Real-Time Water Quality Deployment Report

Lower Churchill River Network

August 3 to September 15, 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 August 3/4, 2016, real-time water quality monitoring instruments were deployed at all four stations on the Lower Churchill River for periods of 42-46 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

	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 August 3/4, to September 15/20, 2016 are summarized in Table 2.

Table 2: Comparison rankings for Lower Churchill River stations August 3/4 to September 15/20, 2016

Churchill River Station and Instrument Number	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Grizzle Rapids (45709)	August 3, 2016	Deployment	Fair	Excellent	Excellent	Excellent	Excellent
	Sept. 15, 2016	Removal	Good	Excellent	Excellent	Good	Excellent
Above upper Muskrat Falls (47590)	August 3, 2016	Deployment	Excellent	Excellent	Excellent	Excellent	Good
	Sept 15, 2016	Removal	Excellent	Excellent	Excellent	Good	Excellent
Below Muskrat Falls (45700)	August 3, 2016	Deployment	Excellent	Good	Excellent	Excellent	N/A
	Sept 15, 2016	Removal	Good	Fair	Excellent	Excellent	N/A
At English Point (45699)	August 4, 2016	Deployment	Excellent	Good	Good	Excellent	Excellent
	Sept 20, 2016	Removal	Good	Excellent	Excellent	Fair	Excellent

- At the station below Grizzle Rapids, pH, conductivity, dissolved oxygen, and turbidity all rank as 'excellent' at deployment. Temperature ranks as 'fair'. The field temperature value was 17.70C and the QA/QC value was 17.19C. 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 and dissolved oxygen all rank 'excellent' while turbidity ranked 'good' at deployment. Upon removal, temperature, pH, conductivity and turbidity all rank 'excellent' while dissolved oxygen ranks as 'good'.
- Upon deployment at the below Muskrat Falls station, temperature, conductivity and dissolved oxygen ranked 'excellent' while pH ranked 'good'. Turbidity was not ranked as there was an issue with the turbidity sensor leading to inaccurate data which has been removed from the dataset. Upon removal, the temperature, conductivity and dissolved oxygen sensors ranked 'good' or excellent and pH ranked 'fair'. The field pH reading was 6.40 while the QAQC reading was 7.02. This is discrepancy is likely due to sensor drift.
- At the station at English Point, temperature, pH, conductivity, turbidity and dissolved oxygen all rank as 'excellent' or 'good' upon deployment. Upon removal, pH, conductivity, and turbidity ranked as 'excellent', temperature ranked as 'good' and dissolved oxygen ranked as 'fair'. The field reading for dissolved oxygen was 10.63 mg/L while the QAQC reading was 10.00 mg/L. The discrepancy in the readings is likely due to the QAQC being recorded before the sonde had acclimated.

Data Interpretation

- The following graphs and discussion illustrate water quality related events occurring from August 3/4 to September 15/20, 2016 on the Lower Churchill River Network.
- 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 station at English Point has been experiencing transmission losses due to a GPS issue, resulting in gaps within the data.
- On August 3, the Churchill River was diverted at the Muskrat Falls dam, located upstream of the below Lower Muskrat Falls and at English Point stations. This diversion directed the water through the spillway for the first time. The Department of Environment and Climate Change was notified ahead of the water release of the potential for sedimentation downstream.
- A landslide occurred at the below Grizzle Rapids station sometime between August 18 and September 15, 2016. The landslide narrowly missed the water quality instrumentation, but may have affected water quality at this station for a short time.
- A backup instrument was deployed at Muskrat Island, downstream of the below Muskrat Falls station, to ensure that any water quality events in the area would be captured. Data from Muskrat Island has been used to supplement the below Muskrat Falls station data when necessary.

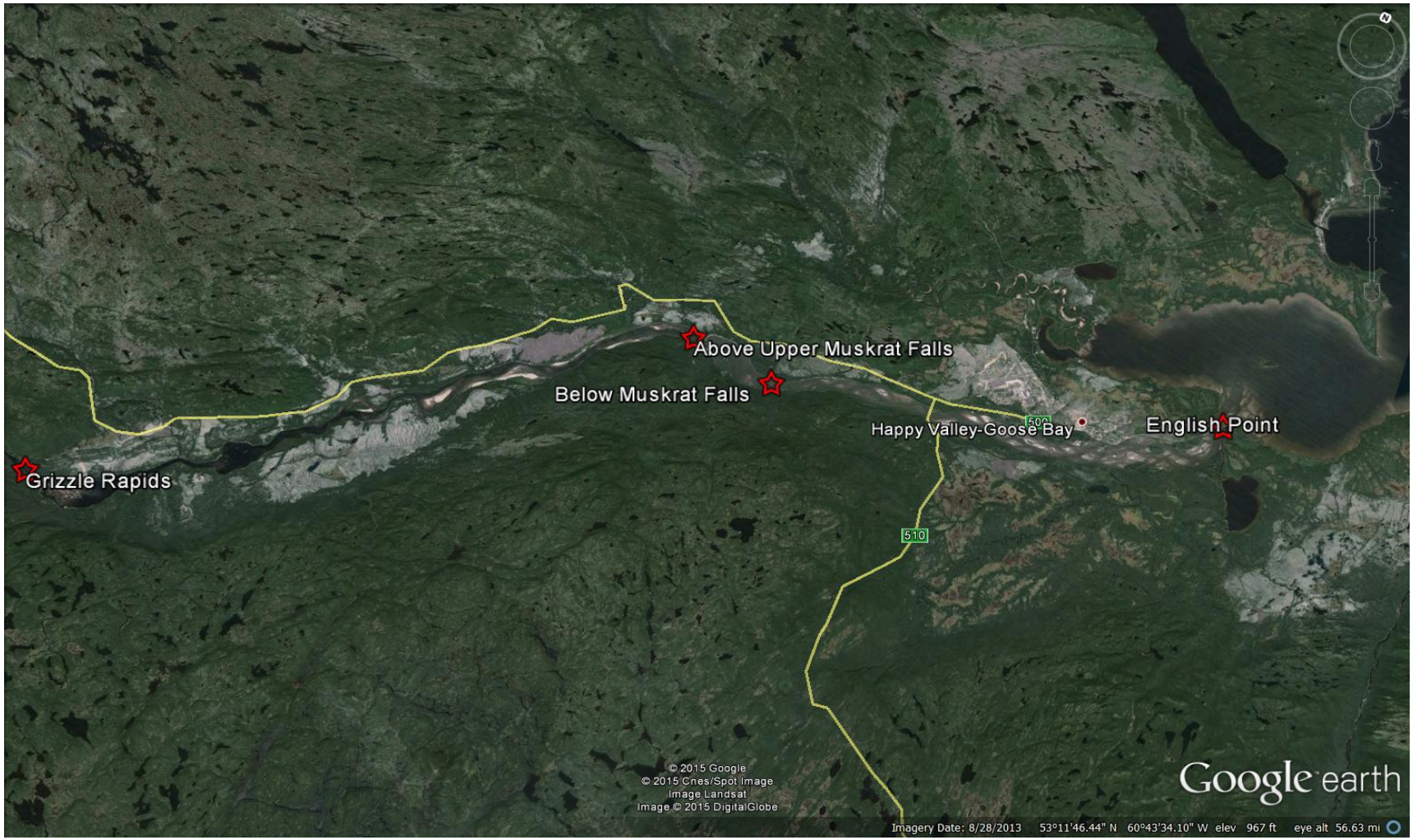

Figure 1: Lower Churchill Network- Station Locations

Churchill River below Grizzle Rapids

Water Temperature

- Water temperature ranges from 12.30°C to 18.20°C with a median value of 15.90°C (Figure 2).
- Water temperatures are generally stable early to mid-August, before starting to decrease late August into September. This trend is expected as water temperatures begin to cool late summer and into the fall months. This trend is mirrored by the average daily air temperature values.

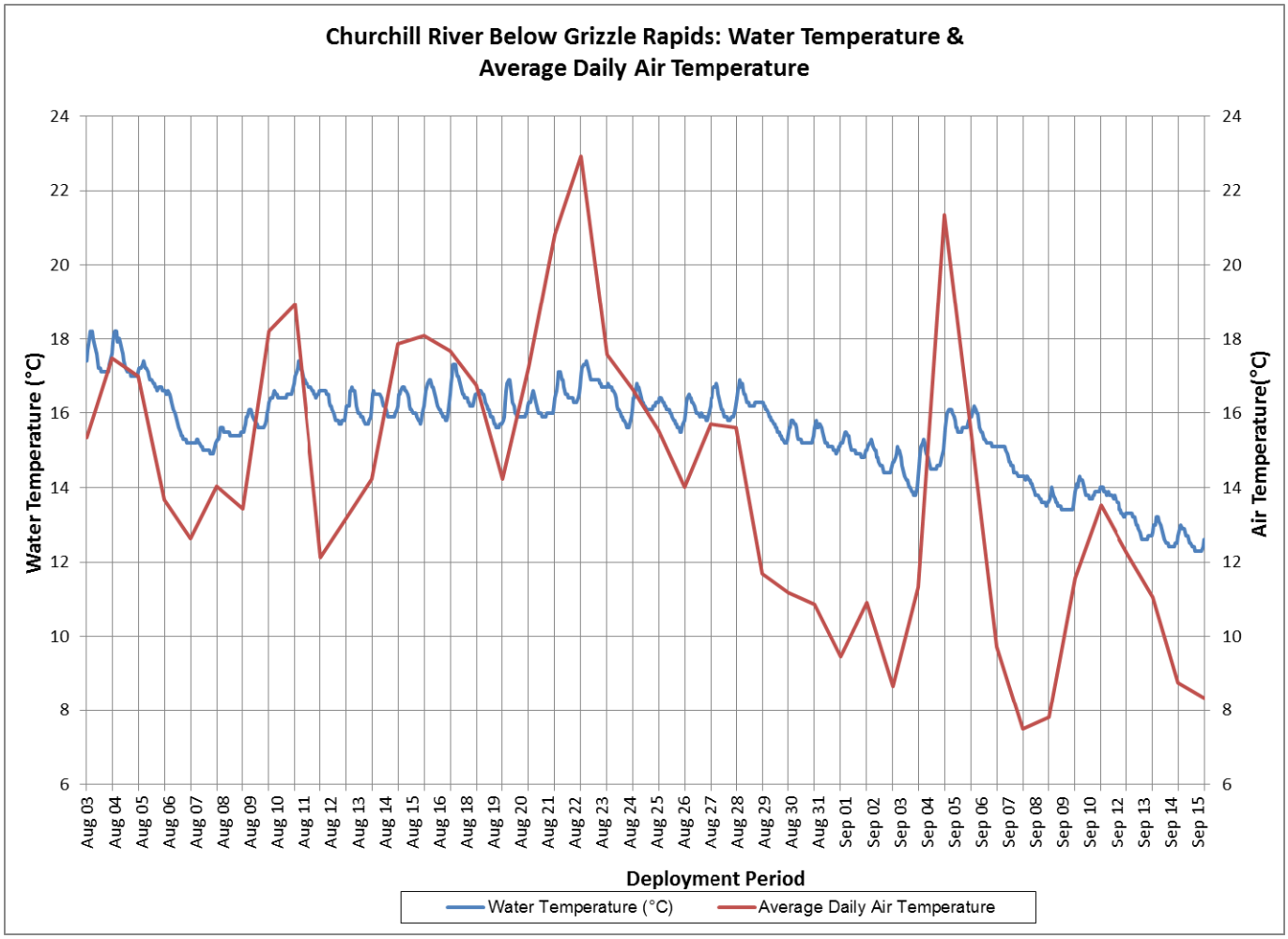

Figure 2: Water Temperature & Daily Average Air Temperature (Muskrat Falls Weather Station) at Churchill River below Grizzle Rapids

pH

- pH ranges between 6.48 and 6.95 pH units with a median value of 6.80 (Figure 3).
- pH values are stable and fall within the CCME Protection of Aquatic Life Guidelines. The only exception is when pH dropped to 6.48 after a significant rainfall on August 6/7.
- 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.

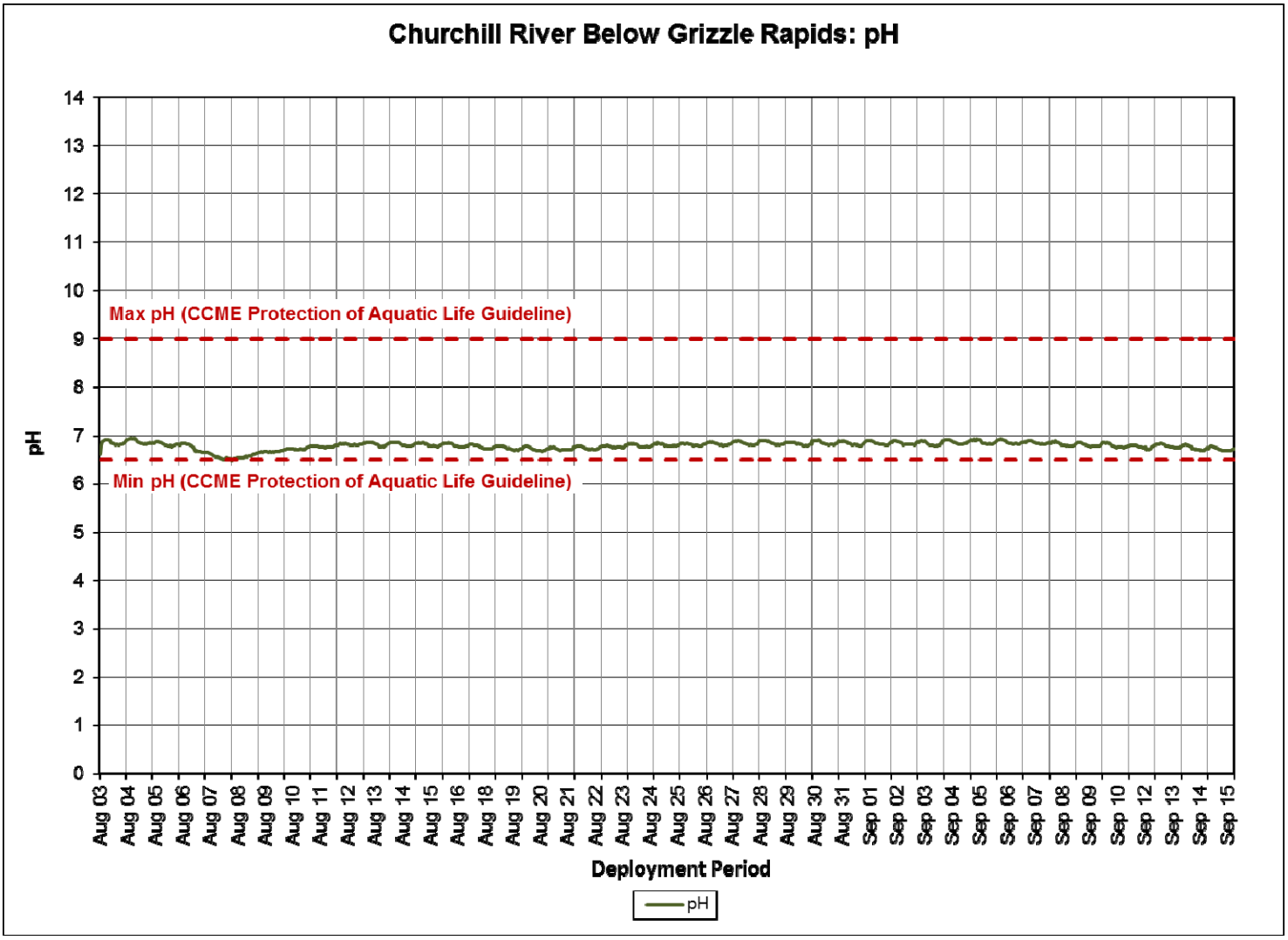

Figure 3: pH at Churchill River below Grizzle Rapids

Specific Conductivity, TDS and Stage

- Specific conductivity ranges from 16.4µS/cm to 21.2µS/cm with a median of 19.7µS/cm (Figure 4).
- TDS (total dissolved solids) ranges from 0.0105 g/L to 0.0135 g/L with a median of 0.0126 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. There is one notable event where conductivity and TDS decreased significantly after a large precipitation event on August 6/7.
- 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.

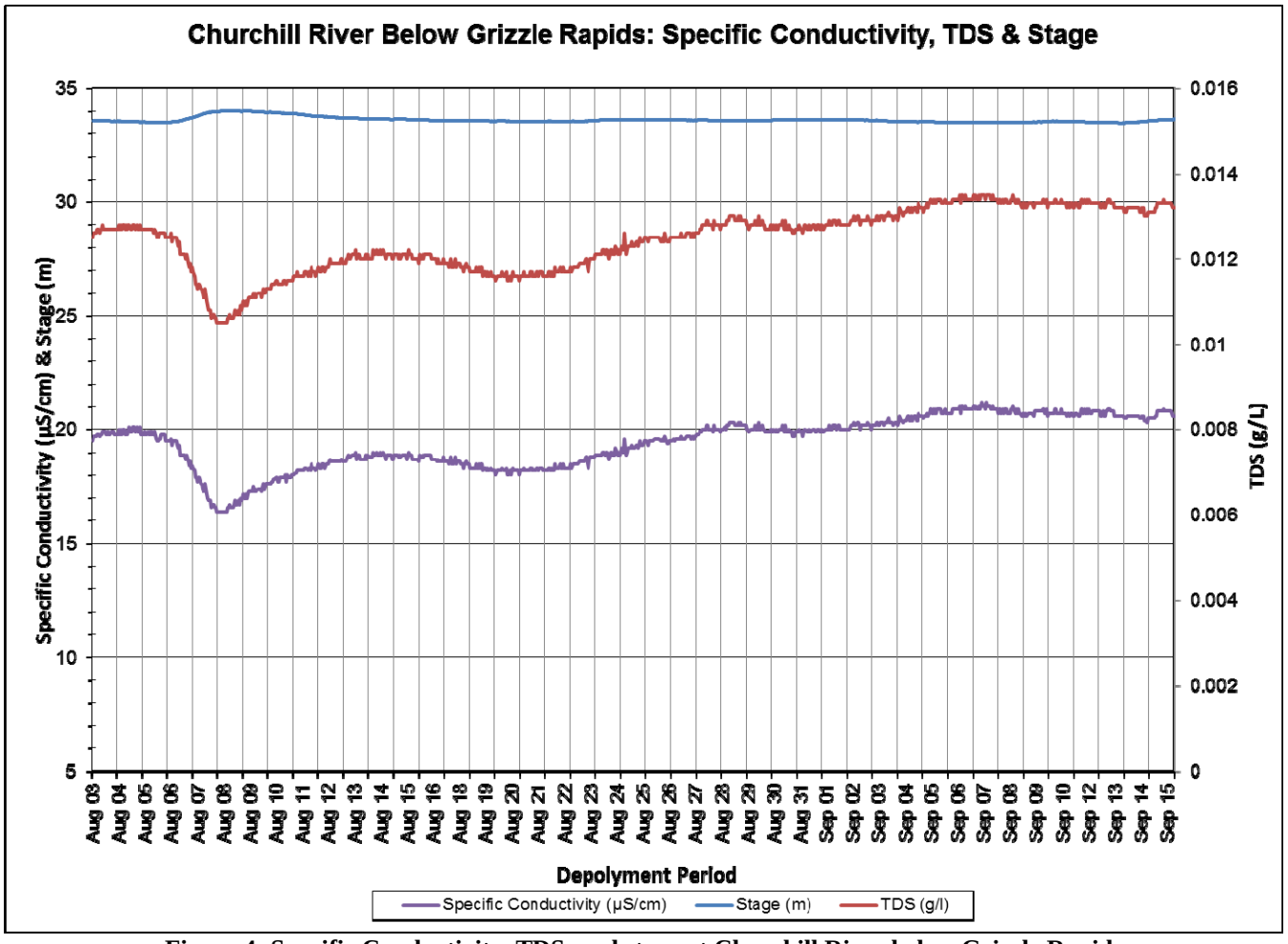

Figure 4: Specific Conductivity, TDS, and stage at Churchill River below Grizzle Rapids

Dissolved Oxygen

- Dissolved oxygen content ranges between 9.12mg/l and 10.15mg/l with a median value of 9.43mg/l. The saturation of dissolved oxygen ranges from 91.5% to 98.3% with a median value of 94.3% (Figure 5).
- There is an evident relationship between water temperature and dissolved oxygen. At the end of the deployment period the dissolved oxygen levels are slowly rising as water temperatures drop into the fall 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 hovered around the CCME Guideline for the Protection of Early Life Stages for the majority of the deployment. As water temperatures began to drop in September, the dissolved oxygen increased above the early life stages guideline.

