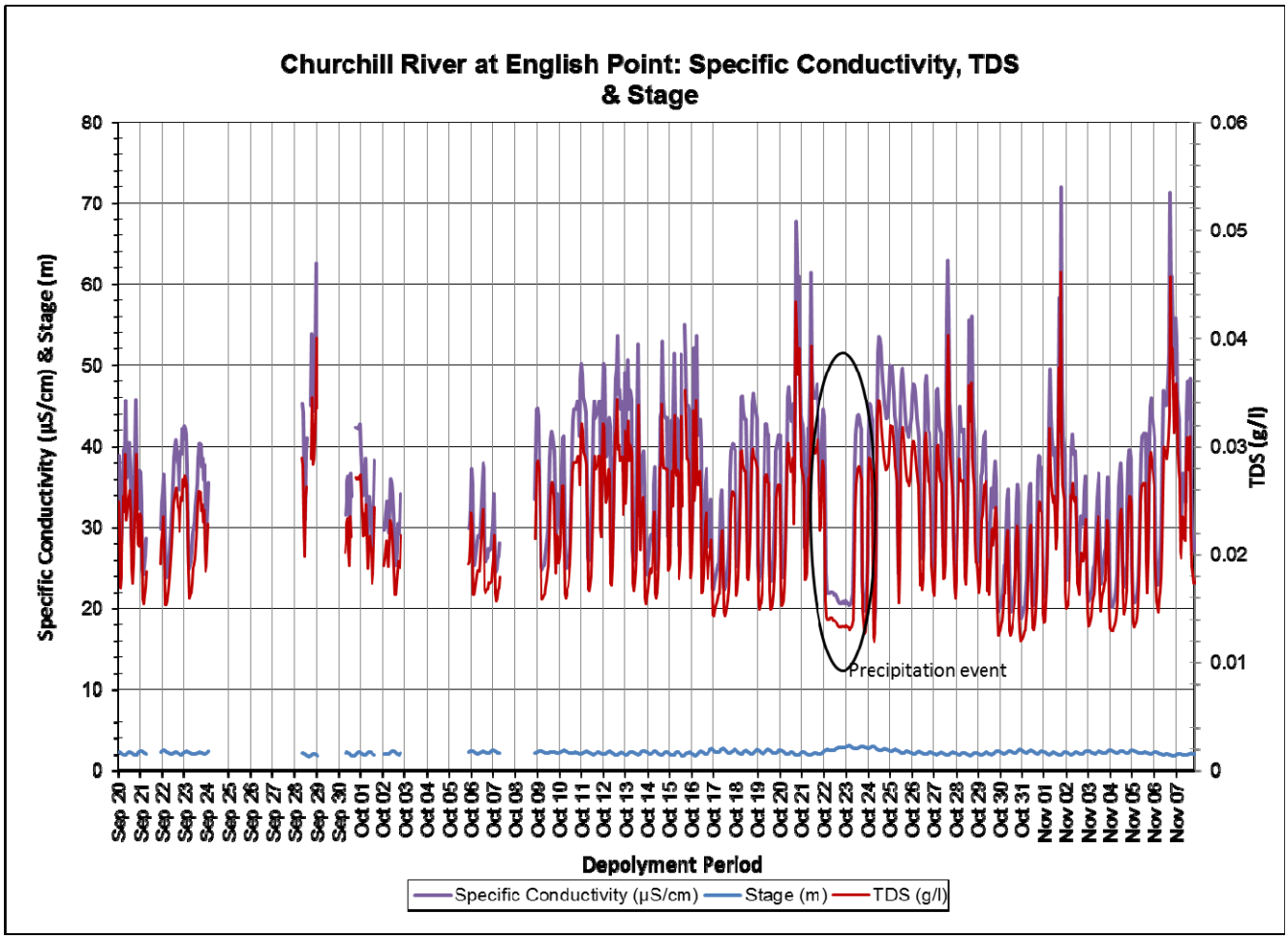

Figure 22: Specific Conductivity & TDS at Churchill River at English Point Station

Dissolved Oxygen

- Dissolved oxygen content ranged between 10.08mg/l and 13.80mg/l during the deployment period with a median value of 11.77mg/L. The saturation of dissolved oxygen ranged from 89.8% to 110.7% with a median value of 98.5% (Figure 23).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period the dissolved oxygen levels are slowly rising as temperatures fall into the winter season. Generally, there is more dissolved oxygen present in a waterbody during cooler temperatures. The dissolved oxygen also follows a diurnal pattern as the water temperature rises and falls under the influence of the ambient air temperature. A variation in this pattern exists October 22-23, when significant precipitation was added to the system.
- The dissolved oxygen levels remained above the CCME Guidelines for the Protection of Early and Other Life Stages throughout the deployment period (Figure 23).

