Real-Time Water Quality Deployment Report

Lower Churchill River Network

June 29/July15 to
August 13/14/September 1, 2020

Newfoundland Labrador

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

Contents

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Real Time Water Quality Monitoring

- Staff with the Department of Environment, Climate Change and Municipalities 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: Churchill River below Metchin River, Churchill River above Grizzle Rapids, Churchill River below Muskrat Falls and Churchill River at English Point.
- The start of the deployment season was delayed this year, in comparison to previous years, due to challenges presented by the Covid-19 pandemic and the unexpected closure of a local helicopter company.
- Real-time water quality monitoring instruments were deployed at Churchill River above Grizzle Rapids, Churchill River below Muskrat Falls and Churchill River at English Point on June 29th. An instrument was deployed at Churchill River below Metchin River on July 15th.
- Instruments at Churchill River above Grizzle Rapids and Churchill River below Muskrat Falls were removed on August 13th for a deployment period of 45 days. The instrument at Churchill River at English Point was removed on August 14th for a deployment period of 46 days. The instrument at Churchill River below Metchin River was removed on September 1st for a deployment period of 48 days.
- The station at Churchill River above Muskrat Falls was not able to be deployed during this deployment period. This station was relocated in October 2016 as it was situated in the flood zone of the Muskrat Falls Reservoir and needed to be moved back to ensure the station did not flood as the reservoir water levels were raised. Even at raised water levels, the above Muskrat Falls station is situated quite far from the water, making it impractical to install monitoring equipment. Additionally, safety requirements with regards to working in and around the reservoir for the Muskrat Falls project further hindered the ability to deploy the instrument at this station.

Quality Assurance and Quality Control

- As part of the Quality Assurance and Quality Control protocol (QA/QC), an assessment of the reliability of data recorded by an instrument is made at the beginning and end of the deployment period. This procedure is based on the approach used by the United States Geological Survey.
- At deployment and removal, a QA/QC 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 QA/QC 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 June 29/July 15 to August 13/14/September 1, 2020 are summarized in Table 2.

Table 2: Comparison rankings for Lower Churchill River stations June 29/July 15 to August 13/14/September 1, 2020

Churchill River Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Below Metchin River	July 15, 2020	Deployment	Good	Excellent	Excellent	Excellent	Excellent
	September 1, 2020	Removal	Good	Excellent	Excellent	Excellent	Excellent
Above Grizzle Rapids	June 29, 2020	Deployment	Excellent	Poor	Excellent	Excellent	Excellent
	August 13, 2020	Removal	Excellent	Good	Excellent	Good	Excellent
Below Muskrat Falls	June 29, 2020	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	August 13, 2020	Removal	Excellent	Good	Excellent	Good	Good
At English Point	June 29, 2020	Deployment	Excellent	Poor	Excellent	Good	Good
	August 14, 2020	Removal	Excellent	Fair	Excellent	Good	Excellent
Above Muskrat Falls	Not deployed	Deployment	N/A	N/A	N/A	N/A	N/A
	Not deployed	Removal	N/A	N/A	N/A	N/A	N/A

- **Churchill River below Metchin River**
  - At deployment, all parameters ranked as either ‘excellent’ or ‘good’.
  - At removal, all parameters again ranked as either ‘excellent’ or ‘good’.
- **Churchill River above Grizzle Rapids**
  - At deployment, pH was ‘poor’, while all other parameters ranked as ‘excellent’. This discrepancy is likely due to the QA/QC sonde not being placed in close enough proximity to the field sonde, or not being given sufficient time to acclimatize. This is supported by an ‘excellent’ ranking for pH between the field sonde and the grab sample.
  - At removal, all parameters ranked as either ‘excellent’ or ‘good'.
- **Churchill River below Muskrat Falls**
  - At deployment, all parameters ranked as either ‘excellent’ or ‘good’
  - At removal, all parameters again ranked as either ‘excellent’ or ‘good’.

- **Churchill River at English Point**
    - At deployment, all parameters ranked as either 'excellent' or 'good', with the exception of pH, which was 'poor'. This discrepancy is likely due to the QA/QC sonde not being placed in close enough proximity to the field sonde, or not being given sufficient time to acclimatize. This is supported by a 'good' ranking for pH between the field sonde and the grab sample.
    - At removal, pH was 'fair', while all other parameters ranked as either 'excellent' or 'good'.

Data Interpretation

- The following graphs and discussion illustrate water quality related events occurring from June 29/July 15 to August 13/14/September 1, 2020 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 stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

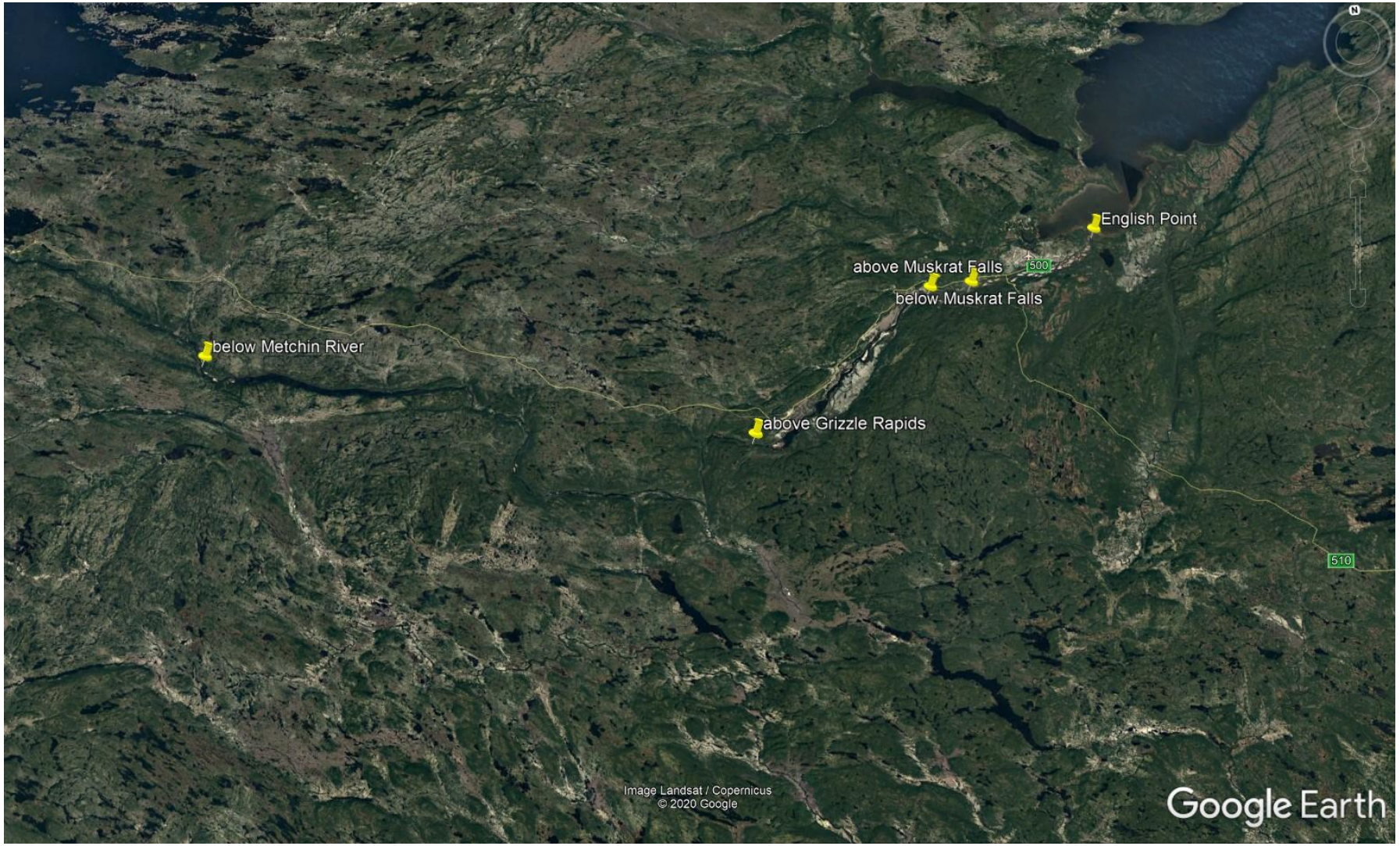

Figure 1: Lower Churchill Network of Real-Time Water Quality Stations

Churchill River below Metchin River

Water Temperature

- Over the deployment period, water temperature ranged from 14.2°C to 21.1°C, with a median value of 17.8°C (Figure 2). Air temperature data was obtained from the Metchin River near TLH Weather Station.
- Water temperature was quite stable over the course of deployment, decreasing slightly towards the end of deployment. This is to be expected as air temperatures were also quite consistent across the summer season. Water temperature data exhibits a diurnal pattern as expected, and closely correlates with ambient air temperatures.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

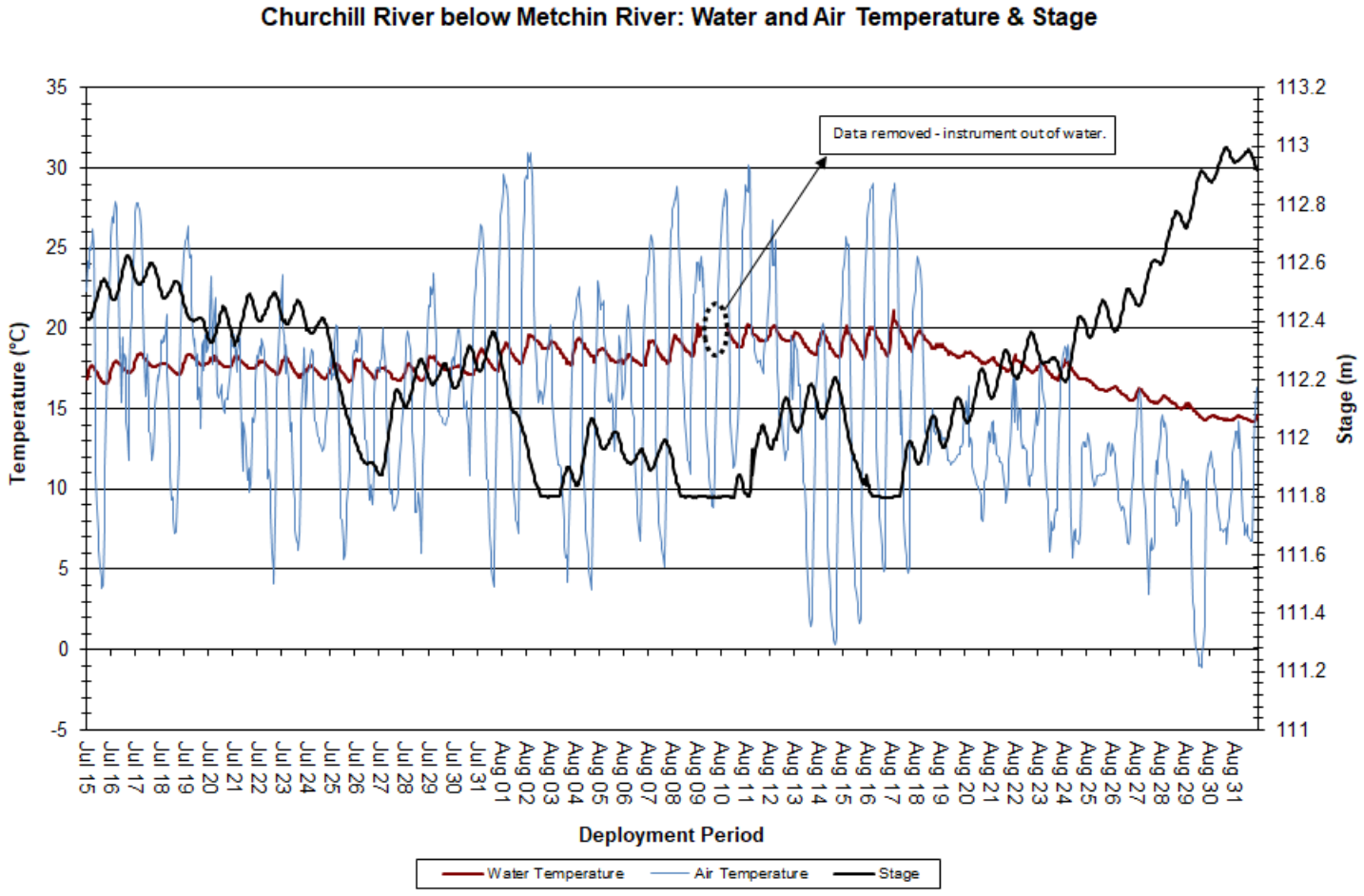

Figure 2: Water and Air Temperature & Stage at Churchill River below Metchin River

pH

- Over the deployment period, pH values ranged from 6.89 to 7.19 pH units, with a median value of 7.04 (Figure 3).
- pH values were stable over the course of deployment and remained within the CCME's Guidelines for the Protection of Aquatic Life for the duration of deployment.
- Photosynthesis uses up hydrogen molecules; this causes the concentration of hydrogen ions to decrease, which in turn causes 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 pH values (Figure 3).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

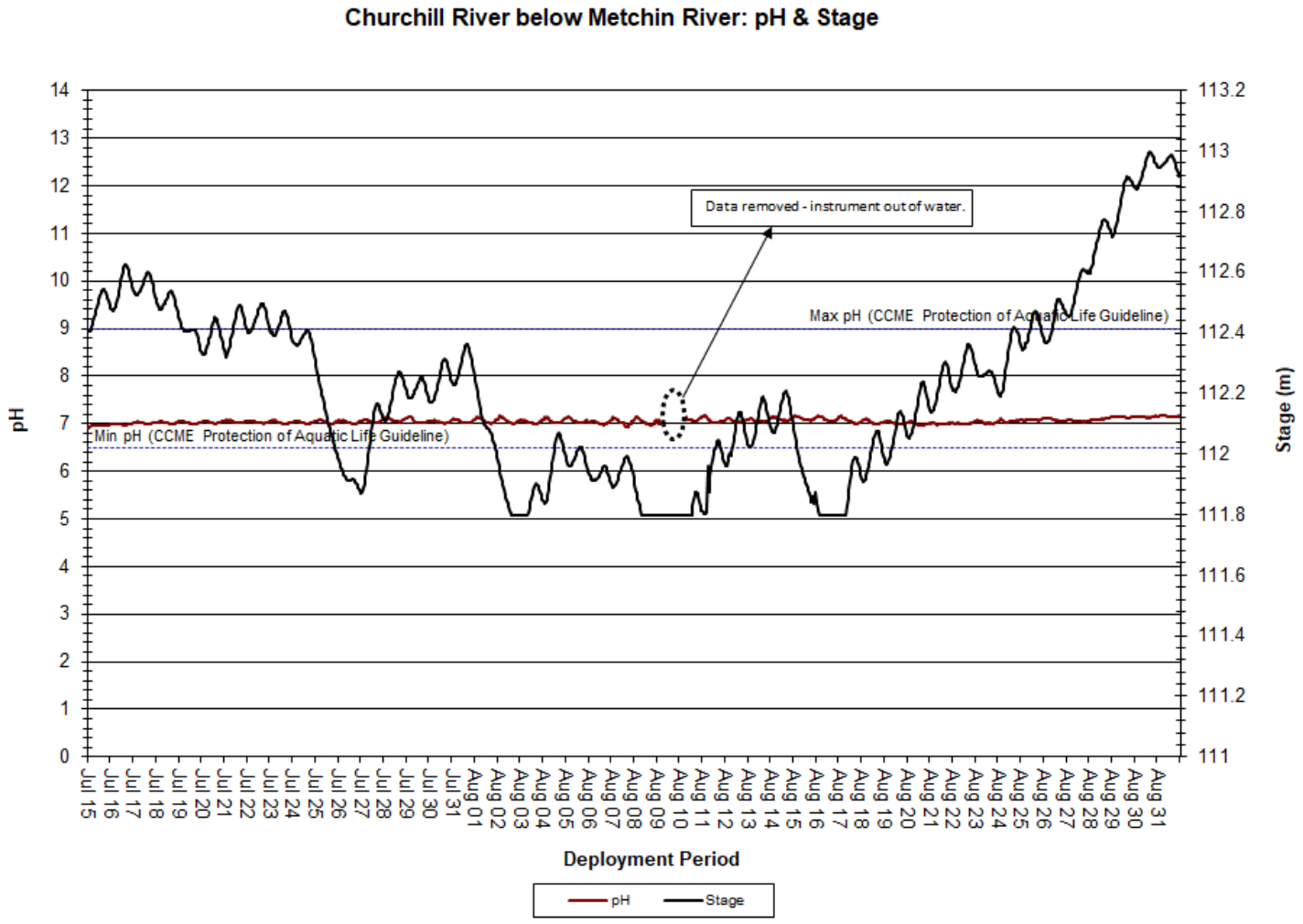

Figure 3: pH & Stage at Churchill River below Metchin River

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 17.8µS/cm to 28.9µS/cm, with a median value of 20.3µS/cm (Figure 4).
- The relationship between conductivity and stage is generally inversed. When stage levels increase, specific conductivity levels decrease as the increased amount of water in the river system dilutes solids that are present. This relationship is somewhat evident in the graph below (Figure 4).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

