# Real-Time Water Quality Deployment Report

## Lower Churchill River Network

**October 4 to October 29/30, 2019**

Newfoundland Labrador

**Government of Newfoundland & Labrador**
**Department of Municipal Affairs & Environment**
**Water Resources Management Division**

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## Real Time Water Quality Monitoring

- Staff with the Department of Municipal Affairs & Environment 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.
- 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 October 4th.
- Instruments at Churchill River below Metchin River and Churchill River above Grizzle Rapids were removed on October 29th. Churchill River above Grizzle Rapids had a deployment period of 25 days. Instruments at Churchill River below Muskrat Falls and Churchill River at English Point were removed on October 30th, for a deployment period of 26 days.
- The instrument at Churchill River below Metchin River was not deployed on October 4th; however, for the purposes of this report, data from this station will be reported as if it had been. The instrument at this station was deployed continuously from September 3rd through October 29th. A 25 day deployment period will be used for reporting purposes, based on the removal date for Churchill River above Grizzle Rapids.
- The station at 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 (as was planned in the fall of 2016). However, due to unforeseen issues, water levels were raised and decreased again. As a result, the newly located above Muskrat Falls station is now situated approximately 650 feet from the edge of the reservoir (i.e. at current water levels) 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 October 4 to October 29/30, 2019 are summarized in Table 2.

**Table 2: Comparison rankings for Lower Churchill River stations October 4 to October 29/30, 2019**

| Churchill River Station | Date | Action | Comparison Ranking | | | | |
|---|---|---|---|---|---|---|---|
| | | | Temperature | pH | Conductivity | Dissolved Oxygen | Turbidity |
| Below Metchin River | October 4, 2019 | Deployment | N/A | N/A | N/A | N/A | N/A |
| | October 29, 2019 | Removal | Good | Good | Excellent | Fair | Good |
| Above Grizzle Rapids | October 4, 2019 | Deployment | Excellent | Fair | Excellent | Excellent | Excellent |
| | October 29, 2019 | Removal | Good | Good | Excellent | Fair | Excellent |
| Below Muskrat Falls | October 4, 2019 | Deployment | Good | Fair | Excellent | Excellent | Excellent |
| | October 30, 2019 | Removal | Excellent | Excellent | Excellent | Good | Marginal |
| At English Point | October 4, 2019 | Deployment | Excellent | Fair | Excellent | Excellent | Excellent |
| | October 30, 2019 | Removal | Good | Excellent | Marginal | Fair | 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**
    - Comparison rankings are not available for deployment since this instrument wasn't physically deployed on October 4th.
    - At removal, conductivity was 'excellent', temperature, pH, and turbidity were 'good', while dissolved oxygen was 'fair'.
- **Churchill River above Grizzle Rapids**
    - At deployment, all parameters were 'excellent' except for pH, which was 'fair'.
    - At removal, conductivity and turbidity were 'excellent', temperature and pH were 'good', while dissolved oxygen was 'fair'.
- **Churchill River below Muskrat Falls**
    - At deployment, all parameters ranked as 'excellent' or 'good' except for pH, which was 'fair'.
    - At removal, all parameters ranked as 'excellent' or 'good' except for turbidity, which was 'marginal'.

- **Churchill River at English Point**
    - At deployment, all parameters ranked as 'excellent' except for pH, which was 'fair'.
    - At removal, pH and turbidity were 'excellent', temperature was 'good', dissolved oxygen was 'fair', and conductivity was 'marginal'.

## Data Interpretation

- The following graphs and discussion illustrate water quality related events occurring from October 4 to October 29/30 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 3.70°C to 7.80°C, with a median value of 6.40°C (Figure 2). Air temperature data was obtained from the Metchin River near TLH Weather Station.
- Water temperature slowly decreased over the course of deployment. This is to be expected as air temperatures were also decreasing over the same period through October. 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.

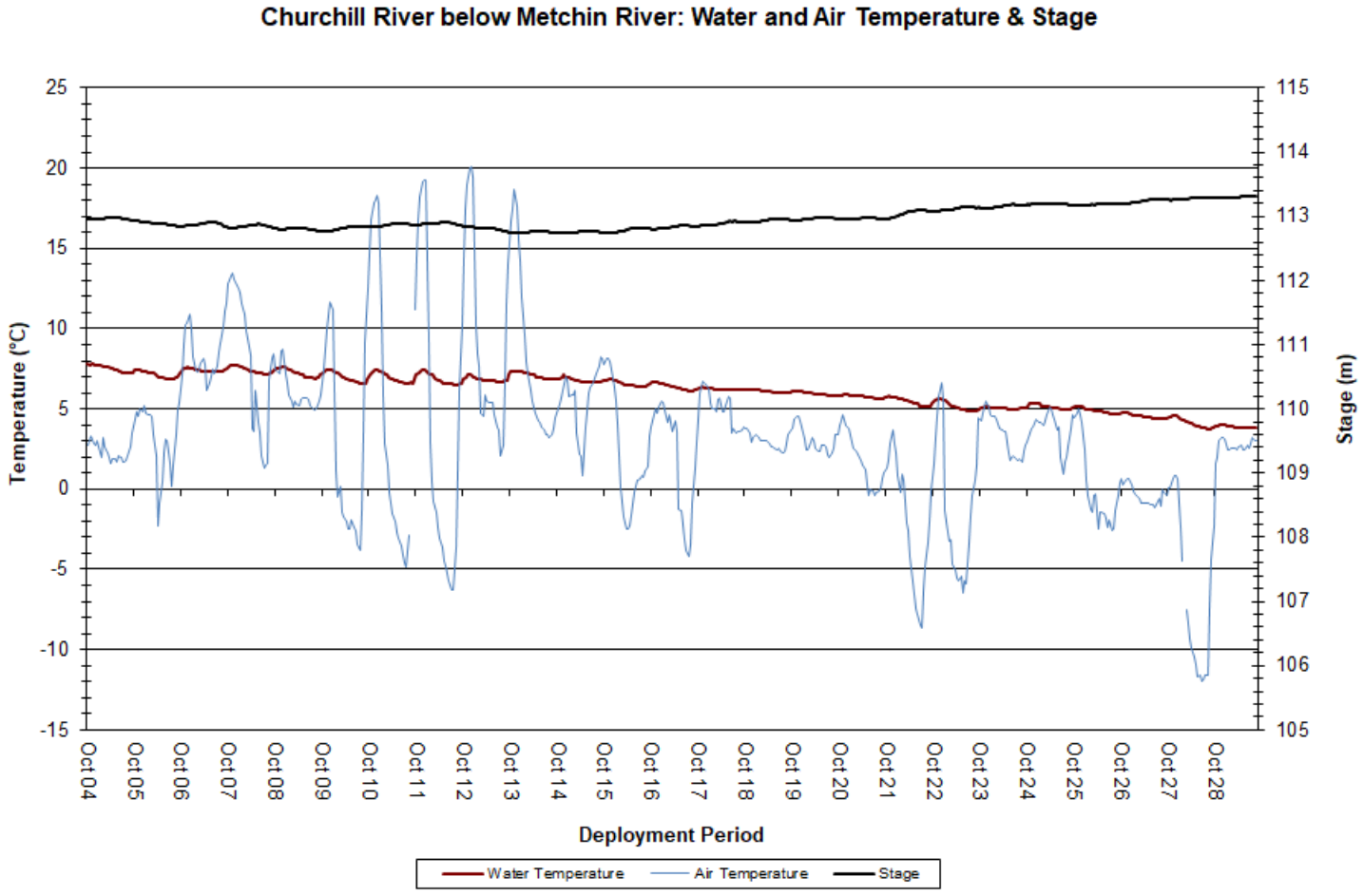


**Figure 2: Water and Air Temperature & Stage at Churchill River below Metchin River**

**pH**

- Over the deployment period, pH values ranged from 5.79 to 7.08 pH units, with a median value of 6.50 (Figure 3).
- pH values were stable at the start of deployment but steadily decreased from October 13th onwards as stage steadily increased. pH remained within the CCME's Guidelines for the Protection of Aquatic Life until October 17th, after which pH fell below the CCME's minimum guideline for the remainder 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.

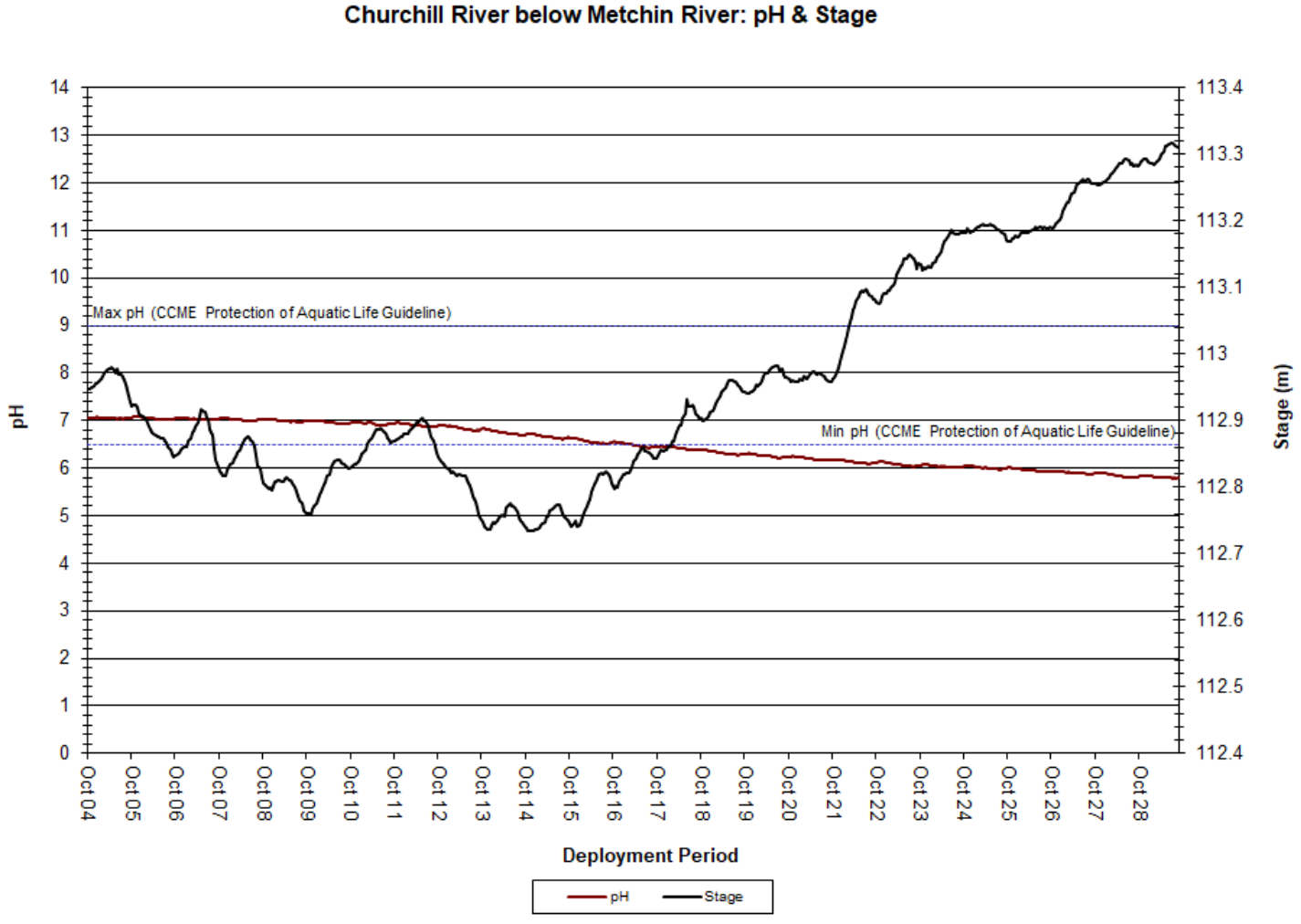


**Figure 3: pH & Stage at Churchill River below Metchin River**

**Specific Conductivity**

- Over the deployment period, specific conductivity ranged from 18.9µS/cm to 20.2µS/cm, with a median value of 19.3µS/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 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.

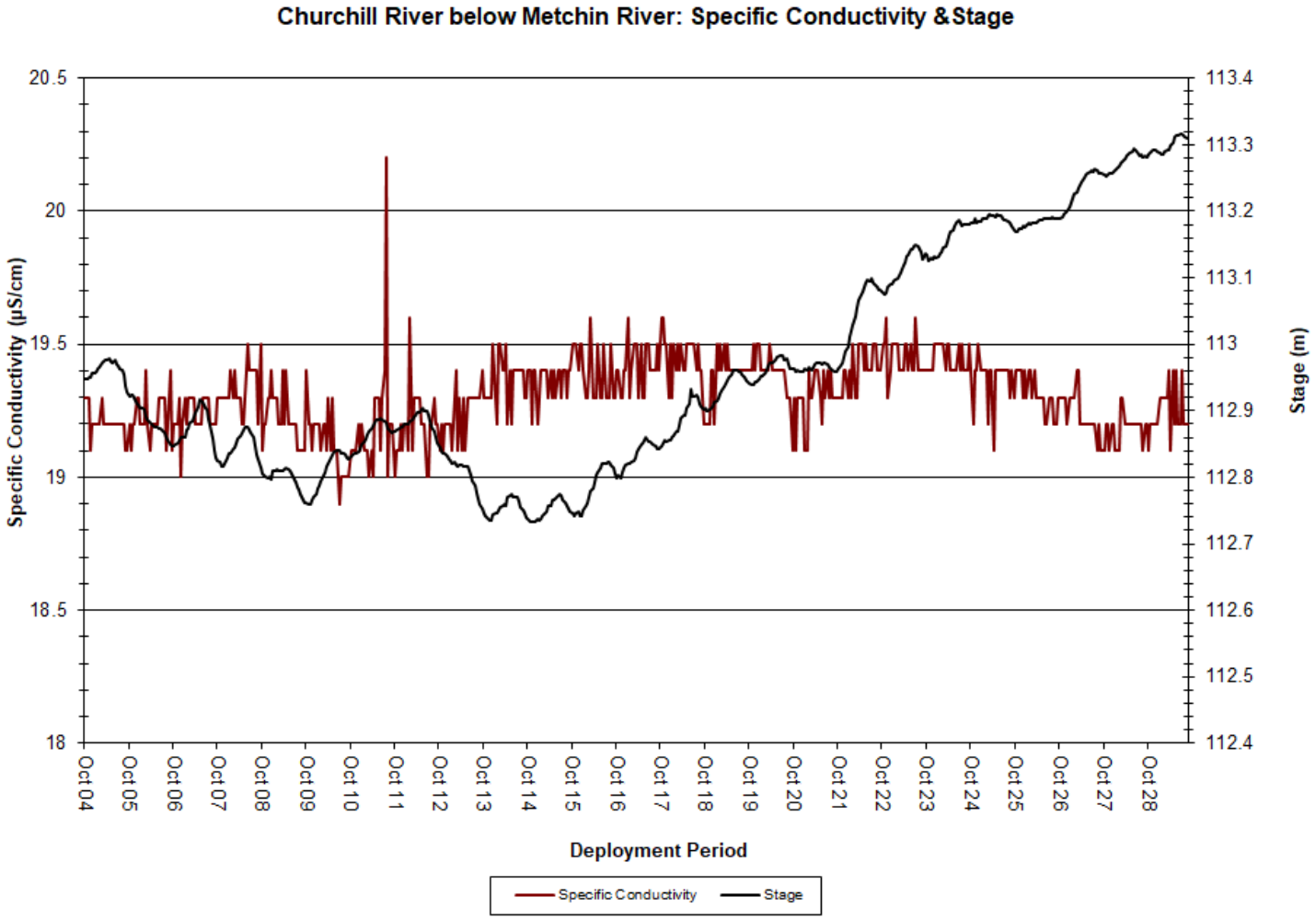


**Figure 4: Specific Conductivity & Stage at Churchill River below Metchin River**

**Dissolved Oxygen**

- Over the deployment period, dissolved oxygen content ranged from 10.90mg/L to 23.11mg/L, with a median value of 11.50mg/L. Saturation of dissolved oxygen ranged from 90.8% to 192.5%, with a median value of 92.8% (Figure 5).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period, dissolved oxygen levels gradually increased, as water temperatures gradually decreased. 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 Guidelines for the Protection of Early and Other Life Stages for the duration of deployment.