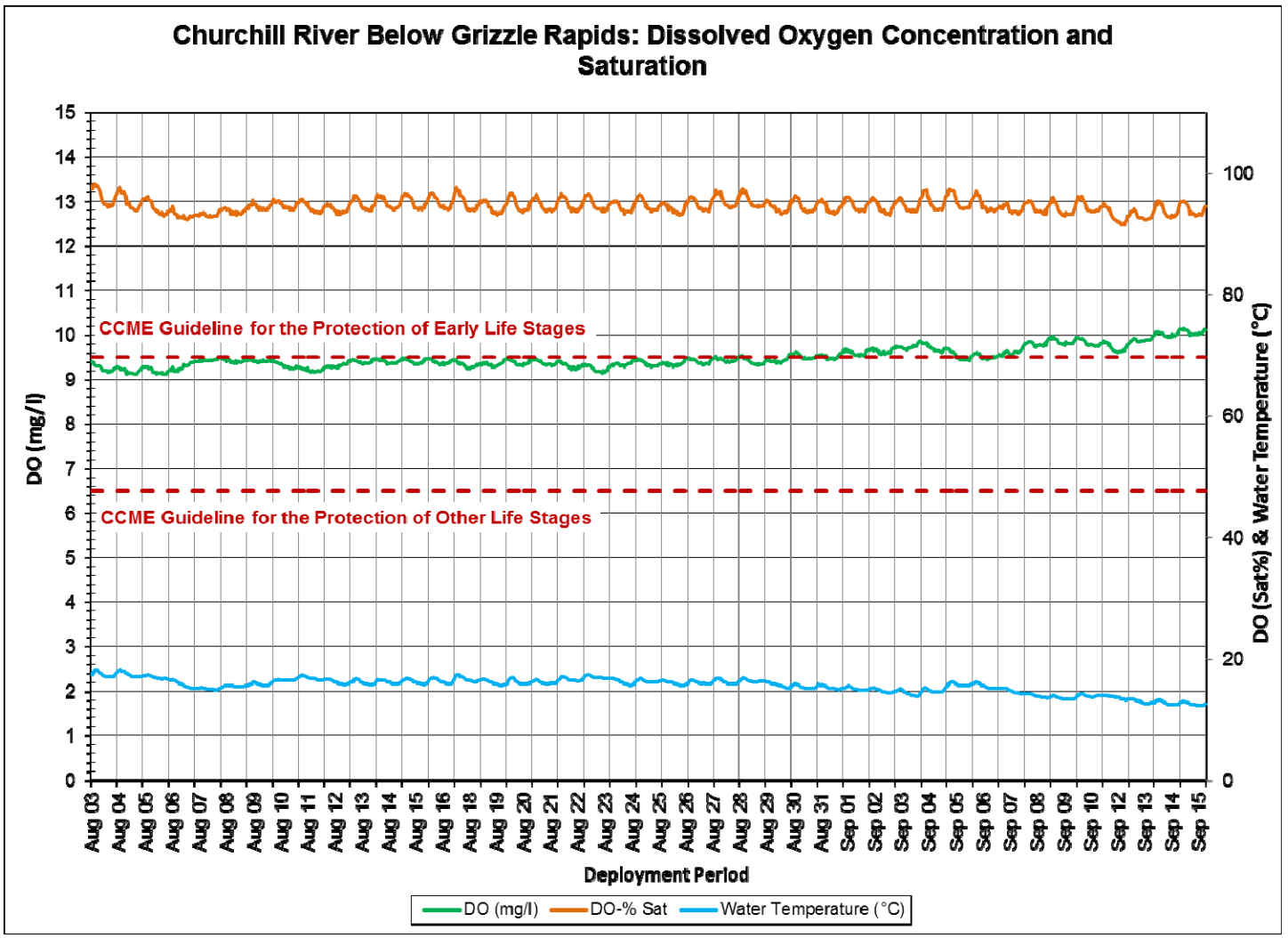

Figure 5: Dissolved Oxygen at Churchill River below Grizzle Rapids

Turbidity, Stage & Total Daily Precipitation

- Turbidity ranges between 0.0NTU and 17.0NTU with a median value of 0.2NTU (Figure 6). A median value near zero indicates this station has low background turbidity.
- The majority of turbidity events in the deployment period correlate to precipitation events. Precipitation can increase the presence of suspended material in water. There is a period from August 4th to 8th where turbidity increased for a few days before returning to background levels. This increase was likely caused by sediment suspension as stage increased at the same time after a series of precipitation events (Figure 7).
- A landslide occurred at the station sometime between August 18 and September 15, 2016, narrowly missing the water quality instrumentation (see Appendix E for photos). There is little turbidity evident in this period, other than the spike on September 1, which may be evidence of the landslide at that time.
- Stage ranges between 33.48m and 34.01m (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.

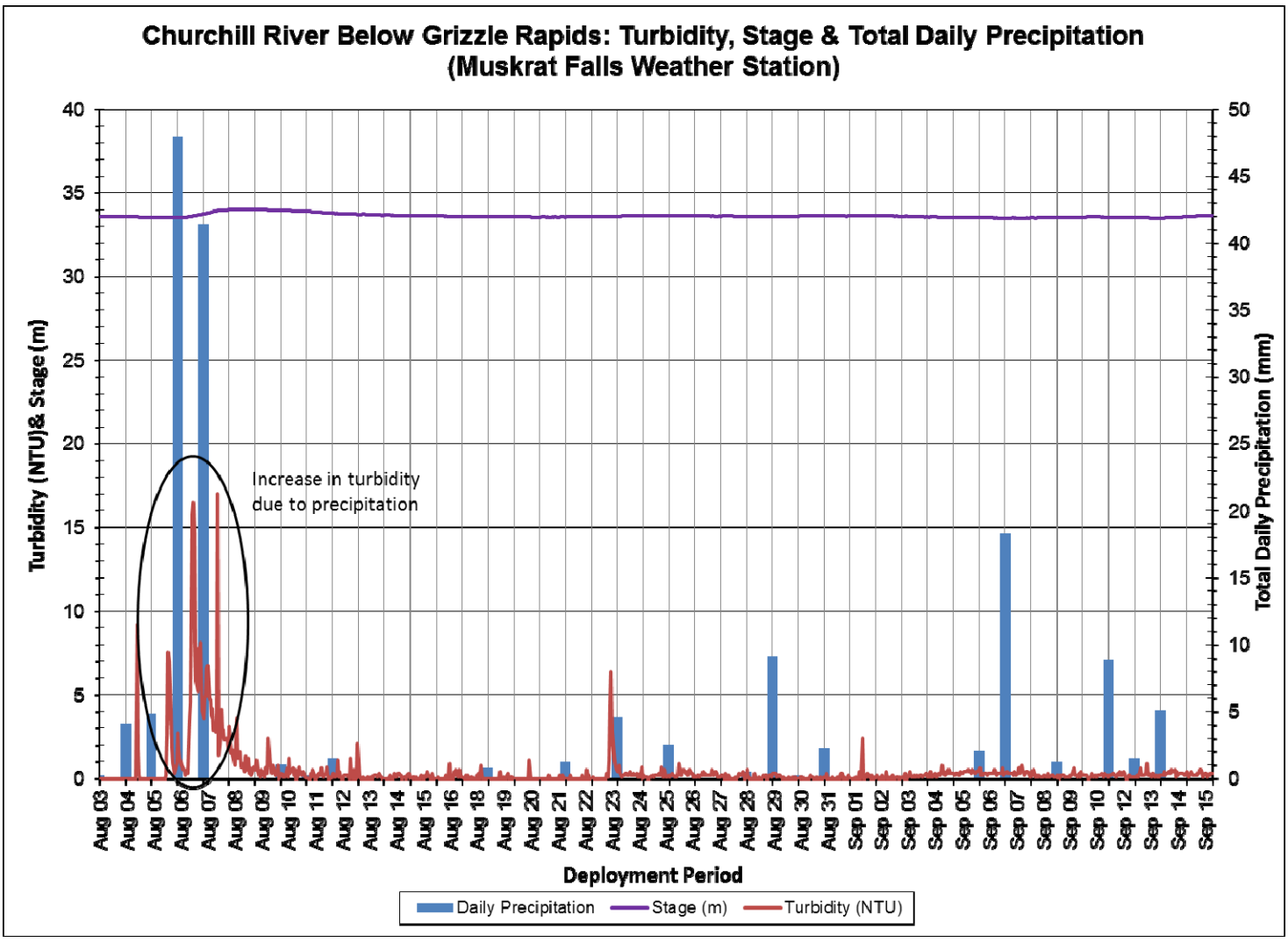

Figure 6: Turbidity, Stage, & Total Daily Precipitation (Muskrat Falls Weather Station) at Churchill River below Grizzle Rapids

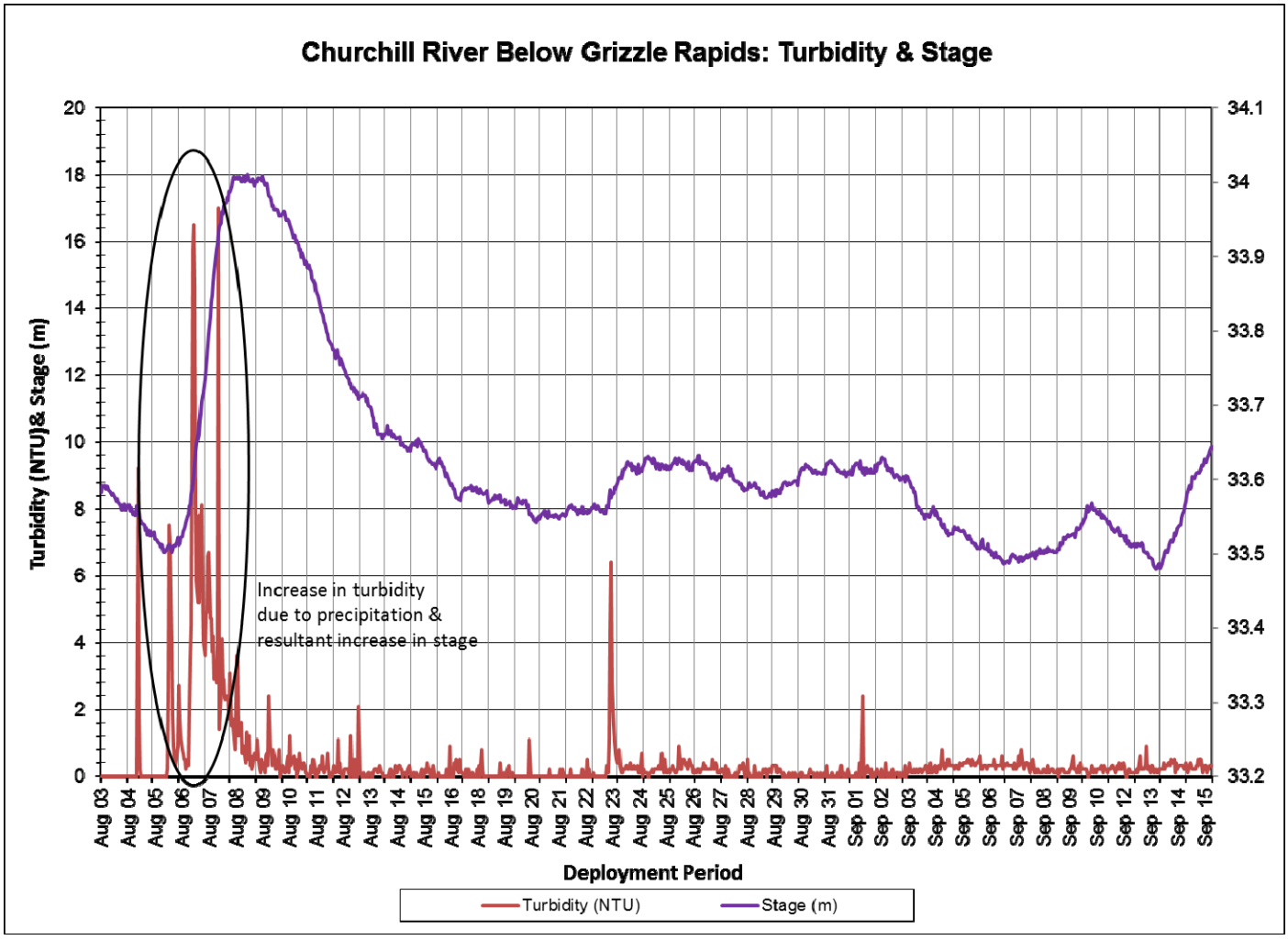

Figure 7: Turbidity & Stage at Churchill River below Grizzle Rapids

Churchill River above Upper Muskrat Falls

Water Temperature

- Water temperature ranges from 11.80°C to 18.36°C with a median value of 15.81°C (Figure 8).
- Water temperatures are generally stable early to mid-August, before starting to decrease late August into September. This trend is expected as water temperatures begin to cool late summer and into the fall months. This trend is mirrored by the average daily air temperature values.

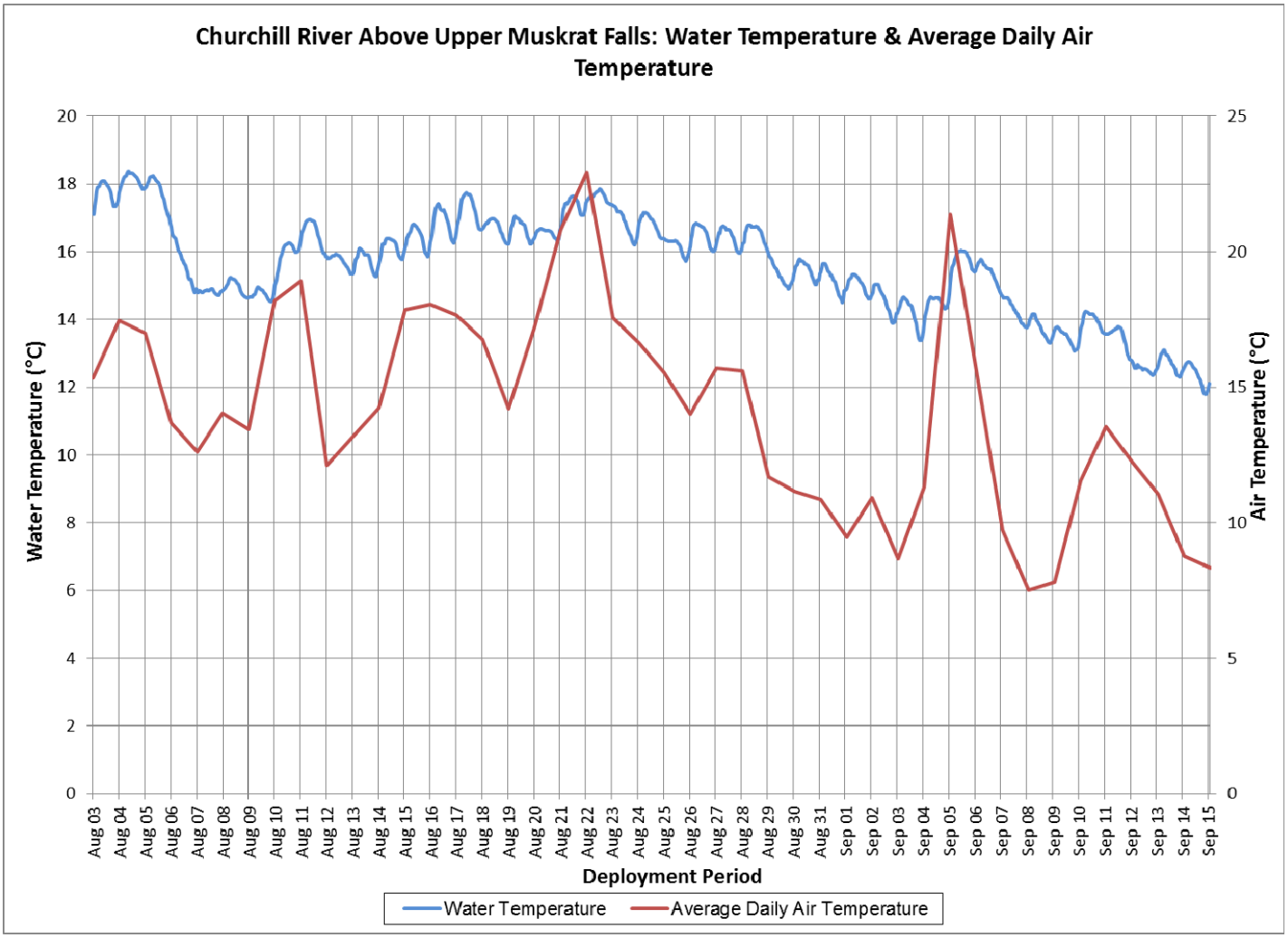

Figure 8: Water Temperature & Average Daily Air Temperature (Muskrat Falls Weather Station) at Churchill River above Upper Muskrat Falls

pH

- pH ranges between 6.46 and 6.99 pH units with a median value of 6.87 (Figure 9).
- pH values are relatively stable and fall within the CCME Protection of Aquatic Life Guidelines the majority of the deployment period, with the exception of a noticeable drop to 6.46 after significant rainfall August 6/7.