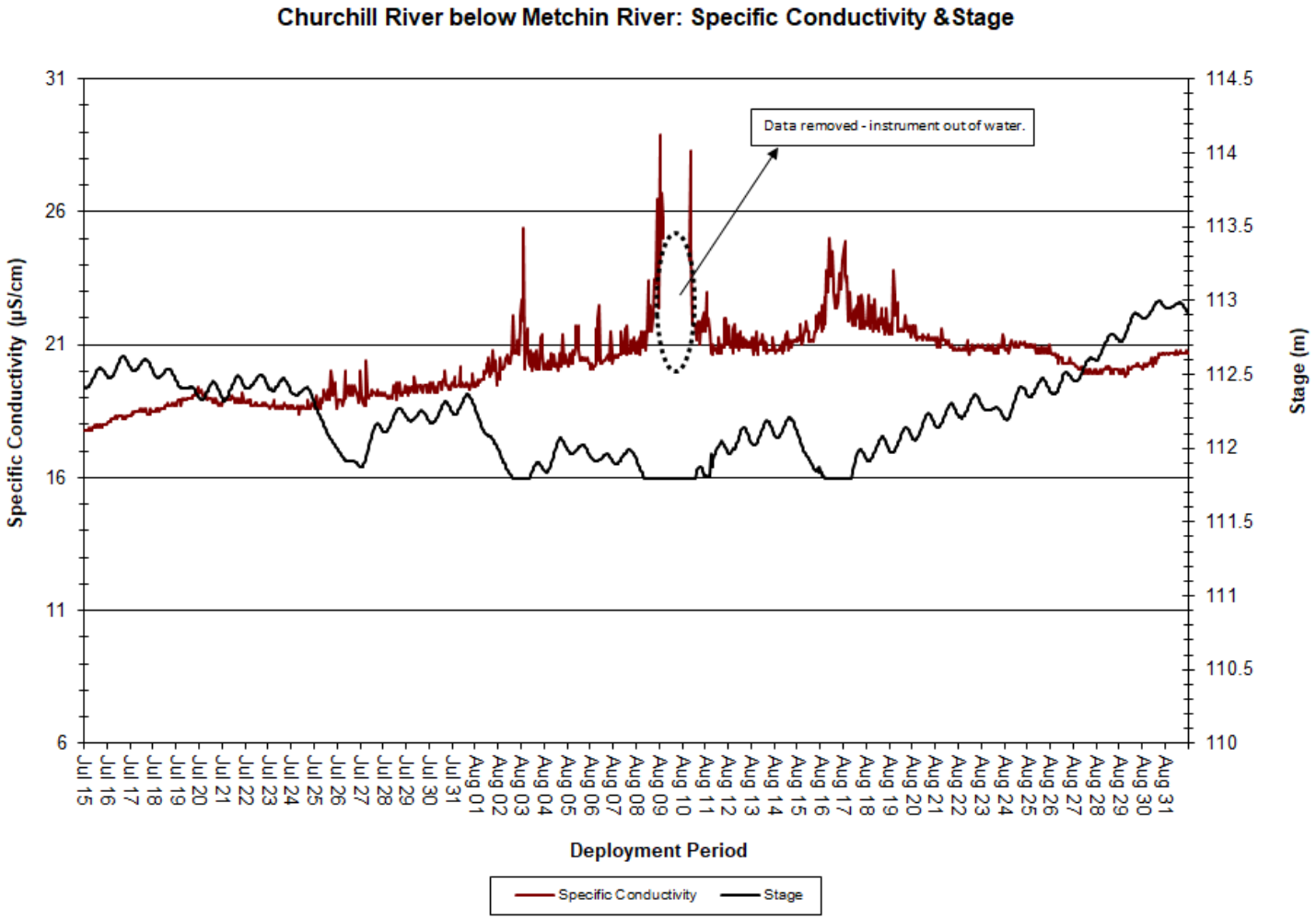

Figure 4: Specific Conductivity & Stage at Churchill River below Metchin River

Dissolved Oxygen

- Over the deployment period, dissolved oxygen content ranged from 8.63mg/L to 9.64mg/L, with a median value of 9.05mg/L. Saturation of dissolved oxygen ranged from 90.7% to 101.0%, with a median value of 95.0% (Figure 5).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period, dissolved oxygen levels were stable and lower, as water temperatures were stable and warmer. Dissolved oxygen also follows a diurnal pattern as water temperatures rise and fall under the influence of ambient air temperatures. Generally, dissolved oxygen levels are higher in a waterbody during cooler temperatures.
- Dissolved oxygen levels hovered around the CCME's Guideline for the Protection of Early Life Stages for the very beginning and very end of deployment, but were otherwise below the guideline. Dissolved oxygen levels remained above the CCME's Guideline for the Protection of Other Life Stages for the duration of deployment.

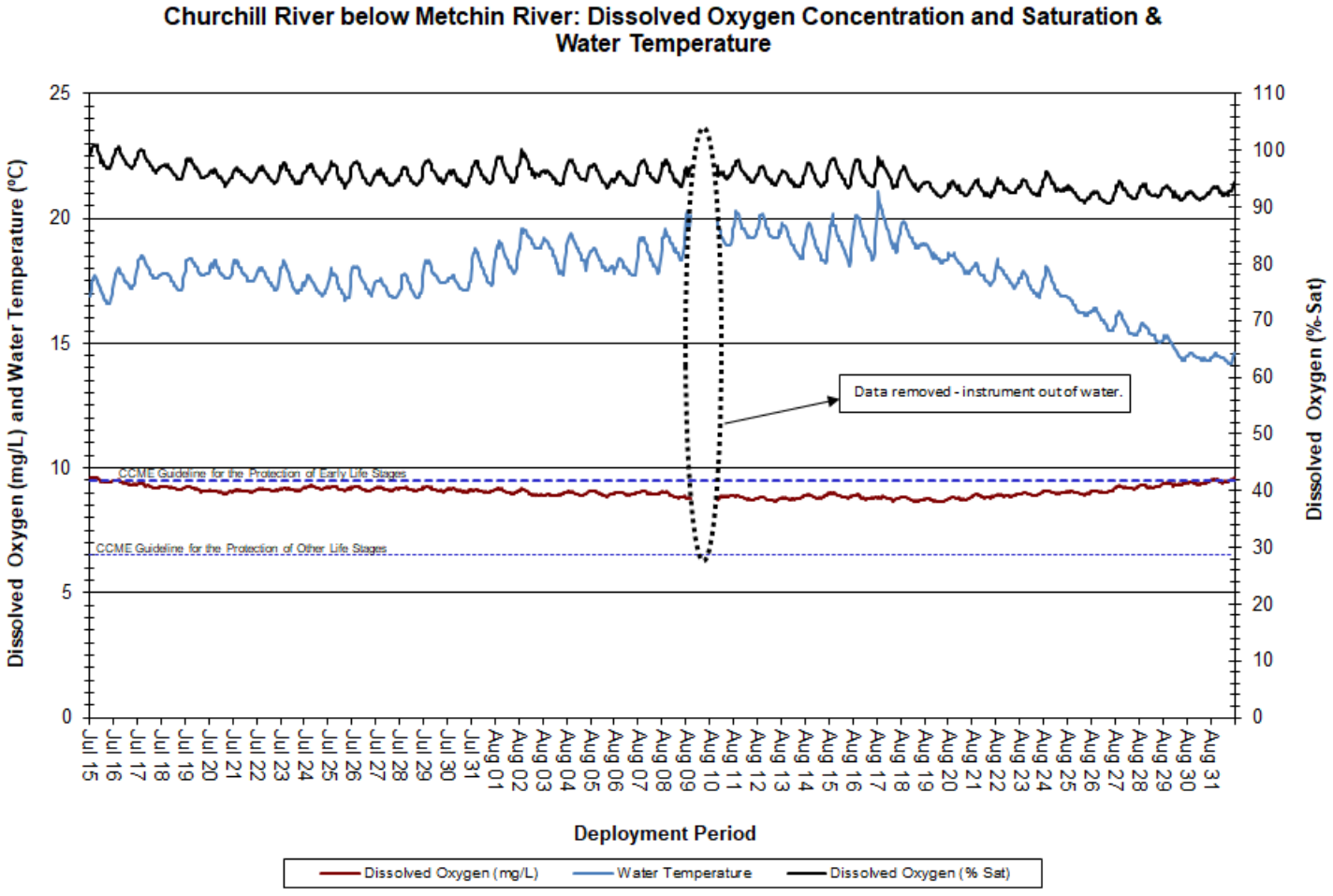

Figure 5: Dissolved Oxygen & Water Temperature at Churchill River below Metchin River

Turbidity

- Over the deployment period, turbidity ranged from 0.0NTU to 32.8NTU, with a median value of 0.0NTU (Figure 6). A median value of 0.0NTU indicates a very low level of natural background turbidity in the waterbody. Precipitation data was obtained from the Metchin River near TLH Weather Station.
- Many of the turbidity spikes observed throughout the deployment period correlate closely with precipitation events (Figure 6); however, some turbidity events do not coincide with any precipitation. This station is located at a wide and deep section of the Churchill River and therefore turbidity levels are likely less susceptible to precipitation events as compared to other areas. Turbidity levels returned to background levels following each observed increase.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

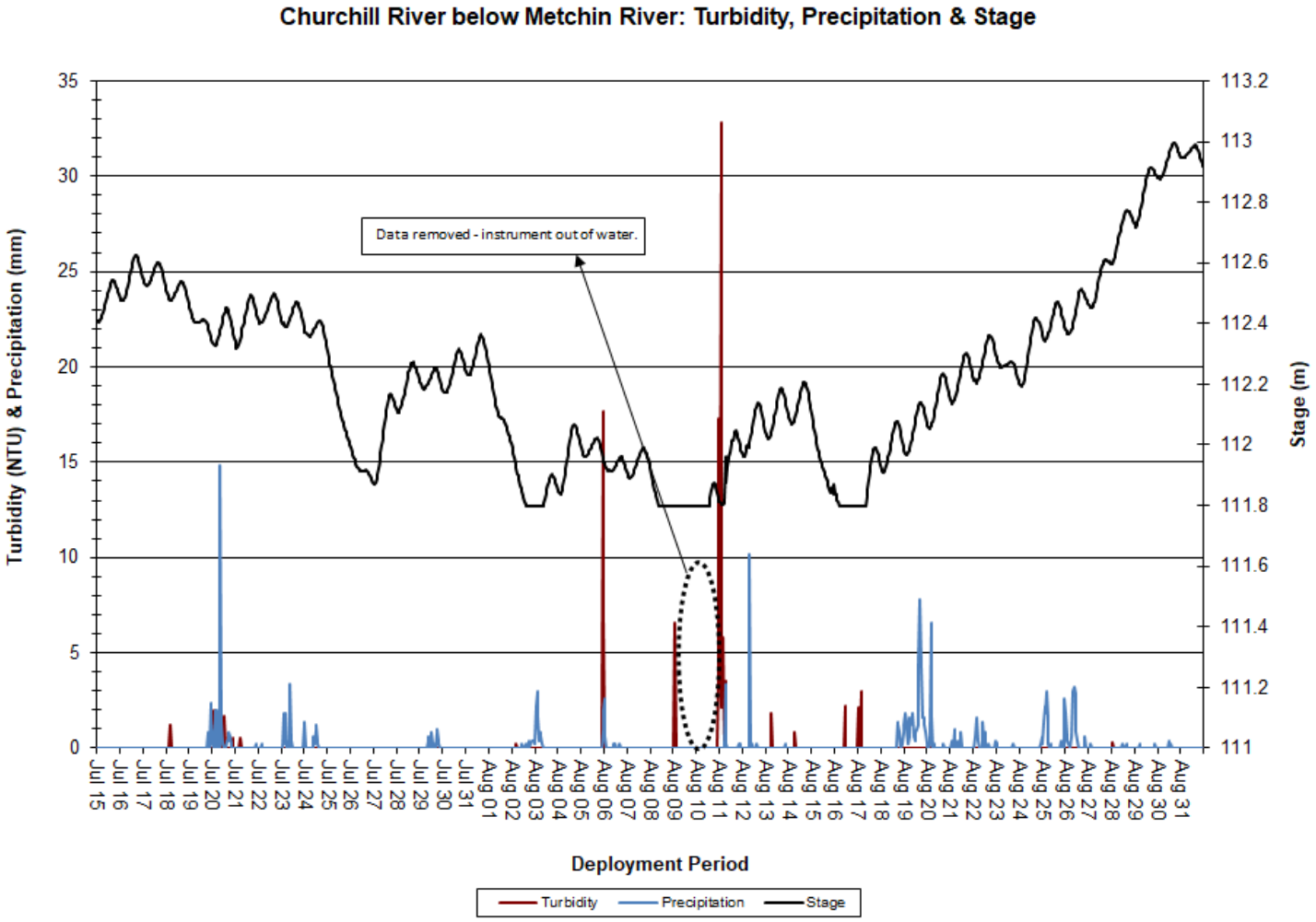

Figure 6: Turbidity, Precipitation & Stage at Churchill River below Metchin River

Stage and Flow

- Over the deployment period, stage levels ranged from 111.80m to 113.00m, with a median value of 112.20m. Flow ranged from 629.12m^3/s to 1208.00m^3/s, with a median value of 877.78m^3/s (Figure 7). Precipitation data was obtained from the Metchin River near TLH Weather Station.
- Stage and flow were slightly variable across the deployment period and followed a similar trend. Precipitation amounts across the same period correlate with increases in both stage and flow (Figure 8).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