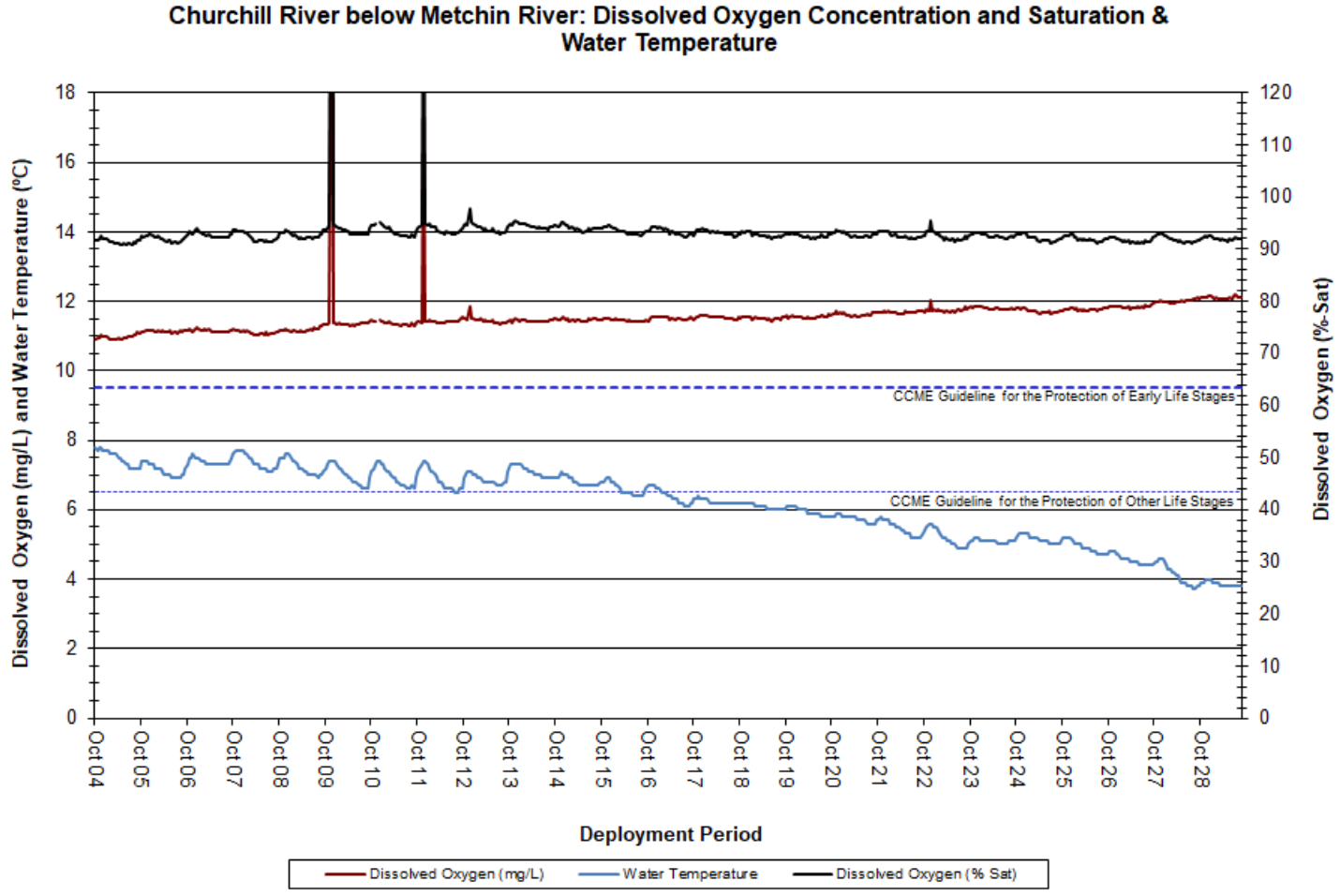


**Figure 5: Dissolved Oxygen & Water Temperature at Churchill River below Metchin River**

**Turbidity**

- Over the deployment period, turbidity ranged from 0.0NTU to 1.5NTU, 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.
- Some of the turbidity spikes observed throughout the deployment period correlate with precipitation events (Figure 6); however, other 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.

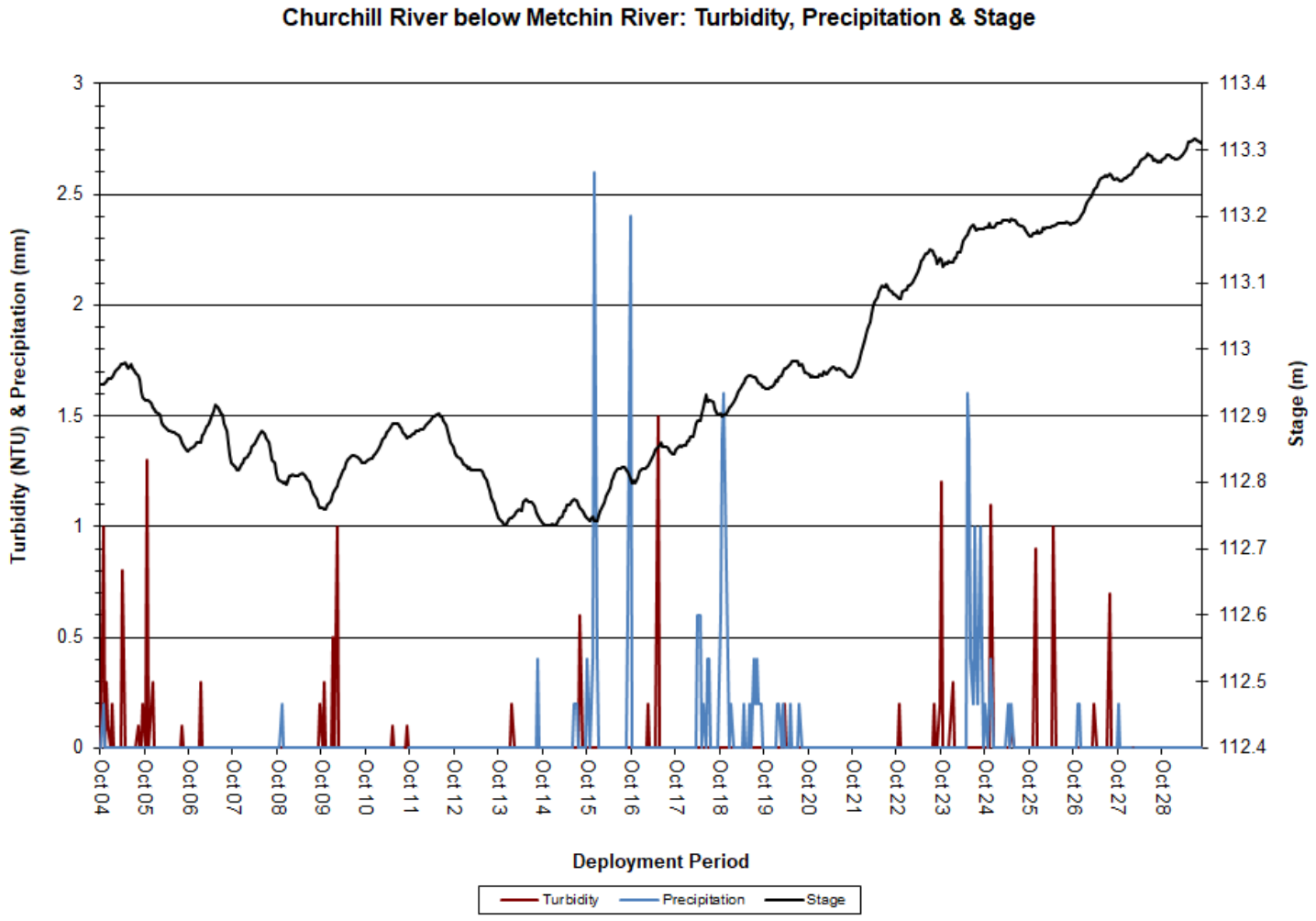


**Figure 6: Turbidity, Precipitation & Stage at Churchill River below Metchin River**

## Stage and Flow

- Over the deployment period, stage levels ranged from 112.73m to 113.32m, with a median value of 112.91m. Flow ranged from 1146.03m$^3$/s to 1335.79m$^3$/s, with a median value of 1207.51m$^3$/s (Figure 7). Precipitation data was obtained from the Metchin River near TLH Weather Station.
- Stage and flow followed a similar trend over the deployment period, and both increased steadily from October 13$^{th}$ onwards. 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.

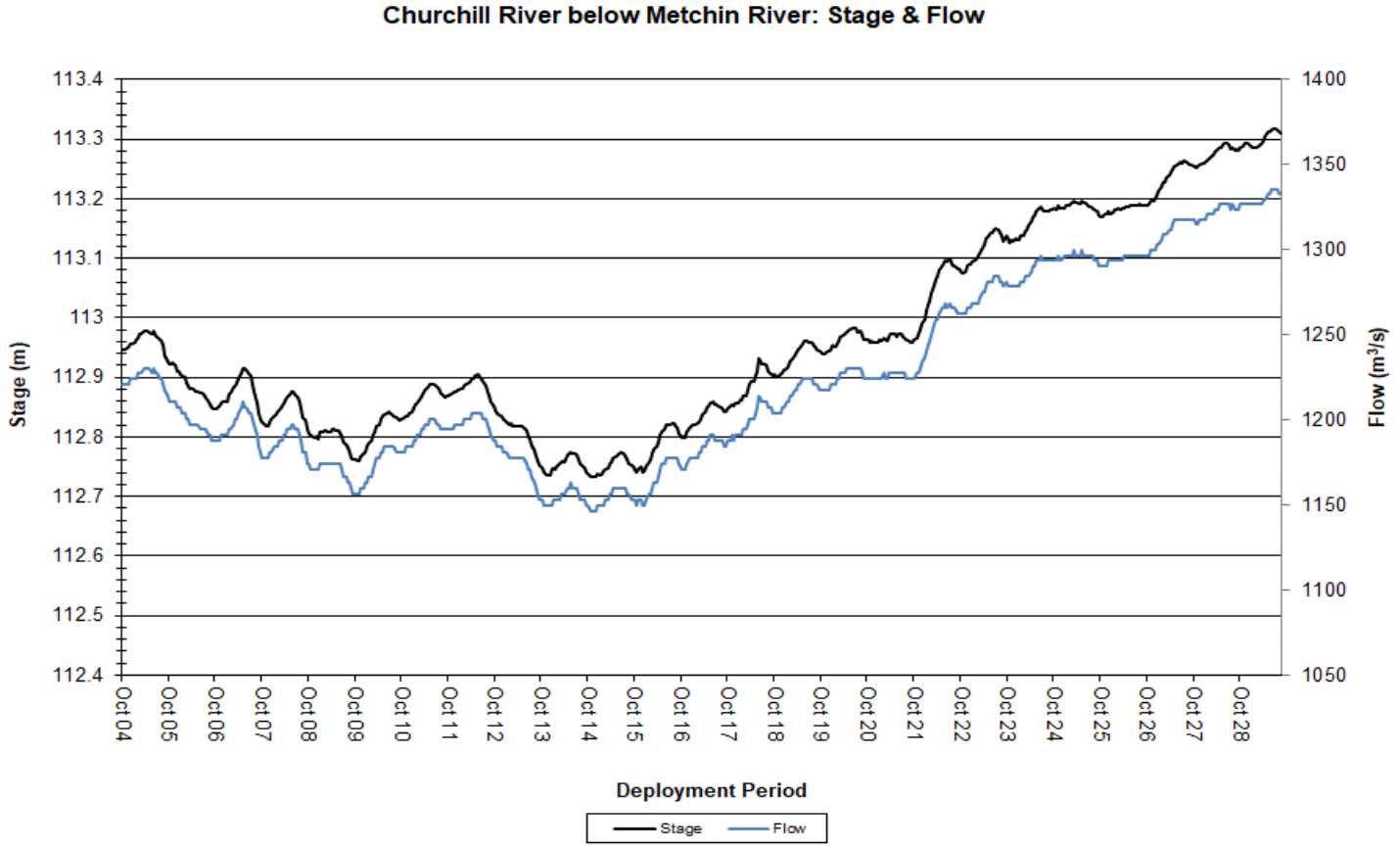


**Figure 7: Stage & Flow at Churchill River below Metchin River**

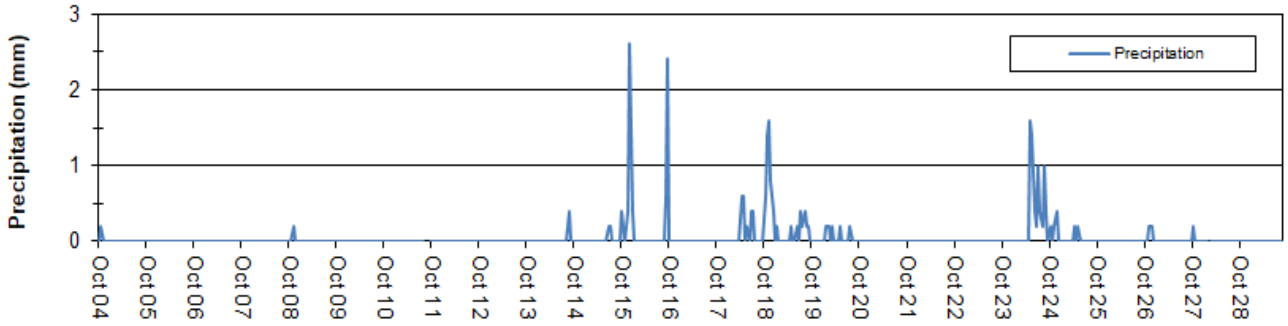


**Figure 8: Precipitation at Churchill River below Metchin River**

## Churchill River above Grizzle Rapids

### Water Temperature

- Over the deployment period, water temperature ranged from 5.40°C to 9.90°C, with a median value of 7.30°C (Figure 9). Air temperature data was obtained from the Metchin River near TLH Weather Station.
- Water temperature slowly decreased across the deployment period. This trend is to be expected as air temperatures also decreased through October. 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.