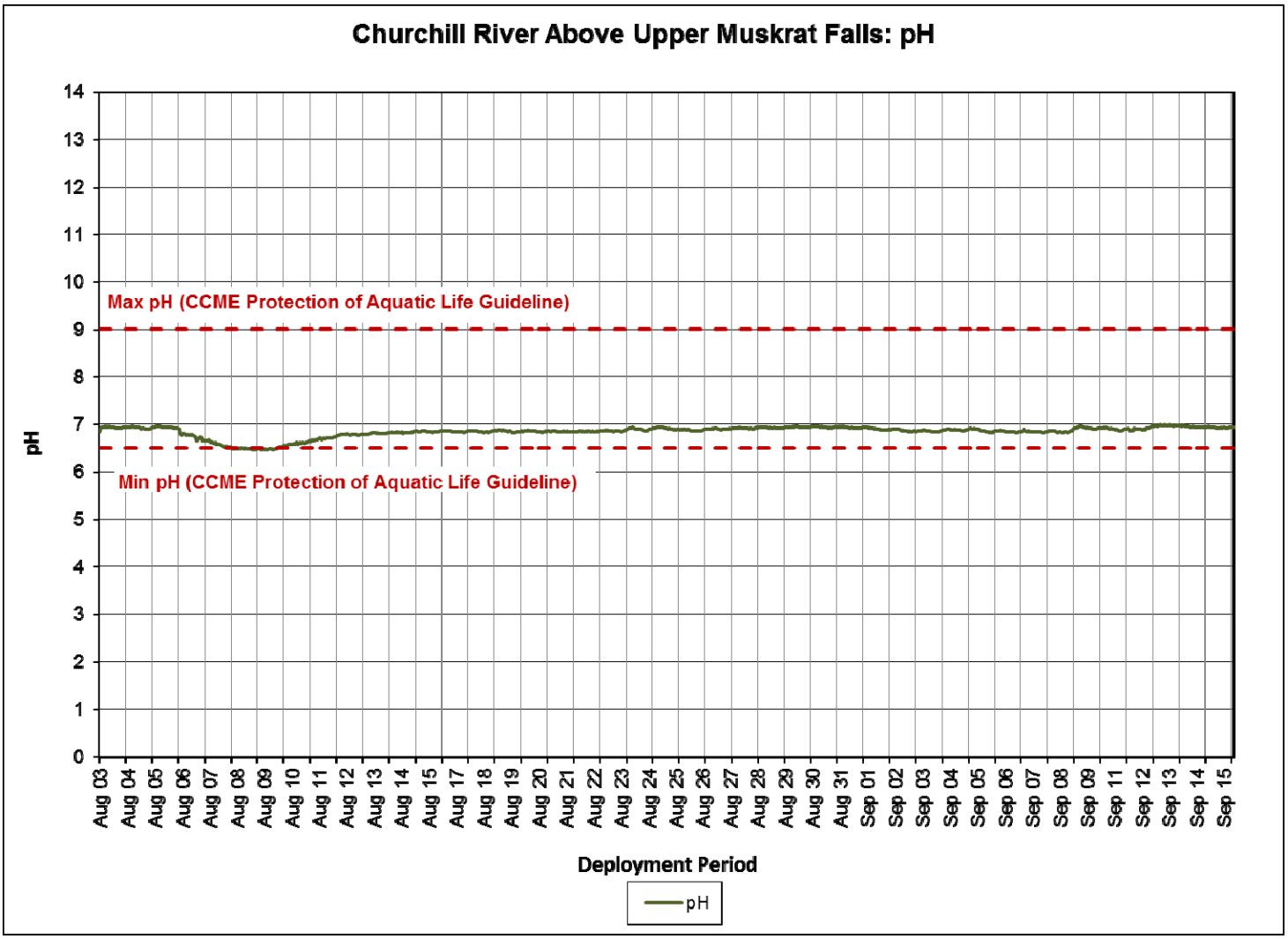

Figure 9: pH at Churchill River above Upper Muskrat Falls

Specific Conductivity, TDS and Stage

- Specific conductivity ranges from 14.7µS/cm to 20.8µS/cm with a median of 18.7µS/cm (Figure 10).
- TDS ranges from 0.0094 g/L to 0.0133 g/L with a median of 0.0120 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 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 trend is evident during a stage increase August 7th following significant precipitation events. As stage increased, conductivity and TDS levels decreased.
- 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.

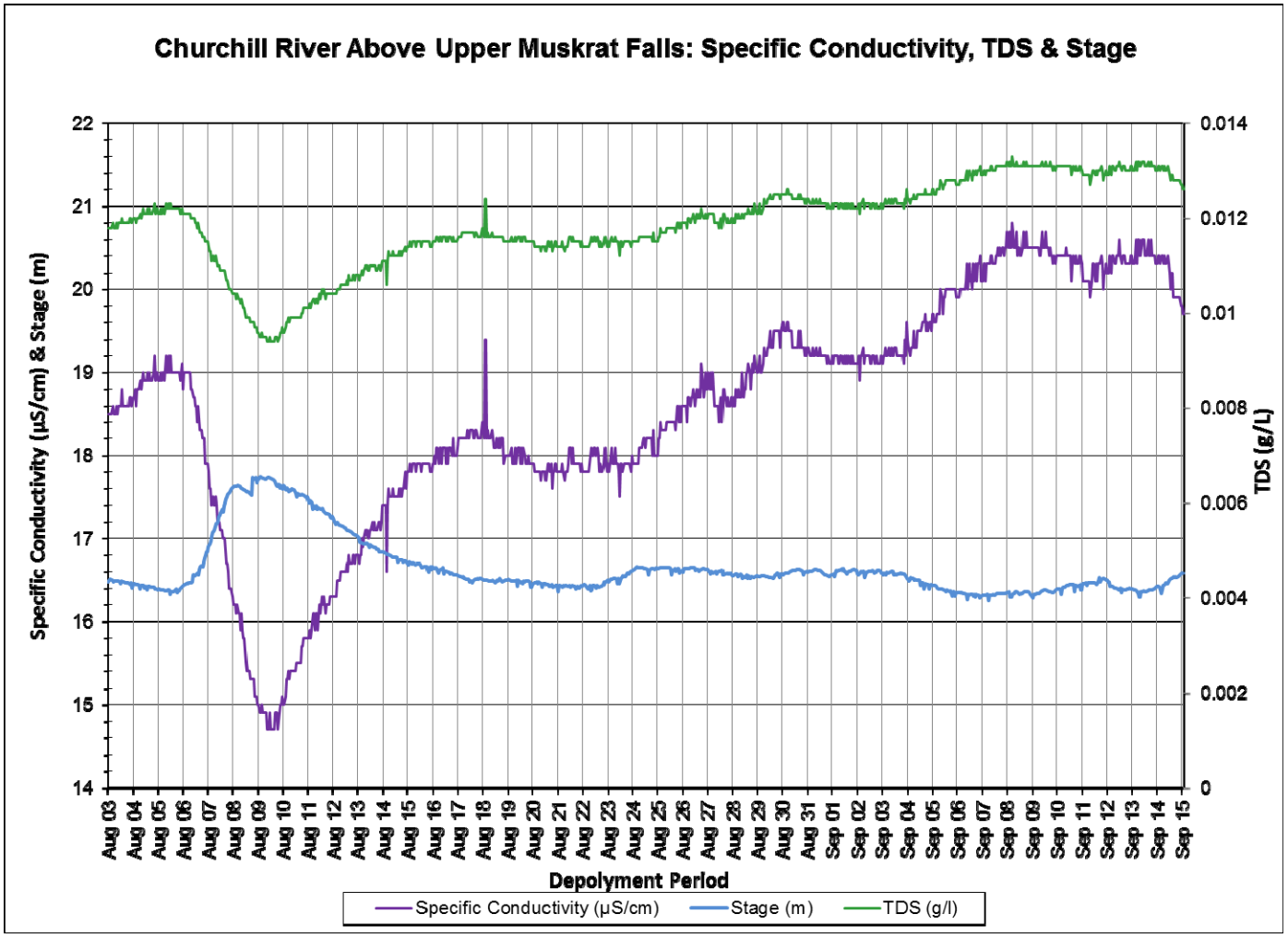

Figure 10: Specific Conductivity, TDS, and Stage at Churchill River above Upper Muskrat Falls

Dissolved Oxygen

- Dissolved oxygen content ranges between 9.01mg/l and 10.15mg/l with a median value of 9.37mg/l. The saturation of dissolved oxygen ranges from 92.2% to 100.2% with a median value of 95.2% (Figure 11).
- There is an evident relationship between water temperature and dissolved oxygen. At the end of the deployment period the dissolved oxygen levels are slowly rising as temperatures drop into the fall 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 hovered around the CCME Guideline for the Protection of Early Life Stages for the majority of the deployment. As water temperatures began to drop in September, the dissolved oxygen increased above the early life stages guideline.

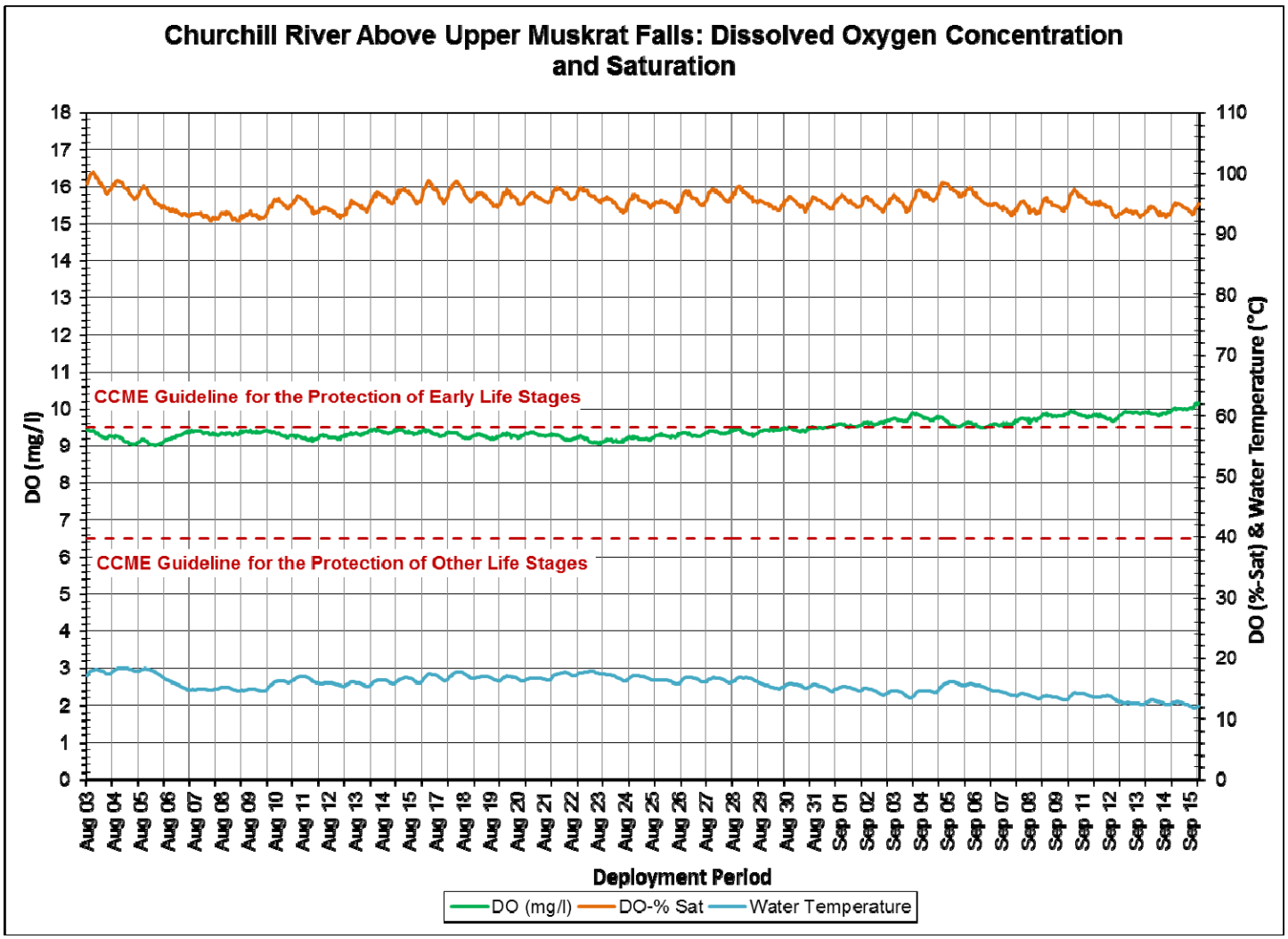

Figure 11: Dissolved oxygen at Churchill River above Upper Muskrat Falls

Chlorophyll

- Chlorophyll ranges between 45.5ug/L and 108.5ug/L, with a median value of 67.05ug/L (Figure 12).
- 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.

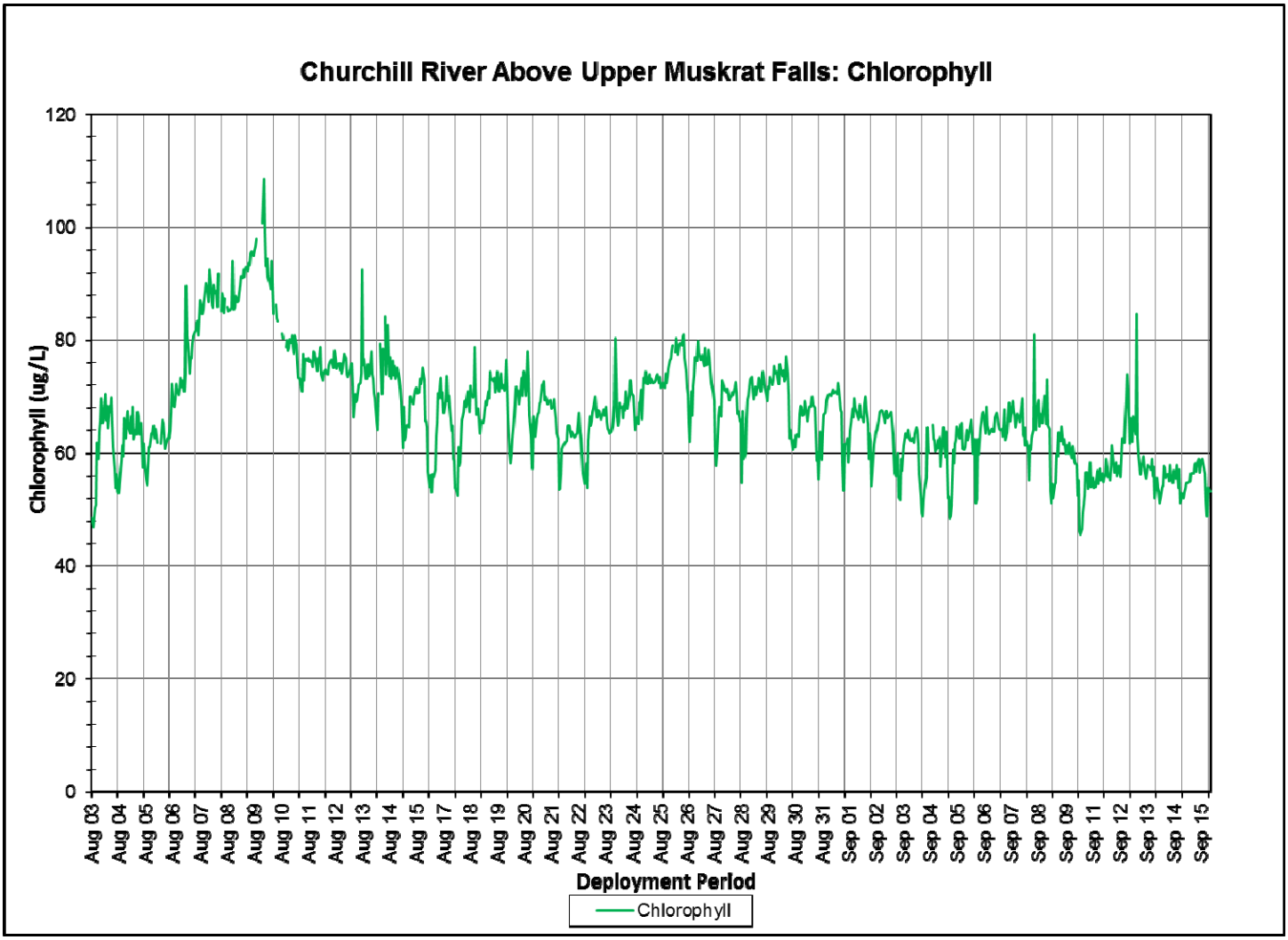

Figure 12: Chlorophyll at Churchill River above Upper Muskrat Falls

Stage, Flow, Turbidity and Precipitation

- Turbidity ranges between 1.1 NTU and 60.3 NTU with a median value of 3.0 NTU (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 23 of the days in the deployment period and amounts are generally low, with the exception of August 6/7 which received a total of 89.4mm over a two day period. A significant increase in turbidity is noticeable at this time.
- Stage ranges between 16.25m and 17.74m, and streamflow ranges from 1450.42m^3/s to 2400.16 m^3/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.