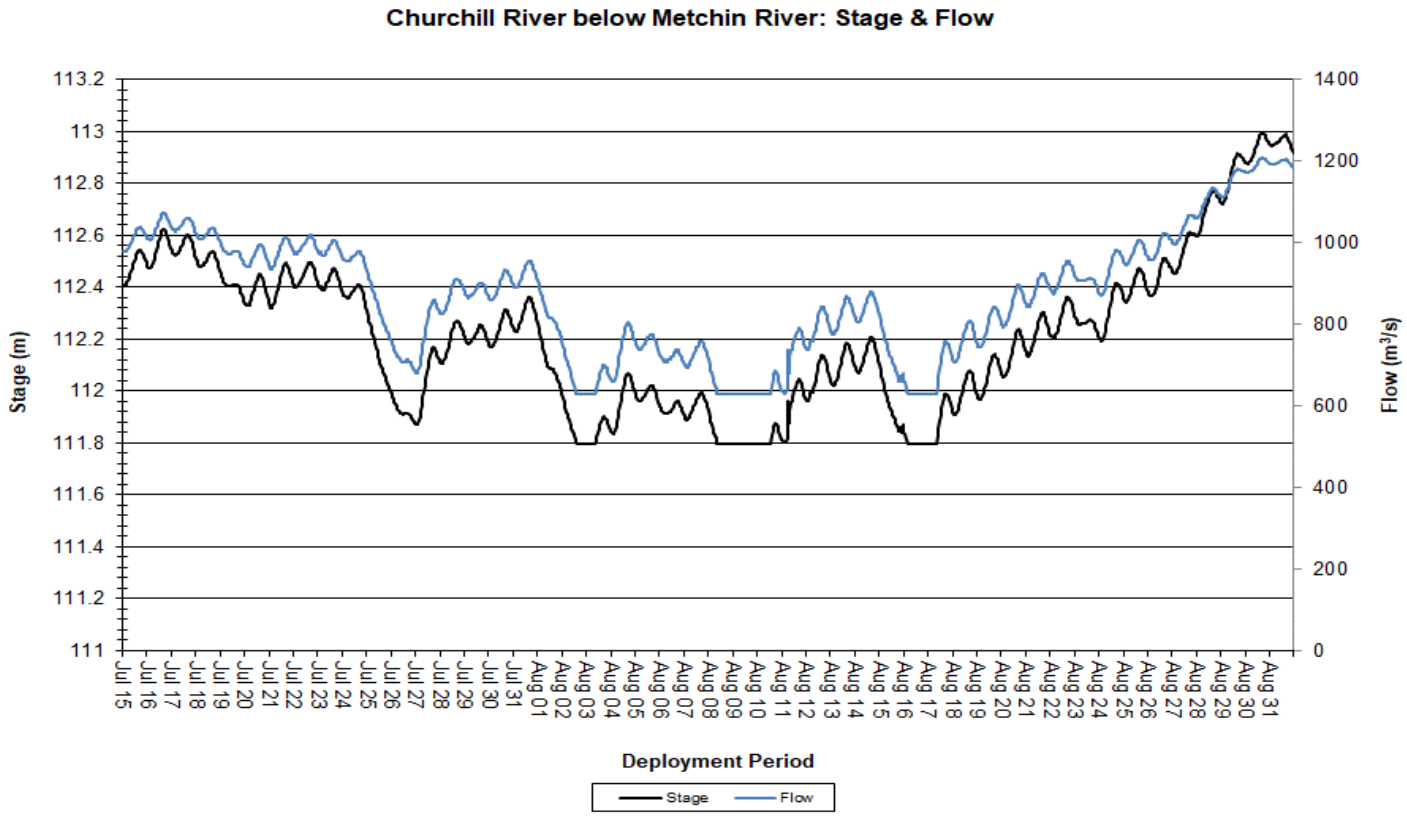

Figure 7: Stage & Flow at Churchill River below Metchin River

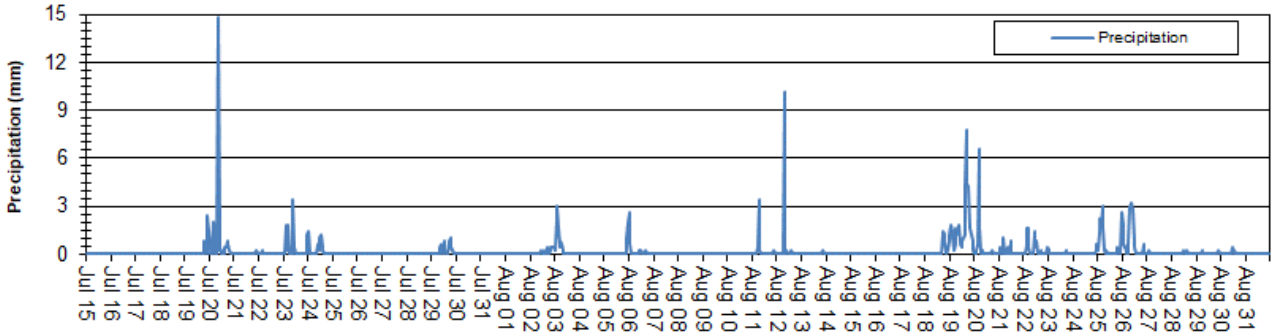

Figure 8: Precipitation at Churchill River below Metchin River

Churchill River above Grizzle Rapids

Water Temperature

- Over the deployment period, water temperature ranged from 8.7°C to 21.2°C, with a median value of 17.6°C (Figure 9). Air temperature data was obtained from the Metchin River near TLH Weather Station.
- Water temperature slowly increased across the deployment period. This trend is to be expected as air temperatures also increased through the summer. Water temperature data exhibits a diurnal pattern, and closely correlates with ambient air temperatures.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

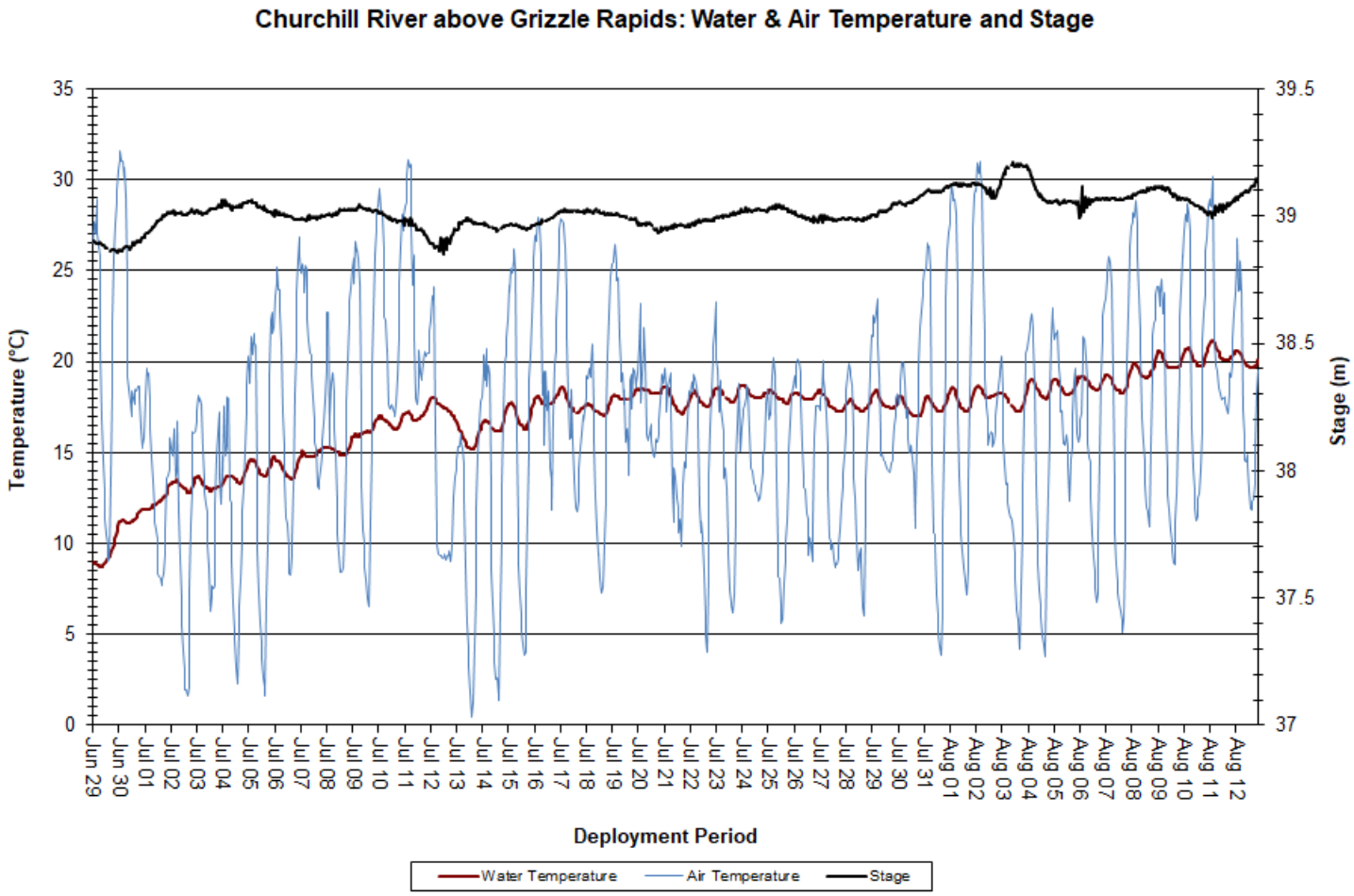

Figure 9: Water and Air Temperature & Stage at Churchill River above Grizzle Rapids

pH

- Over the deployment period, pH values ranged from 6.56 pH units to 6.93 pH units, with a median value of 6.78 (Figure 10).
- pH values were quite stable and remained within the CCME's Guidelines for the Protection of Aquatic Life for the duration of deployment.
- Photosynthesis uses up hydrogen molecules; this causes the concentration of hydrogen ions to decrease, which in turn causes 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 pH values (Figure 10).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

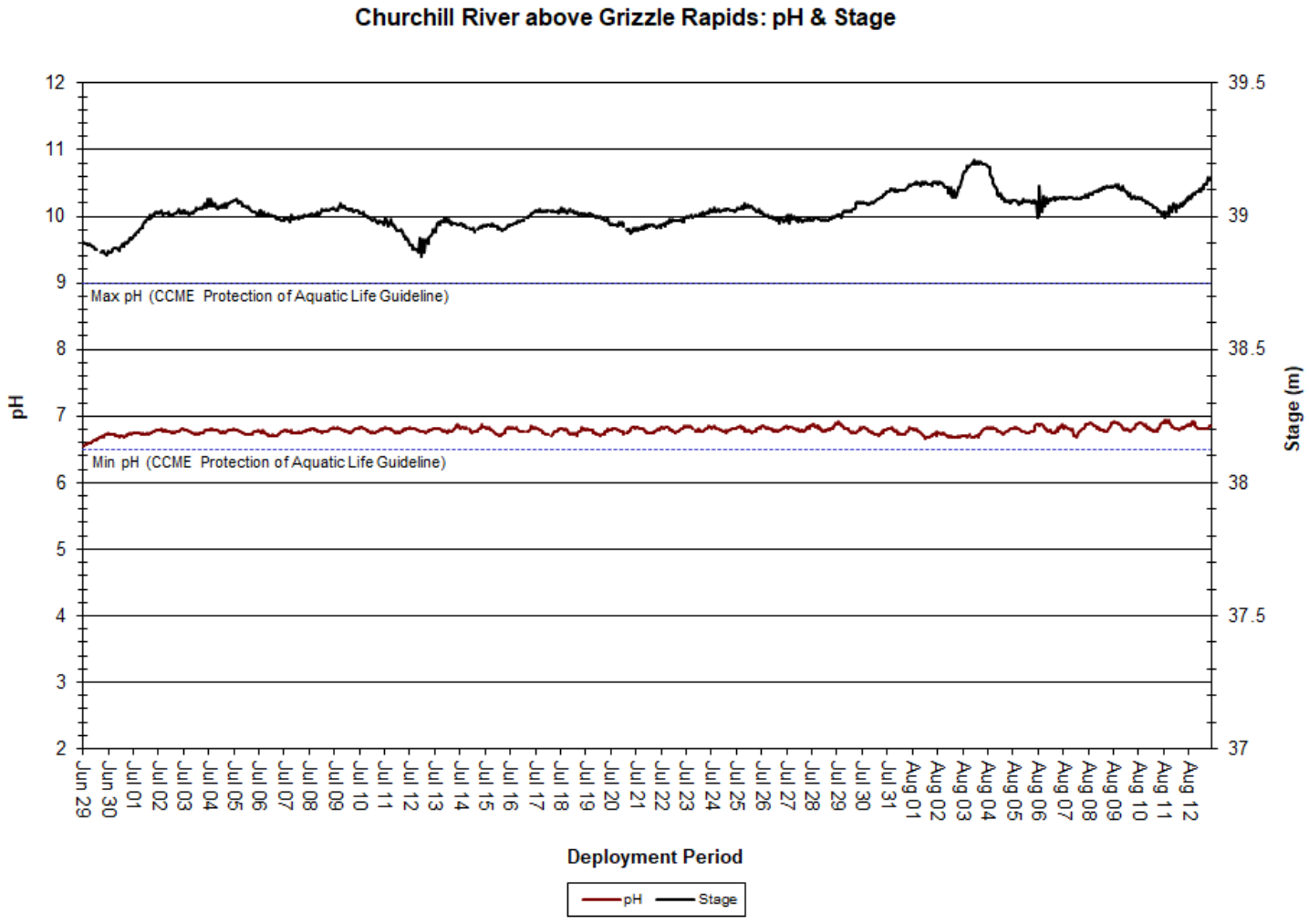

Figure 10: pH & Stage at Churchill River above Grizzle Rapids

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 13.5µS/cm to 20.1µS/cm, with a median of 17.8µS/cm (Figure 11).
- The relationship between conductivity and stage is generally inversed. When stage levels increase, specific conductivity levels generally decrease as the increased amount of water in the river system dilutes solids that are present. This relationship is not overly evident in the graph below, likely because this station is located at a deep and wide section of the Churchill River and other factors in the water column influence conductivity levels.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

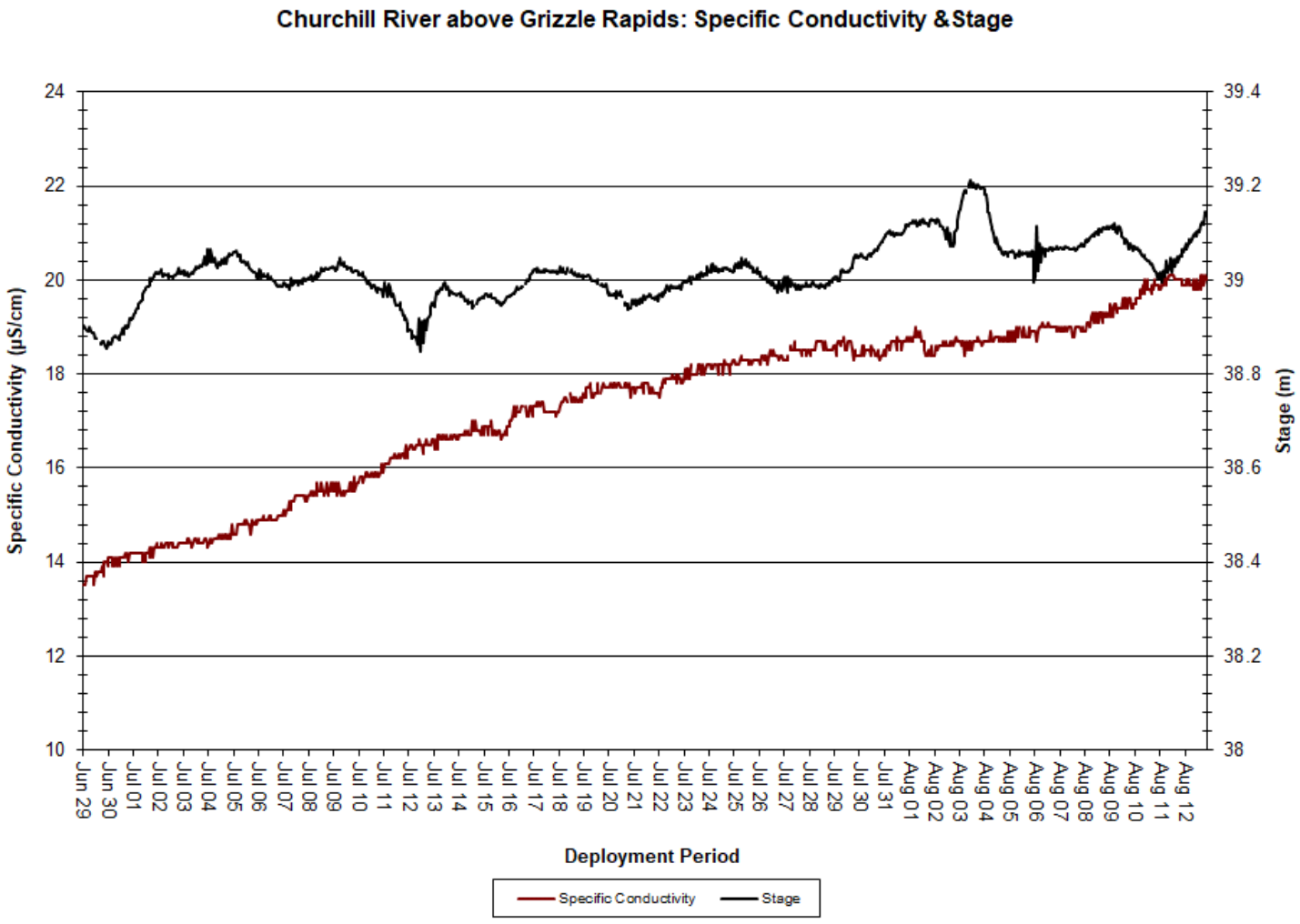

Figure 11: Specific Conductivity & Stage at Churchill River above Grizzle Rapids

Dissolved Oxygen

- Over the deployment period, dissolved oxygen content ranged from 8.30mg/L to 11.63mg/L, with a median value of 9.27mg/L. Saturation of dissolved oxygen ranged from 88.9% saturation to 101.9% saturation, with a median value of 98.0% (Figure 12).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period, dissolved oxygen levels gradually decreased as water temperatures increased through the summer season. Dissolved oxygen also follows a diurnal pattern as water temperatures rise and fall under the influence of ambient air temperatures. Generally, dissolved oxygen levels are higher in a waterbody during cooler temperatures.
- Dissolved oxygen levels were above the CCME's Guideline for the Protection of Early Life Stages for the beginning of deployment, after which levels hovered around and fell below the CCME's Guideline for the Protection of Early Life Stages. This is to be expected given the warmer water temperatures observed through July and August. Dissolved oxygen levels were above the CCME's Guideline for the Protection of Other Life Stages for the duration of deployment.