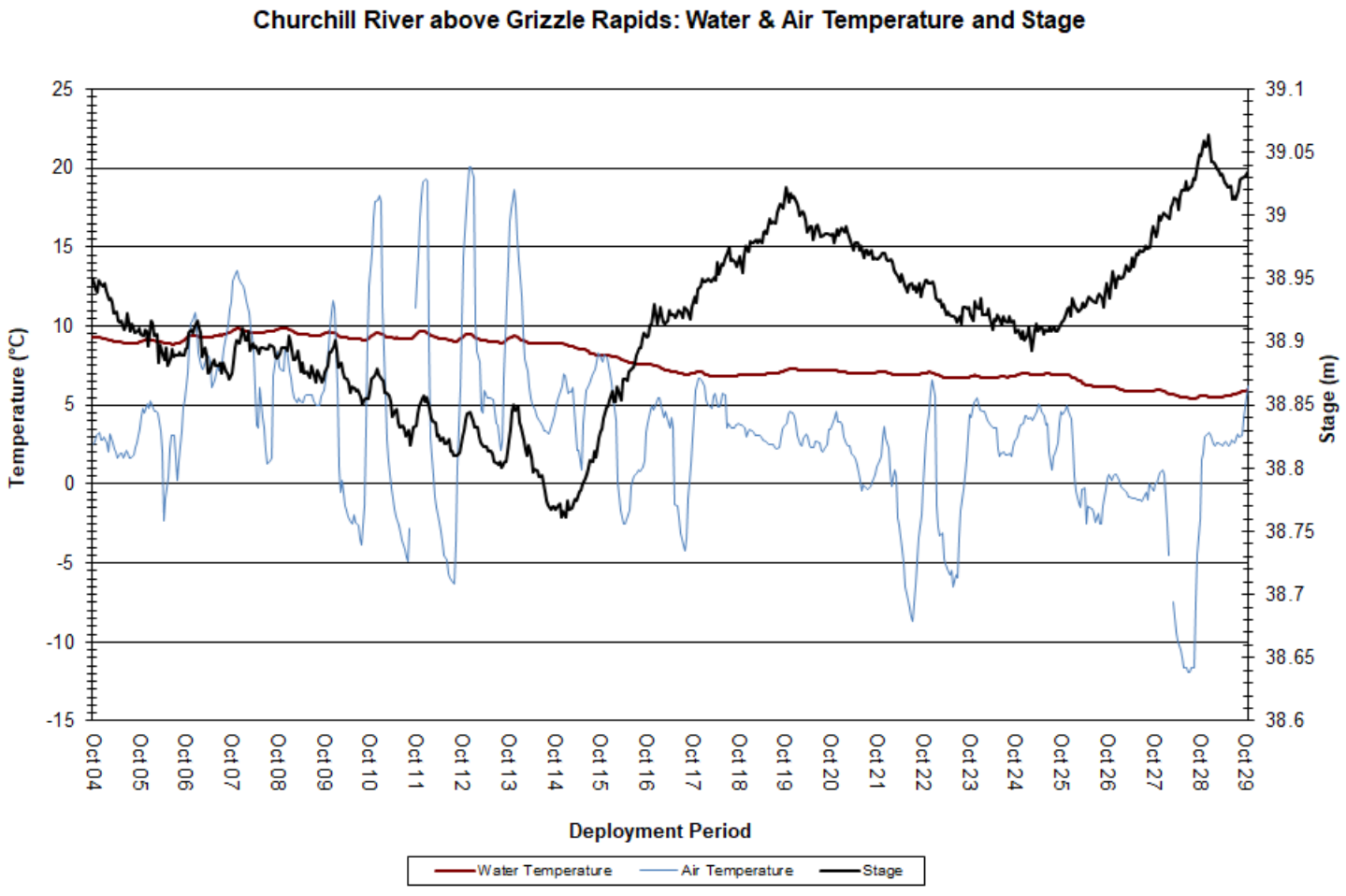


**Figure 9: Water and Air Temperature & Stage at Churchill River above Grizzle Rapids**

**pH**

- Over the deployment period, pH values ranged from 6.96 pH units to 7.17 pH units, with a median value of 7.10 (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.

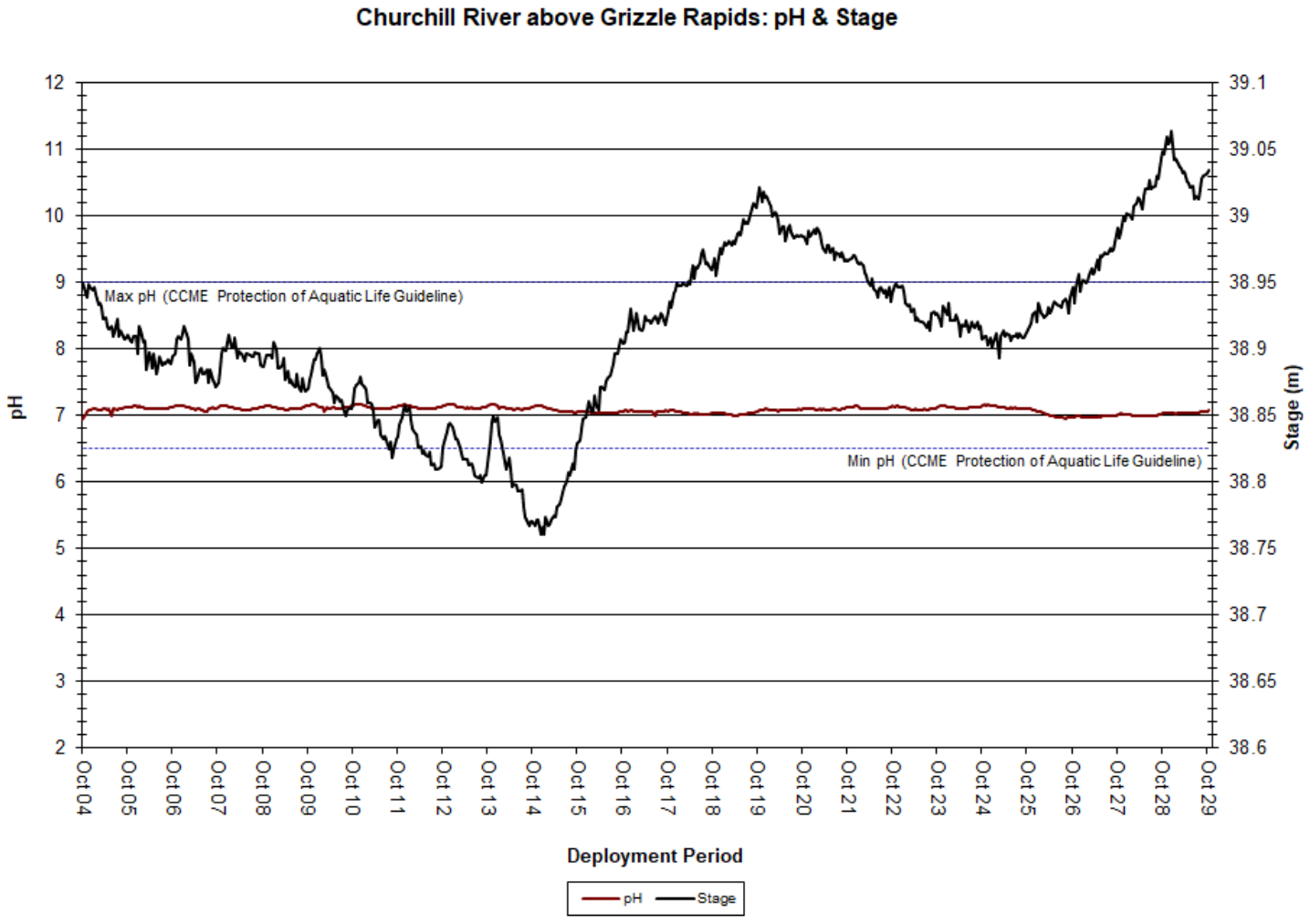


**Figure 10: pH & Stage at Churchill River above Grizzle Rapids**

**Specific Conductivity**

- Over the deployment period, specific conductivity ranged from 15.9µS/cm to 18.2µS/cm, with a median of 17.1µS/cm (Figure 11).
- 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 evident in the graph below (Figure 11).
- 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.

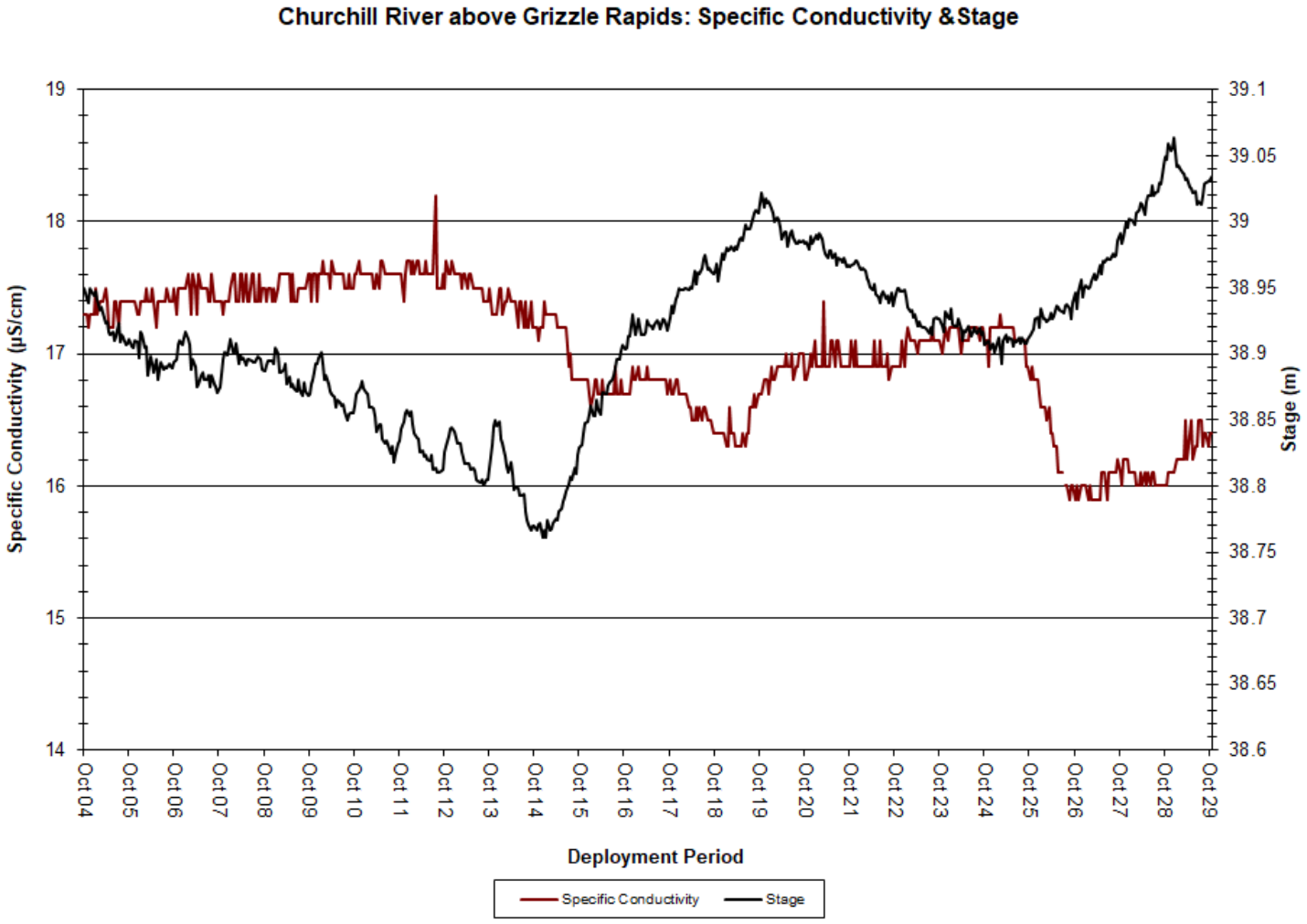


**Figure 11: Specific Conductivity & Stage at Churchill River above Grizzle Rapids**

**Dissolved Oxygen**

- Over the deployment period, dissolved oxygen content ranged from 10.55mg/L to 11.62mg/L, with a median value of 11.04mg/L. Saturation of dissolved oxygen ranged from 90.6% saturation to 96.0% saturation, with a median value of 92.8% (Figure 12).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period, dissolved oxygen levels gradually increased as water temperatures gradually decreased through October. 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 Guidelines for the Protection of Early and Other Life Stages for the duration of deployment. This is to be expected given the cooler water temperatures observed through October.

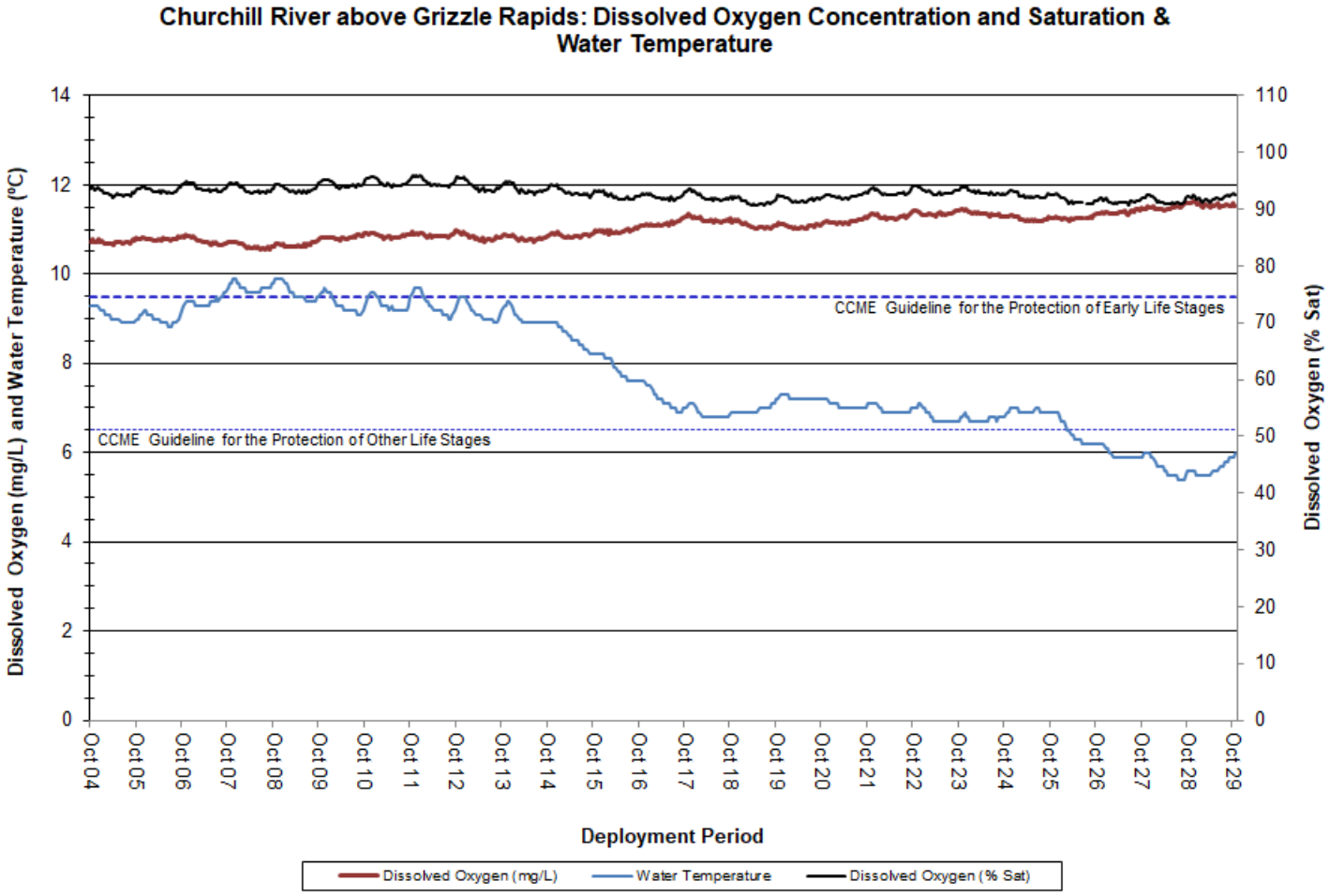


**Figure 12: Dissolved Oxygen & Water Temperature at Churchill River above Grizzle Rapids**

**Turbidity**

- Over the deployment period, turbidity ranged from 0.0NTU to 1.4NTU, with a median value of 0.1NTU (Figure 13). A median value of 0.1NTU indicates a very low level of natural background turbidity in the waterbody.
- Turbidity spikes observed over the deployment period generally correlated well with precipitation events (Figure 13).
- 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.