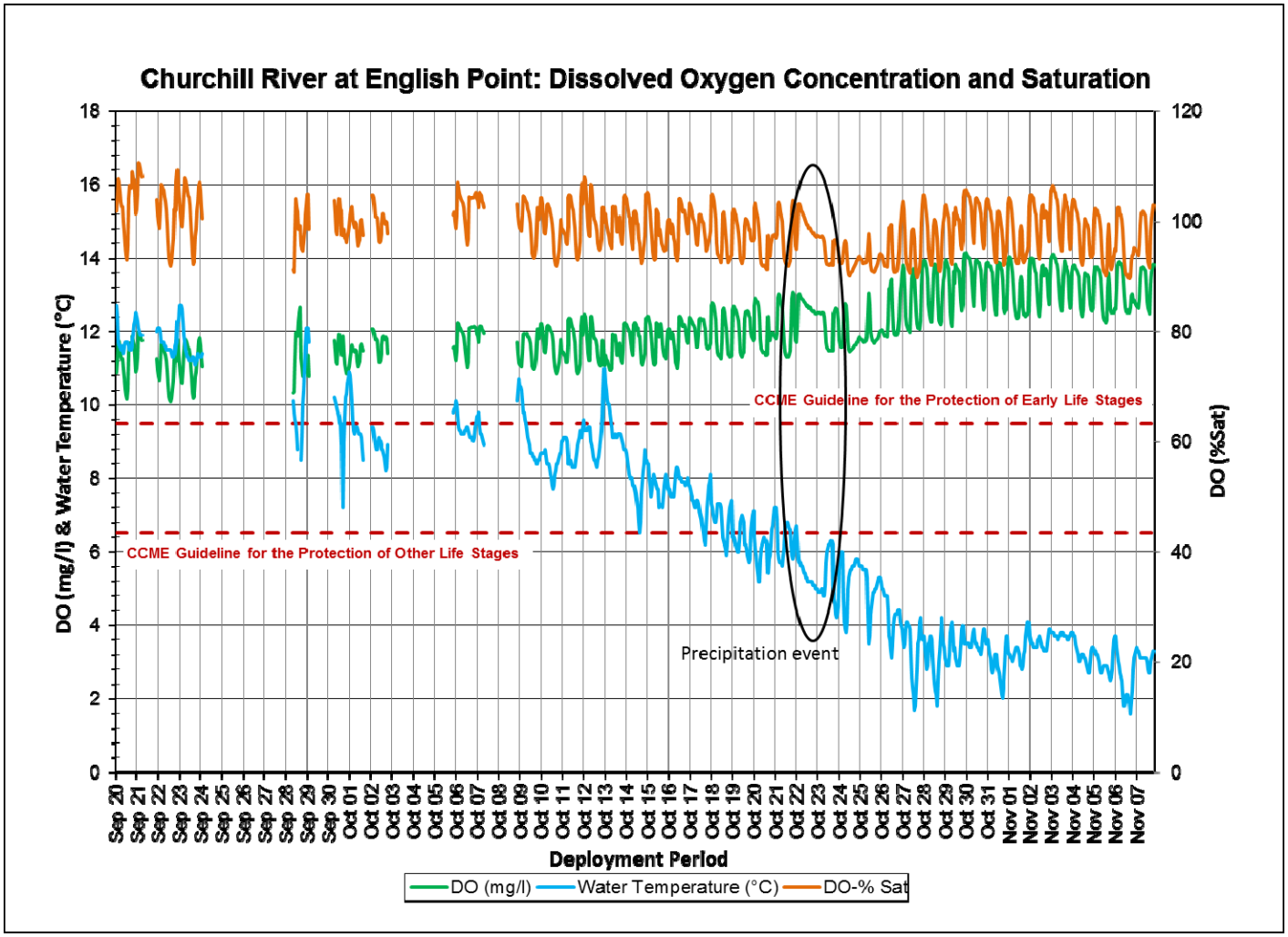

Figure 23: Dissolved Oxygen at Churchill River at English Point Station

Stage, Flow, Turbidity & Precipitation

- Turbidity ranges from 0.0NTU to 138.7NTU during the deployment period, with a median value of 7.3NTU (Figure 24).
- Numerous 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 24).
- Precipitation occurs on 27 of the days in the deployment period and amounts are generally low, with the exception of the 36.1mm of precipitation on received October 23/24 (Figure 24). An increase in stage is very evident at this time.
- 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 25). Tidal action may also suspend material into the water column, causing spikes in turbidity.
- Stage ranges between 1.74m and 3.06m, with a median value of 2.18m (Figure 25).
- 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.

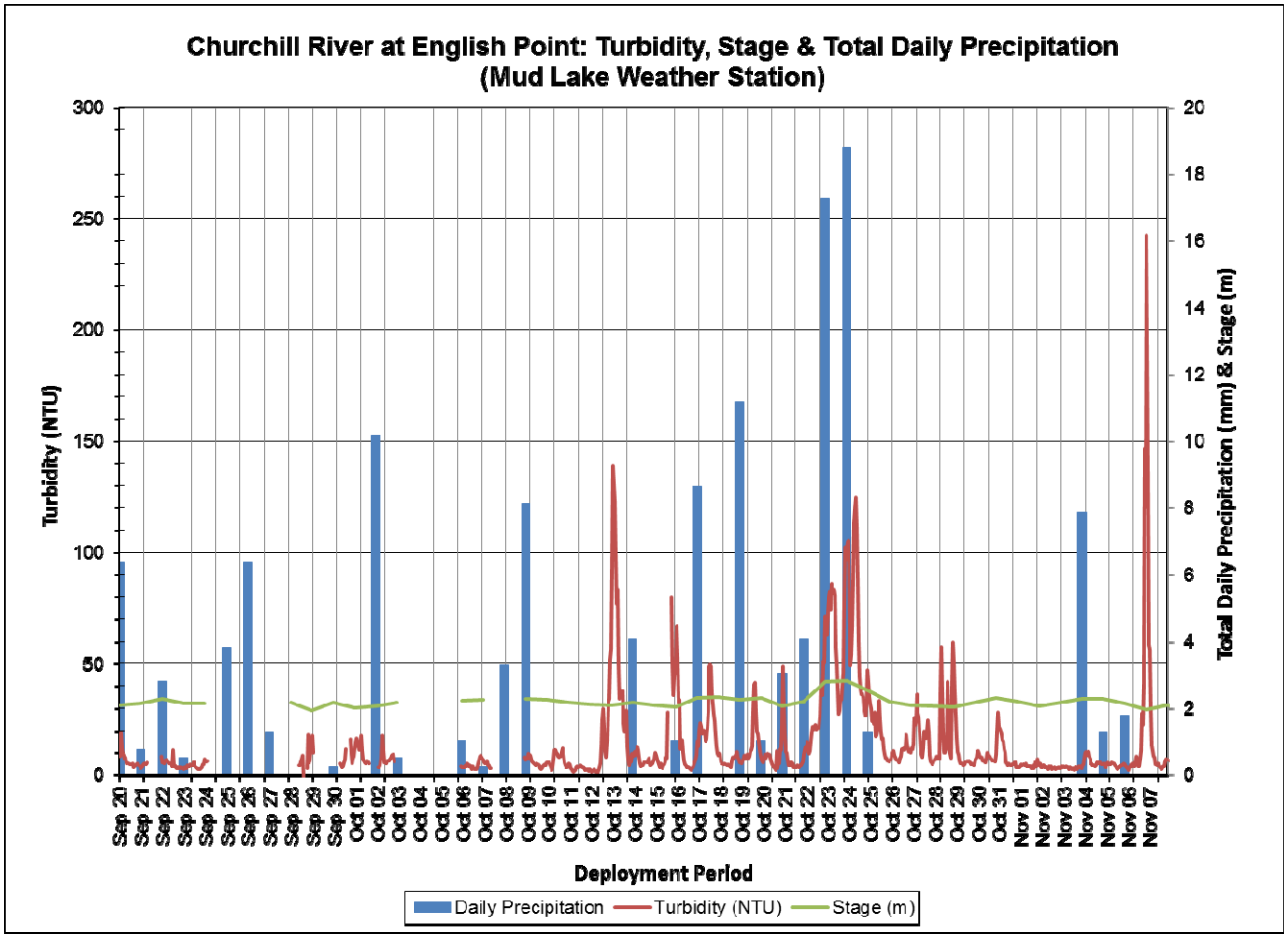

Figure 24: Turbidity, Stage & Total Precipitation (Mud Lake Weather Station) at Churchill River at English Point Station