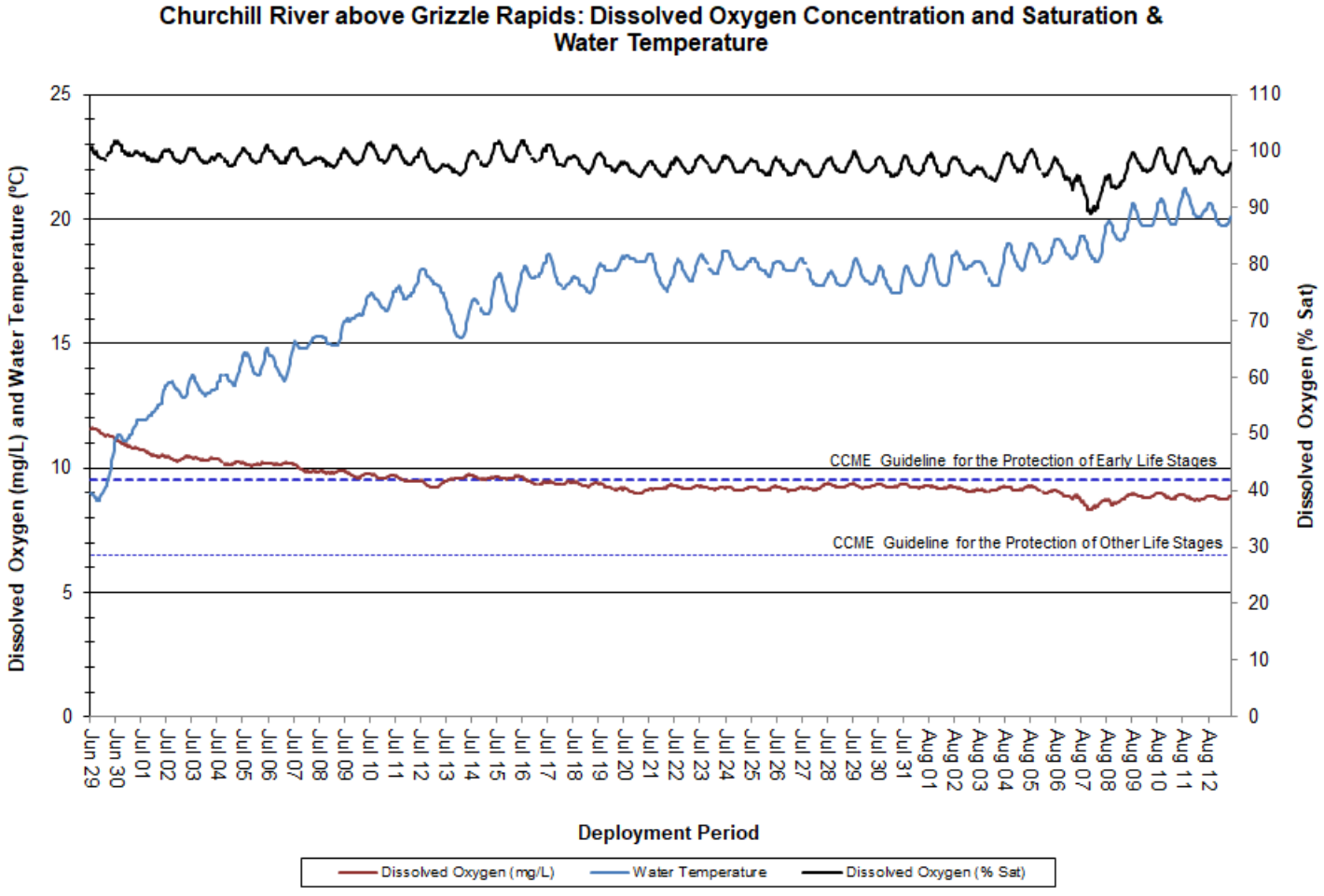

Figure 12: Dissolved Oxygen & Water Temperature at Churchill River above Grizzle Rapids

Turbidity

- Over the deployment period, turbidity ranged from 0.3NTU to 2687NTU, with a median value of 0.9NTU (Figure 13). A median value of 0.9NTU indicates a very low level of natural background turbidity in the waterbody. Precipitation data was obtained from the Metchin River near TLH Weather Station.
- Turbidity spikes observed over the deployment period somewhat correlate with precipitation events (Figure 13). This station is located at a wide and deep section of the Churchill River and therefore turbidity levels are likely less susceptible to precipitation events as compared to other areas. Turbidity levels returned to background levels following each observed increase.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

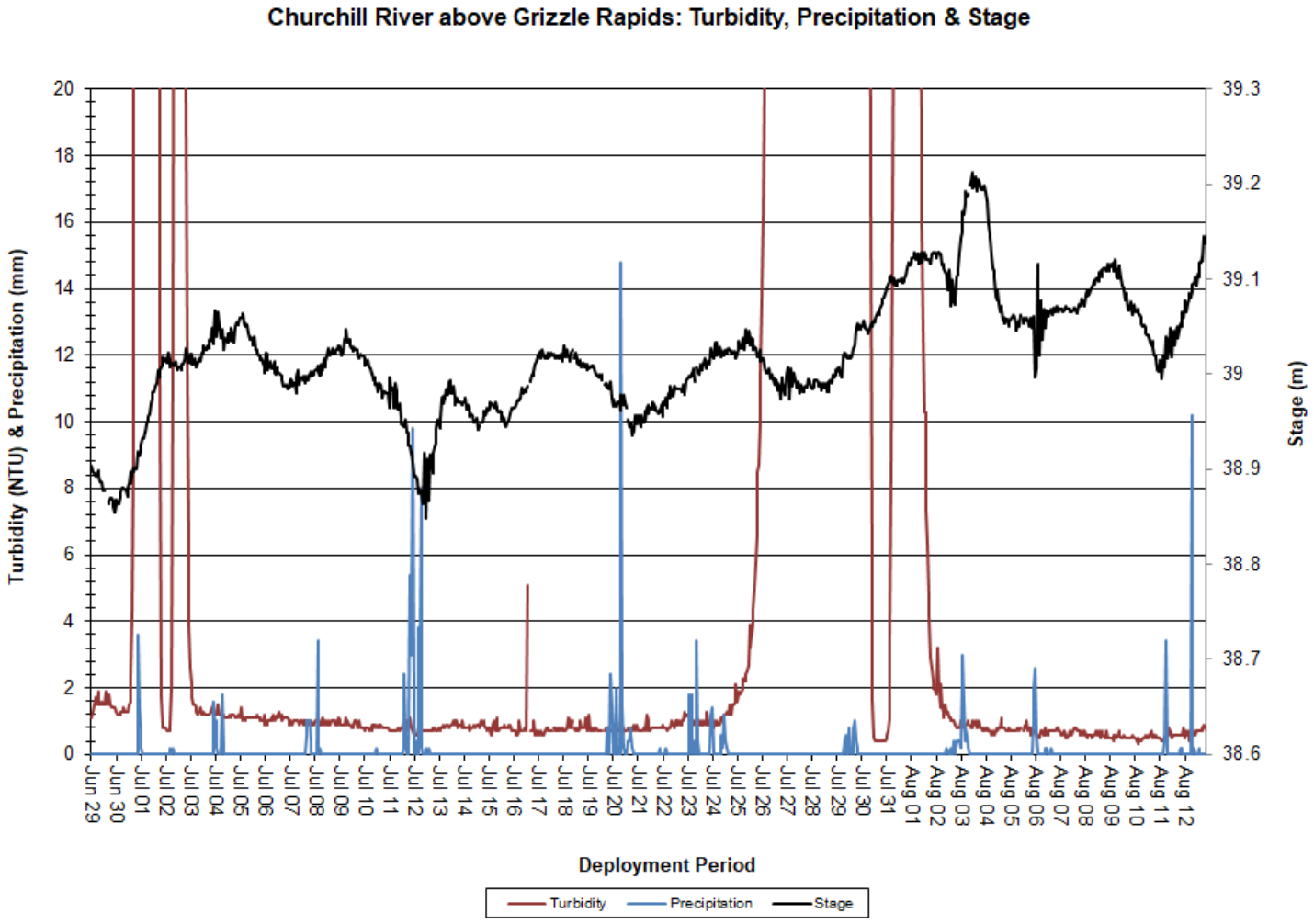

Figure 13: Turbidity, Precipitation & Stage at Churchill River above Grizzle Rapids

Stage

- Over the deployment period, stage ranged from 38.85m to 39.21m, with a median value of 39.02m (Figure 14). Precipitation data was obtained from the Metchin River near TLH Weather Station.
- Stage was somewhat variable across the deployment period, with precipitation events often closely correlating with increases in stage (Figure 14).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

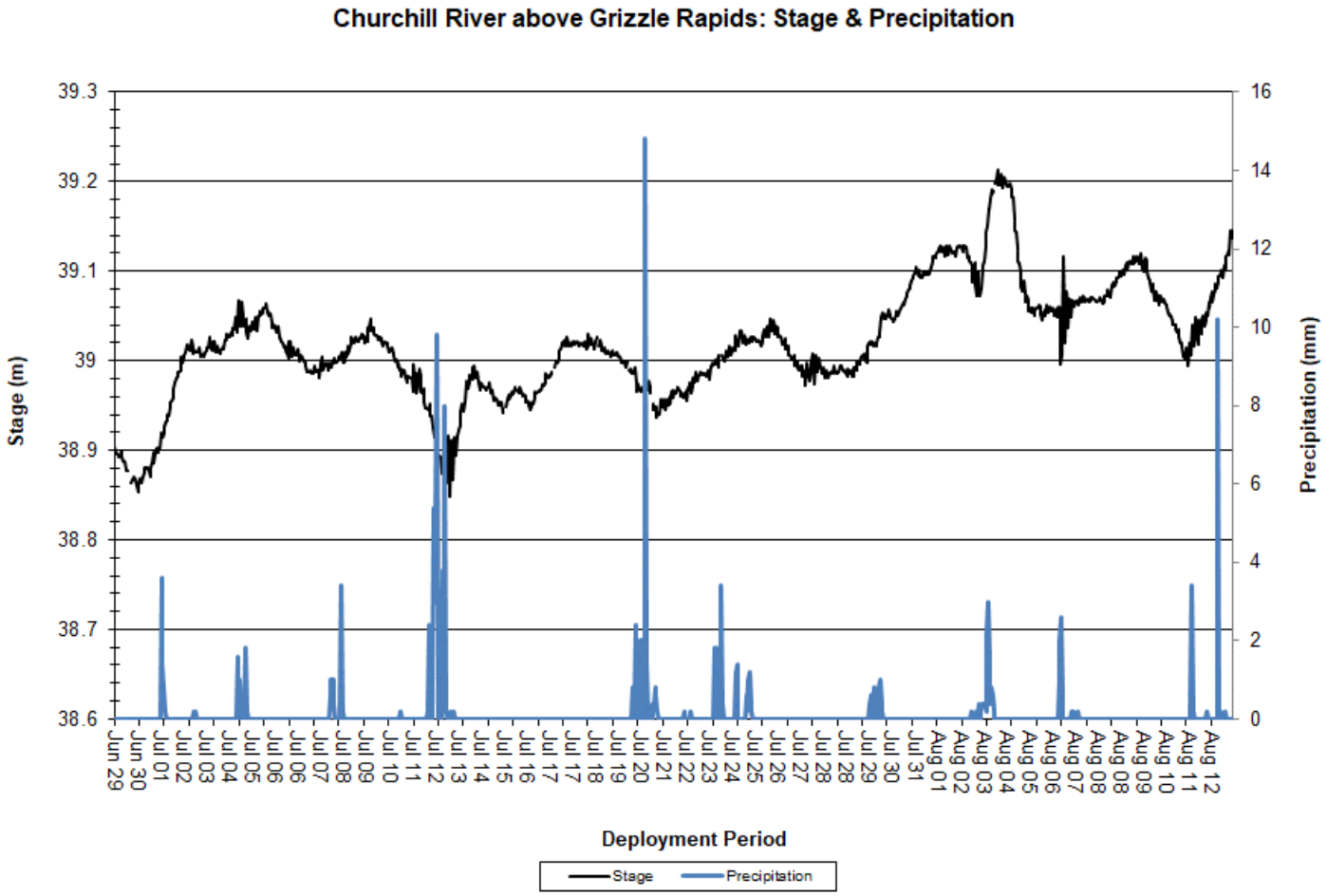

Figure 14: Stage & Precipitation at Churchill River above Grizzle Rapids

Churchill River below Muskrat Falls

Water Temperature

- Over the deployment period, water temperature ranged from 8.03°C to 20.12°C, with a median value of 15.32°C (Figure 15). Air temperature data was obtained from the Metchin River near TLH Weather Station.
- Water temperature slowly increased over the course of the deployment period. This is to be expected as ambient air temperatures also increased through July and August. Water temperatures closely correlate with ambient air temperatures.
- Water temperature data was removed for several periods of time towards the end of deployment, during which the instrument was out of the water and the data was deemed inaccurate.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

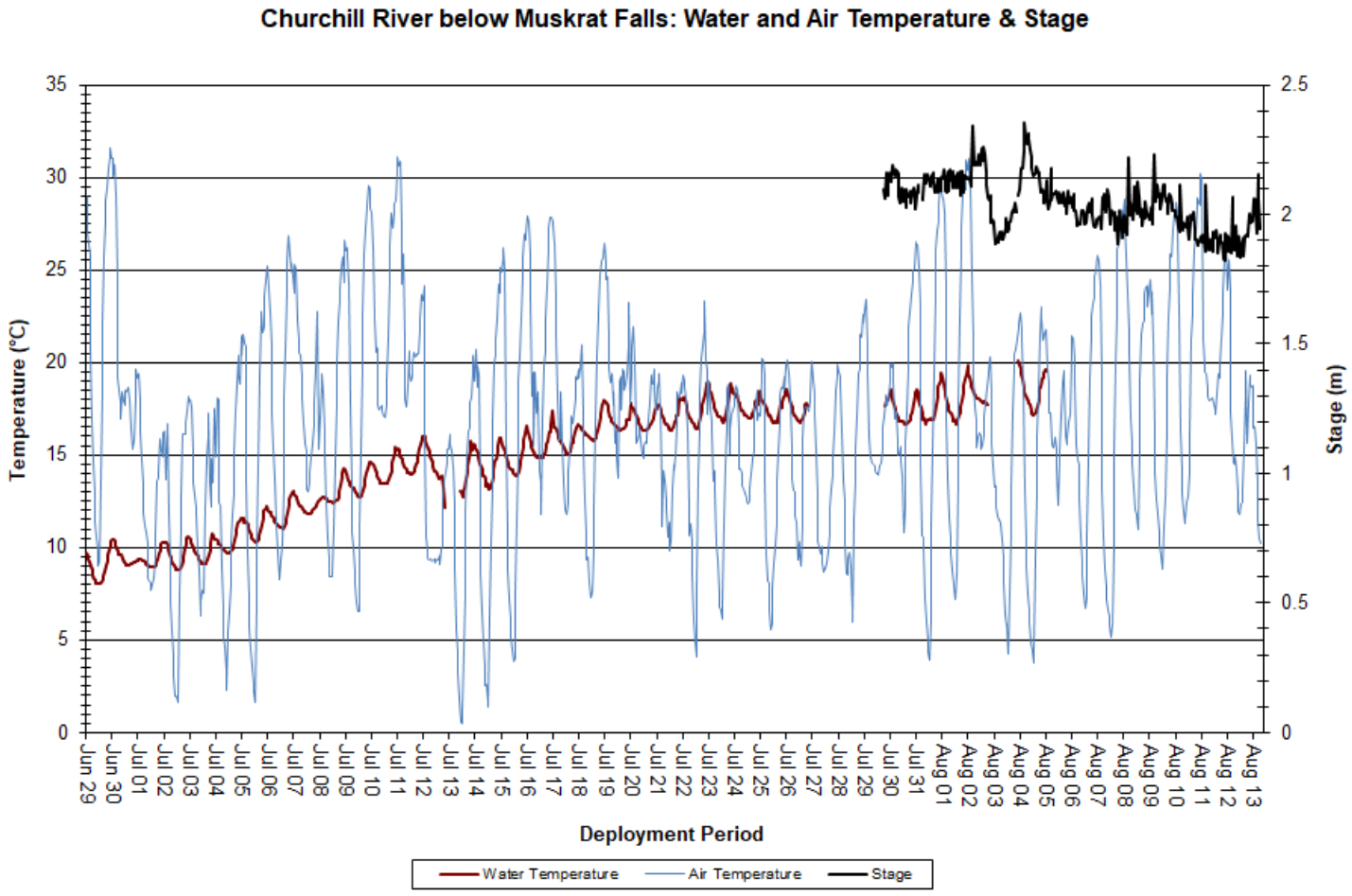

Figure 15: Water and Air Temperature & Stage at Churchill River below Muskrat Falls

pH

- Over the deployment period, pH ranged from 6.63 pH units to 7.03 pH units, with a median value of 6.73 (Figure 16).
- pH values were quite stable over the course of deployment, and remained within the CCME's Guidelines for the Protection of Aquatic Life for the duration of deployment (Figure 16).
- pH data was removed for several periods of time towards the end of deployment, during which the instrument was out of the water and the data was deemed inaccurate.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