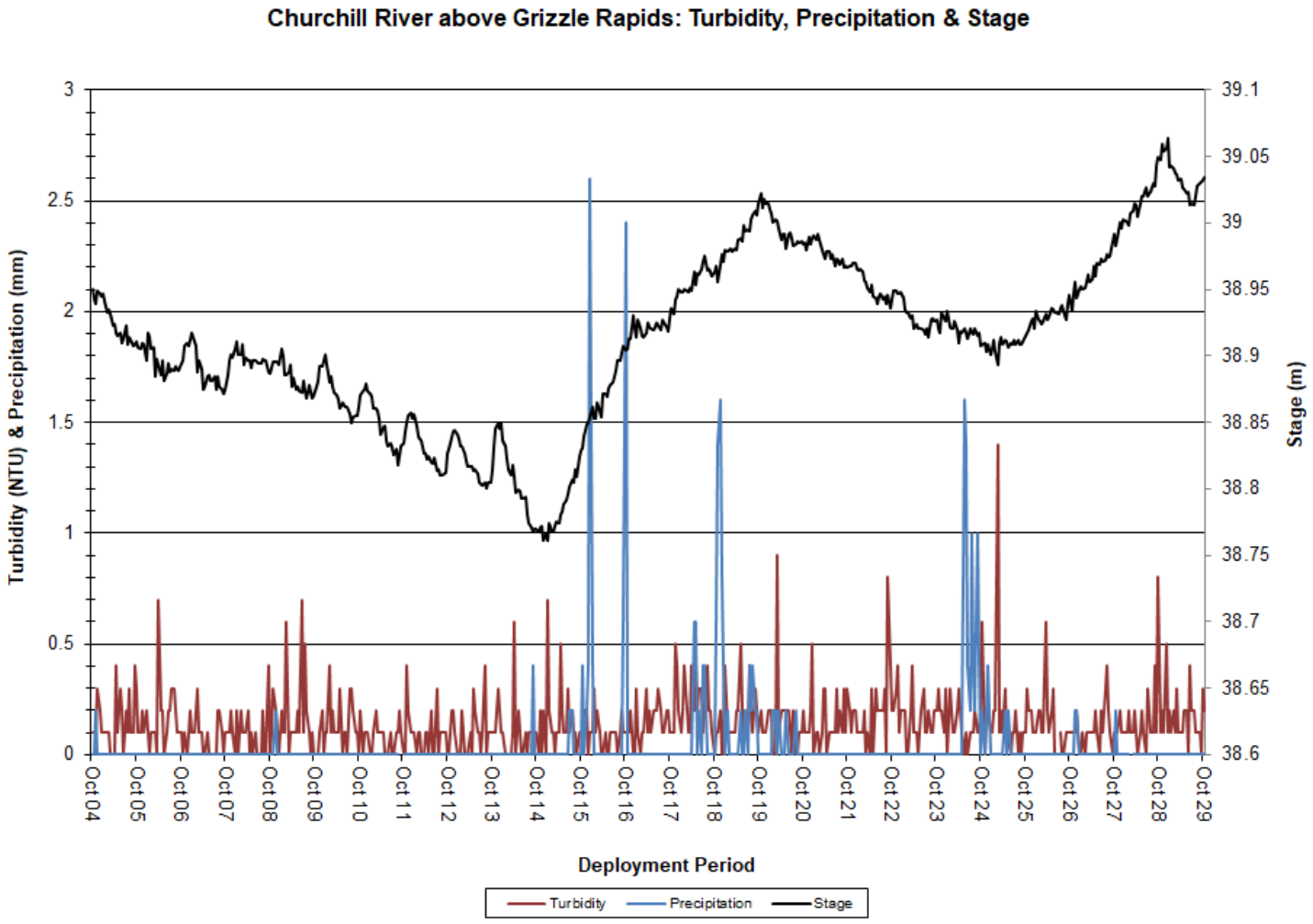


**Figure 13: Turbidity, Precipitation & Stage at Churchill River above Grizzle Rapids**

## Stage

- Over the deployment period, stage ranged from 38.76m to 39.06m, with a median value of 38.91m (Figure 14). Precipitation data was obtained from the Metchin River near TLH Weather Station.
- Stage was variable across the course of deployment, and increases in stage correlated closely with precipitation events across the same period (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.

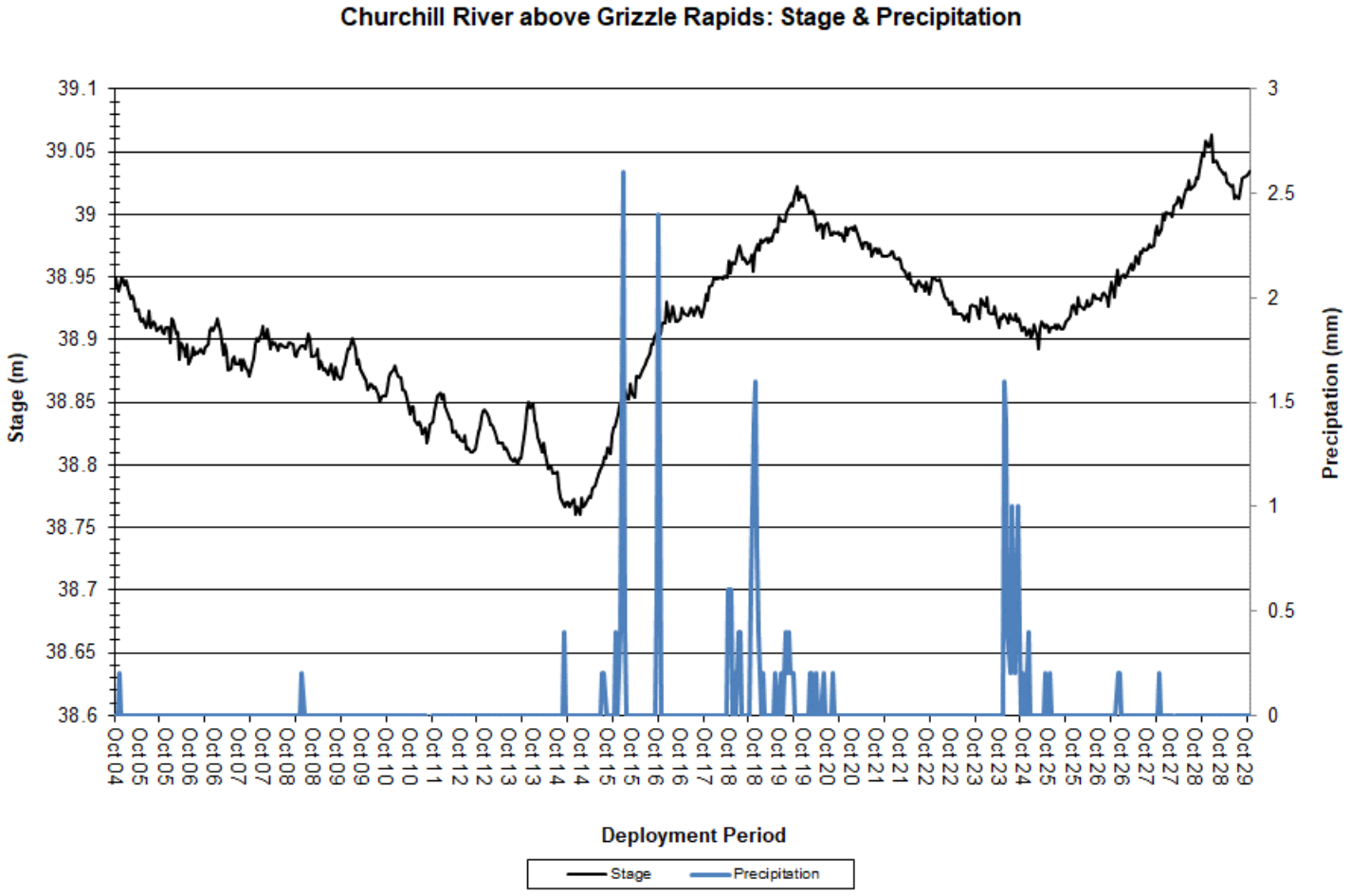


**Figure 14: Stage & Precipitation at Churchill River above Grizzle Rapids**

## Churchill River below Muskrat Falls

### Water Temperature

- Over the deployment period, water temperature ranged from 6.60°C to 11.00°C, with a median value of 8.80°C (Figure 15). Air temperature data was obtained from the Churchill River at End of Mud Lake Road Weather Station.
- Water temperature slowly decreased over the course of the deployment period. This is to be expected as ambient air temperatures also decreased through October. Water temperatures closely correlate 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.

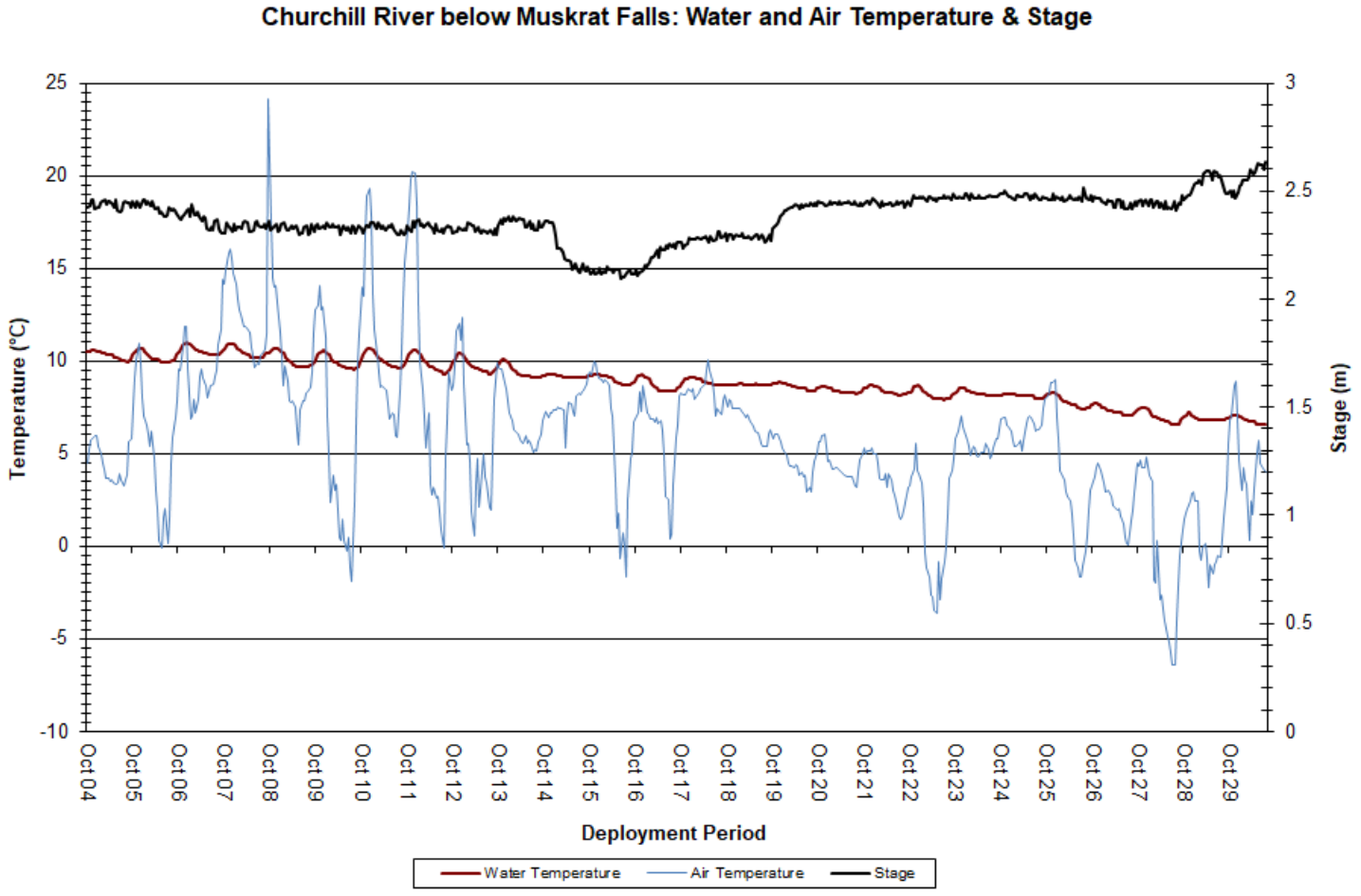


**Figure 15: Water and Air Temperature & Stage at Churchill River below Muskrat Falls**

**pH**

- Over the deployment period, pH ranged from 6.46 pH units to 6.75 pH units, with a median value of 6.67 (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, with the exception of a brief acclimation period at the very beginning of deployment (Figure 16).
- 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.

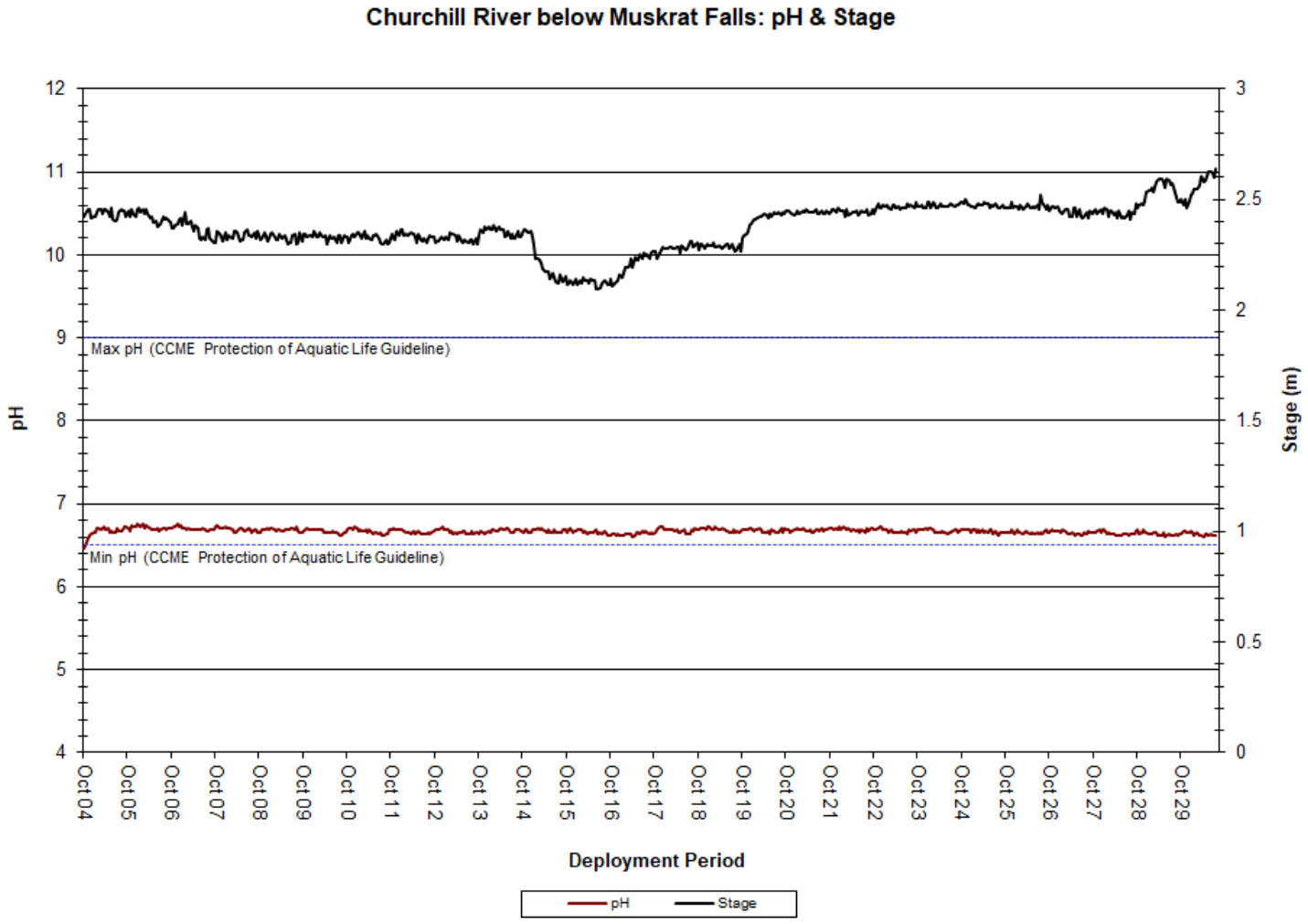


**Figure 16: pH & Stage at Churchill River below Muskrat Falls**

## Specific Conductivity

- Over the deployment period, specific conductivity ranged from 17.7µS/cm to 18.9µS/cm, with a median value of 18.5µS/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 apparent in the graph below.
- 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.

