Real-Time Water Quality Deployment Report

Lower Churchill River Network

August 17/29 to
September 26/October 12, 2018

Newfoundland Labrador

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

Contents

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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 below Metchin River and Churchill River above Grizzle Rapids on August 17th. Instruments at Churchill River below Muskrat Falls and Churchill River at English Point were deployed on August 29th. The instruments at Churchill River below Muskrat Falls and Churchill River at English Point were removed on September 26th for a deployment period of 28 days. The instrument at Churchill River above Grizzle Rapids was removed on October 12th for a deployment period of 56 days.
- The instrument at Churchill River below Metchin River was not removed from the water until November 15th; however, for the purposes of this report, data from this station will be reported as if it had been. A 56 day deployment period will be used for reporting purposes, based on the installation and removal dates 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 August 17/29 to September 26/October 12, 2018 are summarized in Table 2.

Table 2: Comparison rankings for Lower Churchill River stations August 17/29 to September 26/October 12, 2018

Churchill River Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Below Metchin River	August 17, 2018	Deployment	Excellent	Good	Excellent	Excellent	Fair
	October 12, 2018	Removal	N/A	N/A	N/A	N/A	N/A
Above Grizzle Rapids	August 17, 2018	Deployment	Good	Good	Excellent	Excellent	Marginal
	October 12, 2018	Removal	Good	Good	Excellent	Good	Good
Below Muskrat Falls	August 29, 2018	Deployment	Excellent	Excellent	Excellent	Good	Excellent
	September 26, 2018	Removal	Excellent	Excellent	Excellent	Excellent	Good
At English Point	August 29, 2018	Deployment	Good	Good	Excellent	Good	Poor
	September 26, 2018	Removal	Excellent	Excellent	Excellent	Good	Fair
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, temperature, conductivity and dissolved oxygen were 'excellent', pH was 'good' and turbidity was 'fair'.
  - Comparison rankings are not available for removal since this instrument wasn't physically removed from the water until November 15th.
- **Churchill River above Grizzle Rapids**
  - At deployment, conductivity and dissolved oxygen were 'excellent', temperature and pH were 'good', while turbidity was 'marginal'.
  - At removal, conductivity was 'excellent', while all other parameters were 'good'.
- **Churchill River below Muskrat Falls**
  - At deployment, dissolved oxygen was 'good', while all other parameters were 'excellent'.
  - At removal, turbidity was 'good', while all other parameters were 'excellent'.

- **Churchill River at English Point**
    - At deployment, conductivity was 'excellent', temperature, pH and dissolved oxygen were 'good', while turbidity was 'poor'. This discrepancy may have been caused by the QA/QC instrument not being placed in close enough proximity to the field sonde.
    - At removal, temperature, pH and conductivity were 'excellent', dissolved oxygen was 'good', while turbidity was 'fair'.

Data Interpretation

- The following graphs and discussion illustrate water quality related events occurring from August 17/29 to September 26/October 12, 2018 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 -0.30°C to 17.10°C, with a median value of 12.10°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 also decreased through the late summer and fall seasons. 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.