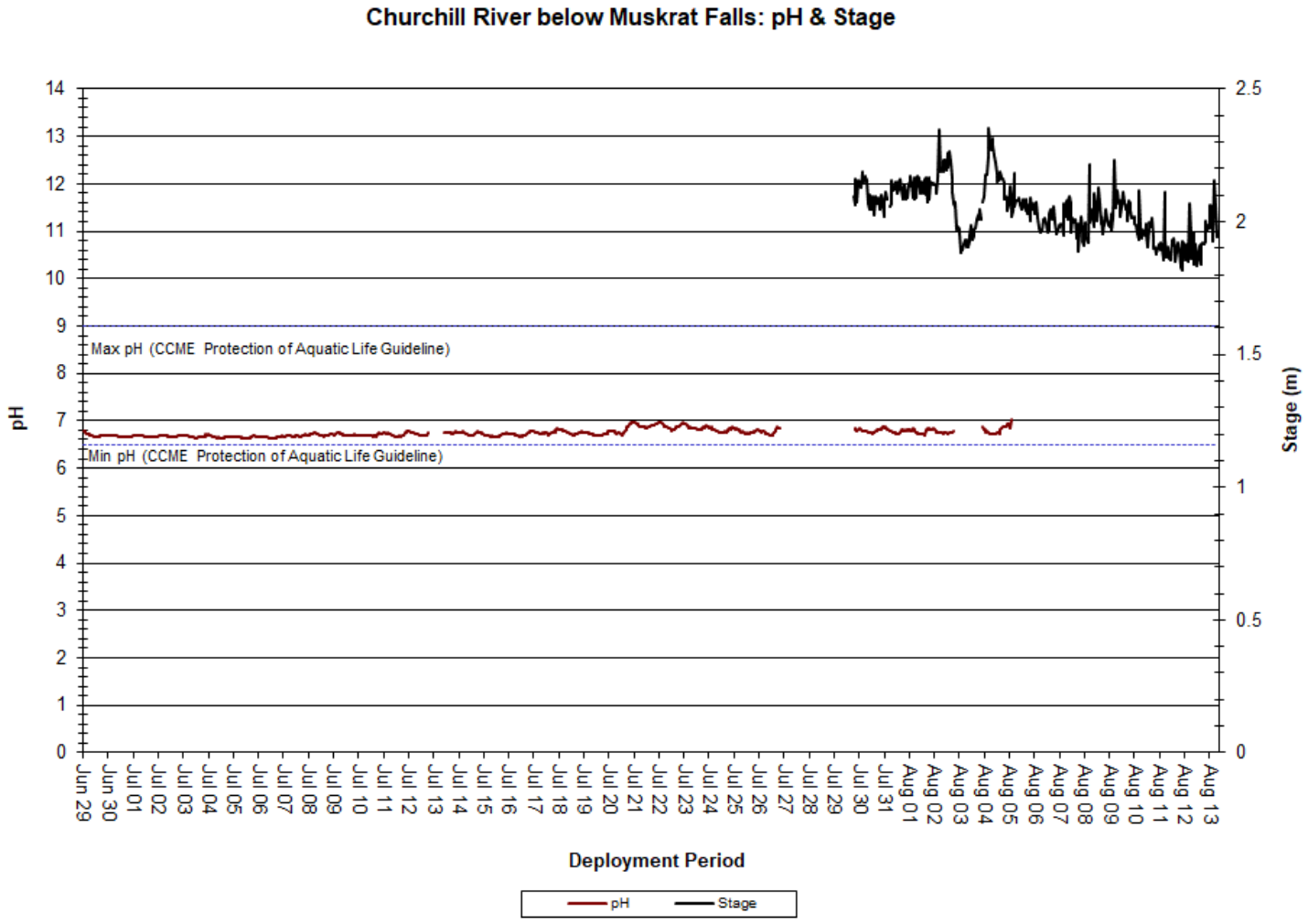

Figure 16: pH & Stage at Churchill River below Muskrat Falls

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 11µS/cm to 18µS/cm, with a median value of 15µS/cm (Figure 17).
- The relationship between conductivity and stage is generally inversed. When stage decreases, specific conductivity increases as the decreased amount of water in the river system concentrates solids that are present, and vice versa. This relationship is not easily observed in the graph below, however, due to a lack of stage data during the deployment period (Figure 17).
- Specific conductivity data was removed for several periods of time towards the end of deployment, during which the instrument was out of the water and the data was deemed inaccurate.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

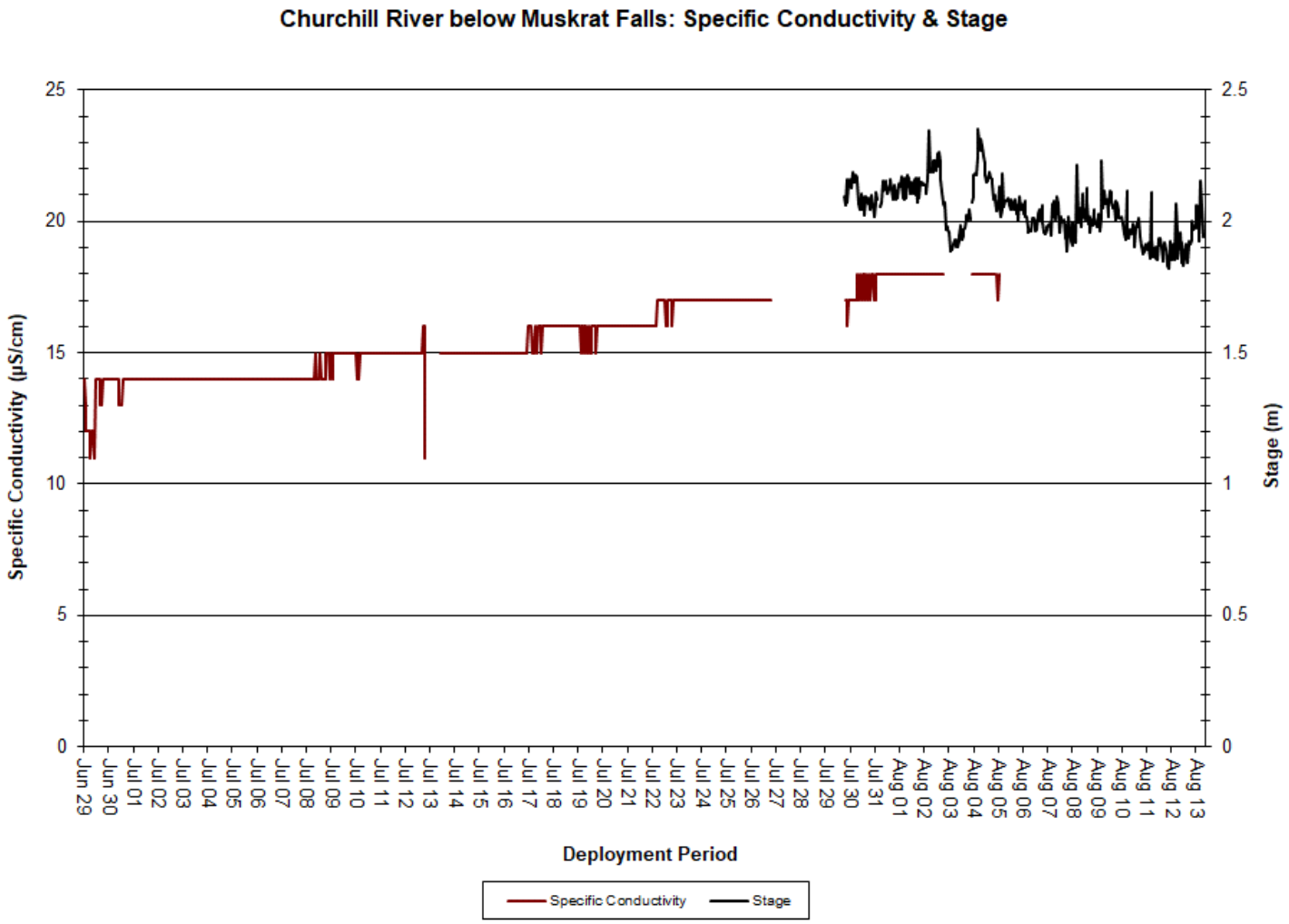

Figure 17: Specific Conductivity & Stage at Churchill River below Muskrat Falls

Dissolved Oxygen

- Over the deployment period, dissolved oxygen concentration ranged from 9.32mg/L to 13.24mg/L, with a median value of 11.08mg/L. Saturation of dissolved oxygen ranged from 99.2% to 117.8%, with a median value of 110.5% (Figure 18).
- Dissolved oxygen and water temperature exhibit an inverse relationship: as one parameter increases, the other decreases, and vice versa. Dissolved oxygen levels slowly decreased over the course of deployment. This is to be expected since water temperatures were slowly increasing over the same period. Dissolved oxygen also follows a diurnal pattern as water temperatures rise and fall under the influence of ambient air temperatures.
- Dissolved oxygen levels remained above the CCME's Guidelines for the Protection of Early and Other Life Stages for the majority of deployment, with exceptions occurring later in the deployment period when water temperatures were warmer.
- Dissolved oxygen and water temperature data were removed for several periods of time towards the end of deployment, during which the instrument was out of the water and the data was deemed inaccurate.

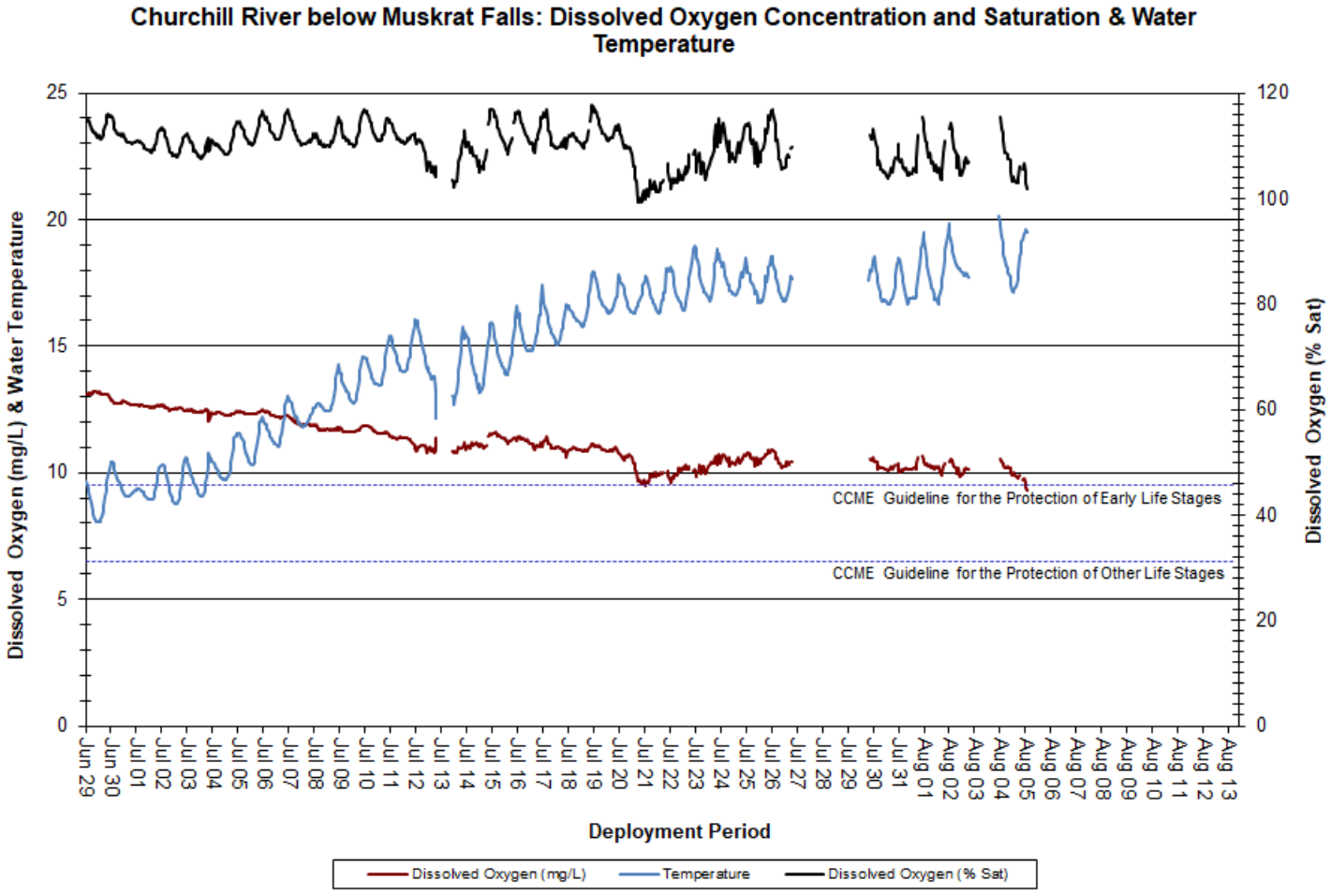

Figure 18: Dissolved Oxygen & Water Temperature at Churchill River below Muskrat Falls

Turbidity

- Over the deployment period, turbidity ranged from 1.1NTU to 129.3NTU, with a median value of 2.4NTU. A median value of 2.4NTU indicates a small amount of natural background turbidity in the waterbody. Precipitation data was obtained from the Metchin River near TLH Weather Station.
- Many of the larger turbidity spikes observed over the deployment period correlate closely with changes in stage and precipitation events (Figure 19). This station is located at a wide and deep section of the Churchill River with a sandy bottom, and therefore turbidity levels are likely less susceptible to precipitation events as compared to other areas.
- Turbidity data was removed for several periods of time towards the end of deployment, during which the instrument was out of the water and the data was deemed inaccurate.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

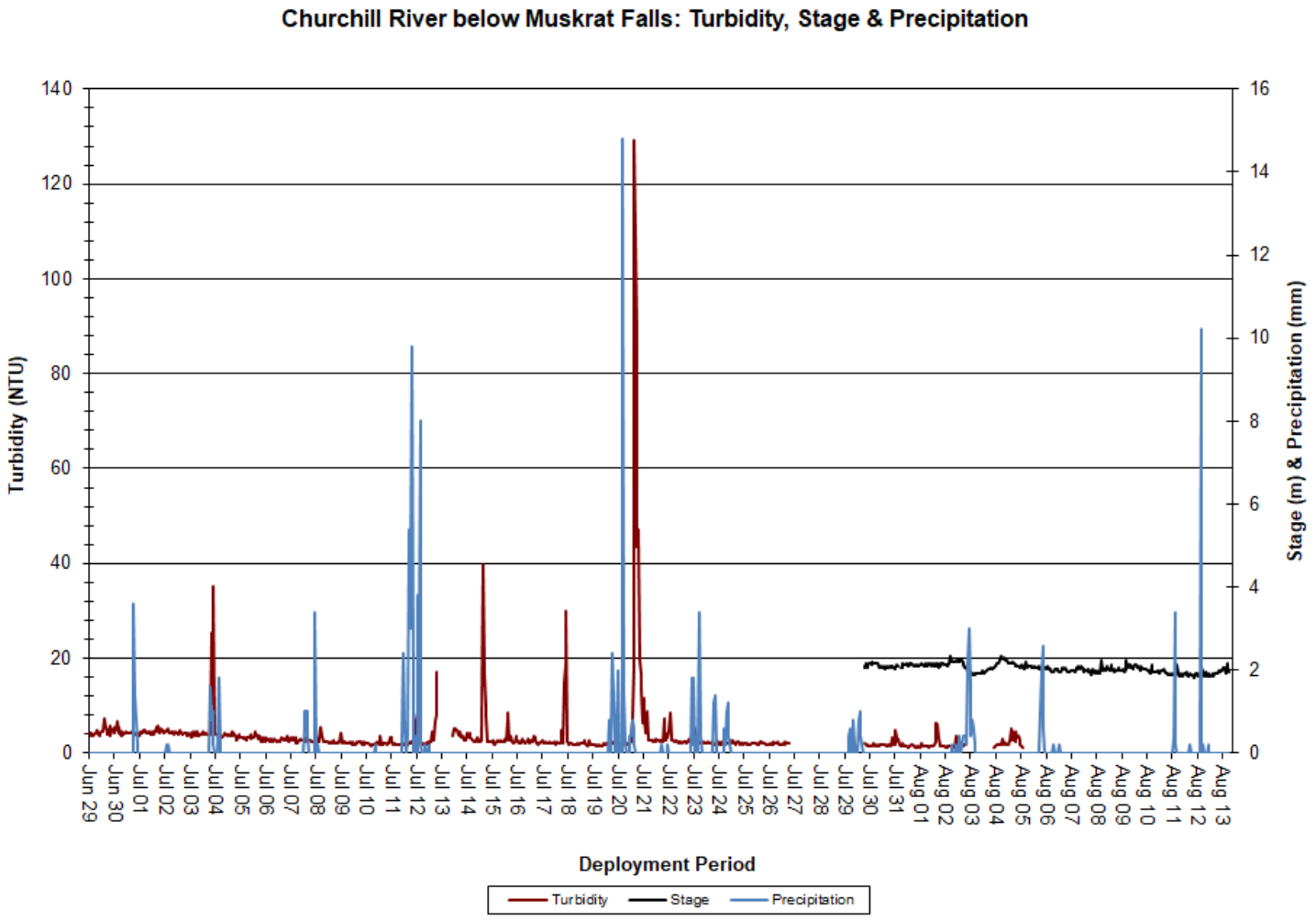

Figure 19: Turbidity, Precipitation & Stage at Churchill River below Muskrat Falls