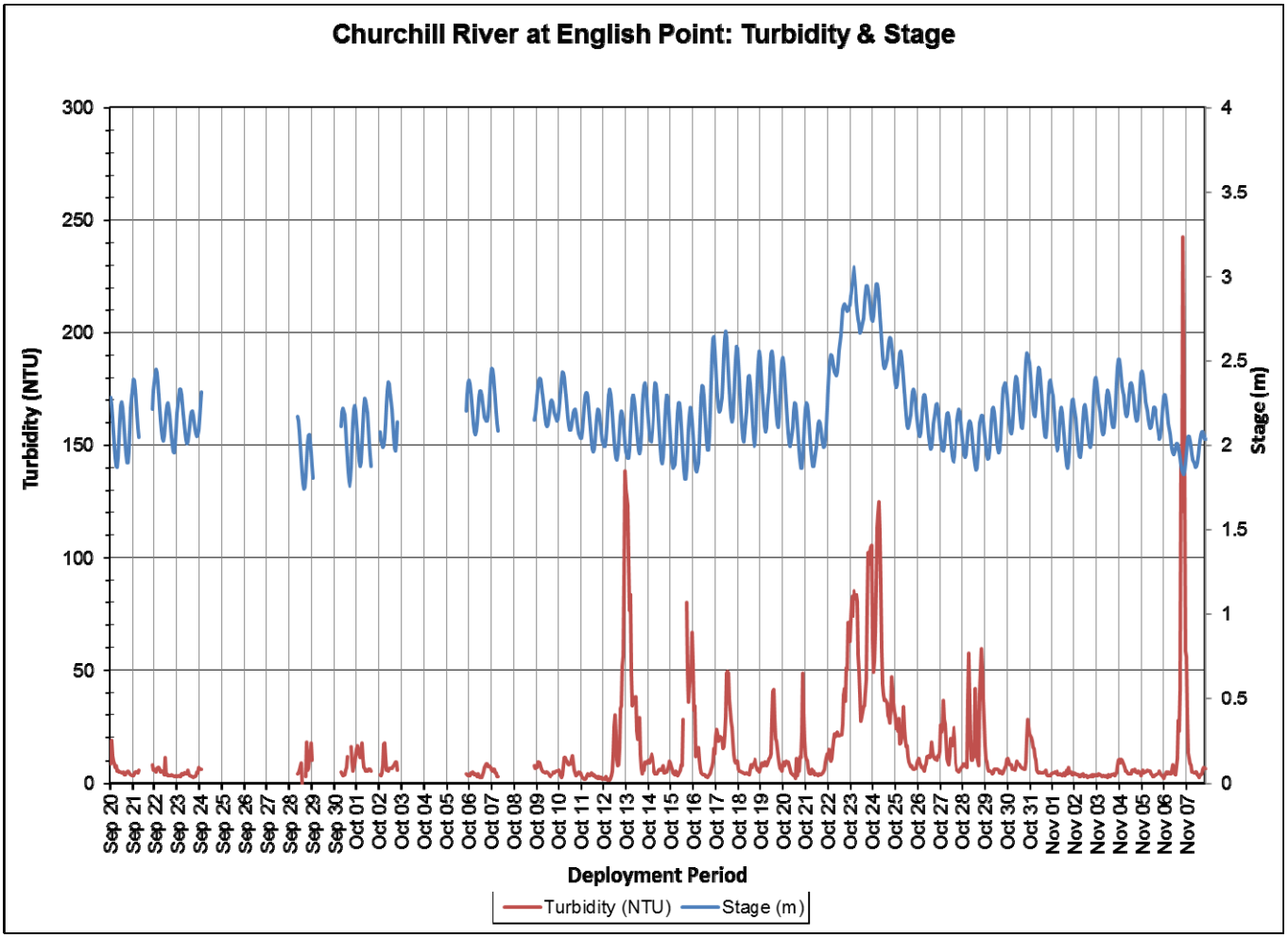

Figure 25: Turbidity & Stage at Churchill River at English Point Station

Conclusions

- Instruments at four water quality monitoring stations on the Lower Churchill River were deployed between September 15/20 and October 11, 26 or November 8, for periods of 26-53 days.
- Stage levels are generally stable at all stations, but increased when large precipitation events brought rain to the system. Water level changes at each of the stations ranged between 0.40m and 1.32m.
- Water temperature was steadily decreasing at all stations, mirroring ambient air temperatures as they cooled into the fall and winter months. Water temperatures typically ranged between 1.70°C and 13.30°C.
- pH remained within the CCME guidelines for the Protection of Aquatic Life at the below Grizzle Rapids and above Muskrat Falls stations. pH at these stations was relatively neutral and stable. During this deployment, the pH at the below Muskrat Falls station stayed above the guideline for the majority of the deployment before dropping below, likely due to sensor drift. At English Point, pH remained within the guidelines for the majority of the deployment, but dropped below after a large influx of freshwater into the system from precipitation.
- Specific conductivity was relatively stable, with all stations deployed being affected by a large precipitation event on October23/24. The stations below Grizzle Rapids, above upper Muskrat Falls and below Muskrat Falls showed little variation in conductivity values, ranging from 14.7µS/cm to 22.9µS/cm, while at English Point, values ranged higher, 18.6µS/cm to 67.8µS/cm as the station is influenced by the tides in Lake Melville.
- Dissolved oxygen was generally increasing steadily throughout the deployment period at all stations as water temperatures cooled into the winter months and could hold more oxygen. Values ranged between 10.08mg/l and 14.99mg/l and were all above the minimum CCME Guidelines for the Protection of Aquatic Life.
- Turbidity information for below Grizzle Rapids was inaccurate and removed from the dataset. At the other three stations, turbidity events were mainly related to precipitation events and corresponding increases in stage. Turbidity at all stations ranged from 0.0 to 241.7NTU, with median values ranging from 1.1NTU to 7.3NTU. There was a notable increase in turbidity on October 5th at both the above Upper Muskrat Falls and below Lower Muskrat Falls stations which did not correlate with precipitation. The cause of this increase is unknown.