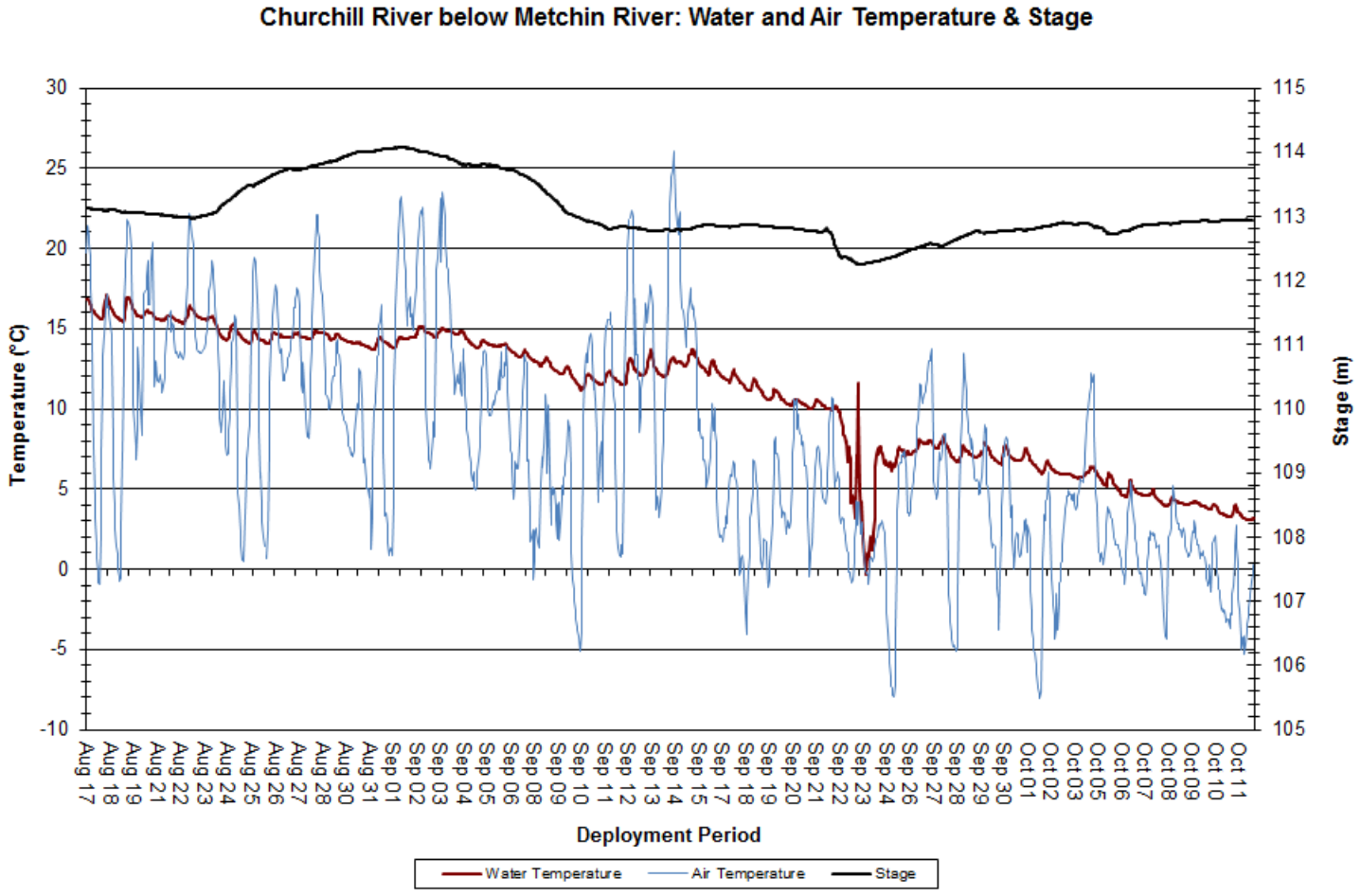

Figure 2: Water and Air Temperature & Stage at Churchill River below Metchin River

pH

- Over the deployment period, pH values ranged from 6.43 to 6.74 pH units, with a median value of 6.62 (Figure 3).
- pH values were stable over the course of deployment and fell within the CCME's Guidelines for the Protection of Aquatic Life for the majority of deployment. A single exception occurred from August 24th to August 26th when a significant increase in stage caused a subsequent decrease in pH.
- 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.