Stage & Flow

- Over the deployment period, stage ranged from 1.82m to 2.35m, with a median value of 2.05m (Figure 20). Precipitation data was obtained from the Metchin River near TLH Weather Station.
- Stage and flow were slightly variable over the course of deployment (based on available data); however, correlation between stage and precipitation events is not particularly close as evidenced in the graph below. This is partly related to the fact that this station is located on a very wide section of the Churchill River and therefore not as easily influenced by smaller precipitation events.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

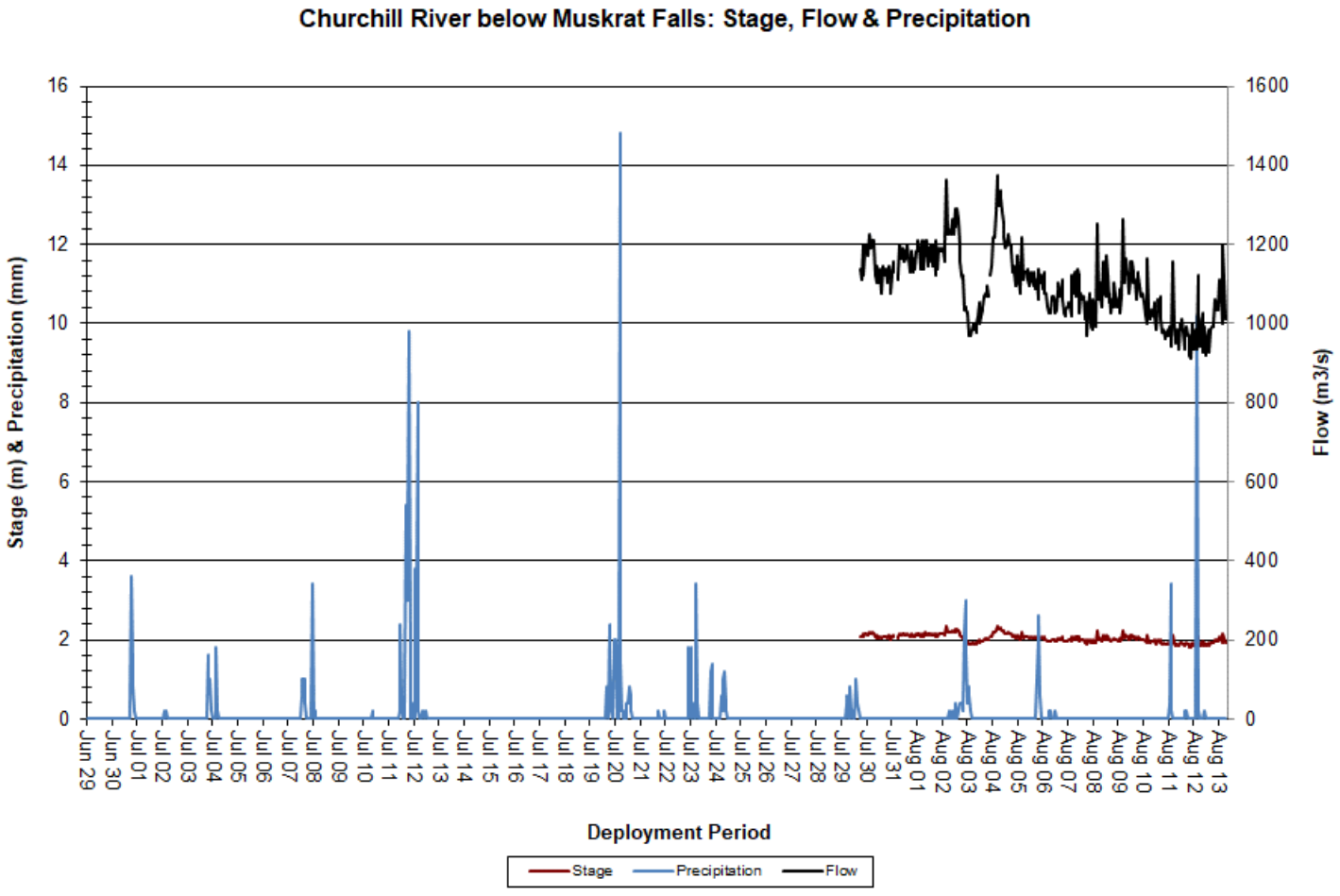

Figure 20: Stage, Flow & Precipitation at Churchill River below Muskrat Falls

Chlorophyll

- Over the deployment period, chlorophyll ranged from 1.36ug/L to 5.63ug/L, with a median value of 2.87ug/L (Figure 21).
- 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.
- Chlorophyll data was removed for several periods of time towards the end of deployment, during which the instrument was out of the water and the data was deemed inaccurate.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

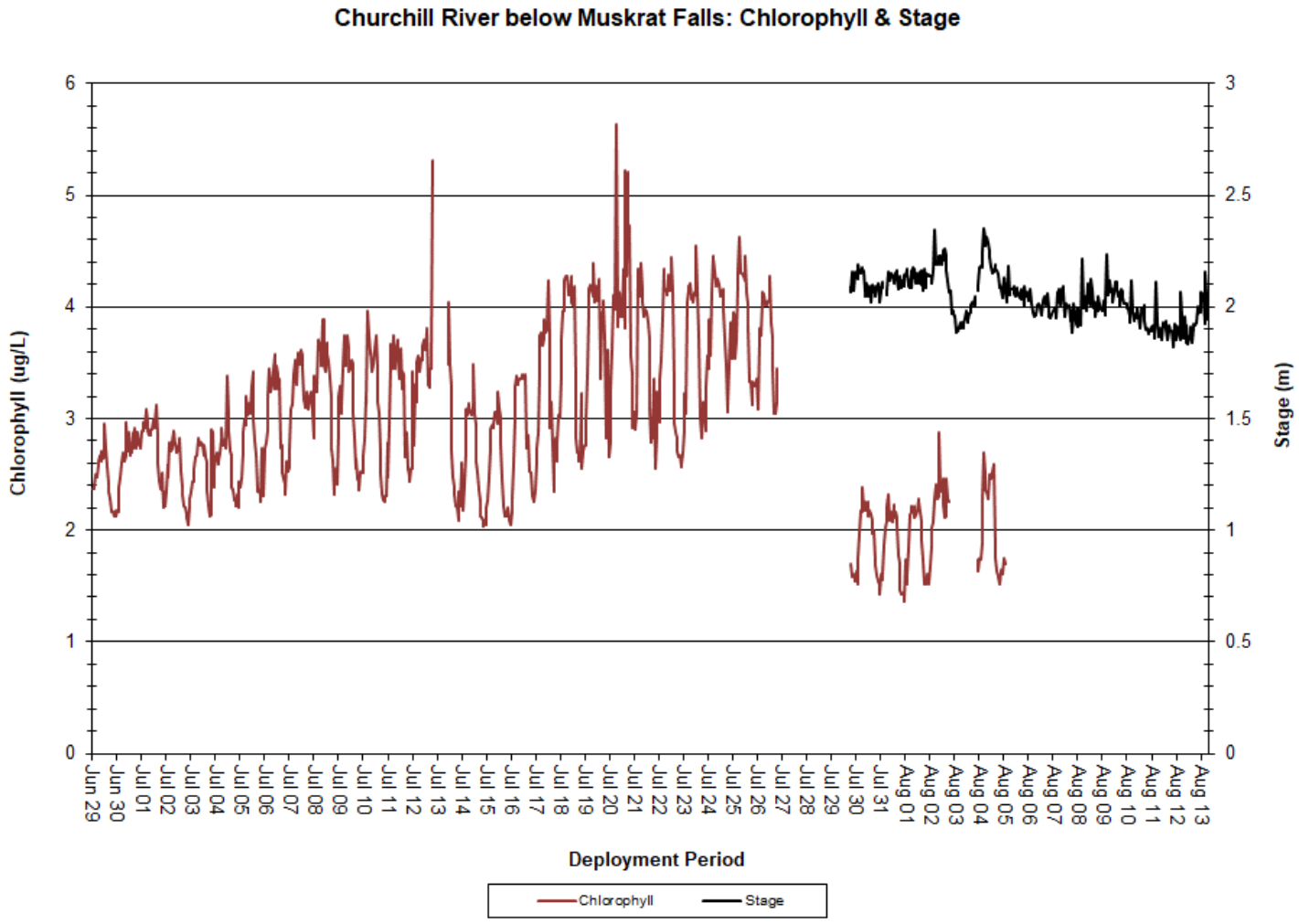

Figure 21: Chlorophyll & Stage at Churchill River below Muskrat Falls

Churchill River at English Point

Water Temperature

- Water temperature ranged from 10.0°C to 23.6°C, with a median value of 17.8°C (Figure 22). Air temperature data was obtained from the End of Mud Lake Road Weather Station.
- Water temperature increased steadily across the deployment period. Water temperatures closely correlated with ambient air temperatures, which followed a similar trend across the same period.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

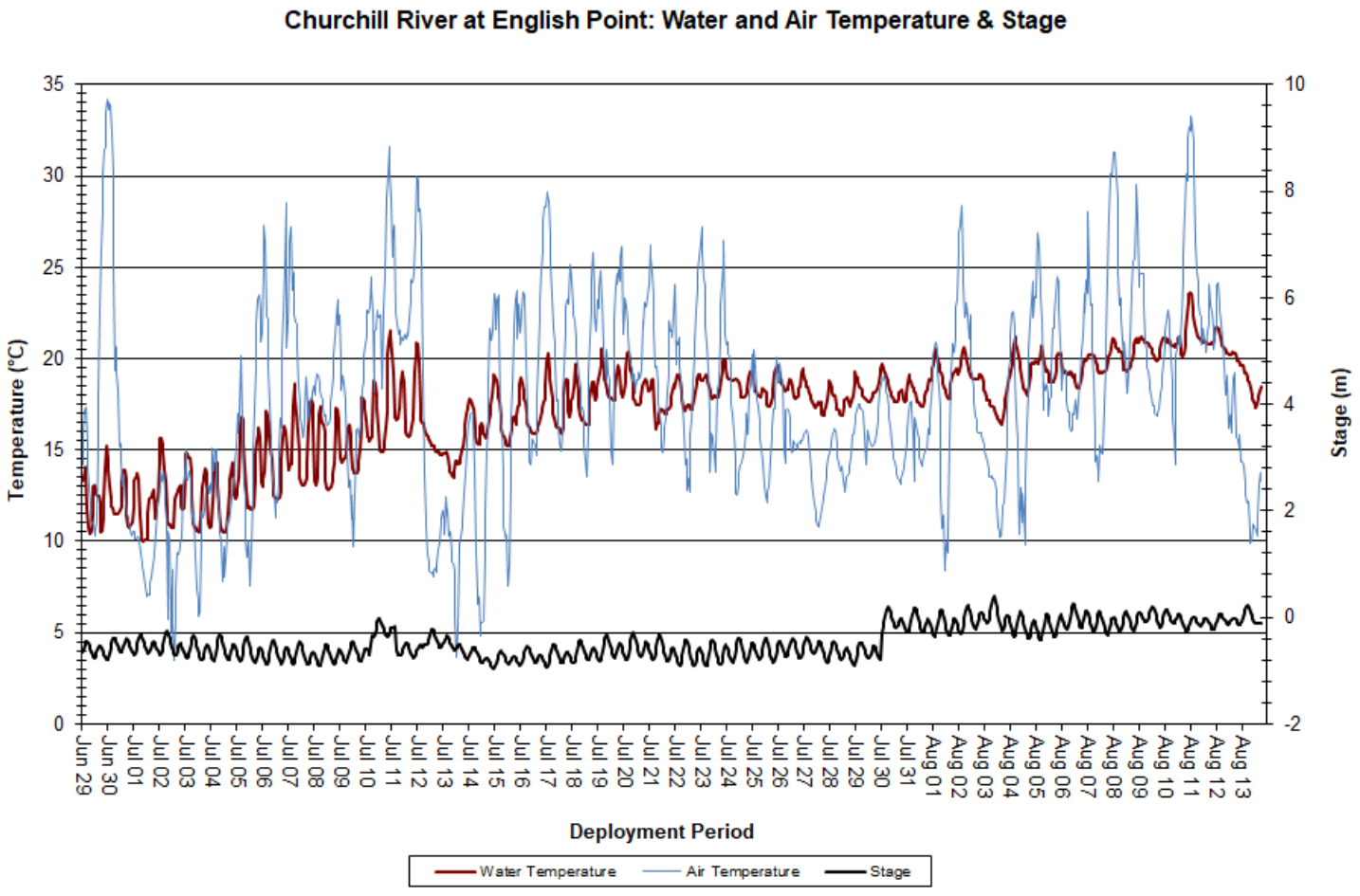

Figure 22: Water and Air Temperature & Stage at Churchill River at English Point

pH

- Over the deployment period, pH ranged from 6.21 pH units to 6.77 pH units, with a median value of 6.37 (Figure 23).
- pH values were relatively stable and remained below the CCME's Guidelines for the Protection of Aquatic Life for the majority of deployment.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

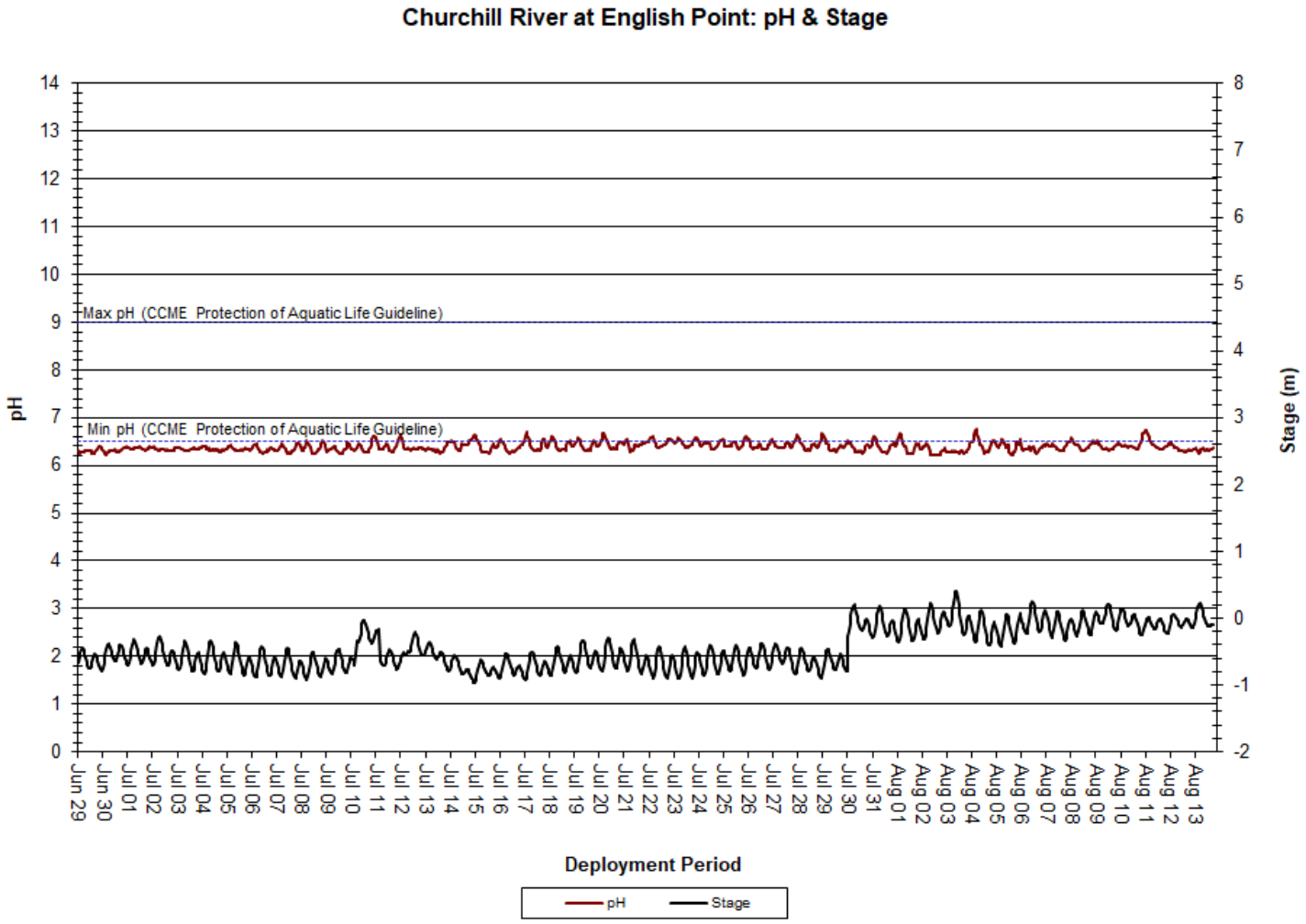

Figure 23: pH & Stage at Churchill River at English Point

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 17.1µS/cm to 52.8µs/cm, with a median value of 27.2µS/cm (Figure 24).
- Specific conductivity fluctuates considerably at this location due to the tidal influences of the Atlantic Ocean on Lake Melville. As the tide comes in, specific conductivity increases as dissolved solids and salinity increase, and vice versa as the tide goes out. This increase and decrease in specific conductivity and stage occurs twice daily. This pattern is generally consistent throughout the deployment period (Figure 24).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