References

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  - 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.
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- YSI a Xylem Brand. The Basics of Chlorophyll Measurement. Accessed December 9, 2015.
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- An Introduction to Algae Measurements Using In Vivo Fluoresces. Accessed December 9, 2015.\
  - 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

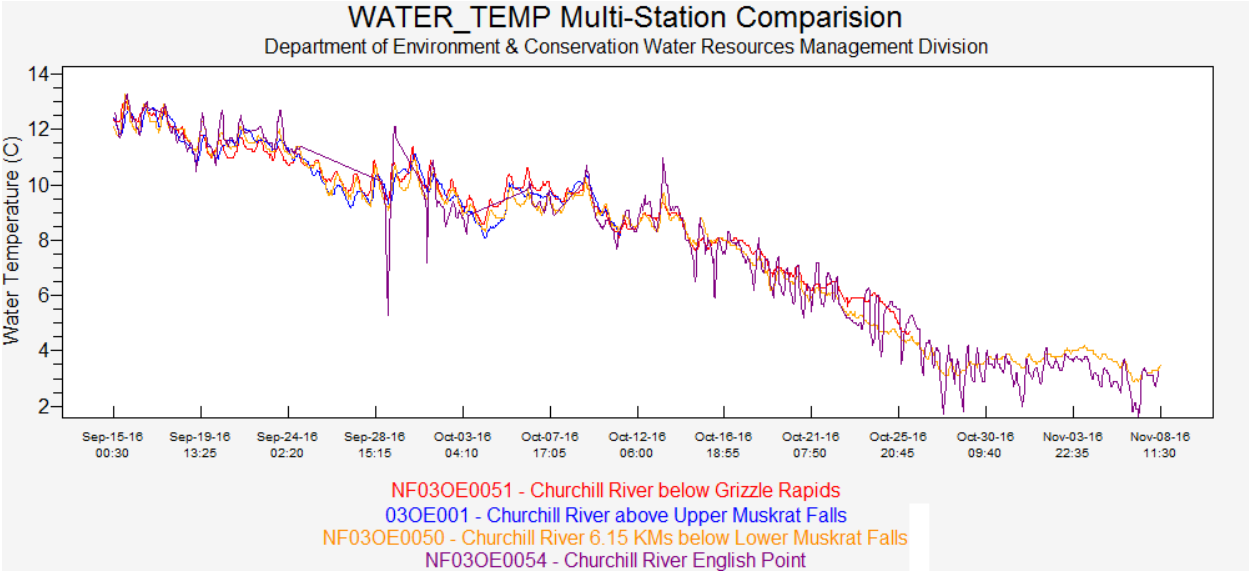

Figure A1: Comparison of Water Temperature at the Real-Time Stations on Churchill River

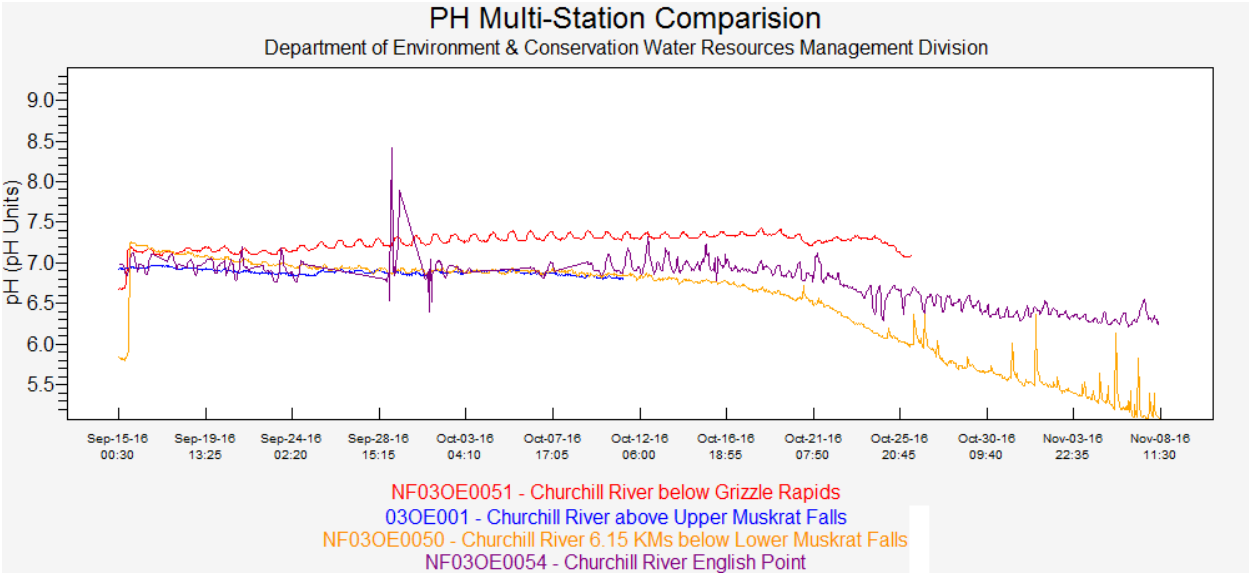

Figure A2: Comparison of pH at the Real-Time Stations on Churchill River

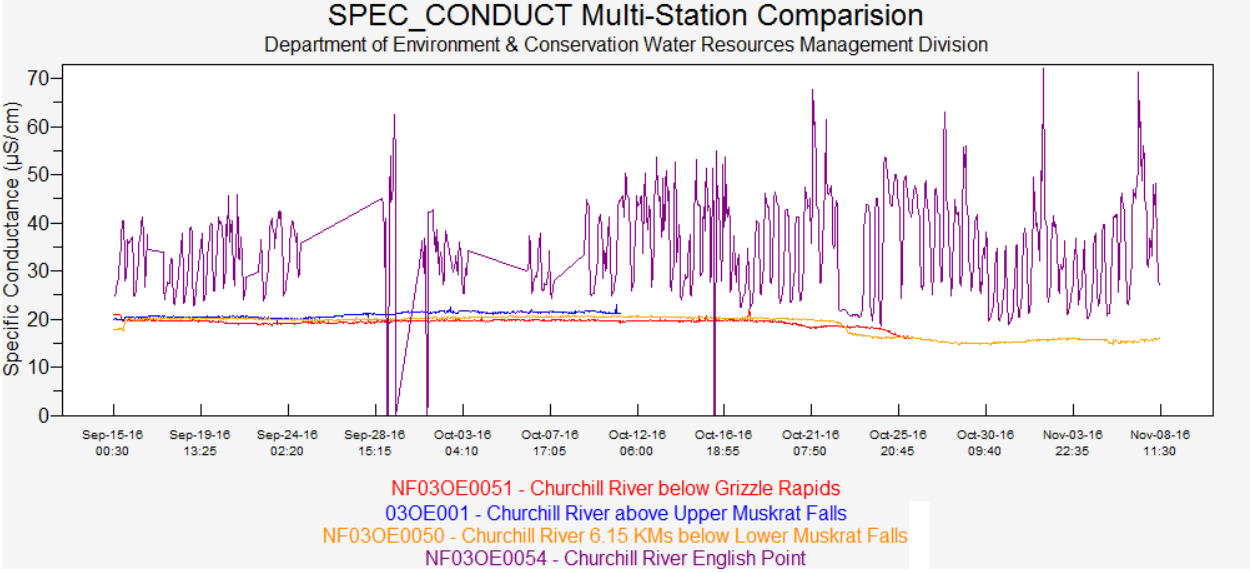

Figure A3: Comparison of Specific Conductivity at the Real-Time Stations on Churchill River