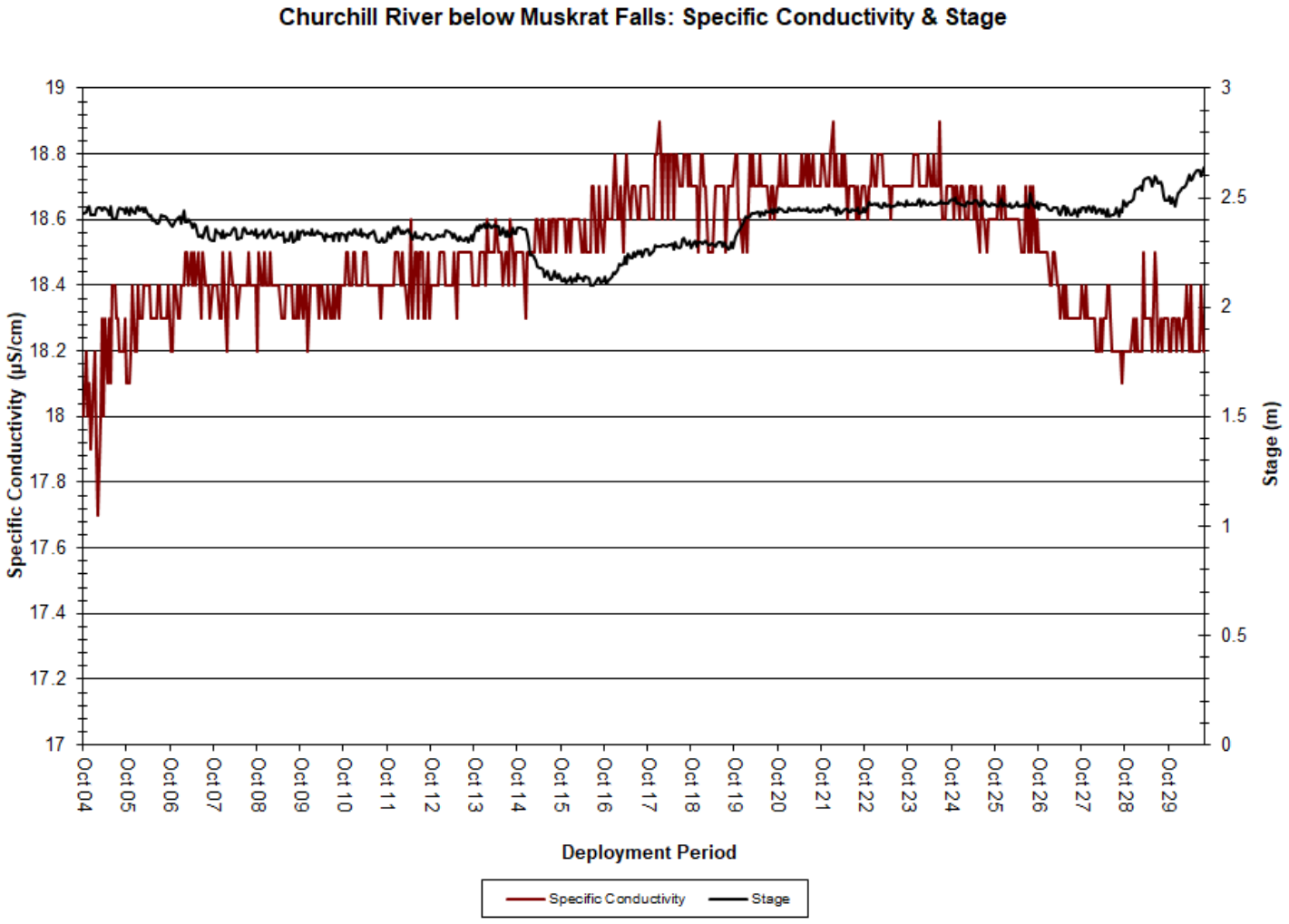


**Figure 17: Specific Conductivity & Stage at Churchill River below Muskrat Falls**

**Dissolved Oxygen**

- Over the deployment period, dissolved oxygen concentration ranged from 11.70mg/L to 13.80mg/L, with a median value of 12.71mg/L. Saturation of dissolved oxygen ranged from 104.7% to 116.2%, with a median value of 109.5% (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 increased over the course of deployment. This is to be expected since water temperatures were slowly decreasing 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 duration of deployment.

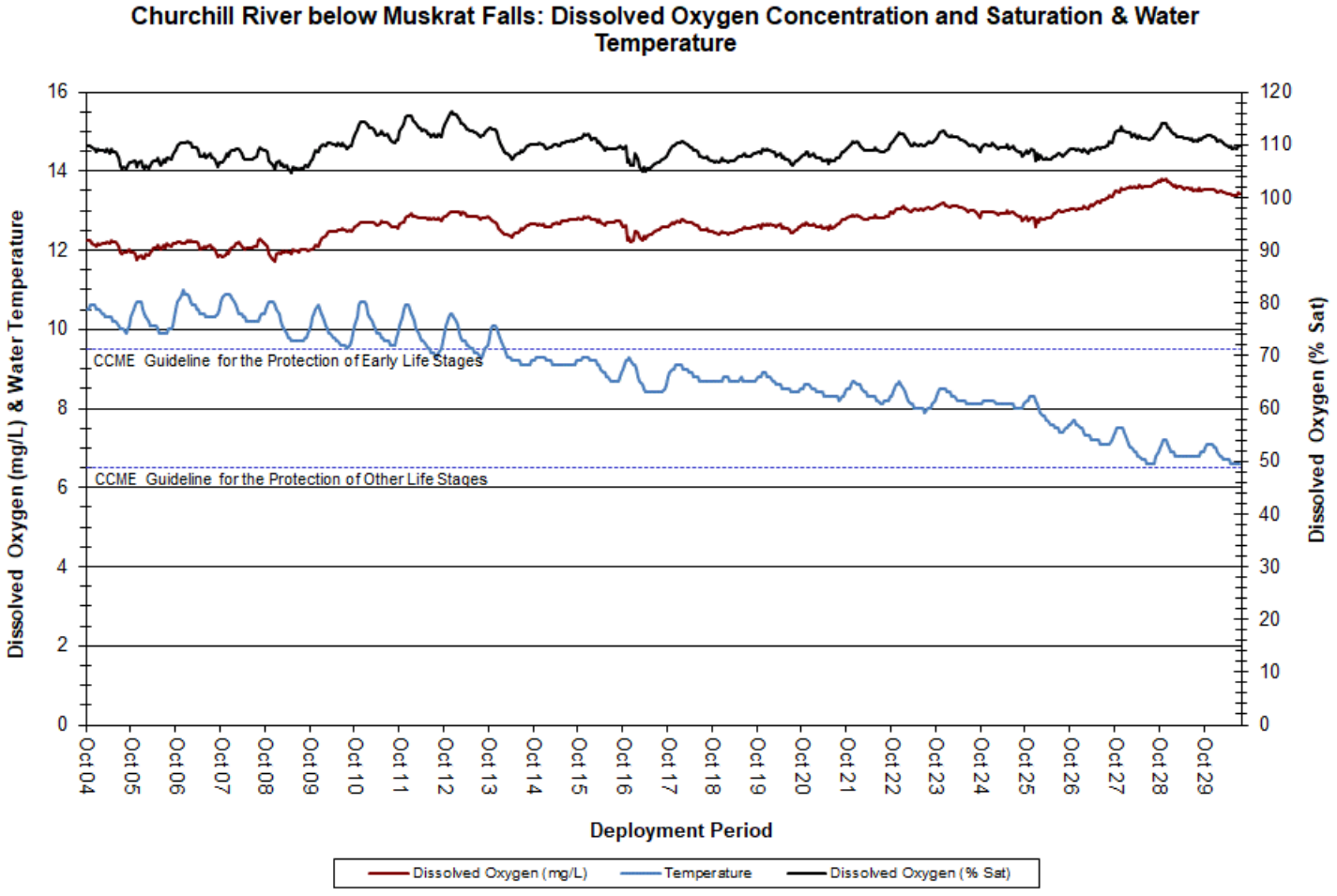


**Figure 18: Dissolved Oxygen & Water Temperature at Churchill River below Muskrat Falls**

**Turbidity**

- Over the deployment period, turbidity ranged from 6.7NTU to 23.1NTU, with a median value of 9.6NTU. A median value of 9.6NTU indicates a fair amount of natural background turbidity in the waterbody. Precipitation data was obtained from the Churchill River at End of Mud Lake Road Weather Station.
- Some of the larger turbidity spikes observed over the deployment period correlate 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 less susceptible to precipitation events as compared to other areas.
- 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.

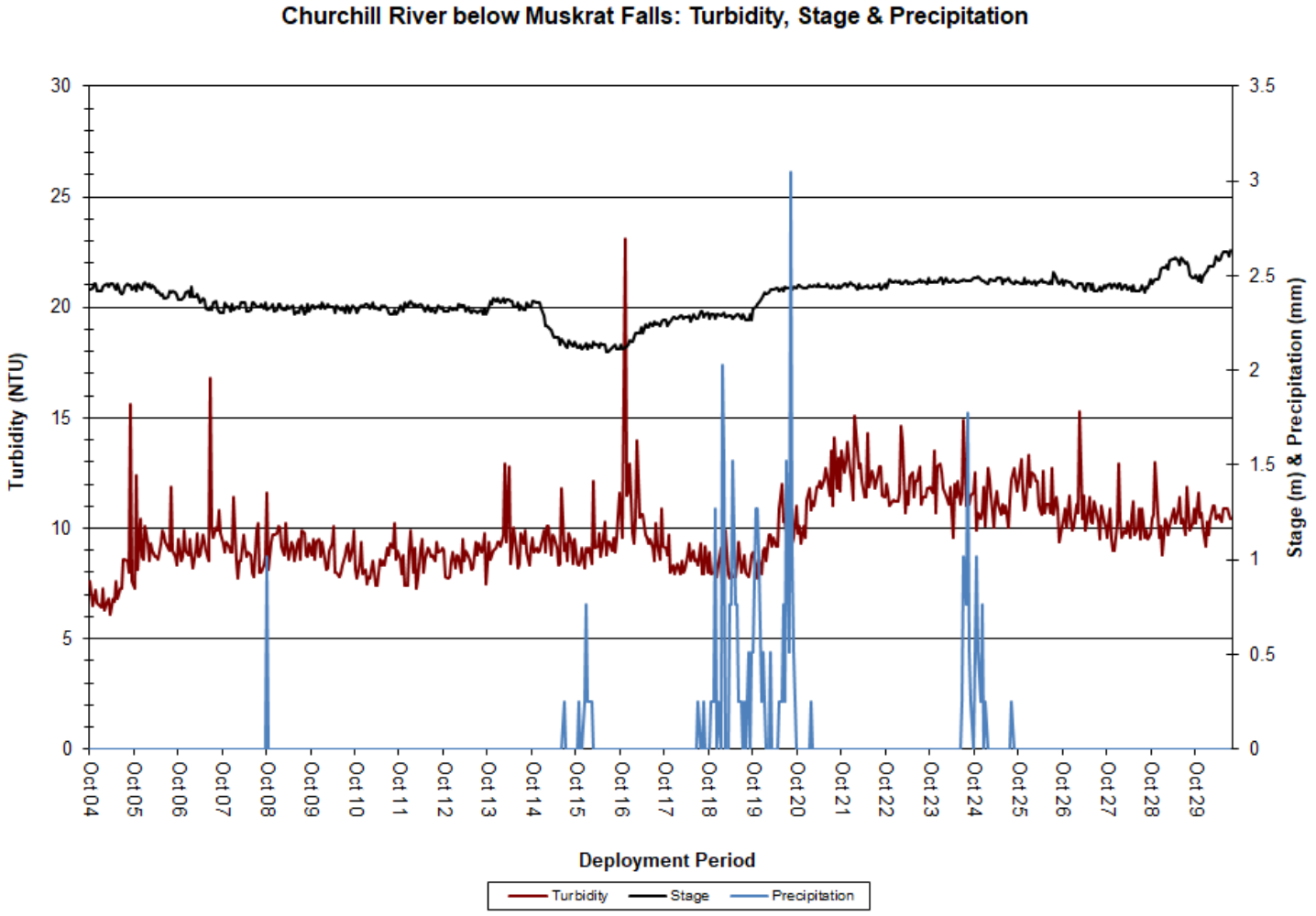


**Figure 19: Turbidity, Precipitation & Stage at Churchill River below Muskrat Falls**

### Stage & Flow

- Over the deployment period, stage ranged from 2.10m to 2.64m, with a median value of 2.38m. Flow ranged from 1122.32m$^3$/s to 1629.11m$^3$/s, with a median value of 1376.04m$^3$/s (Figure 20). Precipitation data was obtained from the Churchill River at End of Mud Lake Road Weather Station.
- Stage and flow were variable over the course of deployment and followed a very similar trend. Increases in stage and flow correlated with precipitation events on several occasions; however, other increases did not correlate with precipitation events. This is likely 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.