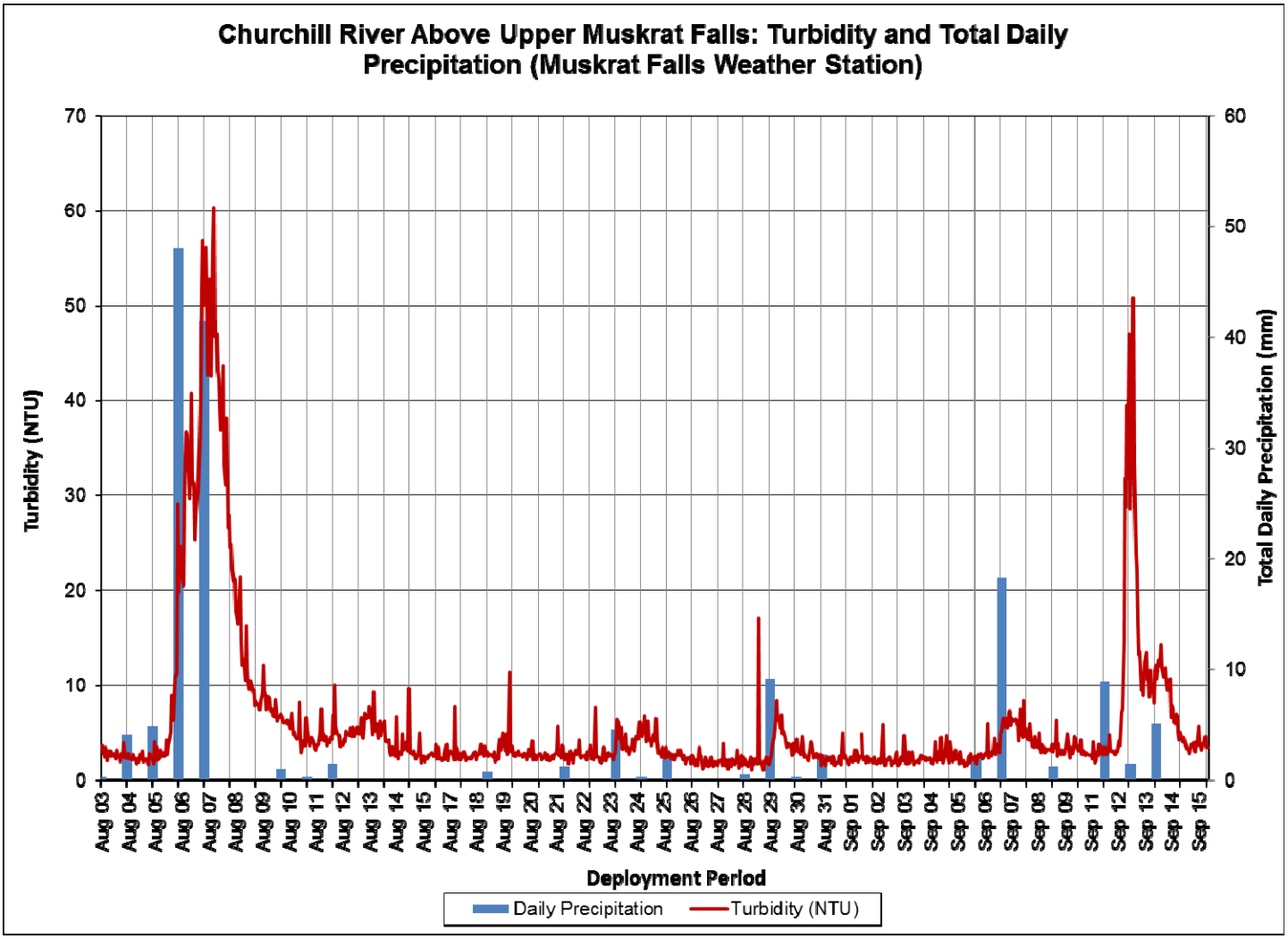

Figure 13: Turbidity and Total Daily Precipitation (Muskrat Falls Weather Station) at Churchill River above Upper Muskrat Falls

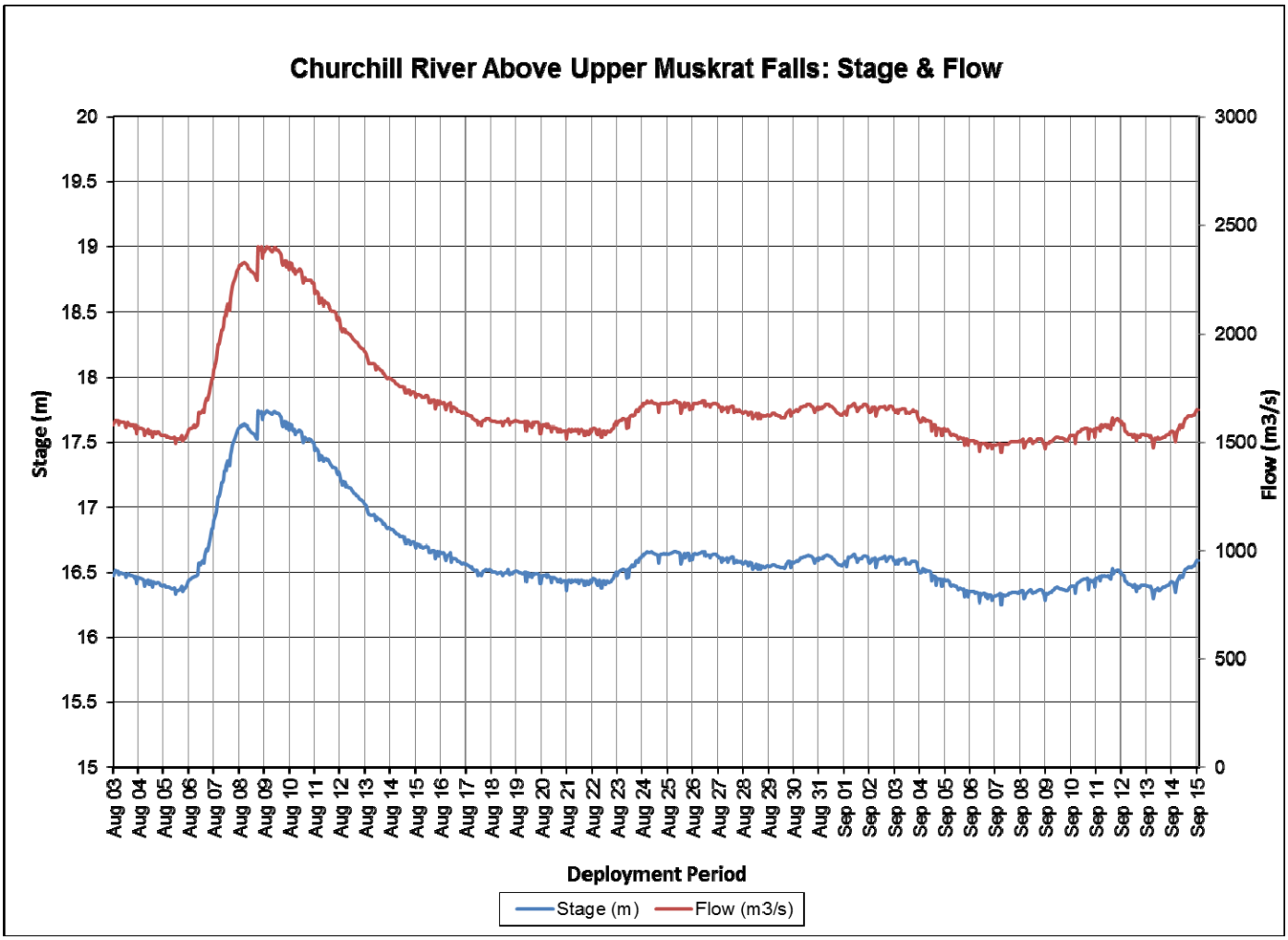

Figure 14: Stage and Flow at Churchill River above Upper Muskrat Falls

Churchill River below Muskrat Falls

Water Temperature

- Water temperature ranges from 11.80°C to 18.30°C with a median value of 15.70°C (Figure 15).
- Water temperatures are generally stable early to mid-August, before starting to decrease late August into September. This trend is expected as water temperatures begin to cool late summer and into the fall months. This trend is mirrored by the average daily air temperature values.

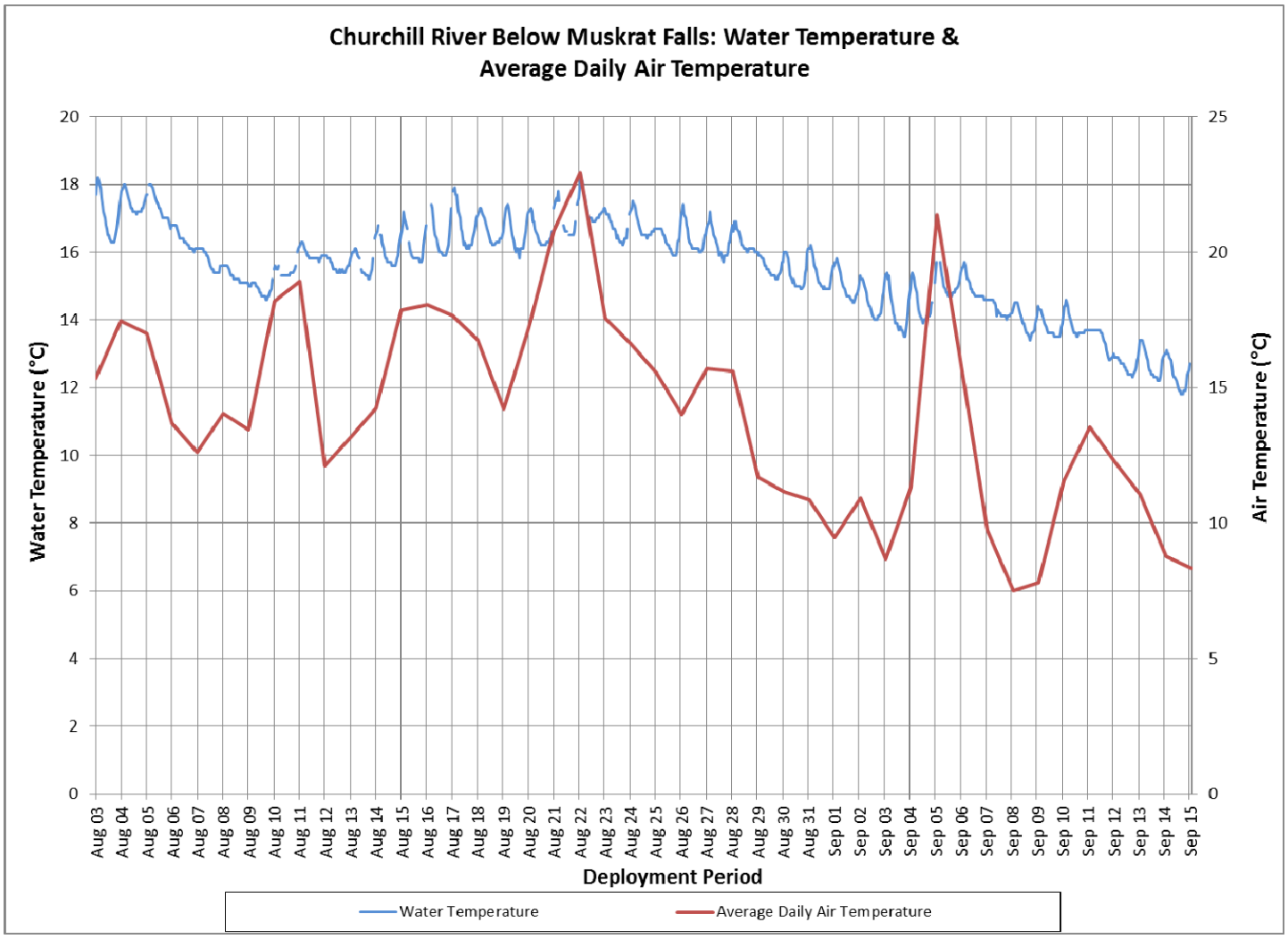

Figure 15: Water Temperature & Daily Average Air Temperature (Muskrat Falls Weather Station) at Churchill River below Muskrat Falls

pH

- At below Lower Muskrat Falls, pH ranges between 5.80 and 6.67 pH units with a median value of 6.34 (Figure 16). The Muskrat Island data is notably higher, with a range of 6.57 to 6.97 and a median value of 6.86 pH units.
- The majority of pH values recorded below Lower Muskrat Falls during this deployment period are slightly below the minimum CCME protection of Aquatic Life Guideline of 6.5. This is unusual for this station. Upon removal, the pH sensor ranked only as 'fair', reading lower than the QAQC sensor, indicating that there may be some sensor drift during the deployment. All values from Muskrat Island were above the guidelines throughout the deployment.
- There are two noticeable events in Figure 16. The first is a drop in pH August 7-11 which corresponds to an influx of freshwater from 89.4mm of rain on August 6-7. The second event is a spike in pH on September 12th at the below Lower Muskrat Falls station. This rapid temporary increase in pH corresponds to a rise in pH and turbidity at Muskrat Island and a significant drop in dissolved oxygen at both below Lower Muskrat Falls and Muskrat Island (Figure 18).

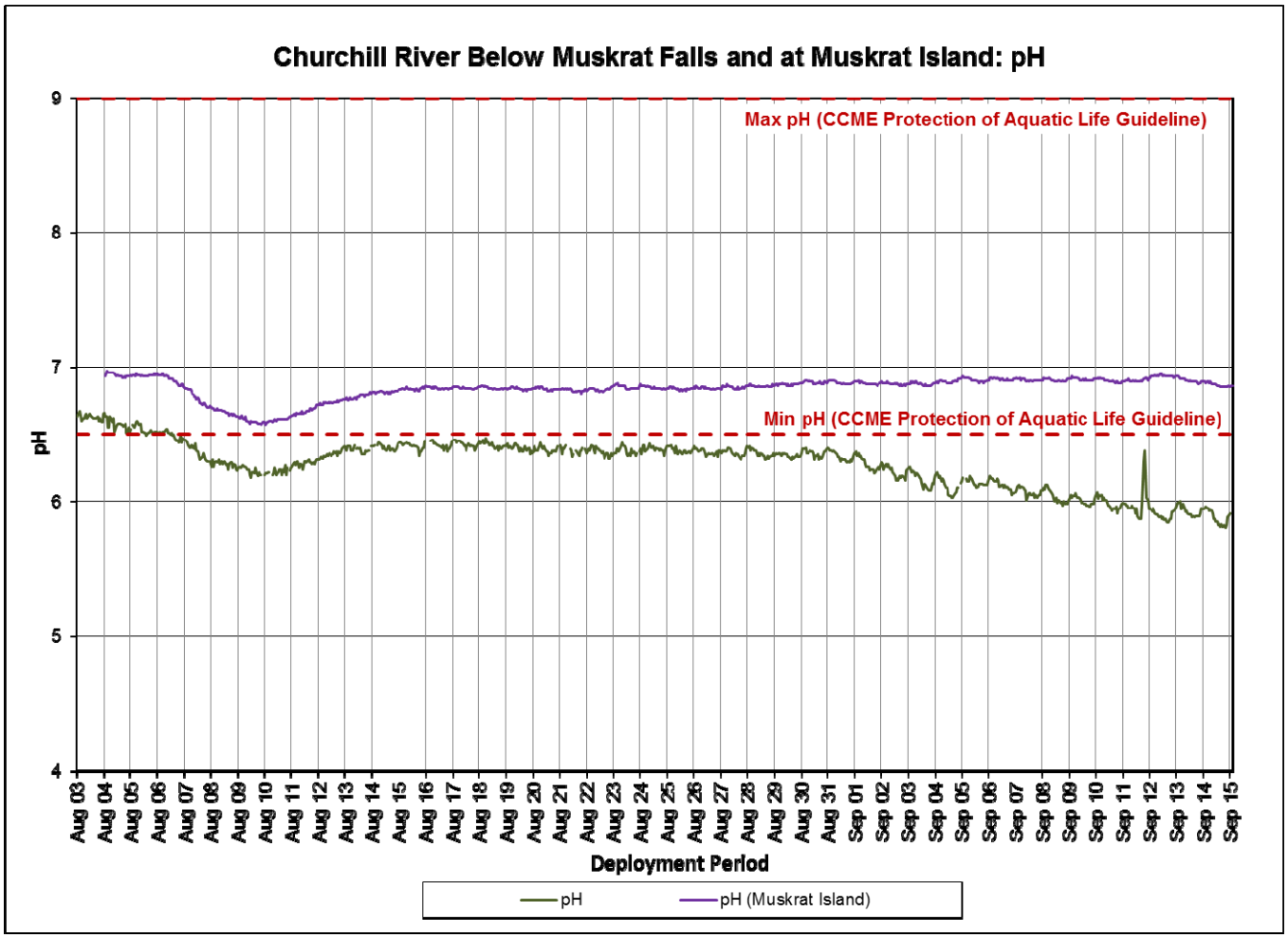

Figure 16: pH at Churchill River below Muskrat Falls and at Muskrat Island

Specific Conductivity, TDS & Stage

- Specific conductance ranges between 14.2µS/cm and 18.7µs/cm during the deployment period, with a median of 17.0µS/cm (Figure 17).
- TDS ranges between 0.0091 g/mL to 0.0120 g/mL during the deployment period, with a median of 0.0109 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. This is evident in Figure 17 as high precipitation on August 6/7 led to an increase in stage and corresponding decrease in conductivity and TDS.
- 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.

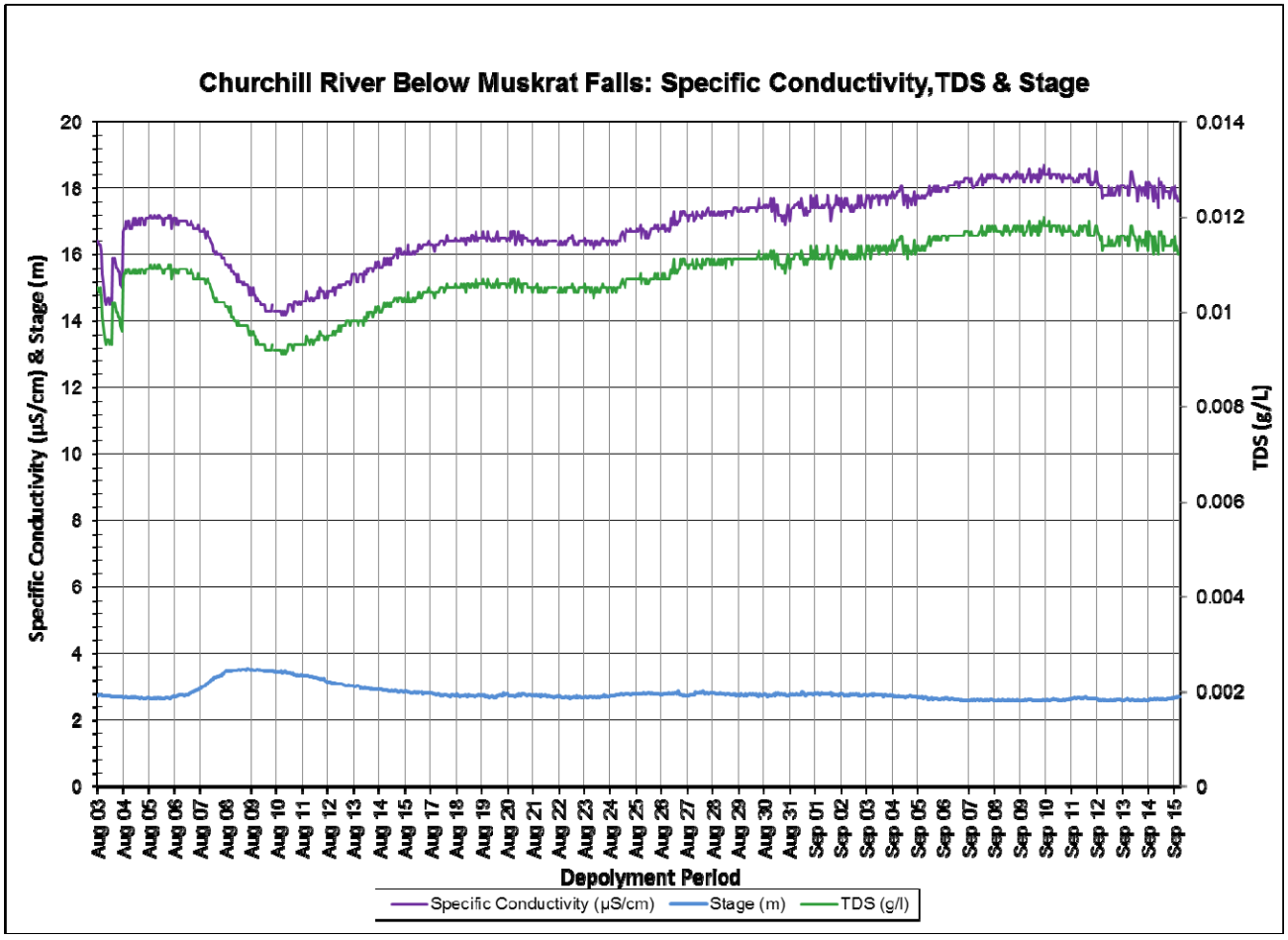

Figure 17: Specific Conductivity, TDS & Stage at Churchill River below Muskrat Falls

Dissolved Oxygen

- At below Lower Muskrat Falls, dissolved oxygen content ranges between 10.05mg/l and 12.38mg/l with a median value of 11.49mg/l. The saturation of dissolved oxygen ranges from 101.2% to 123.3% with a median value of 116.3% (Figure 18). At Muskrat Island, the dissolved oxygen ranges from 10.08 mg/L to 12.14 mg/L, with a median of 11.32 mg/L. These values are very similar to the below Muskrat Falls station, but slightly lower as expected due to the aeration of the water by Muskrat Falls.
- 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 fall 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 and Early Life Stages throughout the deployment. However, there are several noticeable drops in dissolved oxygen which occur at both sites: August 6, August 12, August 23 and September 12. The drop on September 12 occurs the same time as a significant increase in pH and turbidity (Figure 16). This event was reported to Nalcor via email on September 19, 2016.