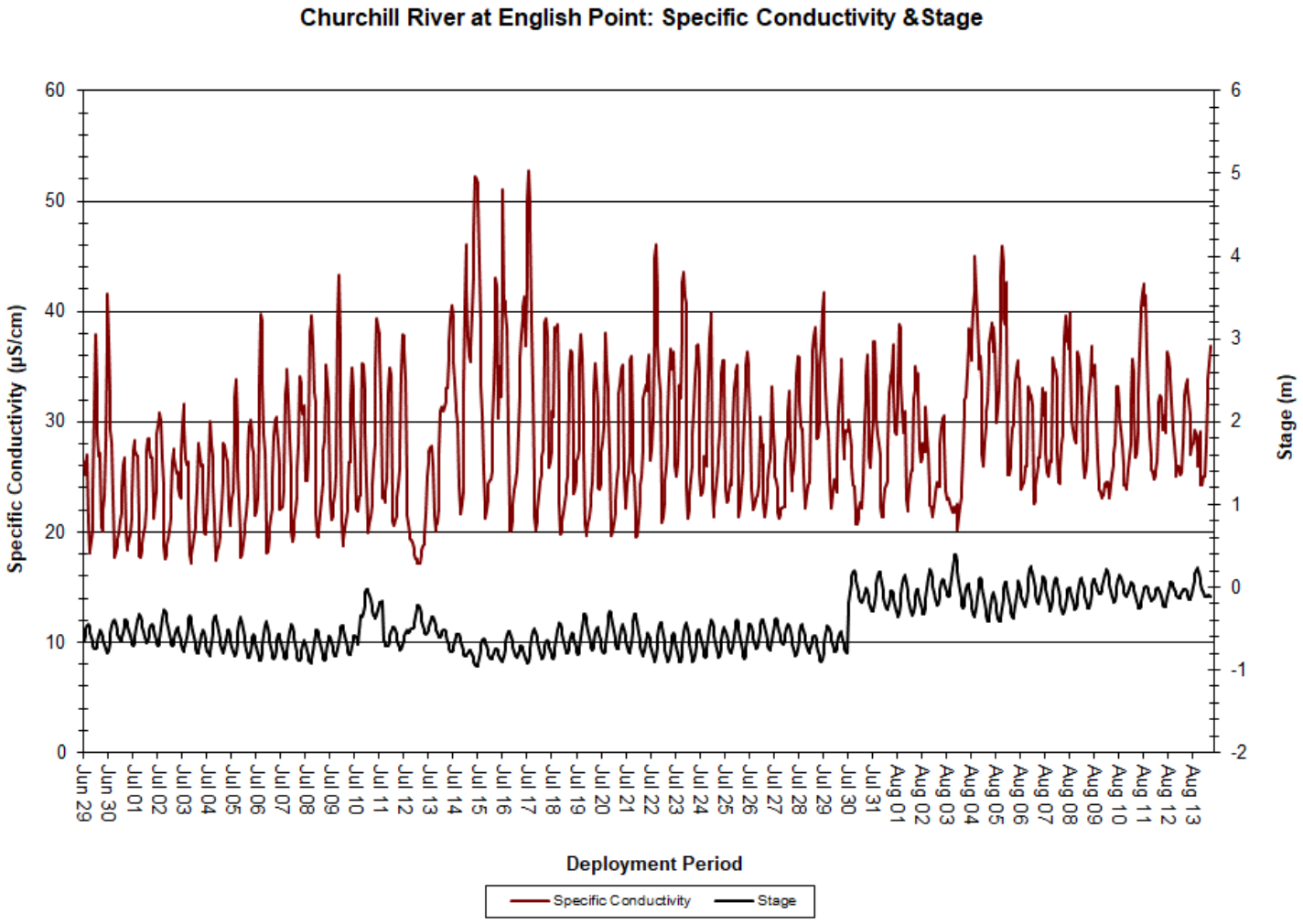

Figure 24: Specific Conductivity & Stage at Churchill River at English Point

Dissolved Oxygen

- Over the deployment period, dissolved oxygen concentration ranged from 8.67mg/L to 12.19mg/L, with a median value of 9.68mg/L. Saturation of dissolved oxygen ranged from 90.3% to 112.7% saturation, with a median value of 102.5% (Figure 25).
- There is an evident relationship between water temperature and dissolved oxygen. As water temperatures increased over the deployment period, dissolved oxygen levels decreased. Dissolved oxygen levels also follow a diurnal pattern as water temperatures rise and fall under the influence of ambient air temperatures. Generally, dissolved oxygen levels are higher in a waterbody during cooler temperatures.
- Dissolved oxygen levels hovered around the CCME's Guideline for the Protection of Early Life Stages for the majority of deployment. Dissolved oxygen levels were above the CCME's Guideline for the Protection of Other Life Stages for the duration of deployment (Figure 25).

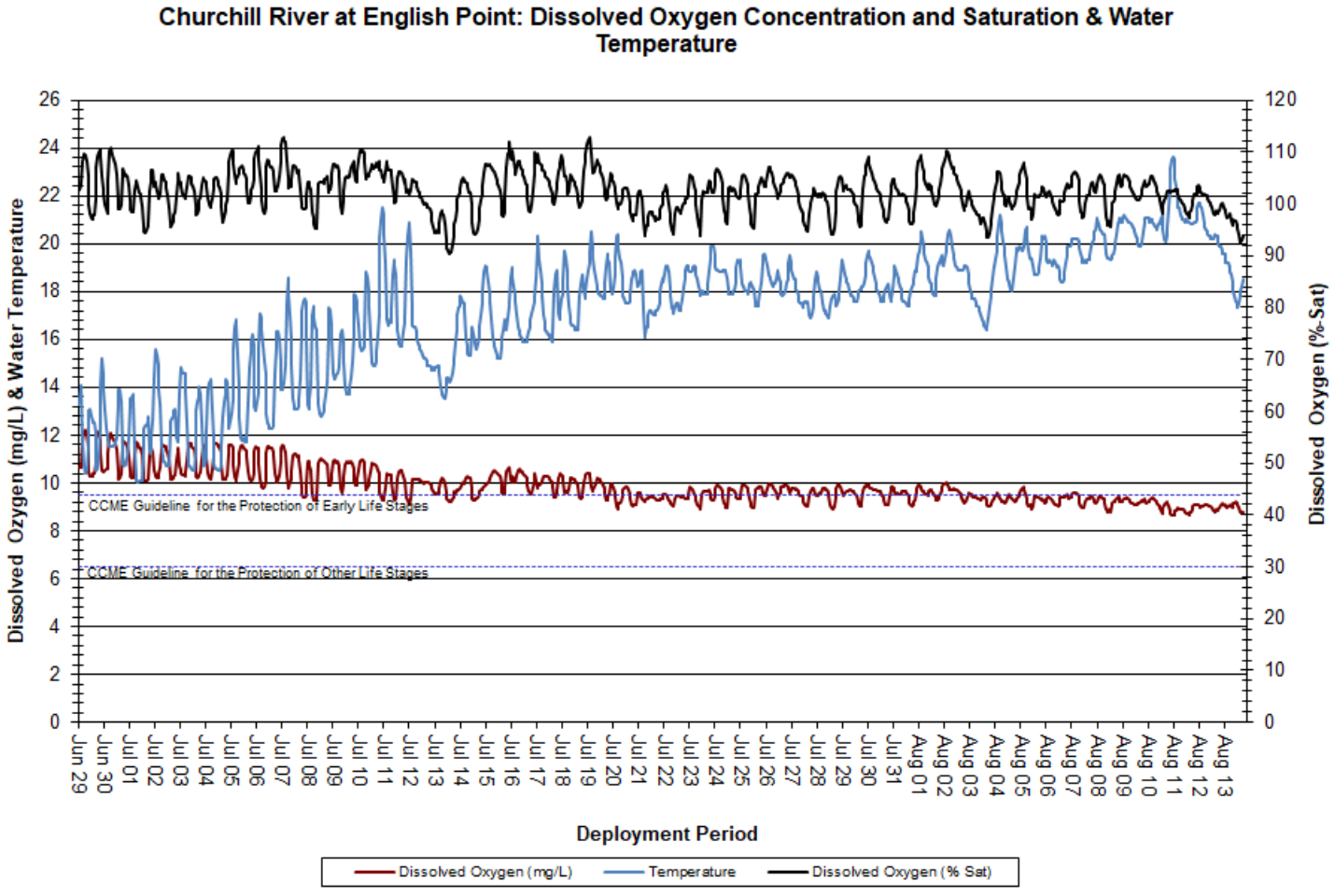

Figure 25: Dissolved Oxygen & Water Temperature at Churchill River at English Point

Turbidity

- Over the deployment period, turbidity ranged from 0.1NTU to 2574NTU, with a median value of 4.9NTU (Figure 26). A median value of 4.9NTU indicates a low level of background turbidity; this is to be expected considering the sandy river bed and tidal influences present at this station. Precipitation data was obtained from the End of Mud Lake Road Weather Station.
- Turbidity events generally correlate with precipitation events, as these can increase the presence of suspended material in water. High winds and tidal influences can also contribute to turbidity events at this station by disturbing sediment from the river bed (Figure 26). Wind speed data was also obtained from the End of Mud Lake Road Weather Station.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

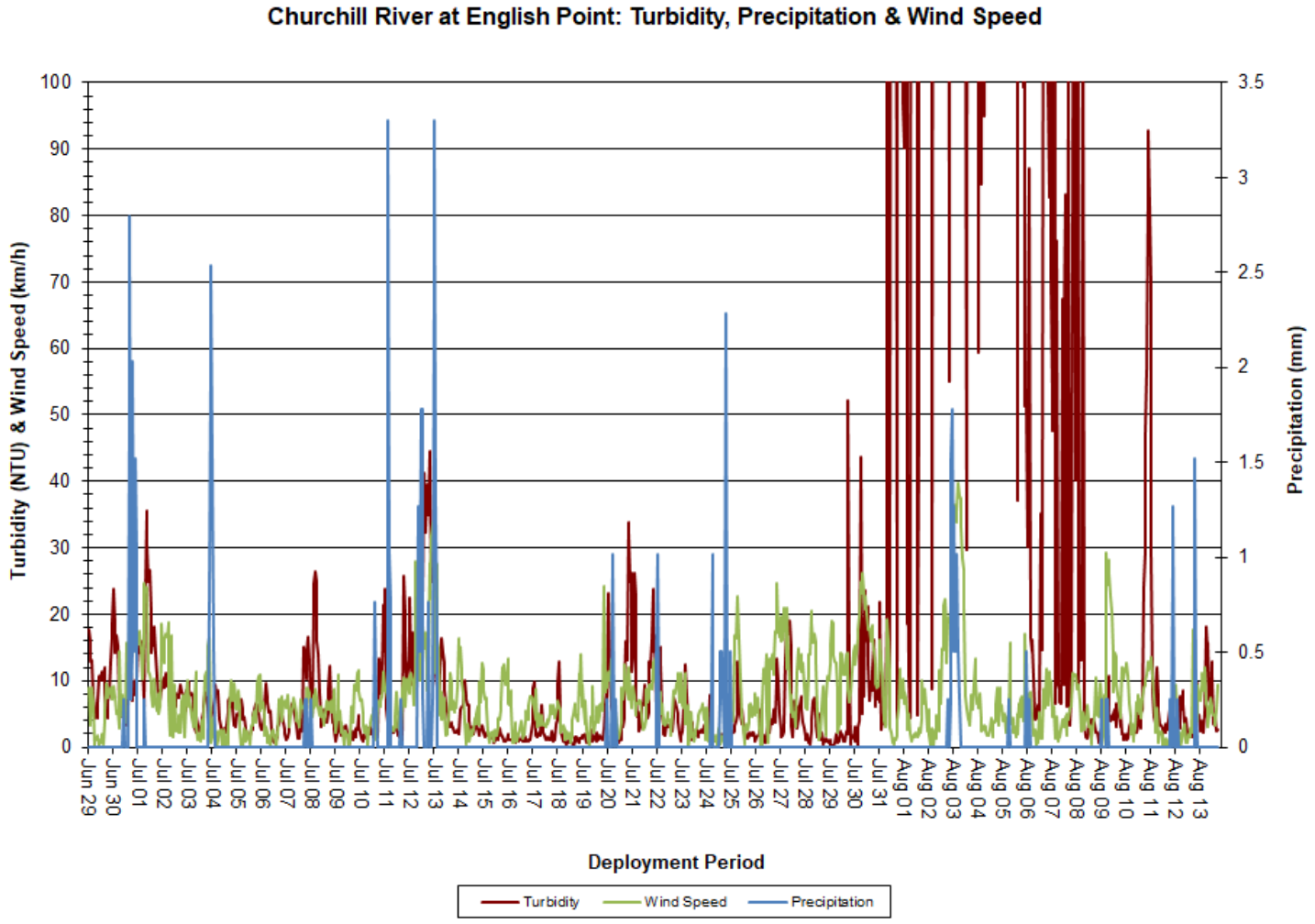

Figure 26: Turbidity, Precipitation & Wind Speed at Churchill River at English Point

Stage

- Over the deployment period, stage ranged from -0.96m to 0.40m, with a median value of -0.52m (Figure 27). Precipitation data was obtained from the End of Mud Lake Road Weather Station.
- Stage fluctuates considerably at this location due to the tidal influences of the Atlantic Ocean. This pattern is consistent over the deployment period. Increases in stage often correlate with precipitation events.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