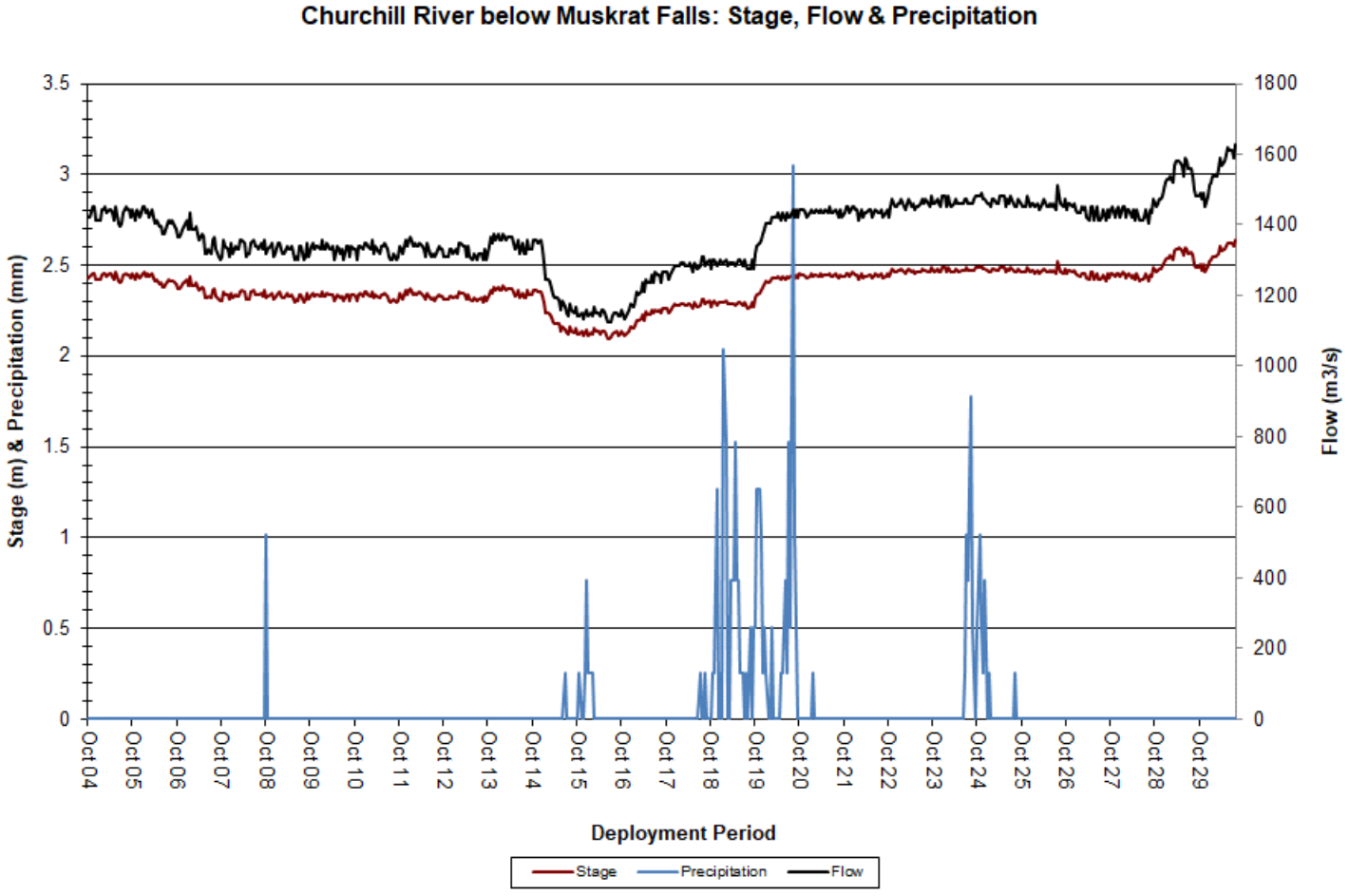


**Figure 20: Stage, Flow & Precipitation at Churchill River below Muskrat Falls**

## Chlorophyll

- Over the deployment period, chlorophyll ranged from 1.56ug/L to 4.36ug/L, with a median value of 2.22ug/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.
- 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.

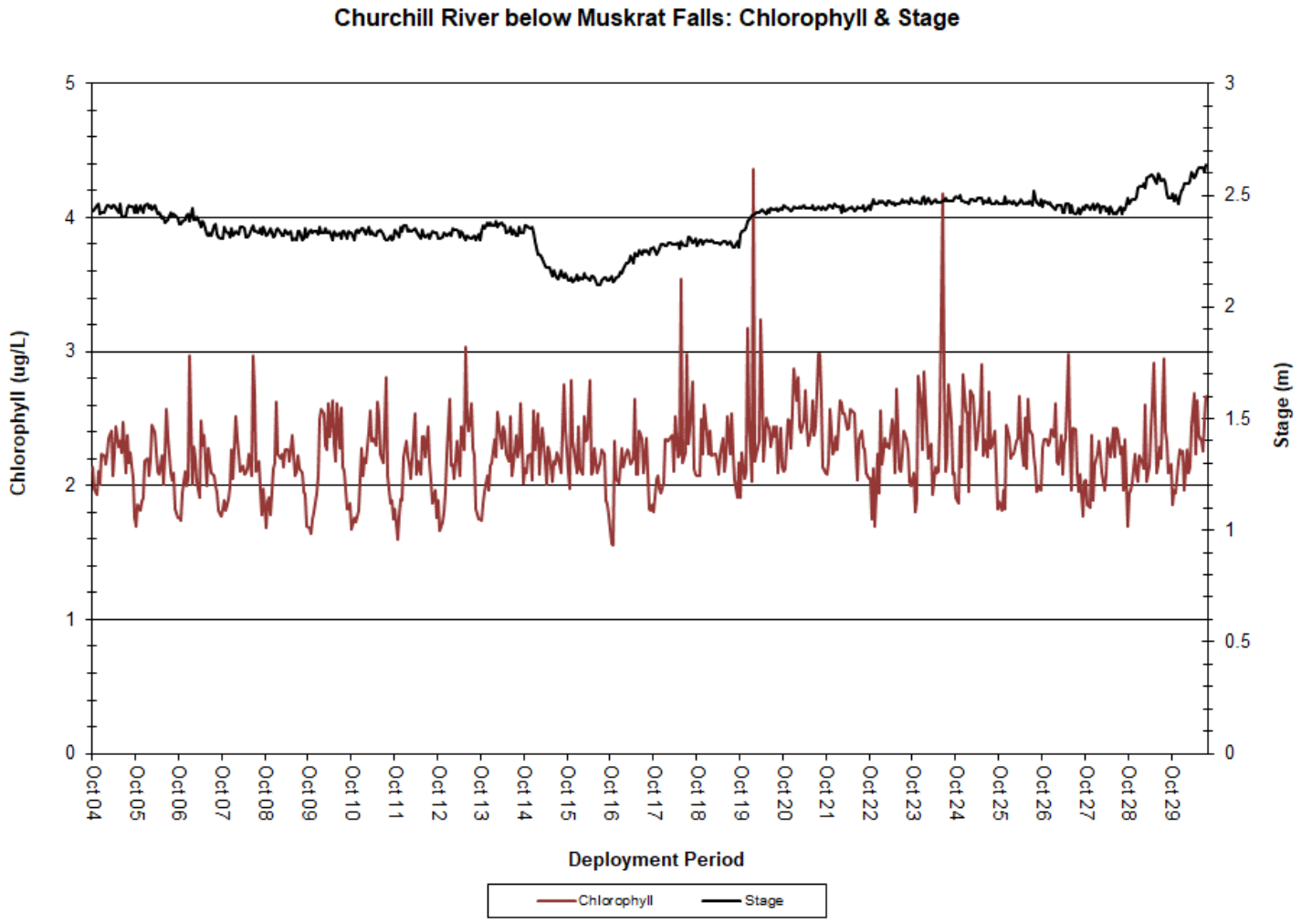


**Figure 21: Chlorophyll & Stage at Churchill River below Muskrat Falls**

## Churchill River at English Point

### Water Temperature

- Water temperature ranged from 5.40°C to 11.30°C, with a median value of 8.50°C (Figure 22). Air temperature data was obtained from the Churchill River at End of Mud Lake Road Weather Station.
- Water temperature decreased slowly over the course of deployment. 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.

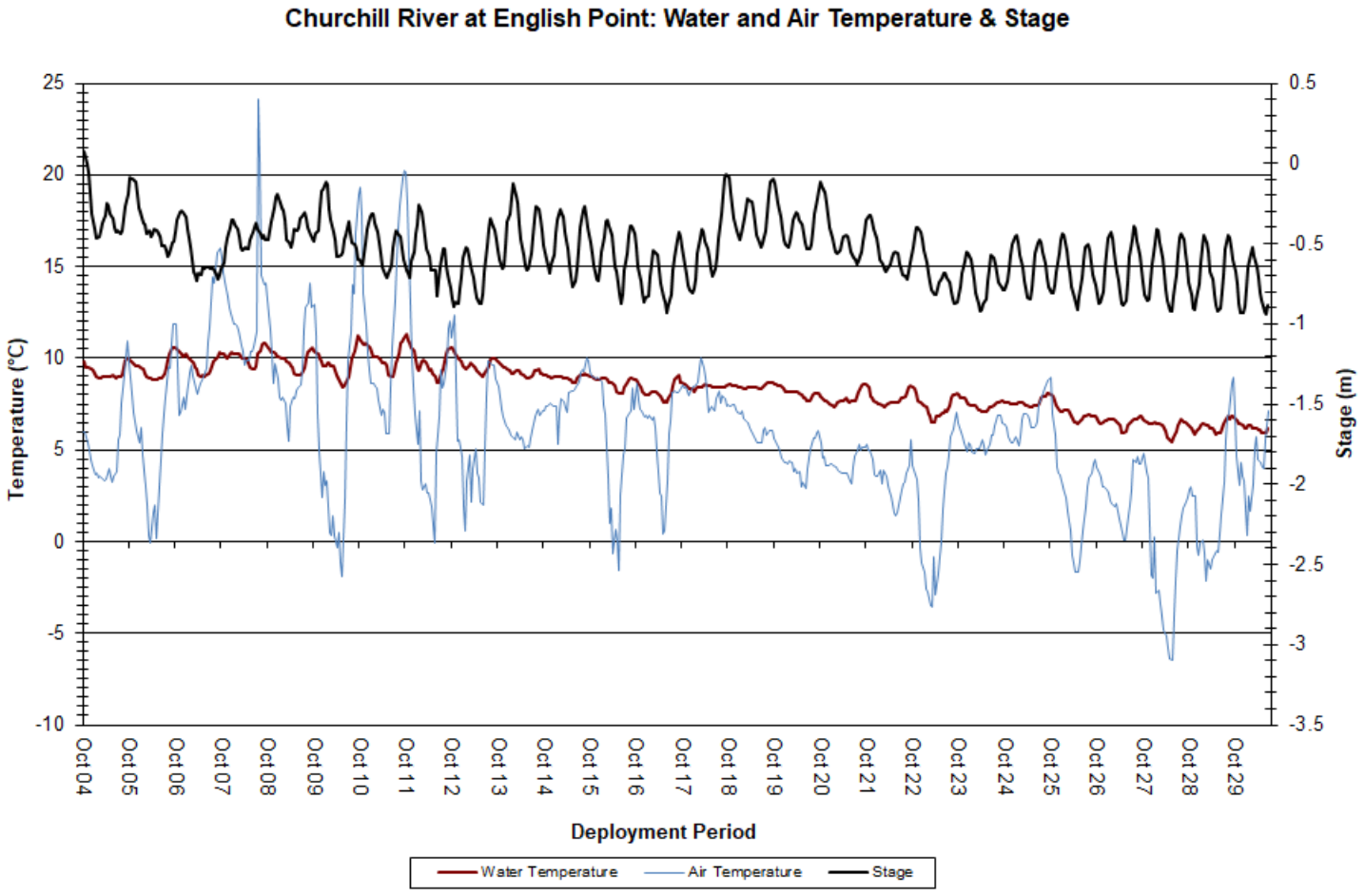


**Figure 22: Water and Air Temperature & Stage at Churchill River at English Point**

**pH**

- Over the deployment period, pH ranged from 6.64 pH units to 7.02 pH units, with a median value of 6.75 (Figure 23).
- pH values were variable across the deployment period but remained within the CCME's Guidelines for the Protection of Aquatic Life for the duration 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.

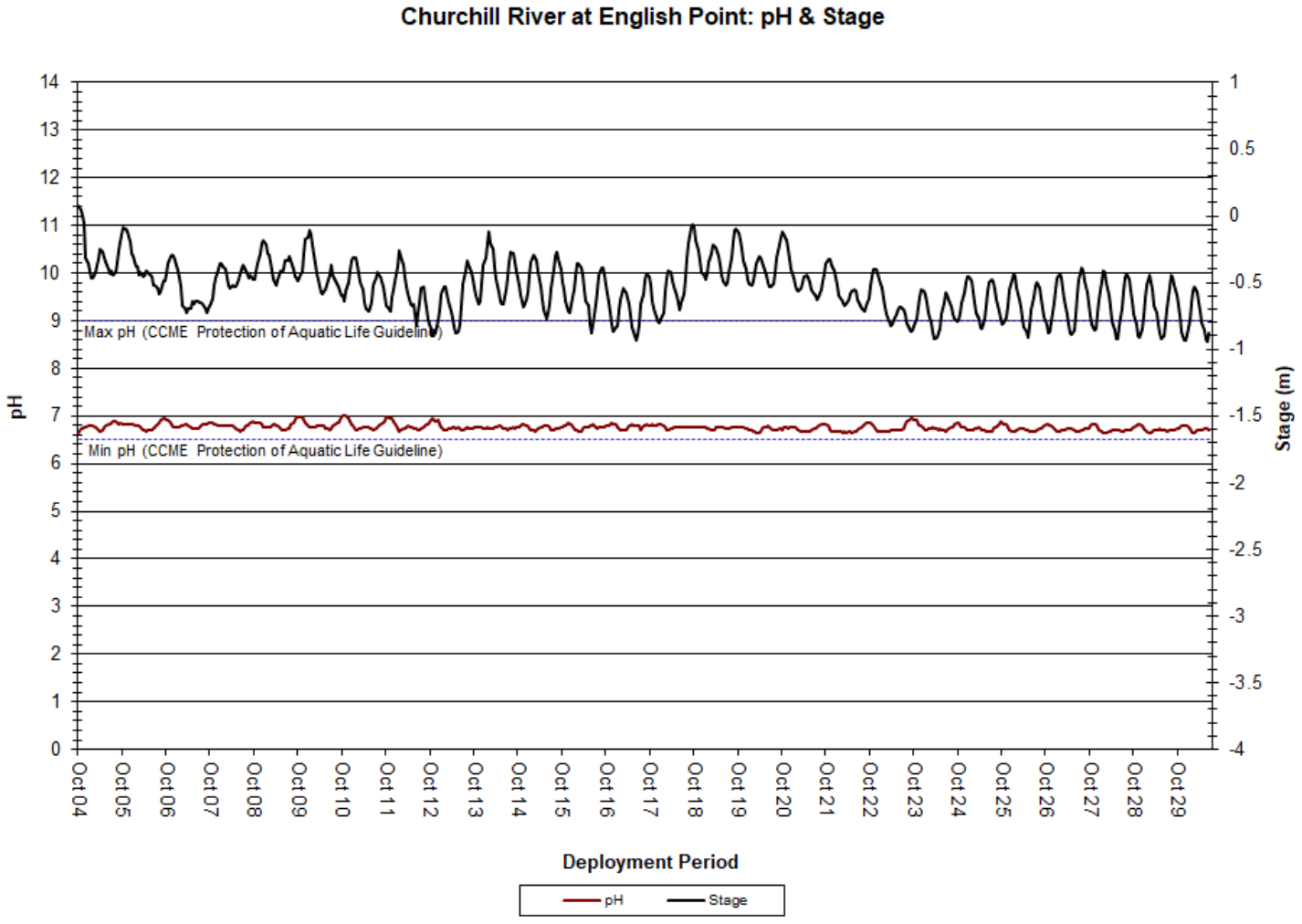


**Figure 23: pH & Stage at Churchill River at English Point**

**Specific Conductivity**

- Over the deployment period, specific conductivity ranged from 20.2µS/cm to 47.8µs/cm, with a median value of 30.2µS/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.