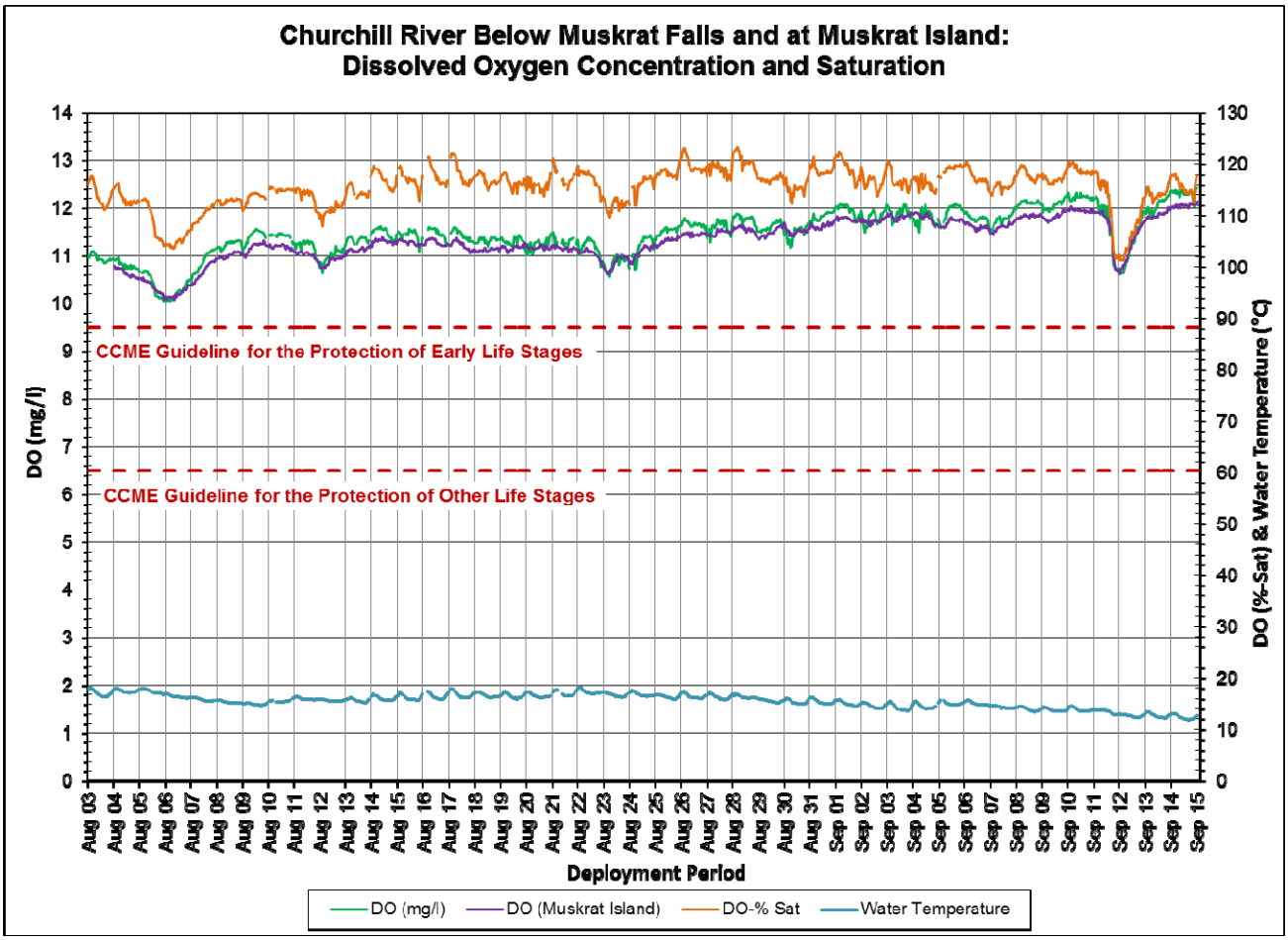

Figure 18: Dissolved Oxygen & Stage at Churchill River below Muskrat Falls and at Muskrat Island

Turbidity, Stage & Precipitation

- Upstream of this site at the Muskrat Falls Dam construction site, river diversion and spillway operations commenced on August 3rd and were expected to cause minor sedimentation. Stations along the Churchill River were visited on August 3rd and 4th for maintenance. Photos from the maintenance visits are available in Appendix F.
- Due to an issue with the turbidity sensor, accurate turbidity data is not available from the below Lower Muskrat Falls station and has been removed from the dataset. A water quality instrument was deployed at Muskrat Island, downstream of Lower Muskrat Falls, August 4 to September 15, 2016. The backup instrument at Muskrat Island was successful in recording turbidity data for this deployment.
- During this deployment at Muskrat Island, turbidity ranged from 0NTU to 57.8NTU, with a median of 4.3NTU (Figure 19). A large climb in turbidity August 6-8 occurs after significant rainfall August 6/7. Spikes in turbidity are also evident before the precipitation but after the spillway became operational August 3rd. A series of spikes in turbidity Sept 8-13 may indicate some influence on turbidity at Muskrat Island during this time frame, which is the same period when pH and DO were influenced by an unknown source at both below Lower Muskrat Falls and Muskrat Island.
- Precipitation occurs on 23 days during the deployment period and amounts are generally small in magnitude, with the largest being a two day event of 89.4mm August 6/7.
- Stage levels at below Lower Muskrat Falls ranged between 2.58m and 3.54m (Figure 20).
- 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.

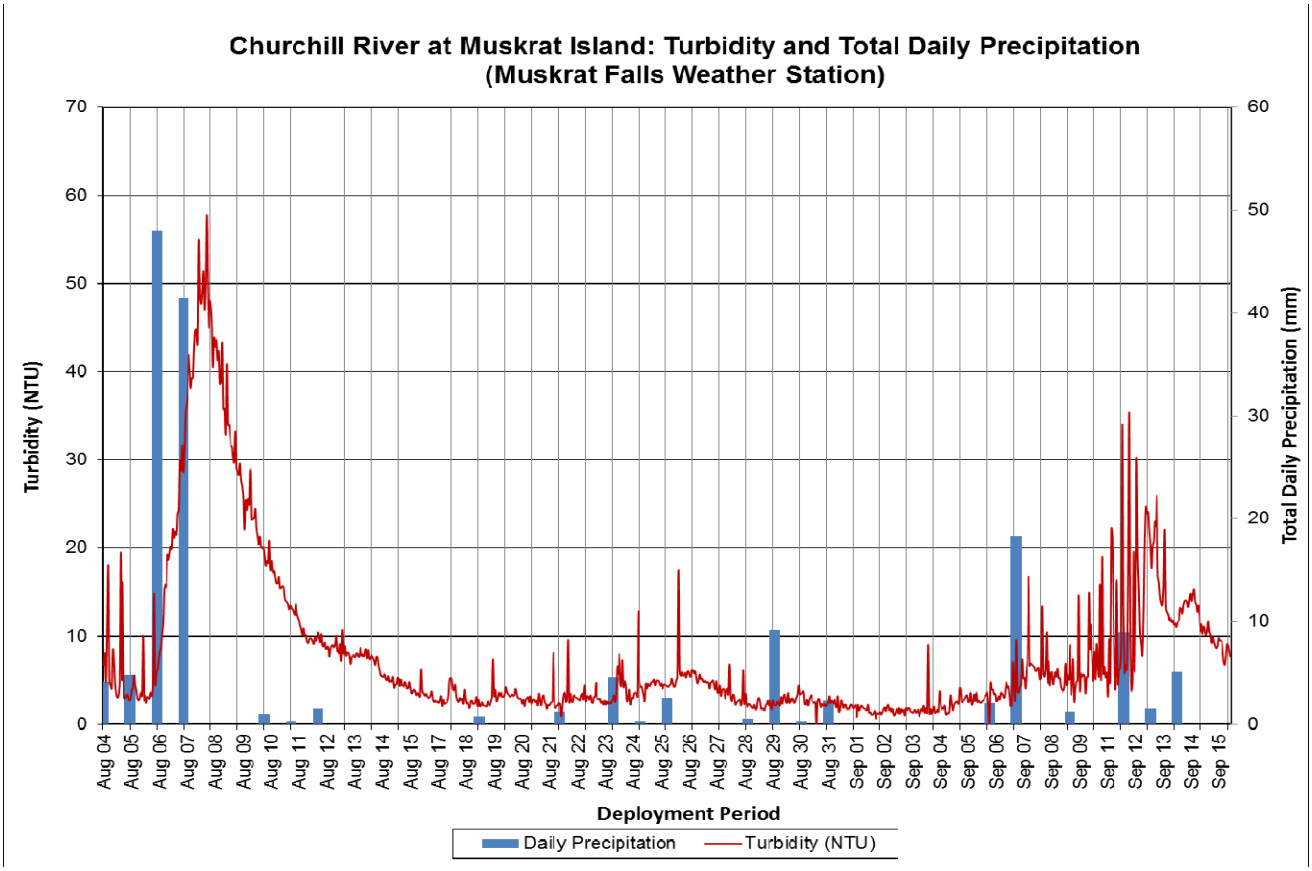

Figure 19: Turbidity & Total Daily Precipitation (Muskrat Falls Weather Station) at Churchill River at Muskrat Island

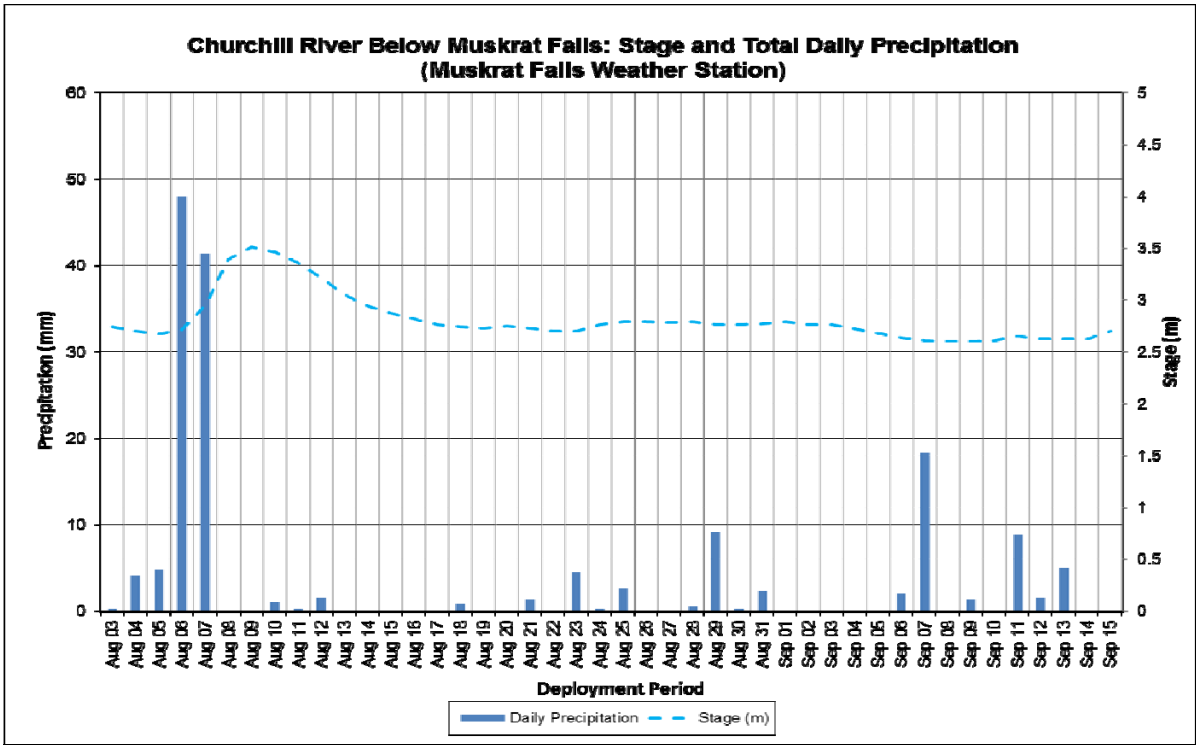

Figure 20: Stage & Total Daily Precipitation (Muskrat Falls Weather Station) at Churchill River below Muskrat Falls

Churchill River at English Point

Water Temperature

- Water temperature ranges from 10.50°C to 19.50°C with a median value of 15.20°C (Figure 21).
- Water temperatures are generally stable early to mid-August, before starting to decrease late August into September. This trend is expected as water temperatures begin to cool late summer and into the fall months. This trend is mirrored by the average daily air temperature values.

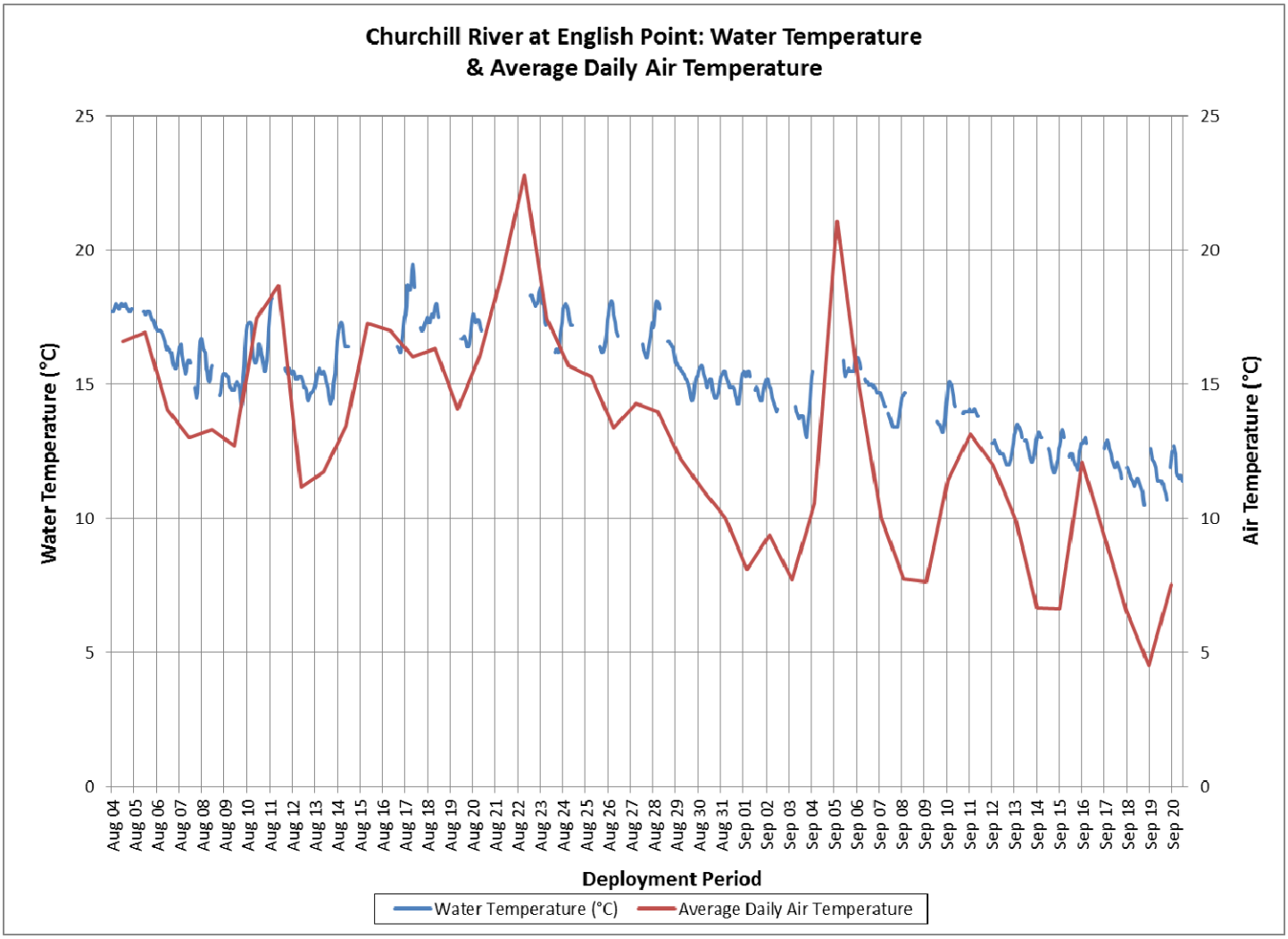

Figure 21: Water Temperature & Daily Average Air Temperature (Mud Lake Weather Station) at Churchill River at English Point

pH

- pH ranges between 6.45 and 7.16 pH units with a median value of 6.93 (Figure 22).
- 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 on August 8, likely due to the large influx of freshwater from an 89.4mm rain event on August 6/7 (as recorded at the Muskrat Falls weather station).