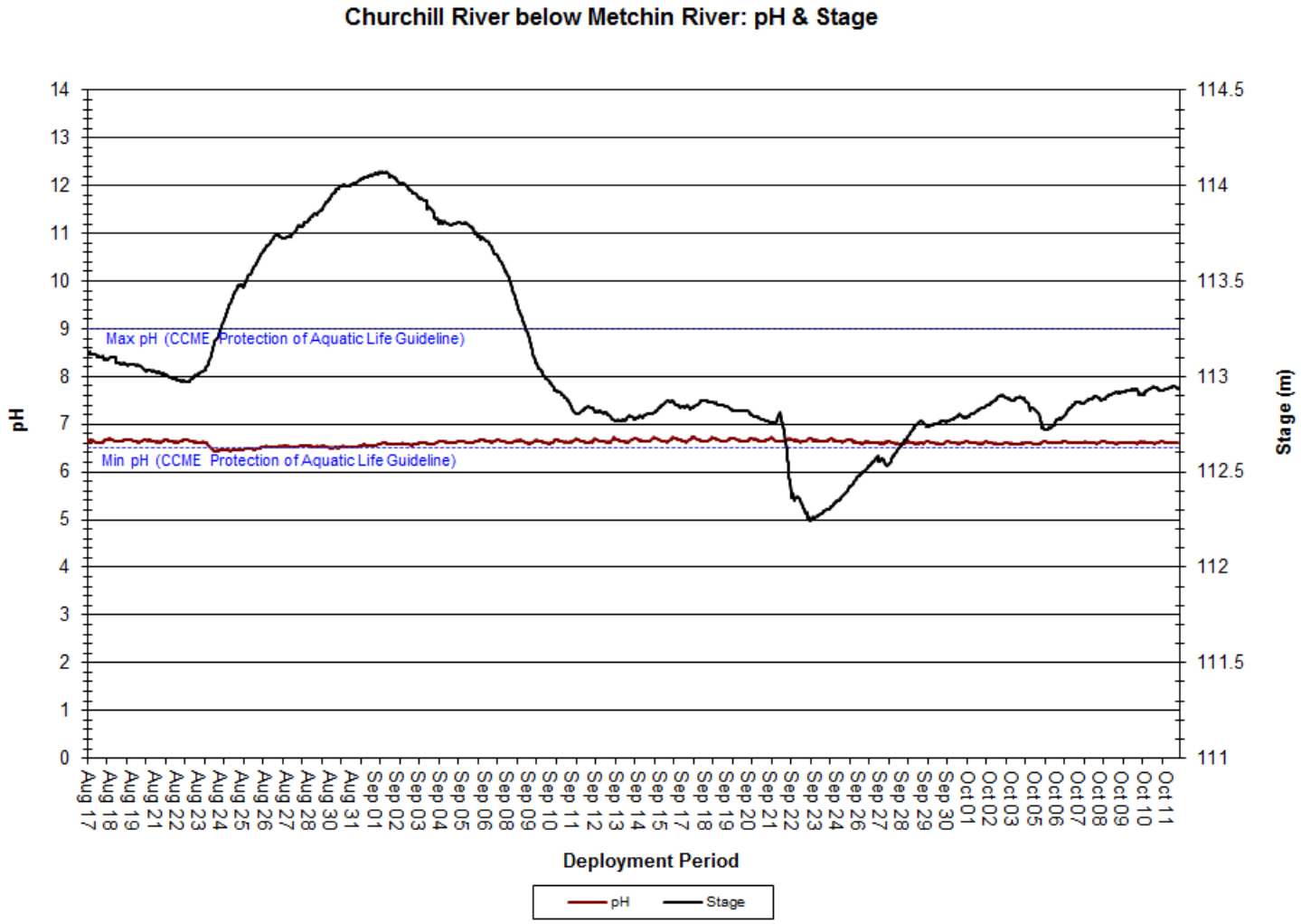

Figure 3: pH & Stage at Churchill River below Metchin River

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 18.9µS/cm to 22.8µS/cm, with a median value of 20.7µS/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.
- 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.