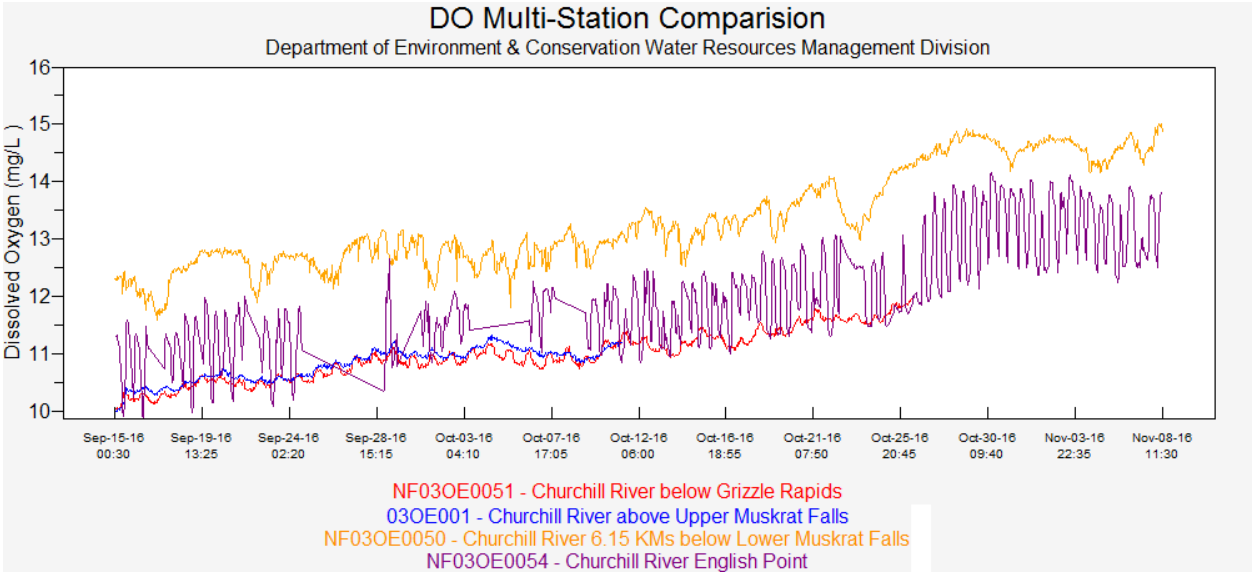

Figure A4: Comparison of Dissolved Oxygen at the Real-Time Stations on Churchill River

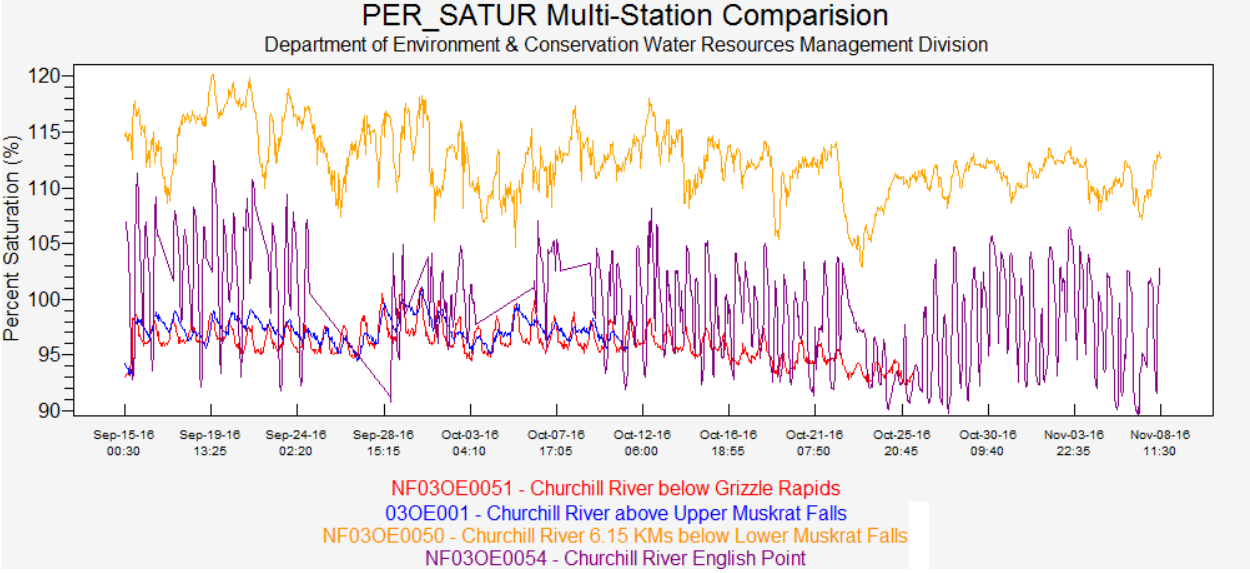

Figure A5: Comparison of Dissolved Oxygen (% Sat) at the Real-Time Stations on Churchill River