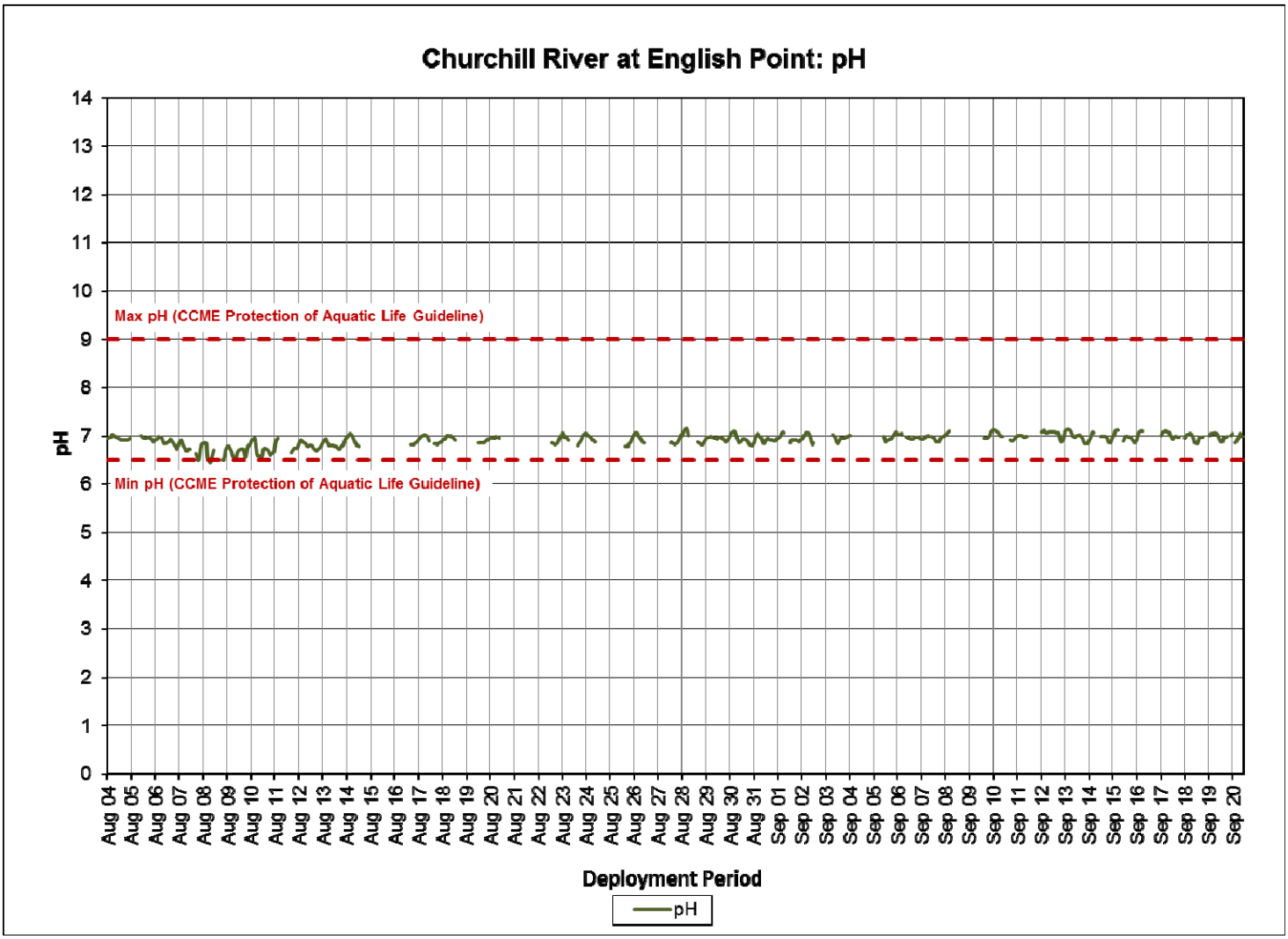

Figure 22: pH at Churchill River at English Point Station

Specific Conductivity and TDS

- Specific conductance ranges between 18.8µS/cm and 45.9µs/cm during the deployment period, with a median of 30.1µS/cm (Figure 23).
- TDS ranges between 0.0120 g/mL to 0.0294 g/mL during the deployment period, with a median of 0.0193 g/mL (Figure 23).
- 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 23).
- 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.

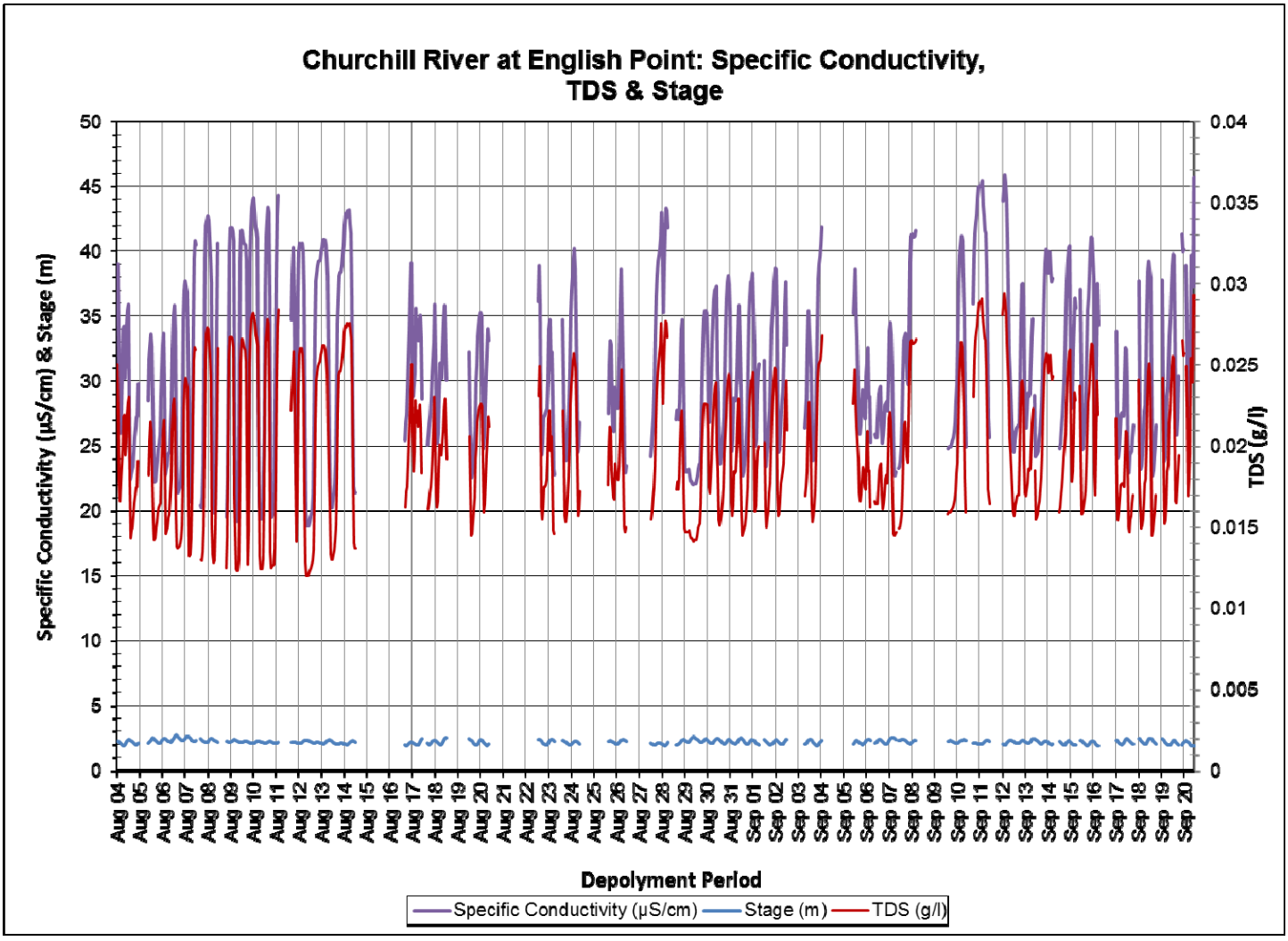

Figure 23: Specific Conductivity & TDS at Churchill River at English Point Station

Dissolved Oxygen

- Dissolved oxygen content ranged between 9.04mg/l and 11.97mg/l during the deployment period with a median value of 10.15mg/L. The saturation of dissolved oxygen ranged from 90.5% to 115.2% with a median value of 102.8% (Figure 24).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period the dissolved oxygen levels are relatively stable in summer before rising late August into September as water temperatures began to drop into the fall 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 24). However, the dissolved oxygen levels dipped slightly below the CCME Guideline for the Protection of Early Life Stages on several occasions when water temperatures were highest. Oxygen levels then rose into the fall season as water temperatures cooled.

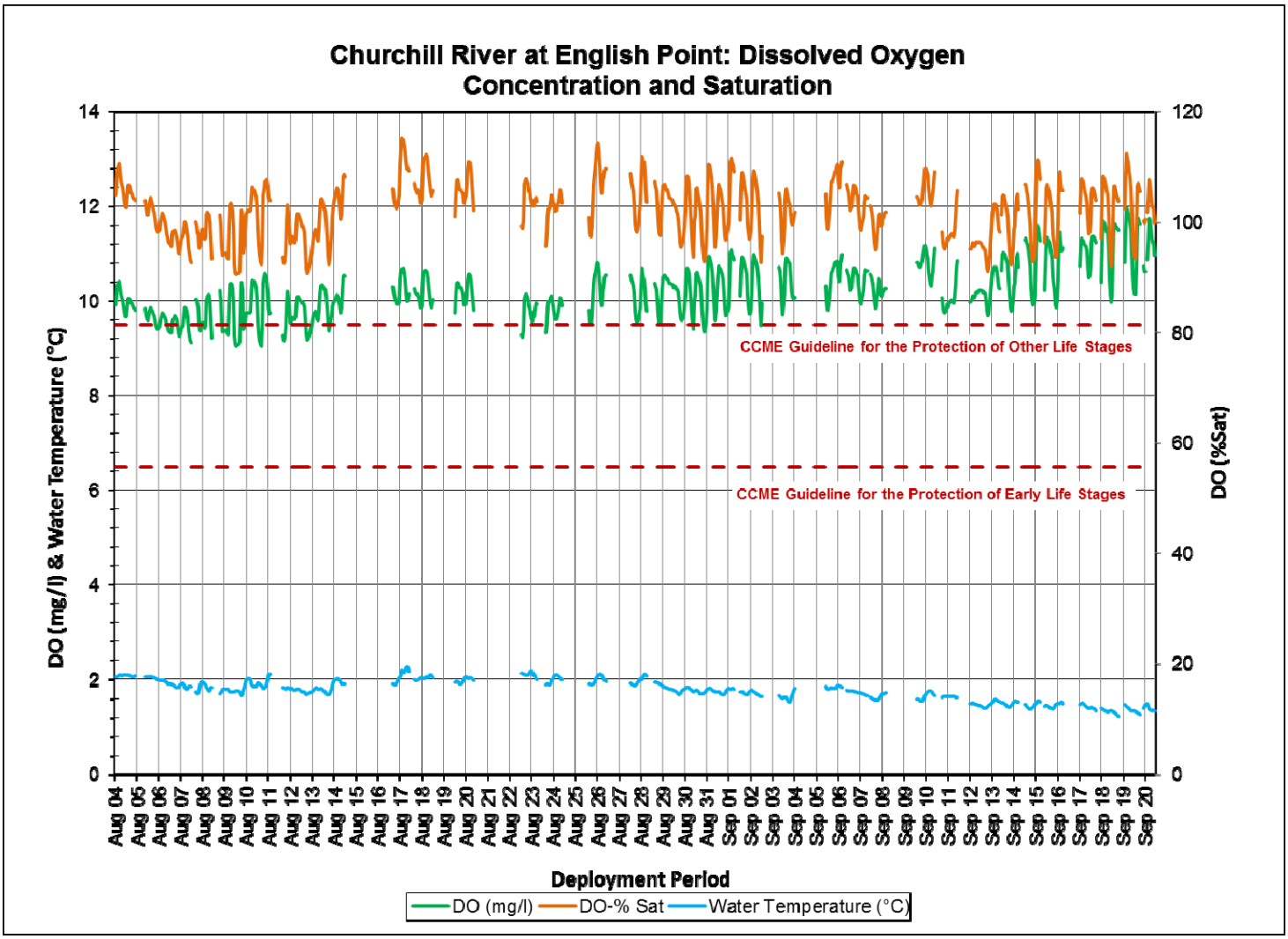

Figure 24: Dissolved Oxygen at Churchill River at English Point Station

Stage, Flow, Turbidity & Precipitation

- The majority of turbidity data for this deployment was removed due to possible sensor drift from biofouling and sedimentation. For the available data, turbidity ranges from 3.4NTU to 92.6NTU, with a median value of 15.9NTU (Figure 25).
- 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 21 of the days in the deployment period and amounts are generally low, with the exception of the 57.15mm of precipitation on August 6/7 (Figure 25).
- 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 26). Tidal action may also suspend material into the water column, causing spikes in turbidity.
- Stage ranges between 1.87m and 2.71m, with a median value of 2.19m (Figure 26).
- 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.

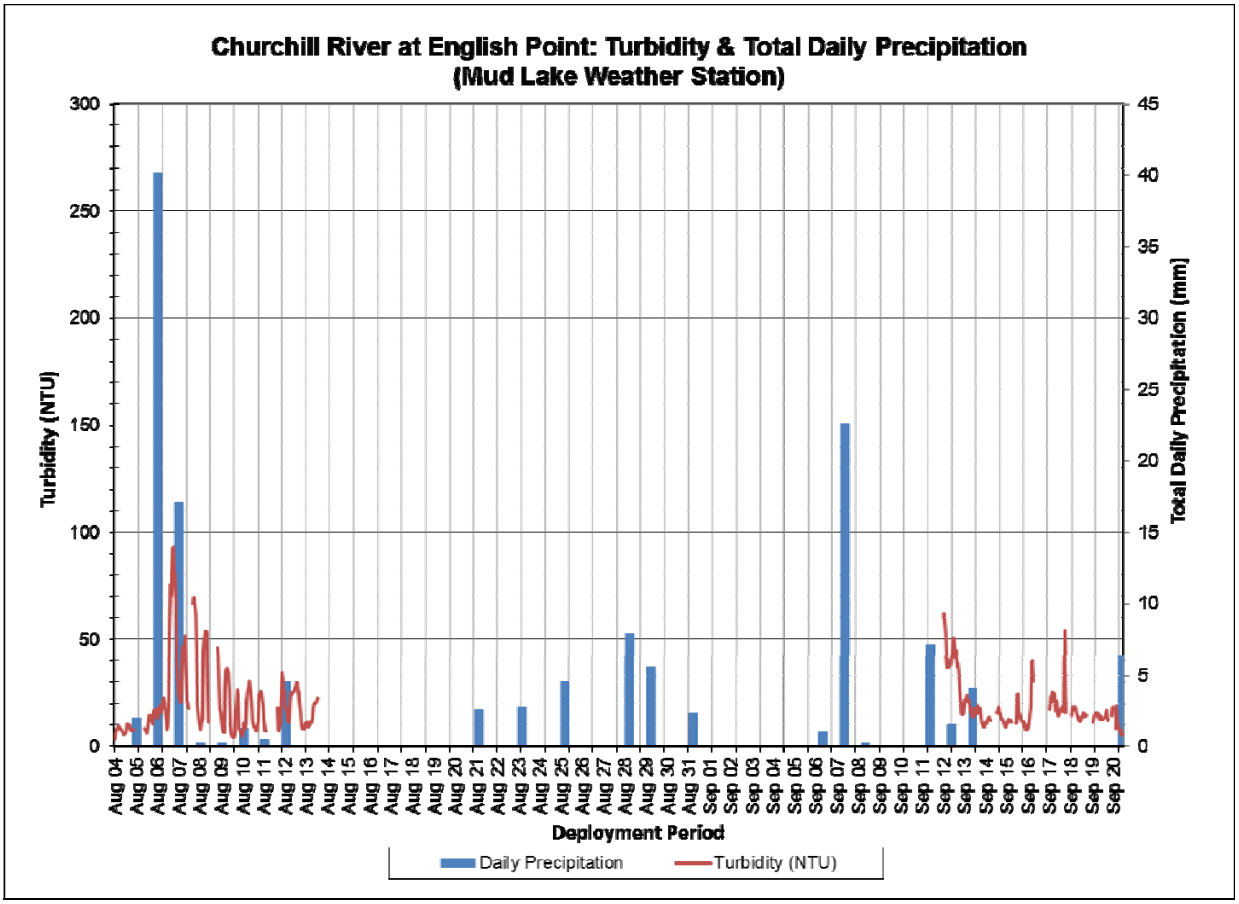

Figure 25: Turbidity, Stage & Total Precipitation (Mud Lake Weather Station) at Churchill River at English Point Station

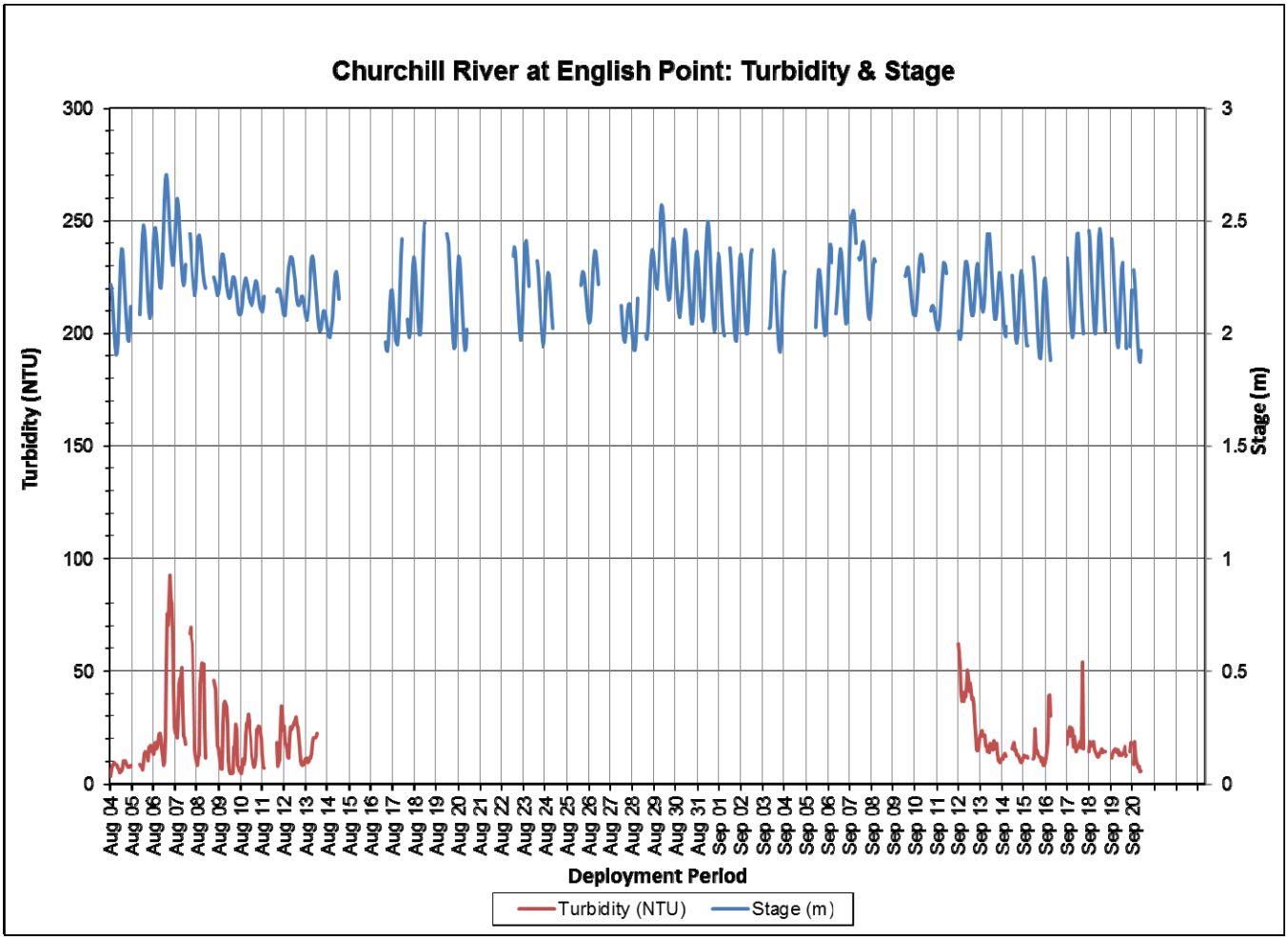

Figure 26: Turbidity & Stage at Churchill River at English Point Station

Conclusions

- Instruments at four water quality monitoring stations on the Lower Churchill River were deployed from August 3/4 to September 15/20 for periods of 42-46 days.
- Stage levels are generally stable at all stations during the summer months. Water level changes at each of the stations ranged between 0.53m and 1.49m.
- Water temperature was stable at all stations in August before decreasing in late August and into September due to the decreasing ambient air temperatures in the region into the fall season. Water temperature typically ranged between 10.50°C and 18.36°C.
- Generally, pH is relatively neutral and stable at stations along the Lower Churchill River. At the below Grizzle, above Upper and English Point stations, pH ranges between 6.45 and 7.16 pH units and were within the CCME guidelines for the Protection of Aquatic Life for the majority of the time. During this deployment, the pH at the below Muskrat Falls station was noticeably lower, ranging between 5.80 and 6.67 pH units and hovering just below the guideline for the entire deployment period. This is likely due to sensor drift at this station.
- Specific conductivity was relatively stable at the stations below Grizzle Rapids, above upper Muskrat Falls and below Muskrat Falls, ranging between 14.2 - 21.2µS/cm, regardless of the fluctuating stage levels. All stations showed little variation in values except at English Point, which is influenced by the tides in Lake Melville. Specific conductivity values at the station at English Point ranged higher at 18.8µS/cm to 45.9µS/cm. This is comparable to other deployments at this location.
- Dissolved oxygen was generally stable into late August before gradually increasing into September as water temperatures began to cool into the fall months and could hold more oxygen. Values ranged between 9.01mg/l and 12.38mg/l. A significant drop in dissolved oxygen was noted September 12th at both the below Lower Muskrat Falls and Muskrat Island (backup) stations.
- Turbidity events occurred at all stations and were mainly related to rainfall events. At the below Grizzle Rapids and above Upper Muskrat Falls stations the median turbidity values are near zero, indicating low background turbidity at these locations. Turbidity data for below Lower Muskrat Falls was inaccurate and thus not reported, but data was available from the backup instrument at Muskrat Island. The majority of turbidity data for English Point was removed as it was likely due to biofouling and sedimentation around the sensor. The range of turbidity values for all reported data was 0.0 to 92.6NTU. The higher turbidity at English Point is related to tidal action as the sonde is deployed in relatively shallow water along the shoreline, with the tidal influence suspending debris and sediment into the water column.