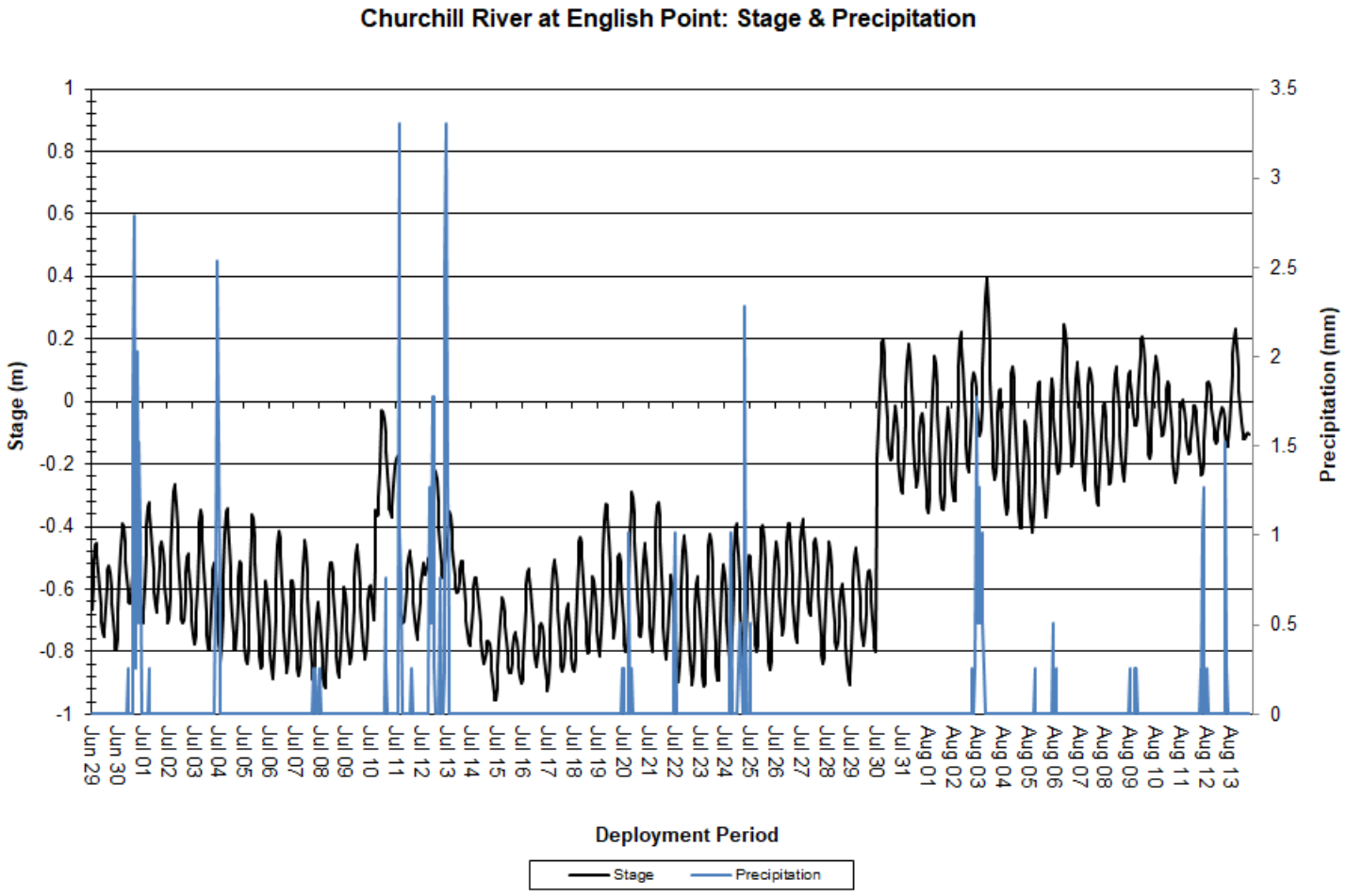

Figure 27: Stage & Precipitation at Churchill River at English Point

Conclusions

- Instruments at four water quality monitoring stations on the Lower Churchill River were deployed from June 29/July 15 through August 13/14/September 1, 2020.
- Water temperature increased steadily at all stations over the course of deployment. This is to be expected based on ambient air temperature trends during the same period through July and August.
- pH was relatively stable at all stations over the course of deployment. pH was within the CCME's Guidelines for the Protection of Aquatic Life for the duration of deployment at Churchill River below Metchin River, above Grizzle Rapids and below Muskrat Falls, while pH hovered around the minimum Guideline at English Point.
- Specific conductivity generally increased over the course of deployment at all stations. Since English Point is influenced by tides in Lake Melville, specific conductivity values at the Churchill River at English Point station had a much wider range, which is comparable to other deployments at this location.
- Dissolved oxygen levels slowly decreased over the course of deployment at all stations as water temperatures increased through the summer. Dissolved oxygen levels are generally higher in water at cooler temperatures. Dissolved oxygen levels fell below the CCME's Guideline for the Protection of Early Life Stages for at least part of the deployment period at all stations. Dissolved oxygen levels were above the CCME's Guideline for the Protection of Other Life Stages for the duration of deployment at all stations.
- Turbidity events occurred at all stations and were generally related to precipitation, wind or tidal events. In most cases, turbidity values returned to background levels following each observed event.

References

Canadian Council of Ministers of the Environment. 2007. Canadian water quality guidelines for the protection of aquatic life: Summary table. Updated December, 2007. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg. Available at: http://st-ts.ccme.ca/en/index.html?chems=154,162&chapters=1 [Accessed December 12, 2017].

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Swenson, H.A., and Baldwin, H.L. (1965). A Primer on Water Quality, U.S. Geological Survey. Available at: https://pubs.usgs.gov/gip/7000057/report.pdf [Accessed December 12, 2017].

United States Geological Survey. (2017). Water properties: Dissolved oxygen [Online]. Available at: https://water.usgs.gov/edu/dissolvedoxygen.html [Accessed December 12, 2017].

APPENDIX A

Water Parameter Description

Water Parameter Description

Dissolved Oxygen - The amount of Dissolved Oxygen (DO) (mg/l or % saturation) in the water is vital to aquatic organisms for their survival. The concentration of DO is affected by such things as water temperature, water depth and flow (e.g., aeration by rapids, riffles etc.), consumption by aerobic organisms, consumption by inorganic chemical reactions, consumption by plants during darkness, and production by plants during the daylight (USGS, 2017).

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 a measure of the relative amount of free hydrogen and hydroxyl ions in water. pH is an important indicator of chemically changing water, and determines the solubility and biological availability of nutrients and heavy metals in the water (USGS, 2017).

Specific conductivity - Specific conductivity (µs/cm) is a measure of water's ability to conduct electricity, with values normalized to a water temperature of 25°C. Specific conductance indicates the concentration of dissolved solids (such as salts) in the water, which can affect the growth and reproduction of aquatic life. Specific conductivity is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Fondriest Environmental Inc, 2016).

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 aquatic processes. 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. In turn, water temperature has an influence on the metabolic rates and biological activity of aquatic organisms (Fondriest Environmental Inc, 2016b).

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 (Swenson 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 (Swenson and Baldwin 1965).

APPENDIX B

Grab Sample Results

REPORT OF ANALYSIS

Lab Report Number: 1935098

Cient:	Department of Environment	**COC Number:**	860544
Attention:	Ms. Leona Hyde	**Date Reported:**	2020-07-28
Client Project:		**Date Submitted:**	2020-07-23
Purchase Order:	219034377-5	**Sample Matrix:**	Water

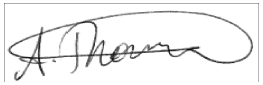
LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1506112	WS-S-0000	2020-6303-00-SI-SP	2020-07-15	Alkalinity as CaCO3	mg/L	5	7
	CR below MR			Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	<1
				Colour	TCU	2	26
				Conductivity	uS/cm	5	18
				Dissolved Organic Carbon	mg/L	0.5	5.1
				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	5
				N-NH3 (Ammonia)	mg/L	0.010	<0.010
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	7.05
				Sulphate	mg/L	1	<1
				Total Dissolved Solids (COND - CALC)	mg/L	1	12
				Total Kjeldahl Nitrogen	mg/L	0.100	0.145
				Total Organic Carbon	mg/L	0.5	5.4
				Turbidity	NTU	0.1	0.6
				Aluminum	mg/L	0.01	0.05

Sample comment:

Holding time for turbidity analysis was exceeded.

Report comment:

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.



APPROVAL:

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: 1935098

Cient:	Department of Environment	**COC Number:**	860544
Attention:	Ms. Leona Hyde	**Date Reported:**	2020-07-28
Client Project:		**Date Submitted:**	2020-07-23
Purchase Order:	219034377-5	**Sample Matrix:**	Water

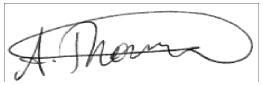
LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1506112	WS-S-0000	2020-6303-00-SI-SP	2020-07-15	Antimony	mg/L	0.0005	<0.0005
	CR below MR			Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	<0.01
				Boron	mg/L	0.01	<0.01
				Calcium	mg/L	1	2
				Cadmium	mg/L	0.0001	<0.0001
				Chromium	mg/L	0.001	<0.001
				Copper	mg/L	0.001	<0.001
				Iron	mg/L	0.03	0.12
				Lead	mg/L	0.001	<0.001
				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	0.01
				Mercury	mg/L	0.0001	<0.0001
				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	<2
				Strontium	mg/L	0.001	0.011

Sample comment:

Holding time for turbidity analysis was exceeded.

Report comment:

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.



APPROVAL:

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: **1935098**

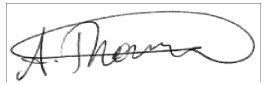
Cient:	Department of Environment	**COC Number:**	860544
Attention:	Ms. Leona Hyde	**Date Reported:**	2020-07-28
Client Project:		**Date Submitted:**	2020-07-23
Purchase Order:	219034377-5	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1506112	WS-S-0000	2020-6303-00-SI-SP	2020-07-15	Uranium	mg/L	0.001	<0.001
	CR below MR			Zinc	mg/L	0.01	<0.01
				Phosphorus	mg/L	0.002	0.003
Sample comment:				Total Suspended Solids	mg/L	2	2

Holding time for turbidity analysis was exceeded.

Report comment:

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: 

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: 1933448

Cient: Department of Environment
Attention: Ms. Leona Hyde
Client Project:
Purchase Order: 219034377-5

COC Number:
Date Reported: 2020-07-09
Date Submitted: 2020-07-03
Sample Matrix: Water

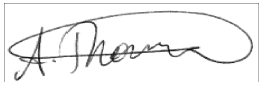
LAB ID	Supply / Description	Client Sample ID	Sample Date
1502074	WS-S-0000 CR Above Grizzle	2020-6302-00-SI-SP	2020-06-29

Sample comment:
Holding time for turbidity analysis was exceeded.

Report comment:

ANALYTE	UNIT	MRL	RESULT
Alkalinity as CaCO3	mg/L	5	6
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	<1
Colour	TCU	2	42
Conductivity	uS/cm	5	36
Dissolved Organic Carbon	mg/L	0.5	5.2
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	5
N-NH3 (Ammonia)	mg/L	0.010	<0.010
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	6.83
Sulphate	mg/L	1	<1
Total Dissolved Solids (COND - CALC)	mg/L	1	23
Total Kjeldahl Nitrogen	mg/L	0.100	<0.100
Total Organic Carbon	mg/L	0.5	5.3
Turbidity	NTU	0.1	0.7
Aluminum	mg/L	0.01	0.07

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.



APPROVAL:
Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: 1933448

Cient: Department of Environment
Attention: Ms. Leona Hyde
Client Project:
Purchase Order: 219034377-5

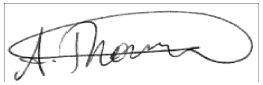
COC Number:
Date Reported: 2020-07-09
Date Submitted: 2020-07-03
Sample Matrix: Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1502074	WS-S-0000 CR Above Grizzle	2020-6302-00-SI-SP	2020-06-29	Antimony	mg/L	0.0005	<0.0005
				Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	<0.01
				Boron	mg/L	0.01	<0.01
				Calcium	mg/L	1	2
				Cadmium	mg/L	0.0001	<0.0001
				Chromium	mg/L	0.001	<0.001
				Copper	mg/L	0.001	<0.001
				Iron	mg/L	0.03	0.15
				Lead	mg/L	0.001	<0.001
				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	<0.01
				Mercury	mg/L	0.0001	<0.0001
				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	<2
				Strontium	mg/L	0.001	0.010

Sample comment:
Holding time for turbidity analysis was exceeded.

Report comment:

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.



APPROVAL:
Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: 1933448

Cient:	Department of Environment	**COC Number:**	
Attention:	Ms. Leona Hyde	**Date Reported:**	2020-07-09
Client Project:		**Date Submitted:**	2020-07-03
Purchase Order:	219034377-5	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1502074	WS-S-0000	2020-6302-00-SI-SP	2020-06-29	Uranium	mg/L	0.001	<0.001
	CR Above Grizzle			Zinc	mg/L	0.01	<0.01
				Phosphorus	mg/L	0.002	0.003
				Total Suspended Solids	mg/L	2	<2

Sample comment:

Holding time for turbidity analysis was exceeded.

Report comment:

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL:

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: 1933448

Cient: Department of Environment
Attention: Ms. Leona Hyde
Client Project:
Purchase Order: 219034377-5

COC Number:
Date Reported: 2020-07-09
Date Submitted: 2020-07-03
Sample Matrix: Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1502073	WS-S-0000 CR Below Muskrat	2020-6301-00-SI-SP	2020-06-29

Sample comment:
Holding time for turbidity analysis was exceeded.

Report comment:

ANALYTE	UNIT	MRL	RESULT
Alkalinity as CaCO3	mg/L	5	5
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	<1
Colour	TCU	2	53
Conductivity	uS/cm	5	15
Dissolved Organic Carbon	mg/L	0.5	5.3
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	5
N-NH3 (Ammonia)	mg/L	0.010	<0.010
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	6.74
Sulphate	mg/L	1	<1
Total Dissolved Solids (COND - CALC)	mg/L	1	10
Total Kjeldahl Nitrogen	mg/L	0.100	<0.100
Total Organic Carbon	mg/L	0.5	5.3
Turbidity	NTU	0.1	3.0
Aluminum	mg/L	0.01	0.16

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL:
Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: 1933448

Cient: Department of Environment
Attention: Ms. Leona Hyde
Client Project:
Purchase Order: 219034377-5

COC Number:
Date Reported: 2020-07-09
Date Submitted: 2020-07-03
Sample Matrix: Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1502073	WS-S-0000 CR Below Muskrat	2020-6301-00-SI-SP	2020-06-29	Antimony	mg/L	0.0005	<0.0005
				Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	<0.01
				Boron	mg/L	0.01	<0.01
				Calcium	mg/L	1	2
				Cadmium	mg/L	0.0001	<0.0001
				Chromium	mg/L	0.001	<0.001
				Copper	mg/L	0.001	<0.001
				Iron	mg/L	0.03	0.23
				Lead	mg/L	0.001	<0.001
				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	0.01
				Mercury	mg/L	0.0001	<0.0001
				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	<2
				Strontium	mg/L	0.001	0.010

Sample comment:
Holding time for turbidity analysis was exceeded.

Report comment:

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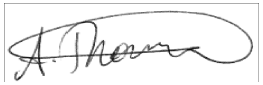

APPROVAL:
Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: 1933448

Cient:	Department of Environment	**COC Number:**	
Attention:	Ms. Leona Hyde	**Date Reported:**	2020-07-09
Client Project:		**Date Submitted:**	2020-07-03
Purchase Order:	219034377-5	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1502073	WS-S-0000	2020-6301-00-SI-SP	2020-06-29	Uranium	mg/L	0.001	<0.001
	CR Below Muskrat			Zinc	mg/L	0.01	<0.01
				Phosphorus	mg/L	0.002	0.007
Sample comment:				Total Suspended Solids	mg/L	2	6

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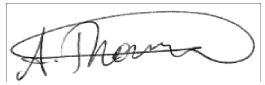
APPROVAL: 

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: 1933448

Cient:	Department of Environment	**COC Number:**	859554
Attention:	Ms. Leona Hyde	**Date Reported:**	2020-07-09
Client Project:		**Date Submitted:**	2020-07-03
Purchase Order:	219034377-5	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1502072	WS-S-0000 CR at English Point	2020-6300-00-SI-SP	2020-06-29

Sample comment:

Holding time for turbidity analysis was exceeded.

Report comment:

ANALYTE	UNIT	MRL	RESULT
Alkalinity as CaCO3	mg/L	5	<5
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	5
Colour	TCU	2	39
Conductivity	uS/cm	5	29
Dissolved Organic Carbon	mg/L	0.5	6.1
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	5
N-NH3 (Ammonia)	mg/L	0.010	<0.010
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	6.65
Sulphate	mg/L	1	<1
Total Dissolved Solids (COND - CALC)	mg/L	1	19
Total Kjeldahl Nitrogen	mg/L	0.100	0.175
Total Organic Carbon	mg/L	0.5	6.1
Turbidity	NTU	0.1	16.2
Aluminum	mg/L	0.01	0.42

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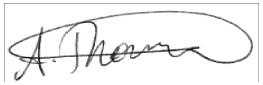

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REPORT OF ANALYSIS

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Attention:	Ms. Leona Hyde	**Date Reported:**	2020-07-09
Client Project:		**Date Submitted:**	2020-07-03
Purchase Order:	219034377-5	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1502072	WS-S-0000 CR at English Point	2020-6300-00-SI-SP	2020-06-29	Antimony	mg/L	0.0005	<0.0005
				Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	0.01
				Boron	mg/L	0.01	<0.01
				Calcium	mg/L	1	2
				Cadmium	mg/L	0.0001	<0.0001
				Chromium	mg/L	0.001	<0.001
				Copper	mg/L	0.001	0.001
				Iron	mg/L	0.03	0.62
				Lead	mg/L	0.001	<0.001
				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	0.03
				Mercury	mg/L	0.0001	<0.0001
				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	3
				Strontium	mg/L	0.001	0.012

Sample comment:

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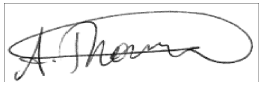

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LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1502072	WS-S-0000	2020-6300-00-SI-SP	2020-06-29	Uranium	mg/L	0.001	<0.001
	CR at English Point			Zinc	mg/L	0.01	<0.01
				Phosphorus	mg/L	0.002	0.021
				Total Suspended Solids	mg/L	2	14

Sample comment:

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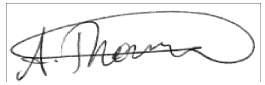
APPROVAL: 

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