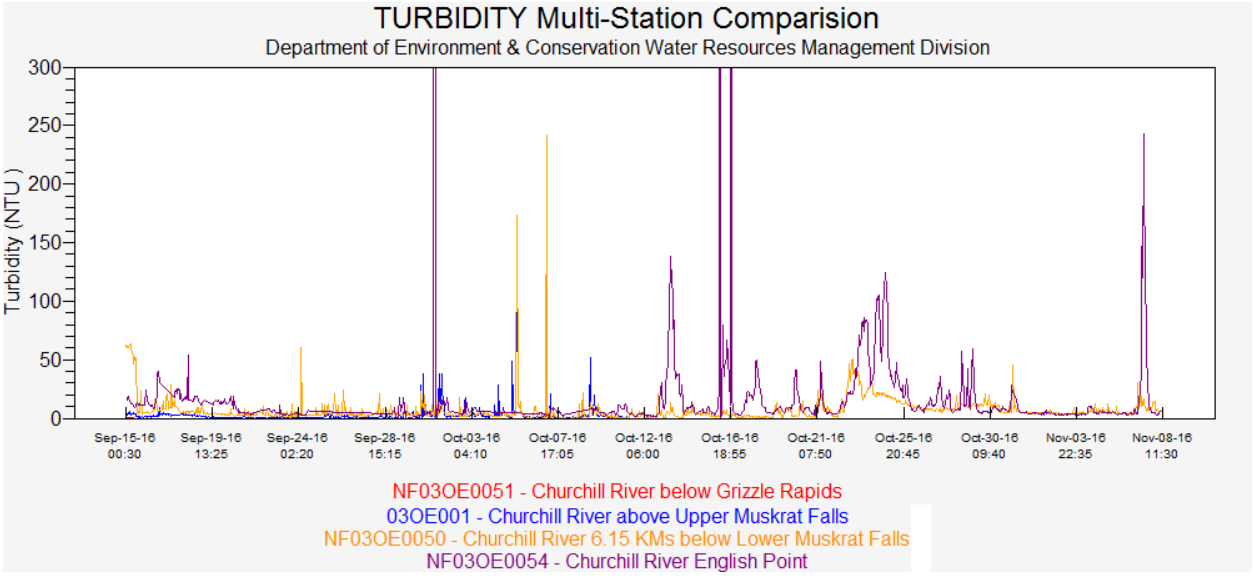

Figure A6: Comparison of Turbidity at the Real-Time Stations on Churchill River

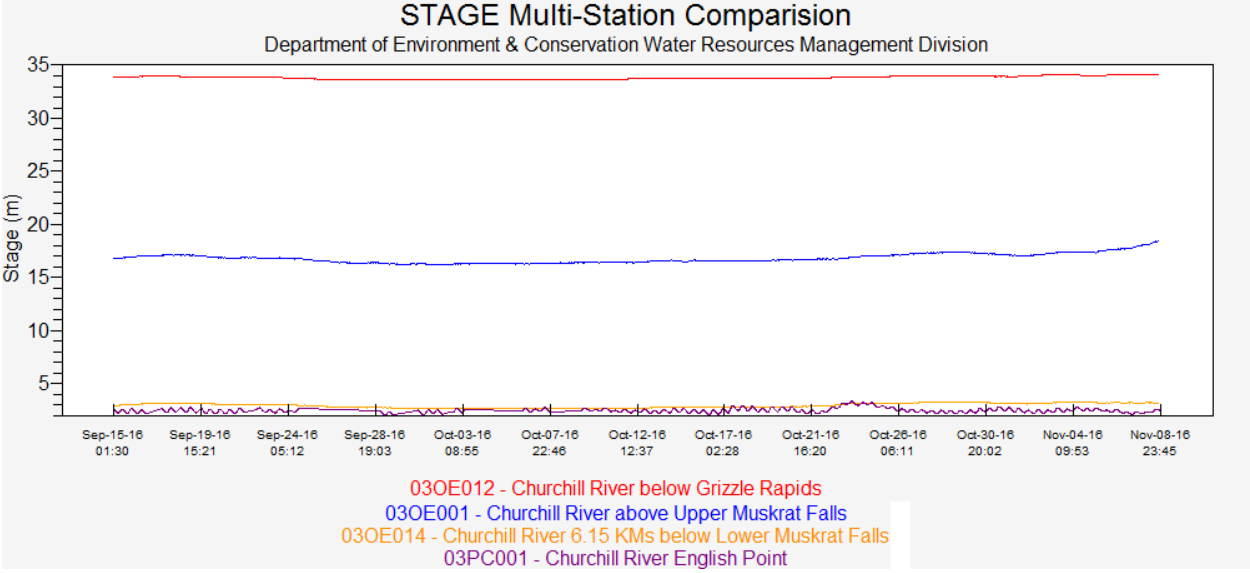

Figure A7: Comparison of Stage at the Real-Time Stations on Churchill River

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 (^oC)* 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.

	Rating				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (^{o}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 Descriptions

- ***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 CO_2 (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 25ºC. 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

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Maxxam Job #: B6K1294
Report Date: 2016/09/29

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

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
DCG330 Grizzle Rapids								
Sampling Date 2016/09/15 10:50								
Matrix W								
Sample # 2016-6328-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	13	1.0	mg/L	N/A	2016/09/28	2016/09/28		4668181
Hardness (CaCO3)	9.8	1.0	mg/L	N/A	2016/09/23	2016/09/23		4668177
Nitrate (N)	<0.050	0.050	mg/L	N/A	2016/09/28	2016/09/28		4668180
Inorganics								
Conductivity	19	1.0	uS/cm	N/A	2016/09/22	2016/09/22	JMV	4671231
Bromide (Br-)	<1.0	1.0	mg/L	N/A	2016/09/26	2016/09/26	FD	4673791
Total Alkalinity (Total as CaCO3)	9.1	5.0	mg/L	N/A	2016/09/27	2016/09/27	MCN	4676005
Dissolved Chloride (Cl)	<1.0	1.0	mg/L	N/A	2016/09/27	2016/09/27	MCN	4676008
Colour	24	5.0	TCU	N/A	2016/09/27	2016/09/27	MCN	4676011
Dissolved Fluoride (F-)	<0.10	0.10	mg/L	N/A	2016/09/22	2016/09/22	JMV	4671232
Total Kjeldahl Nitrogen (TKN)	0.19	0.10	mg/L	+/- <RDL	2016/09/23	2016/09/27	AAY	4673857
Nitrite (N)	<0.010	0.010	mg/L	N/A	2016/09/28	2016/09/28	MCN	4676014
Nitrogen (Ammonia Nitrogen)	<0.050	0.050	mg/L	N/A	2016/09/23	2016/09/23	MCN	4670052
Dissolved Organic Carbon (C)	4.1	0.50	mg/L	N/A	2016/09/26	2016/09/26	SMT	4675954
Total Organic Carbon (C)	4.5	0.50	mg/L	N/A	2016/09/26	2016/09/26	SMT	4675769
pH	7.24	N/A	pH	N/A	2016/09/22	2016/09/22	JMV	4671230
Total Phosphorus	0.005	0.004	mg/L	+/- 0.004	2016/09/23	2016/09/23	SNR	4673372
Dissolved Sulphate (SO4)	<2.0	2.0	mg/L	N/A	2016/09/27	2016/09/27	MCN	4676009
Turbidity	0.77	0.10	NTU	N/A	2016/09/23	2016/09/23	JMV	4671271
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	<0.000013	0.000013	mg/L	N/A	2016/09/23	2016/09/26	ARS	4673228
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	0.051	0.0050	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Antimony (Sb)	<0.0010	0.0010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Arsenic (As)	<0.0010	0.0010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Barium (Ba)	0.0083	0.0010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Boron (B)	<0.050	0.050	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Cadmium (Cd)	<0.000010	0.000010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Calcium (Ca)	2.4	0.10	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Chromium (Cr)	<0.0010	0.0010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Copper (Cu)	<0.0020	0.0020	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Iron (Fe)	0.13	0.050	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Lead (Pb)	<0.00050	0.00050	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Magnesium (Mg)	0.91	0.10	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Manganese (Mn)	0.010	0.0020	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Nickel (Ni)	<0.0020	0.0020	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Potassium (K)	0.44	0.10	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Selenium (Se)	<0.0010	0.0010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Sodium (Na)	0.65	0.10	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Strontium (Sr)	0.013	0.0020	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Uranium (U)	<0.00010	0.00010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Zinc (Zn)	<0.0050	0.0050	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498