References

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- 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.ysi.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.\
  - 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

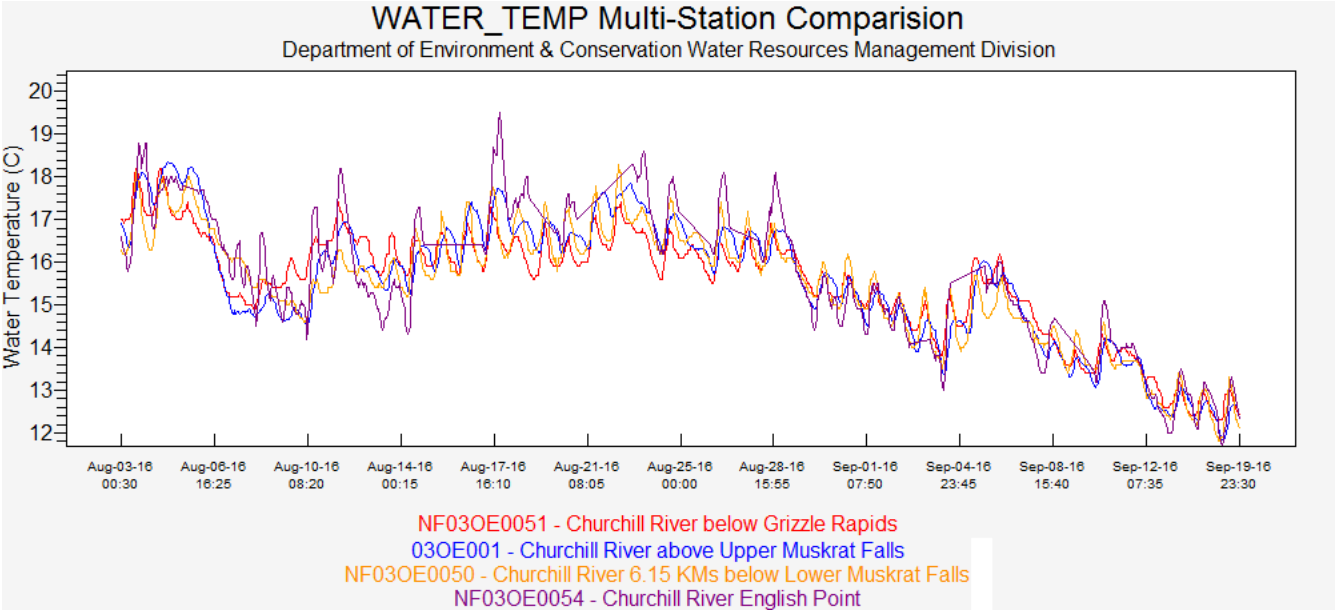


Figure A1: Comparison of Water Temperature at the Real-Time Stations on Churchill River

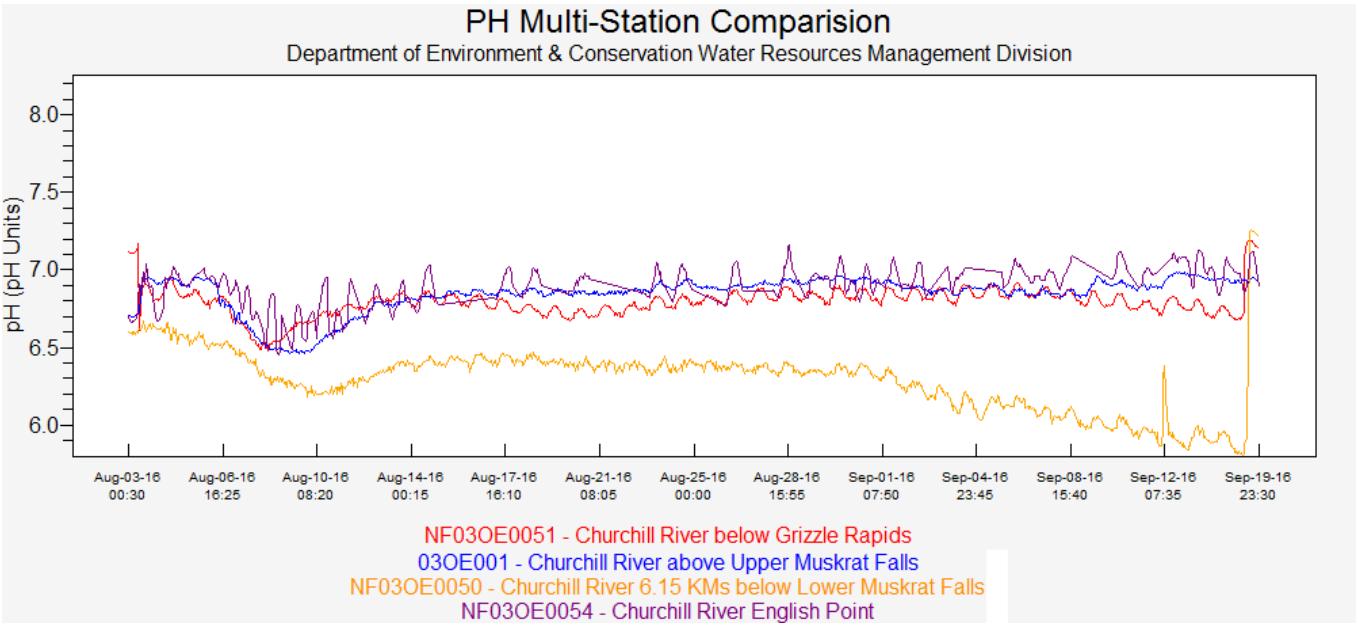


Figure A2: Comparison of pH at the Real-Time Stations on Churchill River

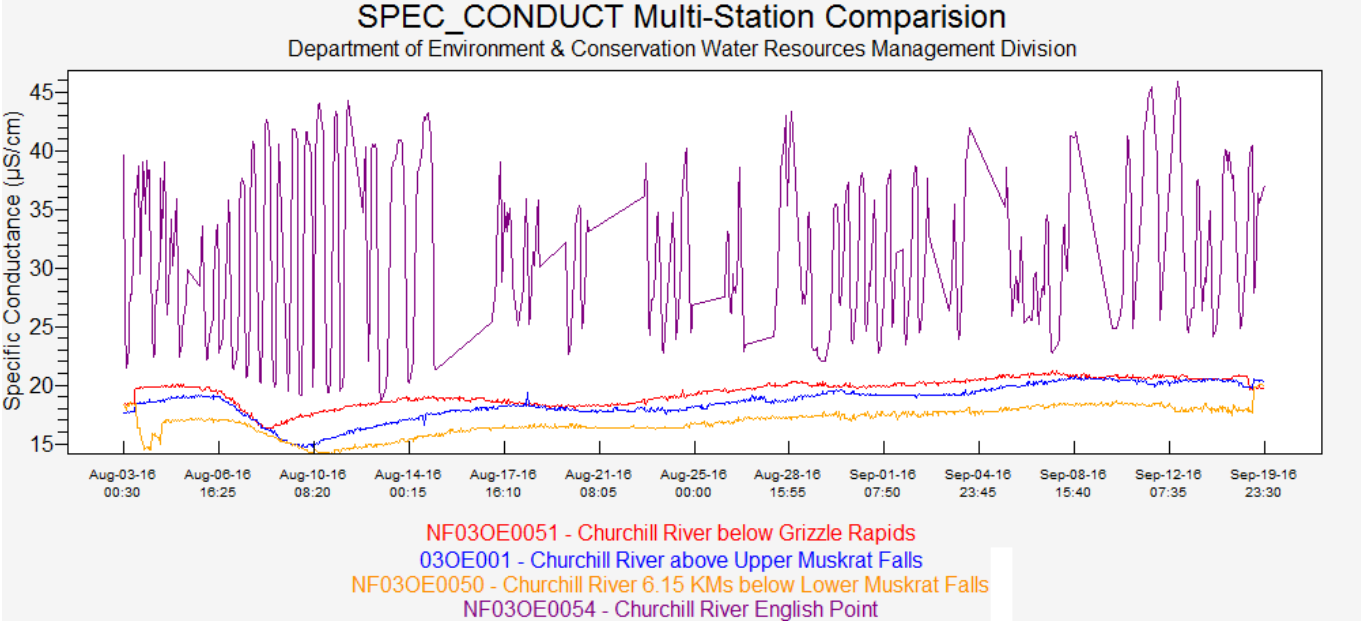


Figure A3: Comparison of Specific Conductivity at the Real-Time Stations on Churchill River

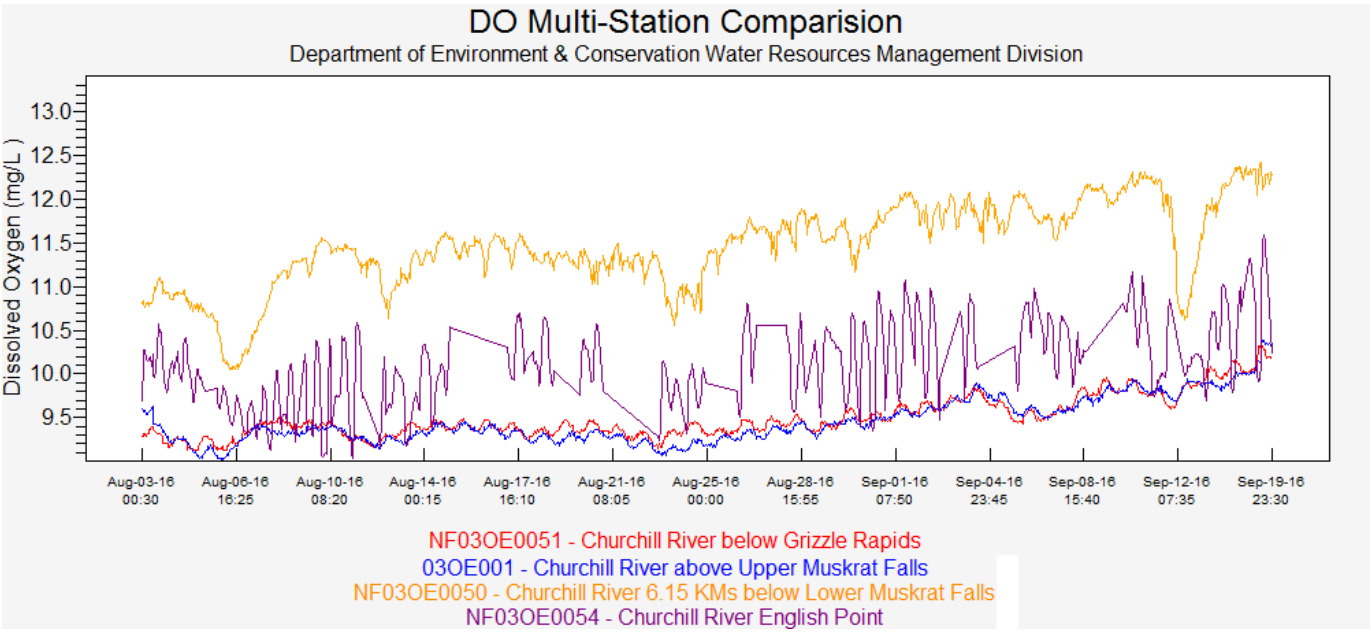


Figure A4: Comparison of Dissolved Oxygen at the Real-Time Stations on Churchill River

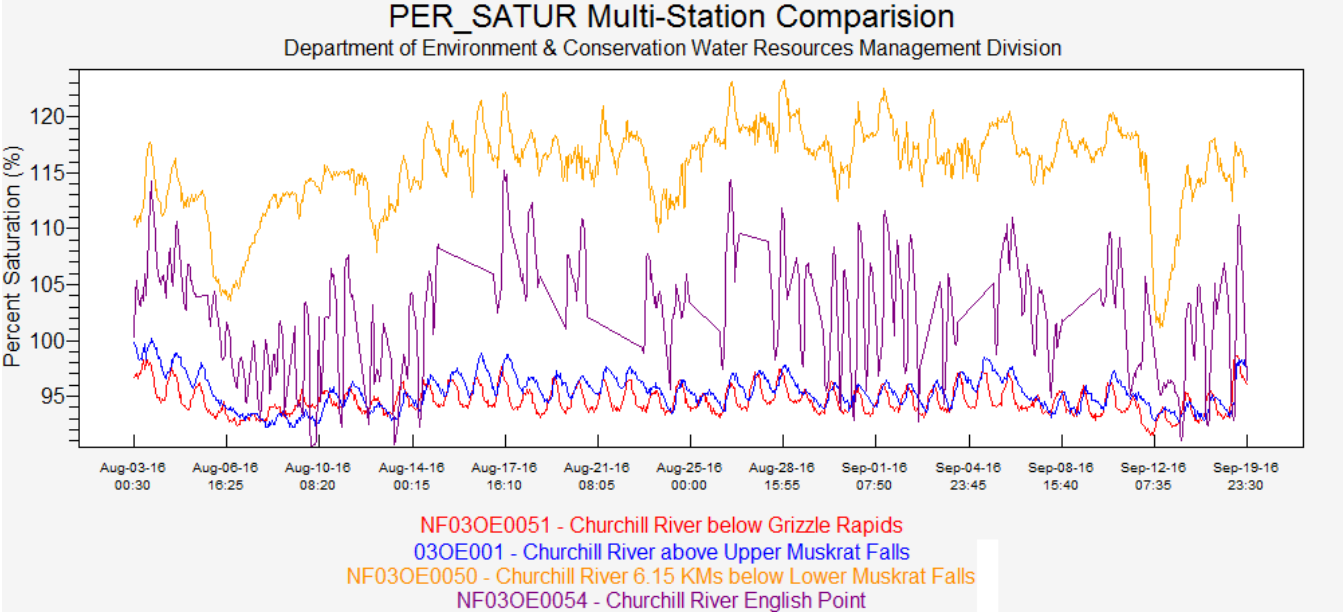
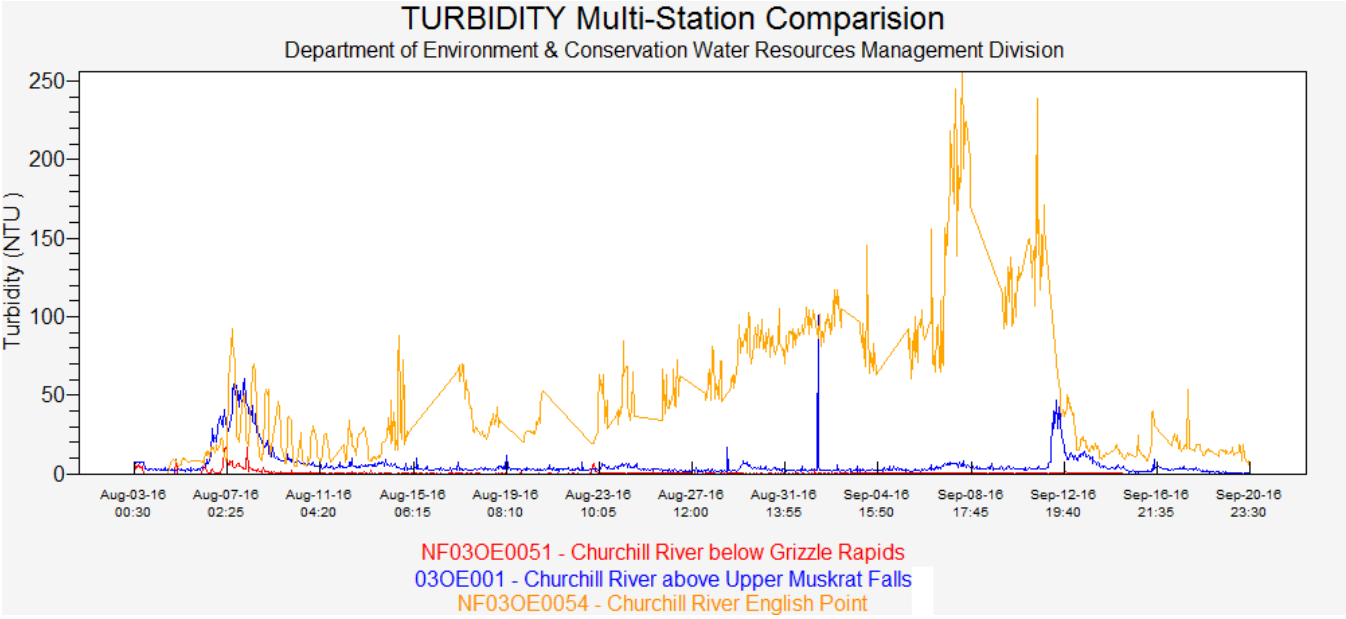


Figure A5: Comparison of Dissolved Oxygen (% Sat) at the Real-Time Stations on Churchill River



*Turbidity values for the below Lower Muskrat Falls station were removed from the dataset due to an issue with the sensor.