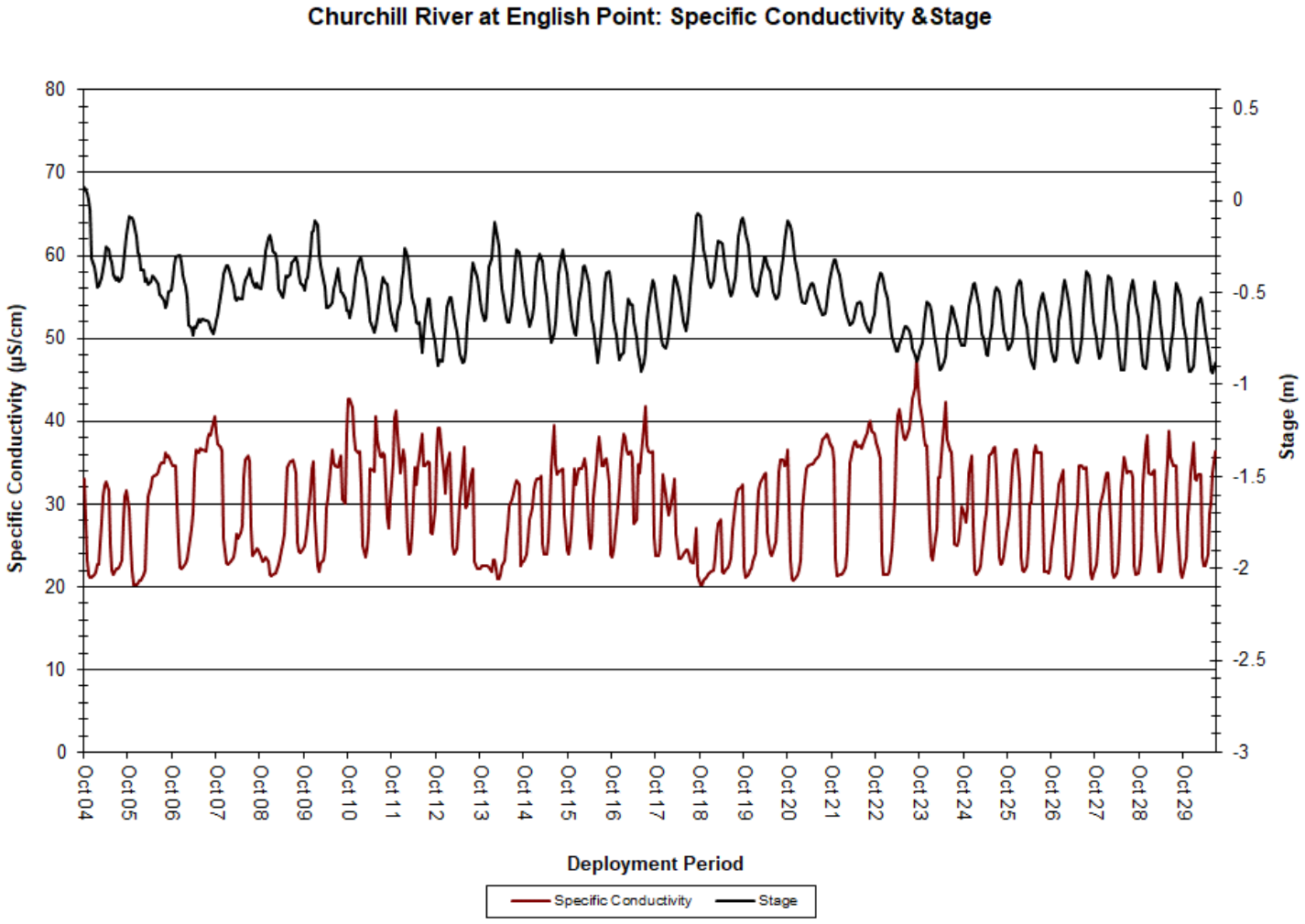


**Figure 24: Specific Conductivity & Stage at Churchill River at English Point**

### Dissolved Oxygen

- Over the deployment period, dissolved oxygen concentration ranged from 10.62mg/L to 13.04mg/L, with a median value of 11.55mg/L. Saturation of dissolved oxygen ranged from 90.9% to 111.3% saturation, with a median value of 99.2% (Figure 25).
- There is an evident relationship between water temperature and dissolved oxygen. As water temperatures decreased over the deployment period, dissolved oxygen levels gradually increased. 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 remained above the CCME's Guidelines for the Protection of Early and Other Life Stages for the duration of deployment (Figure 25).

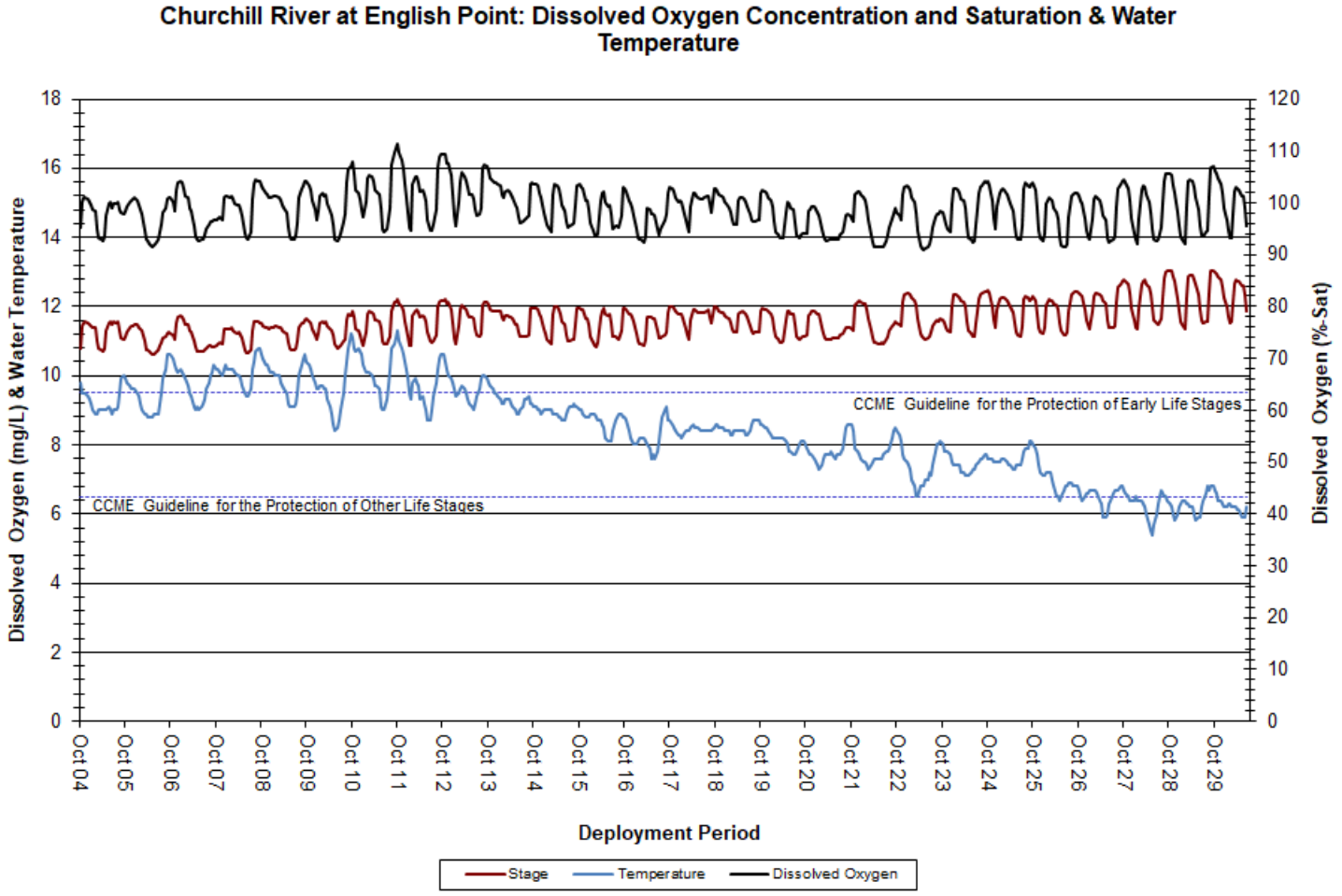


**Figure 25: Dissolved Oxygen & Water Temperature at Churchill River at English Point**

**Turbidity**

- Over the deployment period, turbidity ranged from 1.9NTU to 51.9NTU, with a median value of 5.2NTU (Figure 26). A median value of 5.2NTU 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 Churchill River at 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 obtained from the Churchill River at 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.

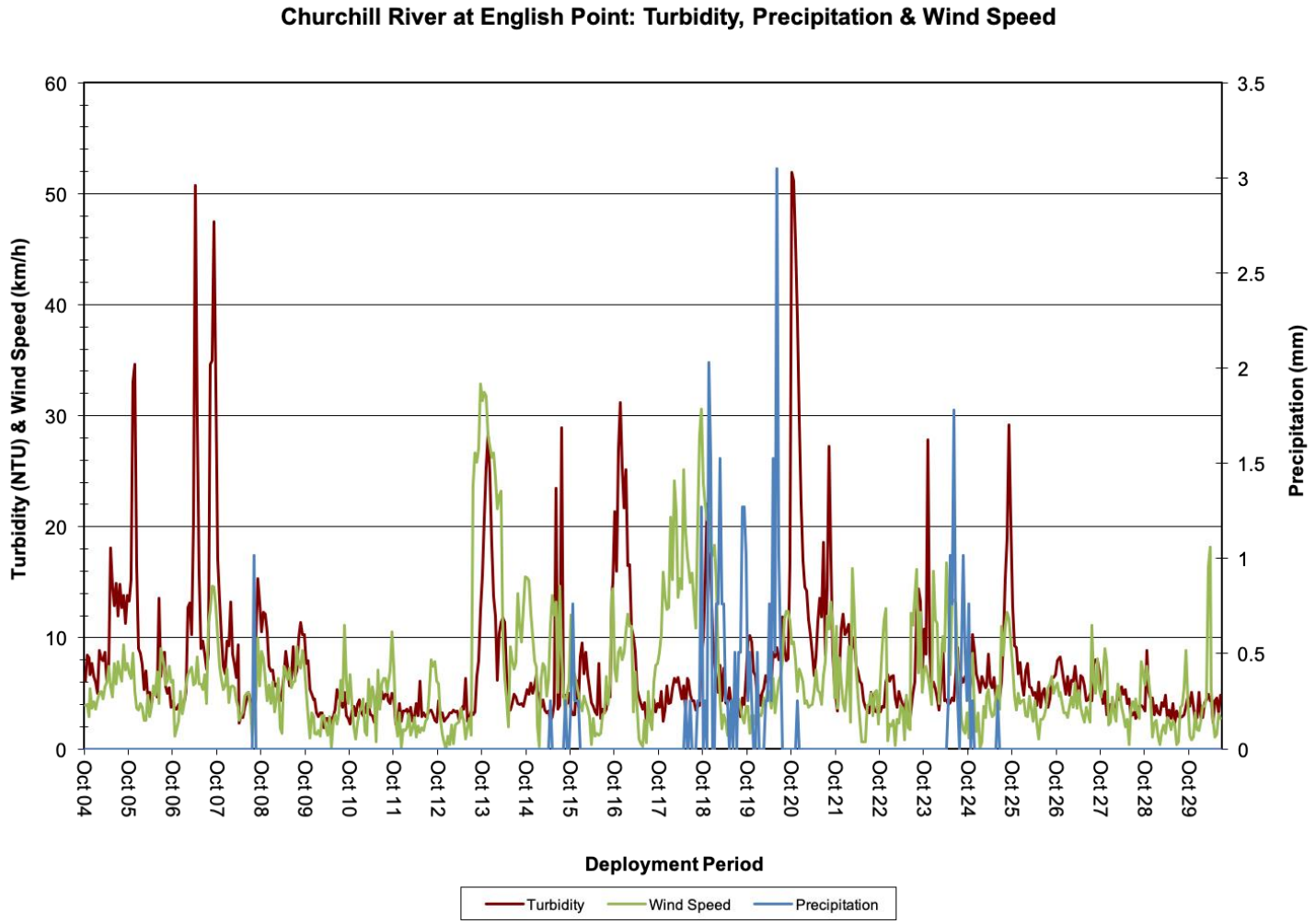


**Figure 26: Turbidity, Precipitation & Wind Speed at Churchill River at English Point**

### Stage

- Over the deployment period, stage ranged from -0.94m to 0.07m, with a median value of -0.53m (Figure 27). Precipitation data was obtained from the Churchill River at 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 (Figure 27).
- 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.

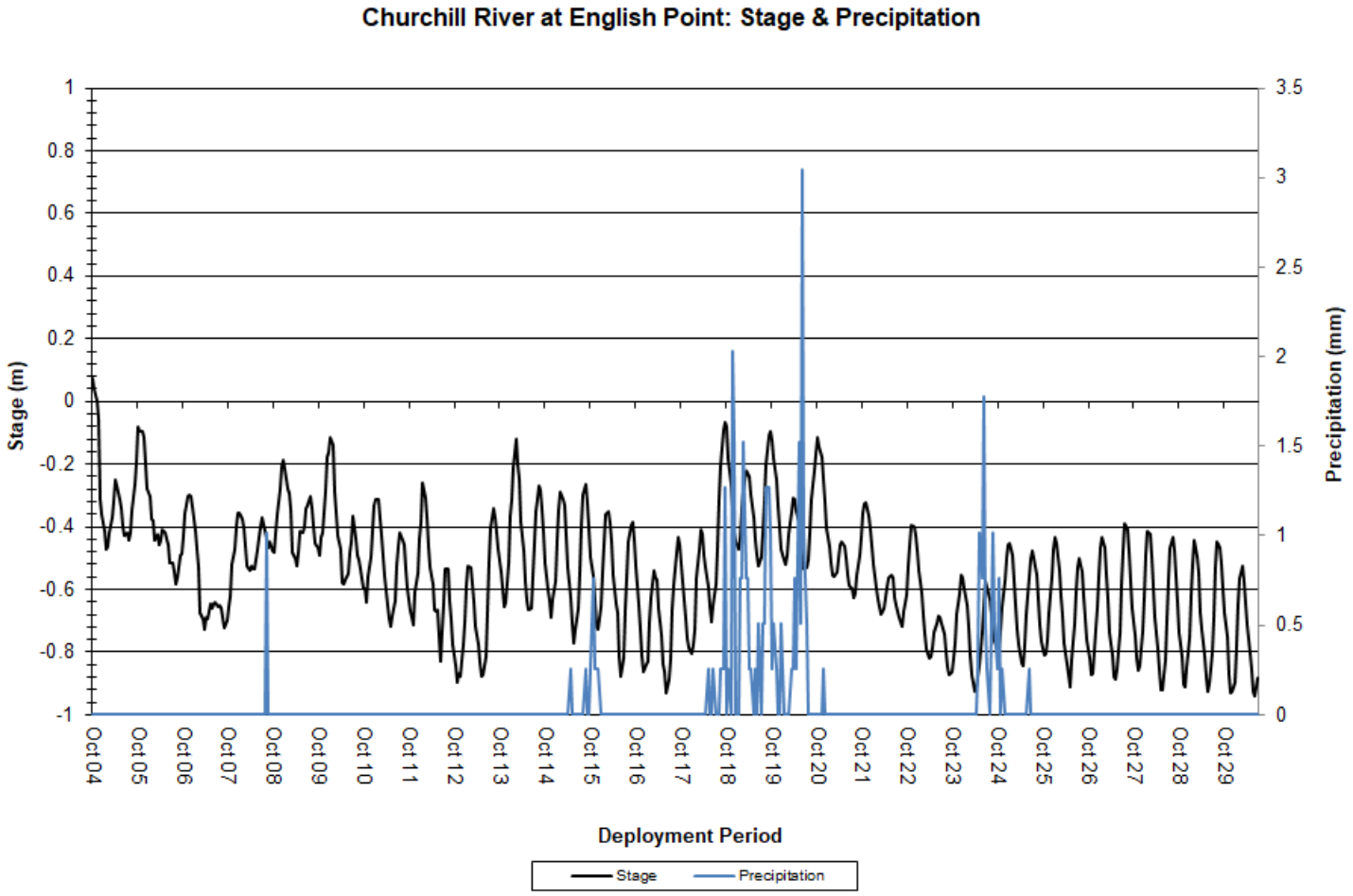


**Figure 27: Stage & Precipitation at Churchill River at English Point**

## Conclusions

- Instruments at four water quality monitoring stations on the Lower Churchill River were deployed from October 4 to October 29/30, 2019.
- Water temperature decreased slowly at all stations over the course of deployment. This is to be expected based on ambient air temperature trends during the same period through October.
- 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 above Grizzle Rapids, below Muskrat Falls and at English Point, while pH fell below the minimum Guideline partway through deployment at Churchill River below Metchin River.
- Specific conductivity was variable 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 increased over the course of deployment at all stations as water temperatures decreased through October. Dissolved oxygen levels are generally higher in water at cooler temperatures. Dissolved oxygen levels remained above the CCME's Guidelines for the Protection of Early and Other Life Stages for the duration of deployment at all stations.
- Turbidity events occurred at all stations and were generally related to precipitation events. In all 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].