Maxxam Analytics International Corporation o/a Maxxam Analytics 200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel: 902-420-0203 Toll-free: 800-565-7227 Fax: 902-420-8612 www.maxxamanalytics.com

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Maxxam Job #: B6K1308
Report Date: 2016/09/23

Department of Environment & Conservation
Site Location: CHURCHILL RIVER
Your P.O. #: 216009736

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
DCG383 Grizzle Rapids Sampling Date 2016/09/15 10:50 Matrix W Sample # 2016-6328-00-SI-SP Registration # WS-S-0000 **RESULTS OF ANALYSES OF WATER**								
Inorganics								
Total Suspended Solids	<1.0	1.0	mg/L	N/A	2016/09/21	2016/09/22	MM9	4669542

Maxxam Analytics International Corporation o/a Maxxam Analytics 200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel: 902-420-0203 Toll-free: 800-565-7227 Fax: 902-420-8612 www.maxxamanalytics.com

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Maxxam Job #: B6K1294
Report Date: 2016/09/29

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

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
DCG331 CR @ Upper MF								
Sampling Date 2016/09/15 13:00								
Matrix W								
Sample # 2016-6329-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	13	1.0	mg/L	N/A	2016/09/28	2016/09/28		4668181
Hardness (CaCO3)	9.8	1.0	mg/L	N/A	2016/09/23	2016/09/23		4668177
Nitrate (N)	<0.050	0.050	mg/L	N/A	2016/09/28	2016/09/28		4668180
Inorganics								
Conductivity	20	1.0	uS/cm	N/A	2016/09/22	2016/09/22	JMV	4671231
Bromide (Br-)	<1.0	1.0	mg/L	N/A	2016/09/26	2016/09/26	FD	4673791
Total Alkalinity (Total as CaCO3)	9.1	5.0	mg/L	N/A	2016/09/27	2016/09/27	MCN	4676005
Dissolved Chloride (Cl)	<1.0	1.0	mg/L	N/A	2016/09/27	2016/09/27	MCN	4676008
Colour	27	5.0	TCU	N/A	2016/09/27	2016/09/27	MCN	4676011
Dissolved Fluoride (F-)	<0.10	0.10	mg/L	N/A	2016/09/22	2016/09/22	JMV	4671232
Total Kjeldahl Nitrogen (TKN)	0.18	0.10	mg/L	+/- <RDL	2016/09/23	2016/09/27	AAY	4673857
Nitrite (N)	<0.010	0.010	mg/L	N/A	2016/09/28	2016/09/28	MCN	4676014
Nitrogen (Ammonia Nitrogen)	<0.050	0.050	mg/L	N/A	2016/09/23	2016/09/23	MCN	4670052
Dissolved Organic Carbon (C)	4.4	0.50	mg/L	N/A	2016/09/26	2016/09/26	SMT	4675954
Total Organic Carbon (C)	4.6	0.50	mg/L	N/A	2016/09/26	2016/09/26	SMT	4675769
pH	7.32	N/A	pH	N/A	2016/09/22	2016/09/22	JMV	4671230
Total Phosphorus	0.016	0.004	mg/L	+/- 0.005	2016/09/23	2016/09/23	SNR	4673372
Dissolved Sulphate (SO4)	<2.0	2.0	mg/L	N/A	2016/09/27	2016/09/27	MCN	4676009
Turbidity	5.0	0.10	NTU	N/A	2016/09/23	2016/09/23	JMV	4671271
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	0.000013	0.000013	mg/L	N/A	2016/09/23	2016/09/29	ARS	4677688
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	0.29	0.0050	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Antimony (Sb)	<0.0010	0.0010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Arsenic (As)	<0.0010	0.0010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Barium (Ba)	0.012	0.0010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Boron (B)	<0.050	0.050	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Cadmium (Cd)	<0.000010	0.000010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Calcium (Ca)	2.5	0.10	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Chromium (Cr)	<0.0010	0.0010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Copper (Cu)	<0.0020	0.0020	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Iron (Fe)	0.42	0.050	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Lead (Pb)	<0.00050	0.00050	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Magnesium (Mg)	0.90	0.10	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Manganese (Mn)	0.022	0.0020	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Nickel (Ni)	<0.0020	0.0020	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Potassium (K)	0.49	0.10	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Selenium (Se)	<0.0010	0.0010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Sodium (Na)	0.77	0.10	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Strontium (Sr)	0.013	0.0020	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Uranium (U)	<0.00010	0.00010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Zinc (Zn)	<0.0050	0.0050	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498

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Maxxam Job #: B6K1308
Report Date: 2016/09/23

Department of Environment & Conservation
Site Location: CHURCHILL RIVER
Your P.O. #: 216009736

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
DCG384 CR @ Upper MF								
Sampling Date 2016/09/15 13:00								
Matrix W								
Sample # 2016-6329-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Inorganics								
Total Suspended Solids	7.8	1.0	mg/L	N/A	2016/09/21	2016/09/22	MM9	4669542

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Maxxam Job #: B6K1294
Report Date: 2016/09/29