**The majority of turbidity values displayed for English Point in the above comparison graph were removed from the dataset due to sedimentation and biofouling of the sensor (August 13 to September 11).

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

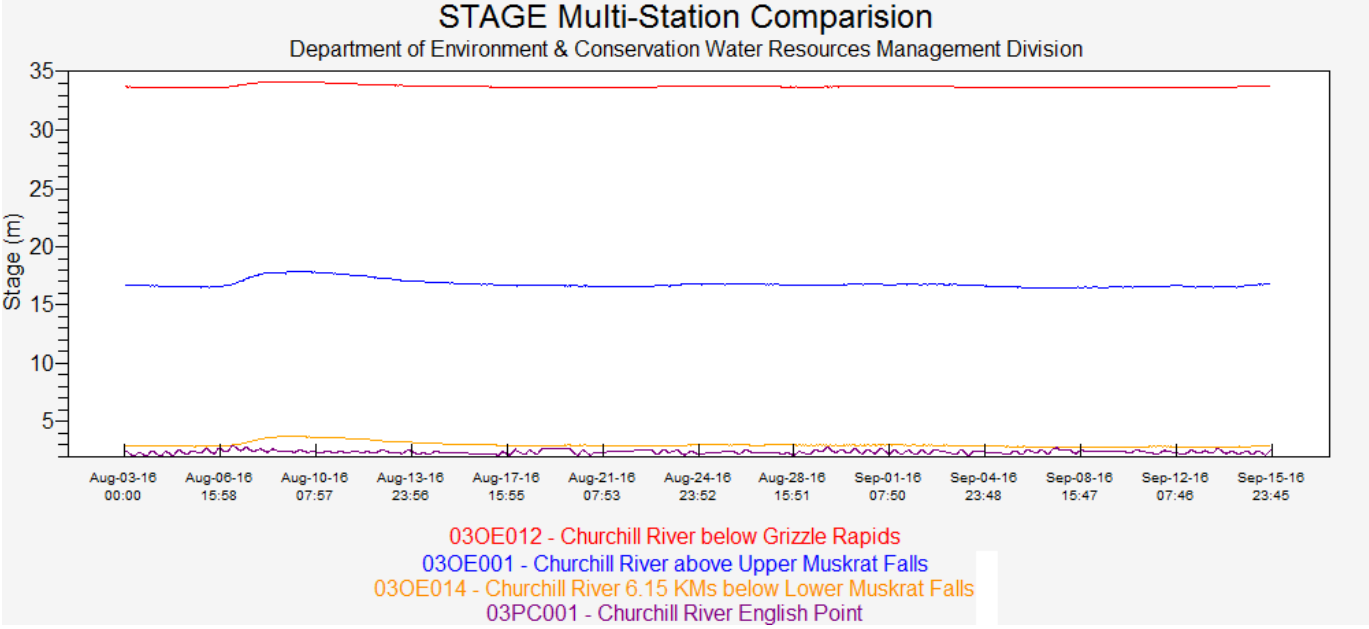


Figure A7: Comparison of Stage at the Real-Time Stations on Churchill River

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

Maxxam
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Success Through Science®

Maxxam Job #: B6G6841
Report Date: 2016/08/18

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

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CVS343 CR below GR								
Sampling Date 2016/08/03 10:45								
Matrix W								
Sample # 2016-6318-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	13	1.0	mg/L	N/A	2016/08/18	2016/08/18		4611356
Hardness (CaCO3)	8.8	1.0	mg/L	N/A	2016/08/12	2016/08/12		4611349
Nitrate (N)	0.055	0.050	mg/L	N/A	2016/08/17	2016/08/17		4611352
Inorganics								
Conductivity	17	1.0	uS/cm	N/A	2016/08/12	2016/08/12	KMC	4615699
Bromide (Br-)	<1.0	1.0	mg/L	N/A	2016/08/12	2016/08/12	FD	4616316
Total Alkalinity (Total as CaCO3)	9.4	5.0	mg/L	N/A	2016/08/16	2016/08/16	NRG	4619579
Dissolved Chloride (Cl)	<1.0	1.0	mg/L	N/A	2016/08/18	2016/08/18	NRG	4619581
Colour	21	5.0	TCU	N/A	2016/08/17	2016/08/17	NRG	4619584
Dissolved Fluoride (F-)	<0.10	0.10	mg/L	N/A	2016/08/12	2016/08/12	KMC	4615703
Total Kjeldahl Nitrogen (TKN)	0.18	0.10	mg/L	+/- <RDL	2016/08/16	2016/08/16	AAY	4620894
Nitrite (N)	<0.010	0.010	mg/L	N/A	2016/08/17	2016/08/17	MCN	4619587
Nitrogen (Ammonia Nitrogen)	<0.050	0.050	mg/L	N/A	2016/08/17	2016/08/17	NRG	4619483
Dissolved Organic Carbon (C)	3.7	0.50	mg/L	N/A	2016/08/11	2016/08/11	SMT	4615243
Total Organic Carbon (C)	3.8	0.50	mg/L	N/A	2016/08/11	2016/08/11	SMT	4615128
pH	7.17	N/A	pH	N/A	2016/08/12	2016/08/12	KMC	4615686
Total Phosphorus	<0.004	0.004	mg/L	N/A	2016/08/15	2016/08/15	SNR	4619362
Dissolved Sulphate (SO4)	<2.0	2.0	mg/L	N/A	2016/08/17	2016/08/17	NRG	4619582
Turbidity	1.4	0.10	NTU	N/A	2016/08/11	2016/08/11	KMC	4615915
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	<0.000013	0.000013	mg/L	N/A	2016/08/12	2016/08/15	ARS	4616833
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	0.045	0.0050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Antimony (Sb)	<0.0010	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Arsenic (As)	<0.0010	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Barium (Ba)	0.0084	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Boron (B)	<0.050	0.050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Cadmium (Cd)	0.000038	0.000010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Calcium (Ca)	2.3	0.10	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Chromium (Cr)	<0.0010	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Copper (Cu)	<0.0020	0.0020	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Iron (Fe)	0.094	0.050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Lead (Pb)	<0.00050	0.00050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Magnesium (Mg)	0.75	0.10	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Manganese (Mn)	0.0084	0.0020	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Nickel (Ni)	<0.0020	0.0020	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Potassium (K)	0.31	0.10	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Selenium (Se)	<0.0010	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Sodium (Na)	0.61	0.10	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Strontium (Sr)	0.012	0.0020	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Uranium (U)	<0.00010	0.00010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118
Total Zinc (Zn)	<0.0050	0.0050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615118

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

Maxxam Job #: B6G6765
Report Date: 2016/08/11

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

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CVS095 CR Below GR								
Sampling Date 2016/08/03 10:45								
Matrix W								
Sample # 2016-6318-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Inorganics								
Total Suspended Solids	<1.0	1.0	mg/L	N/A	2016/08/10	2016/08/11	MM9	4613382

Maxxam Analytics International Corporation o/a Maxxam Analytics 49-55 Elizabeth Ave, Suite 101A, St.John's, NL, Canada A1A 1W9 Tel: 709-754-0203 Toll Free: 888-492-7227 Fax: 709-754-8612 www.maxxamanalytics.com

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Maxxam Job #: B6G6841
Report Date: 2016/08/18

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

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CVS344 CR @ upper MF								
Sampling Date 2016/08/03 11:30								
Matrix W								
Sample # 2016-6319-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	13	1.0	mg/L	N/A	2016/08/18	2016/08/18		4611356
Hardness (CaCO3)	8.9	1.0	mg/L	N/A	2016/08/12	2016/08/12		4611349
Nitrate (N)	0.053	0.050	mg/L	N/A	2016/08/17	2016/08/17		4611352
Inorganics								
Conductivity	17	1.0	uS/cm	N/A	2016/08/12	2016/08/12	KMC	4615699
Bromide (Br-)	<1.0	1.0	mg/L	N/A	2016/08/12	2016/08/12	FD	4616316
Total Alkalinity (Total as CaCO3)	9.4	5.0	mg/L	N/A	2016/08/16	2016/08/16	NRG	4619579
Dissolved Chloride (Cl)	<1.0	1.0	mg/L	N/A	2016/08/18	2016/08/18	NRG	4619581
Colour	26	5.0	TCU	N/A	2016/08/17	2016/08/17	NRG	4619584
Dissolved Fluoride (F-)	<0.10	0.10	mg/L	N/A	2016/08/12	2016/08/12	KMC	4615703
Total Kjeldahl Nitrogen (TKN)	0.14	0.10	mg/L	+/- <RDL	2016/08/16	2016/08/16	AAY	4620894
Nitrite (N)	<0.010	0.010	mg/L	N/A	2016/08/17	2016/08/17	MCN	4619587
Nitrogen (Ammonia Nitrogen)	<0.050	0.050	mg/L	N/A	2016/08/17	2016/08/17	NRG	4619483
Dissolved Organic Carbon (C)	4.7	0.50	mg/L	N/A	2016/08/11	2016/08/11	SMT	4615243
Total Organic Carbon (C)	4.2	0.50	mg/L	N/A	2016/08/11	2016/08/11	SMT	4615128
pH	7.07	N/A	pH	N/A	2016/08/12	2016/08/12	KMC	4615686
Total Phosphorus	0.009	0.004	mg/L	+/- 0.004	2016/08/15	2016/08/15	SNR	4619362
Dissolved Sulphate (SO4)	<2.0	2.0	mg/L	N/A	2016/08/17	2016/08/17	NRG	4619582
Turbidity	3.0	0.10	NTU	N/A	2016/08/11	2016/08/11	KMC	4615915
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	<0.000013	0.000013	mg/L	N/A	2016/08/12	2016/08/15	ARS	4616833
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	0.24	0.0050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Antimony (Sb)	<0.0010	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Arsenic (As)	<0.0010	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Barium (Ba)	0.0094	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Boron (B)	<0.050	0.050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Cadmium (Cd)	<0.000010	0.000010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Calcium (Ca)	2.3	0.10	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Chromium (Cr)	<0.0010	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Copper (Cu)	<0.0020	0.0020	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Iron (Fe)	0.24	0.050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Lead (Pb)	<0.00050	0.00050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Magnesium (Mg)	0.78	0.10	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Manganese (Mn)	0.011	0.0020	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Nickel (Ni)	<0.0020	0.0020	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Potassium (K)	0.36	0.10	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Selenium (Se)	<0.0010	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Sodium (Na)	0.69	0.10	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Strontium (Sr)	0.013	0.0020	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Uranium (U)	<0.00010	0.00010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Zinc (Zn)	<0.0050	0.0050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107

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Maxxam Job #: B6G6765
Report Date: 2016/08/11

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

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CVS096 CR @ upper MF								
Sampling Date 2016/08/03 11:30								
Matrix W								
Sample # 2016-6319-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Inorganics								
Total Suspended Solids	3.6	1.0	mg/L	N/A	2016/08/10	2016/08/11	MM9	4613382

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Maxxam Job #: B6G6841
Report Date: 2016/08/18

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

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CVS345 CR below MF								
Sampling Date 2016/08/03 11:50								
Matrix W								
Sample # 2016-6320-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	13	1.0	mg/L	N/A	2016/08/18	2016/08/18		4611356
Hardness (CaCO3)	8.8	1.0	mg/L	N/A	2016/08/12	2016/08/12		4611349
Nitrate (N)	0.054	0.050	mg/L	N/A	2016/08/17	2016/08/17		4611352
Inorganics								
Conductivity	16	1.0	uS/cm	N/A	2016/08/12	2016/08/12	KMC	4615699
Bromide (Br-)	<1.0	1.0	mg/L	N/A	2016/08/12	2016/08/12	FD	4616316
Total Alkalinity (Total as CaCO3)	9.1	5.0	mg/L	N/A	2016/08/16	2016/08/16	NRG	4619579
Dissolved Chloride (Cl)	<1.0	1.0	mg/L	N/A	2016/08/18	2016/08/18	NRG	4619581
Colour	30	5.0	TCU	N/A	2016/08/17	2016/08/17	NRG	4619584
Dissolved Fluoride (F-)	<0.10	0.10	mg/L	N/A	2016/08/12	2016/08/12	KMC	4615703
Total Kjeldahl Nitrogen (TKN)	0.20	0.10	mg/L	+/- <RDL	2016/08/16	2016/08/16	AAY	4620894
Nitrite (N)	<0.010	0.010	mg/L	N/A	2016/08/17	2016/08/17	MCN	4619587
Nitrogen (Ammonia Nitrogen)	<0.050	0.050	mg/L	N/A	2016/08/17	2016/08/17	NRG	4619483
Dissolved Organic Carbon (C)	4.5	0.50	mg/L	N/A	2016/08/11	2016/08/11	SMT	4615243
Total Organic Carbon (C)	4.4	0.50	mg/L	N/A	2016/08/11	2016/08/11	SMT	4615128
pH	7.00	N/A	pH	N/A	2016/08/12	2016/08/12	KMC	4615686
Total Phosphorus	0.010	0.004	mg/L	+/- 0.004	2016/08/15	2016/08/15	SNR	4619362
Dissolved Sulphate (SO4)	<2.0	2.0	mg/L	N/A	2016/08/17	2016/08/17	NRG	4619582
Turbidity	4.2	0.10	NTU	N/A	2016/08/11	2016/08/11	KMC	4615915
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	<0.000013	0.000013	mg/L	N/A	2016/08/12	2016/08/15	ARS	4616833
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	0.24	0.0050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Antimony (Sb)	<0.0010	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Arsenic (As)	<0.0010	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Barium (Ba)	0.011	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Boron (B)	<0.050	0.050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Cadmium (Cd)	0.000013	0.000010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Calcium (Ca)	2.2	0.10	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Chromium (Cr)	<0.0010	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Copper (Cu)	<0.0020	0.0020	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Iron (Fe)	0.28	0.050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Lead (Pb)	<0.00050	0.00050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Magnesium (Mg)	0.79	0.10	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Manganese (Mn)	0.012	0.0020	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Nickel (Ni)	<0.0020	0.0020	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Potassium (K)	0.40	0.10	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Selenium (Se)	<0.0010	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Sodium (Na)	0.69	0.10	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Strontium (Sr)	0.012	0.0020	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Uranium (U)	<0.00010	0.00010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Zinc (Zn)	<0.0050	0.0050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107

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Maxxam Job #: B6G6765
Report Date: 2016/08/11

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

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CVS097 CR below MF								
Sampling Date 2016/08/03 11:50								
Matrix W								
Sample # 2016-6320-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Inorganics								
Total Suspended Solids	6.4	1.0	mg/L	N/A	2016/08/10	2016/08/11	MM9	4613382

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Maxxam Job #: B6G6841
Report Date: 2016/08/18

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

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CVS355 CR @ English Point								
Sampling Date 2016/08/04 12:55								
Matrix W								
Sample # 2016-6322-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	22	1.0	mg/L	N/A	2016/08/18	2016/08/18		4611356
Hardness (CaCO3)	9.4	1.0	mg/L	N/A	2016/08/12	2016/08/12		4611349
Nitrate (N)	0.057	0.050	mg/L	N/A	2016/08/17	2016/08/17		4611352
Inorganics								
Conductivity	31	1.0	uS/cm	N/A	2016/08/12	2016/08/12	KMC	4615699
Bromide (Br-)	<1.0	1.0	mg/L	N/A	2016/08/12	2016/08/12	FD	4616316
Total Alkalinity (Total as CaCO3)	10	5.0	mg/L	N/A	2016/08/16	2016/08/16	NRG	4619579
Dissolved Chloride (Cl)	4.5	1.0	mg/L	N/A	2016/08/18	2016/08/18	NRG	4619581
Colour	38	5.0	TCU	N/A	2016/08/17	2016/08/17	NRG	4619584
Dissolved Fluoride (F-)	<0.10	0.10	mg/L	N/A	2016/08/12	2016/08/12	KMC	4615703
Total Kjeldahl Nitrogen (TKN)	0.14	0.10	mg/L	+/- <RDL	2016/08/16	2016/08/16	AAY	4620894
Nitrite (N)	<0.010	0.010	mg/L	N/A	2016/08/17	2016/08/17	MCN	4619587
Nitrogen (Ammonia Nitrogen)	<0.050	0.050	mg/L	N/A	2016/08/17	2016/08/17	NRG	4619483
Dissolved Organic Carbon (C)	5.7	0.50	mg/L	N/A	2016/08/11	2016/08/11	SMT	4615243
Total Organic Carbon (C)	5.4	0.50	mg/L	N/A	2016/08/11	2016/08/11	SMT	4615128
pH	7.07	N/A	pH	N/A	2016/08/12	2016/08/12	KMC	4615686
Total Phosphorus	0.011	0.004	mg/L	+/- 0.005	2016/08/15	2016/08/15	SNR	4619362
Dissolved Sulphate (SO4)	<2.0	2.0	mg/L	N/A	2016/08/17	2016/08/17	NRG	4619582
Turbidity	4.7	0.10	NTU	N/A	2016/08/11	2016/08/11	KMC	4615915
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	<0.000013	0.000013	mg/L	N/A	2016/08/12	2016/08/15	ARS	4616833
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	0.20	0.0050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Antimony (Sb)	<0.0010	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Arsenic (As)	<0.0010	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Barium (Ba)	0.0090	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Boron (B)	<0.050	0.050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Cadmium (Cd)	<0.000010	0.000010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Calcium (Ca)	2.1	0.10	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Chromium (Cr)	<0.0010	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Copper (Cu)	<0.0020	0.0020	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Iron (Fe)	0.34	0.050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Lead (Pb)	<0.00050	0.00050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Magnesium (Mg)	0.99	0.10	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Manganese (Mn)	0.011	0.0020	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Nickel (Ni)	<0.0020	0.0020	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Potassium (K)	0.51	0.10	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Selenium (Se)	<0.0010	0.0010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Sodium (Na)	3.4	0.10	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Strontium (Sr)	0.016	0.0020	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Uranium (U)	<0.00010	0.00010	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107
Total Zinc (Zn)	<0.0050	0.0050	mg/L	N/A	2016/08/11	2016/08/12	BAN	4615107

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Maxxam Job #: B6G6765
Report Date: 2016/08/11

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

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CVS224 CR @ English Point								
Sampling Date 2016/08/04 12:55								
Matrix W								
Sample # 2016-6322-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Inorganics								
Total Suspended Solids	3.0	1.0	mg/L	N/A	2016/08/10	2016/08/11	MM9	4613382

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Appendix E –Below Grizzle Rapids Landslide

A landslide occurred at the below Grizzle Rapids Station sometime between August 18 (station visit by ECCC) and September 15 (station visit by ECC), 2016. The instrumentation was located only several feet from the landslide, in front of the large boulder shown below. The only turbidity event during this period which could not be attributed to precipitation was Septemebr 1, thus the landslide may have occurred at this time.

Appendix F -River Diversion/Spillway Operations

August 3, 2016 – Pre River Diversion through Spillway: (a) At Muskrat Falls Dam (b) At below Lower Muskrat Falls Station

(a)

(b)

August 4, 2016 – Post River Diversion through Spillway: (a) At Muskrat Falls Dam (b) At below Lower Muskrat Falls Station

(a)

(b)