Fondriest Environmental Inc. (2016a). Fundamentals of Environmental Measurements [Online]. Available at: http://www.fondriest.com/environmental-measurements/parameters/water-quality/conductivity-salinity-tds/#cond15 [Accessed December 12, 2017].

Fondriest Environmental Inc. (2016b). Fundamentals of Environmental Measurements [Online]. Available at: http://www.fondriest.com/environmental-measurements/parameters/water-quality/water-temperature/#watertemp1 [Accessed December 12, 2017].

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:** **1918439**

| | | | |
|---|---|---|---|
| **Cient:** | Department of Environment | **COC Number:** | 849909 |
| **Attention:** | Ms. Leona Hyde | **Date Reported:** | 2019-10-17 |
| **Client Project:** | | **Date Submitted:** | 2019-10-08 |
| **Purchase Order:** | 2180014303 | **Sample Matrix:** | Water |

| LAB ID | Supply / Description | Client Sample ID | Sample Date | ANALYTE | UNIT | MRL | RESULT |
|---|---|---|---|---|---|---|---|
| 1458298 | WS-S-0000 CR above GR | 2019-6329-00-SI-SP | 2019-10-04 | Alkalinity as CaCO3 | mg/L | 5 | 8 |
| | | | | Bromide | mg/L | 0.25 | <0.25 |
| | | | | Chloride | mg/L | 1 | <1 |
| | | | | Colour | TCU | 2 | 26 |
| | | | | Conductivity | uS/cm | 5 | 20 |
| | | | | Dissolved Organic Carbon | mg/L | 0.5 | 4.0 |
| | | | | Fluoride | mg/L | 0.10 | <0.10 |
| | | | | Hardness as CaCO3 | mg/L | 1 | 5 |
| | | | | N-NH3 (Ammonia) | mg/L | 0.01 | 0.04 |
| | | | | N-NO2 (Nitrite) | mg/L | 0.10 | <0.10 |
| | | | | N-NO3 (Nitrate) | mg/L | 0.10 | <0.10 |
| | | | | pH | | 1.00 | 7.14 |
| | | | | Sulphate | mg/L | 1 | <1 |
| | | | | Total Dissolved Solids (COND - CALC) | mg/L | 1 | 13 |
| | | | | Total Kjeldahl Nitrogen | mg/L | 0.1 | 0.1 |
| | | | | Total Organic Carbon | mg/L | 0.5 | 4.0 |
| | | | | Turbidity | NTU | 0.1 | 0.8 |
| | | | | Aluminum | mg/L | 0.01 | 0.04 |

Sample comment:

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: Sarah Horner

# REPORT OF ANALYSIS

**Lab Report Number:** **1918439**

| | | | |
|---|---|---|---|
| **Cient:** | Department of Environment | **COC Number:** | 849909 |
| **Attention:** | Ms. Leona Hyde | **Date Reported:** | 2019-10-17 |
| **Client Project:** | | **Date Submitted:** | 2019-10-08 |
| **Purchase Order:** | 2180014303 | **Sample Matrix:** | Water |

| LAB ID | Supply / Description | Client Sample ID | Sample Date | ANALYTE | UNIT | MRL | RESULT |
|---|---|---|---|---|---|---|---|
| 1458298 | WS-S-0000 | 2019-6329-00-SI-SP | 2019-10-04 | Antimony | mg/L | 0.0005 | <0.0005 |
| | CR above GR | | | Arsenic | mg/L | 0.001 | <0.001 |
| | | | | Barium | mg/L | 0.01 | <0.01 |
| Sample comment: | | | | Boron | mg/L | 0.01 | <0.01 |
| | | | | Calcium | mg/L | 1 | 2 |
| | | | | Cadmium | mg/L | 0.0001 | <0.0001 |
| Report comment: | | | | 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 | 0.013 |

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Methods references and/or additional QA/QC information available on request.

APPROVAL: Sarah Horner

# REPORT OF ANALYSIS

**Lab Report Number:** **1918439**

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| **Cient:** | Department of Environment | **COC Number:** | 849909 |
| **Attention:** | Ms. Leona Hyde | **Date Reported:** | 2019-10-17 |
| **Client Project:** | | **Date Submitted:** | 2019-10-08 |
| **Purchase Order:** | 2180014303 | **Sample Matrix:** | Water |

| LAB ID | Supply / Description | Client Sample ID | Sample Date | ANALYTE | UNIT | MRL | RESULT |
|---|---|---|---|---|---|---|---|
| 1458298 | WS-S-0000 | 2019-6329-00-SI-SP | 2019-10-04 | Uranium | mg/L | 0.001 | <0.001 |
| | CR above GR | | | Zinc | mg/L | 0.01 | <0.01 |
| | | | | Phosphorus | mg/L | 0.002 | 0.003 |
| Sample comment: | | | | Total Suspended Solids | mg/L | 2 | <2 |

Report comment:

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
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APPROVAL: Sarah Horner

# REPORT OF ANALYSIS

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| | | | |
|---|---|---|---|
| **Cient:** | Department of Environment | **COC Number:** | |
| **Attention:** | Ms. Leona Hyde | **Date Reported:** | 2019-10-17 |
| **Client Project:** | | **Date Submitted:** | 2019-10-08 |
| **Purchase Order:** | 2180014303 | **Sample Matrix:** | Water |

| LAB ID | Supply / Description | Client Sample ID | Sample Date | ANALYTE | UNIT | MRL | RESULT |
|---|---|---|---|---|---|---|---|
| 1458299 | WS-S-0000 | 2019-6330-00-SI-SP | 2019-10-04 | Alkalinity as CaCO3 | mg/L | 5 | 10 |
| | CR below MF | | | Bromide | mg/L | 0.25 | <0.25 |
| | | | | Chloride | mg/L | 1 | <1 |
| Sample comment: | | | | Colour | TCU | 2 | 30 |
| | | | | Conductivity | uS/cm | 5 | 26 |
| | | | | Dissolved Organic Carbon | mg/L | 0.5 | 4.3 |
| Report comment: | | | | Fluoride | mg/L | 0.10 | <0.10 |
| | | | | Hardness as CaCO3 | mg/L | 1 | 5 |
| | | | | N-NH3 (Ammonia) | mg/L | 0.01 | 0.04 |
| | | | | N-NO2 (Nitrite) | mg/L | 0.10 | <0.10 |
| | | | | N-NO3 (Nitrate) | mg/L | 0.10 | <0.10 |
| | | | | pH | | 1.00 | 7.41 |
| | | | | Sulphate | mg/L | 1 | 1 |
| | | | | Total Dissolved Solids (COND - CALC) | mg/L | 1 | 17 |
| | | | | Total Kjeldahl Nitrogen | mg/L | 0.1 | 0.1 |
| | | | | Total Organic Carbon | mg/L | 0.5 | 4.2 |
| | | | | Turbidity | NTU | 0.1 | 2.7 |
| | | | | Aluminum | mg/L | 0.01 | 0.10 |

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Methods references and/or additional QA/QC information available on request.

APPROVAL: Sarah Horner

# REPORT OF ANALYSIS

**Lab Report Number:** 1918439

| | | | |
|---|---|---|---|
| **Cient:** | Department of Environment | **COC Number:** | |
| **Attention:** | Ms. Leona Hyde | **Date Reported:** | 2019-10-17 |
| **Client Project:** | | **Date Submitted:** | 2019-10-08 |
| **Purchase Order:** | 2180014303 | **Sample Matrix:** | Water |

| LAB ID | Supply / Description | Client Sample ID | Sample Date | ANALYTE | UNIT | MRL | RESULT |
|---|---|---|---|---|---|---|---|
| 1458299 | WS-S-0000 | 2019-6330-00-SI-SP | 2019-10-04 | Antimony | mg/L | 0.0005 | <0.0005 |
| | CR below MF | | | Arsenic | mg/L | 0.001 | <0.001 |
| | | | | Barium | mg/L | 0.01 | <0.01 |
| Sample comment: | | | | Boron | mg/L | 0.01 | <0.01 |
| | | | | Calcium | mg/L | 1 | 2 |
| | | | | Cadmium | mg/L | 0.0001 | <0.0001 |
| Report comment: | | | | Chromium | mg/L | 0.001 | <0.001 |
| | | | | Copper | mg/L | 0.001 | <0.001 |
| | | | | Iron | mg/L | 0.03 | 0.18 |
| | | | | 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 | 0.013 |

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: Sarah Horner

# REPORT OF ANALYSIS

**Lab Report Number:** 1918439

| | | | |
|---|---|---|---|
| **Cient:** | Department of Environment | **COC Number:** | |
| **Attention:** | Ms. Leona Hyde | **Date Reported:** | 2019-10-17 |
| **Client Project:** | | **Date Submitted:** | 2019-10-08 |
| **Purchase Order:** | 2180014303 | **Sample Matrix:** | Water |

| LAB ID | Supply / Description | Client Sample ID | Sample Date | ANALYTE | UNIT | MRL | RESULT |
|---|---|---|---|---|---|---|---|
| 1458299 | WS-S-0000 | 2019-6330-00-SI-SP | 2019-10-04 | Uranium | mg/L | 0.001 | <0.001 |
| | CR below MF | | | Zinc | mg/L | 0.01 | <0.01 |
| | | | | Phosphorus | mg/L | 0.002 | 0.005 |
| Sample comment: | | | | Total Suspended Solids | mg/L | 2 | <2 |

Report comment:

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
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APPROVAL: Sarah Horner

# REPORT OF ANALYSIS

**Lab Report Number:** 1918439

| | | | |
|---|---|---|---|
| **Cient:** | Department of Environment | **COC Number:** | |
| **Attention:** | Ms. Leona Hyde | **Date Reported:** | 2019-10-17 |
| **Client Project:** | | **Date Submitted:** | 2019-10-08 |
| **Purchase Order:** | 2180014303 | **Sample Matrix:** | Water |

| LAB ID | Supply / Description | Client Sample ID | Sample Date | ANALYTE | UNIT | MRL | RESULT |
|---|---|---|---|---|---|---|---|
| 1458301 | WS-S-0000 CR @ EP | 2019-6332-00-SI-SP | 2019-10-04 | Alkalinity as CaCO3 | mg/L | 5 | 9 |
| | | | | Bromide | mg/L | 0.25 | <0.25 |
| | | | | Chloride | mg/L | 1 | 5 |
| | | | | Colour | TCU | 2 | 67 |
| | | | | Conductivity | uS/cm | 5 | 41 |
| | | | | Dissolved Organic Carbon | mg/L | 0.5 | 6.3 |
| | | | | Fluoride | mg/L | 0.10 | <0.10 |
| | | | | Hardness as CaCO3 | mg/L | 1 | 9 |
| | | | | N-NH3 (Ammonia) | mg/L | 0.01 | 0.03 |
| | | | | N-NO2 (Nitrite) | mg/L | 0.10 | <0.10 |
| | | | | N-NO3 (Nitrate) | mg/L | 0.10 | <0.10 |
| | | | | pH | | 1.00 | 7.36 |
| | | | | Sulphate | mg/L | 1 | <1 |
| | | | | Total Dissolved Solids (COND - CALC) | mg/L | 1 | 27 |
| | | | | Total Kjeldahl Nitrogen | mg/L | 0.1 | 0.2 |
| | | | | Total Organic Carbon | mg/L | 0.5 | 6.3 |
| | | | | Turbidity | NTU | 0.1 | 6.3 |
| | | | | Aluminum | mg/L | 0.01 | 0.22 |

Sample comment:

Report comment:

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Methods references and/or additional QA/QC information available on request.

APPROVAL: Sarah Horner

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**Lab Report Number:** 1918439

| | | | |
|---|---|---|---|
| **Cient:** | Department of Environment | **COC Number:** | |
| **Attention:** | Ms. Leona Hyde | **Date Reported:** | 2019-10-17 |
| **Client Project:** | | **Date Submitted:** | 2019-10-08 |
| **Purchase Order:** | 2180014303 | **Sample Matrix:** | Water |

| LAB ID | Supply / Description | Client Sample ID | Sample Date | ANALYTE | UNIT | MRL | RESULT |
|---|---|---|---|---|---|---|---|
| 1458301 | WS-S-0000 CR @ EP | 2019-6332-00-SI-SP | 2019-10-04 | 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 | 0.50 |
| | | | | 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 | 4 |
| | | | | Strontium | mg/L | 0.001 | 0.018 |

Sample comment:

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.
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# REPORT OF ANALYSIS

**Lab Report Number:** **1918439**

| | | | |
|---|---|---|---|
| **Cient:** | Department of Environment | **COC Number:** | |
| **Attention:** | Ms. Leona Hyde | **Date Reported:** | 2019-10-17 |
| **Client Project:** | | **Date Submitted:** | 2019-10-08 |
| **Purchase Order:** | 2180014303 | **Sample Matrix:** | Water |

| LAB ID | Supply / Description | Client Sample ID | Sample Date | ANALYTE | UNIT | MRL | RESULT |
|---|---|---|---|---|---|---|---|
| 1458301 | WS-S-0000 | 2019-6332-00-SI-SP | 2019-10-04 | Uranium | mg/L | 0.001 | <0.001 |
| | CR @ EP | | | Zinc | mg/L | 0.01 | <0.01 |
| | | | | Phosphorus | mg/L | 0.002 | 0.012 |
| Sample comment: | | | | Total Suspended Solids | mg/L | 2 | 5 |

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: Sarah Horner