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

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
DCG332 CR below MF								
Sampling Date 2016/09/15 14:10								
Matrix W								
Sample # 2016-6330-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	14	1.0	mg/L	N/A	2016/09/28	2016/09/28		4668181
Hardness (CaCO3)	9.4	1.0	mg/L	N/A	2016/09/23	2016/09/23		4668177
Nitrate (N)	<0.050	0.050	mg/L	N/A	2016/09/28	2016/09/28		4668180
Inorganics								
Conductivity	19	1.0	uS/cm	N/A	2016/09/22	2016/09/22	JMV	4671231
Bromide (Br-)	<1.0	1.0	mg/L	N/A	2016/09/26	2016/09/26	FD	4673791
Total Alkalinity (Total as CaCO3)	9.3	5.0	mg/L	N/A	2016/09/27	2016/09/27	MCN	4676005
Dissolved Chloride (Cl)	1.0	1.0	mg/L	N/A	2016/09/27	2016/09/27	MCN	4676008
Colour	27	5.0	TCU	N/A	2016/09/27	2016/09/27	MCN	4676011
Dissolved Fluoride (F-)	<0.10	0.10	mg/L	N/A	2016/09/22	2016/09/22	JMV	4671232
Total Kjeldahl Nitrogen (TKN)	0.19	0.10	mg/L	+/- <RDL	2016/09/23	2016/09/27	AAY	4673857
Nitrite (N)	<0.010	0.010	mg/L	N/A	2016/09/28	2016/09/28	MCN	4676014
Nitrogen (Ammonia Nitrogen)	<0.050	0.050	mg/L	N/A	2016/09/23	2016/09/23	MCN	4670052
Dissolved Organic Carbon (C)	4.3	0.50	mg/L	N/A	2016/09/26	2016/09/26	SMT	4675954
Total Organic Carbon (C)	4.6	0.50	mg/L	N/A	2016/09/26	2016/09/26	SMT	4675769
pH	7.33	N/A	pH	N/A	2016/09/22	2016/09/22	JMV	4671230
Total Phosphorus	0.011	0.004	mg/L	+/- 0.005	2016/09/23	2016/09/23	SNR	4673372
Dissolved Sulphate (SO4)	<2.0	2.0	mg/L	N/A	2016/09/27	2016/09/27	MCN	4676009
Turbidity	5.4	0.10	NTU	N/A	2016/09/23	2016/09/23	JMV	4671271
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	0.000013	0.000013	mg/L	N/A	2016/09/23	2016/09/29	ARS	4677688
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	0.27	0.0050	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Antimony (Sb)	<0.0010	0.0010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Arsenic (As)	<0.0010	0.0010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Barium (Ba)	0.010	0.0010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Boron (B)	<0.050	0.050	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Cadmium (Cd)	0.000015	0.000010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Calcium (Ca)	2.4	0.10	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Chromium (Cr)	<0.0010	0.0010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Copper (Cu)	<0.0020	0.0020	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Iron (Fe)	0.32	0.050	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Lead (Pb)	<0.00050	0.00050	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Magnesium (Mg)	0.86	0.10	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Manganese (Mn)	0.013	0.0020	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Nickel (Ni)	<0.0020	0.0020	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Potassium (K)	0.43	0.10	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Selenium (Se)	<0.0010	0.0010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Sodium (Na)	0.73	0.10	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Strontium (Sr)	0.013	0.0020	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Uranium (U)	<0.00010	0.00010	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498
Total Zinc (Zn)	<0.0050	0.0050	mg/L	N/A	2016/09/21	2016/09/22	BAN	4669498

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Maxxam Job #: B6K1308
Report Date: 2016/09/23

Department of Environment & Conservation
Site Location: CHURCHILL RIVER
Your P.O. #: 216009736

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
DCG412 CR below MF								
Sampling Date 2016/09/15 14:10								
Matrix W								
Sample # 2016-6330-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Inorganics								
Total Suspended Solids	8.4	1.0	mg/L	N/A	2016/09/21	2016/09/22	MM9	4669542

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Maxxam Job #: B6K6046
Report Date: 2016/10/12

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
DDB525 CR @ English Point								
Sampling Date 2016/09/20 14:45								
Matrix W								
Sample # 2016-6332-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	26	1.0	mg/L	N/A	2016/10/06	2016/10/06		4675802
Hardness (CaCO3)	11	1.0	mg/L	N/A	2016/09/28	2016/09/28		4675795
Nitrate (N)	<0.050	0.050	mg/L	N/A	2016/10/06	2016/10/06		4675798
Inorganics								
Conductivity	37	1.0	uS/cm	N/A	2016/09/28	2016/09/28	JMV	4679094
Bromide (Br-)	<1.0	1.0	mg/L	N/A	2016/09/29	2016/09/29	FD	4680428
Total Alkalinity (Total as CaCO3)	12	5.0	mg/L	N/A	2016/10/04	2016/10/04	MCN	4687073
Dissolved Chloride (Cl)	5.3	1.0	mg/L	N/A	2016/10/05	2016/10/05	MCN	4687074
Colour	55	25	TCU	N/A	2016/10/04	2016/10/04	MCN	4687077
Dissolved Fluoride (F-)	<0.10	0.10	mg/L	N/A	2016/09/28	2016/09/28	JMV	4679095
Total Kjeldahl Nitrogen (TKN)	0.11	0.10	mg/L	+/- <RDL	2016/09/28	2016/09/29	AAY	4679730
Nitrite (N)	<0.010	0.010	mg/L	N/A	2016/10/05	2016/10/05	MCN	4687080
Nitrogen (Ammonia Nitrogen)	0.052	0.050	mg/L	N/A	2016/10/03	2016/10/03	MCN	4685665
Dissolved Organic Carbon (C)	5.3	0.50	mg/L	N/A	2016/10/04	2016/10/04	SMT	4687304
Total Organic Carbon (C)	5.4	0.50	mg/L	N/A	2016/10/04	2016/10/04	SMT	4686115
pH	7.11	N/A	pH	N/A	2016/09/28	2016/09/28	JMV	4679093
Total Phosphorus	0.021	0.008	mg/L	+/- <RDL	2016/09/29	2016/09/30	SNR	4681877
Dissolved Sulphate (SO4)	<2.0	2.0	mg/L	N/A	2016/10/05	2016/10/05	MCN	4687075
Turbidity	13	0.10	NTU	N/A	2016/09/28	2016/09/28	JMV	4679142
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	<0.000013	0.000013	mg/L	N/A	2016/10/03	2016/10/04	ARS	4685869
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	0.53	0.0050	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Antimony (Sb)	<0.0010	0.0010	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Arsenic (As)	<0.0010	0.0010	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Barium (Ba)	0.013	0.0010	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Boron (B)	<0.050	0.050	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Cadmium (Cd)	<0.000010	0.000010	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Calcium (Ca)	2.3	0.10	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Chromium (Cr)	0.0013	0.0010	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Copper (Cu)	<0.0020	0.0020	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Iron (Fe)	0.88	0.050	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Lead (Pb)	<0.00050	0.00050	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Magnesium (Mg)	1.2	0.10	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Manganese (Mn)	0.033	0.0020	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Nickel (Ni)	<0.0020	0.0020	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Potassium (K)	0.67	0.10	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Selenium (Se)	<0.0010	0.0010	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Sodium (Na)	4.2	0.10	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Strontium (Sr)	0.018	0.0020	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Uranium (U)	<0.00010	0.00010	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349
Total Zinc (Zn)	<0.0050	0.0050	mg/L	N/A	2016/09/27	2016/09/27	BAN	4677349

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Maxxam Job #: B6K6040
Report Date: 2016/10/03

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

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
DDB501 CR @ English Point Sampling Date 2016/09/20 14:45 Matrix W Sample # 2016-6332-00-SI-SP Registration # WS-S-0000 **RESULTS OF ANALYSES OF WATER** **Inorganics**								
Total Suspended Solids	14	1.0	mg/L	N/A	2016/09/27	2016/10/03	MM9	4677506

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