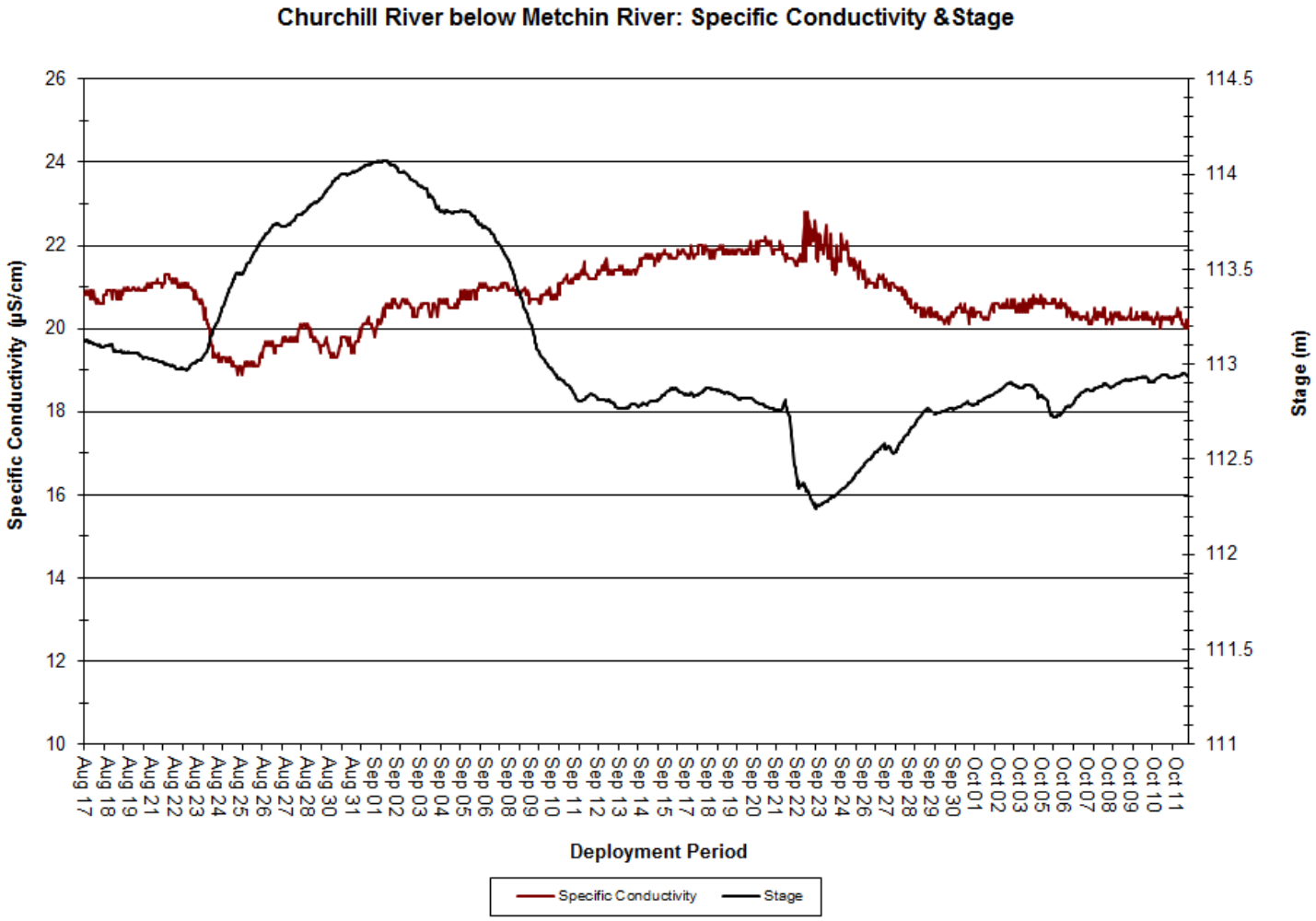

Figure 4: Specific Conductivity & Stage at Churchill River below Metchin River

Dissolved Oxygen

- Over the deployment period, dissolved oxygen content ranged from 9.18mg/L to 12.68mg/L, with a median value of 10.27mg/L. Saturation of dissolved oxygen ranged from 91.1% to 98.0%, with a median value of 94.2% (Figure 5).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period, dissolved oxygen levels gradually increased as temperatures decreased through the late summer and fall seasons. 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 below the CCME's Guideline for the Protection of Early Life Stages until August 24th, after which they remained above the CCME's Guideline for the remainder of deployment.

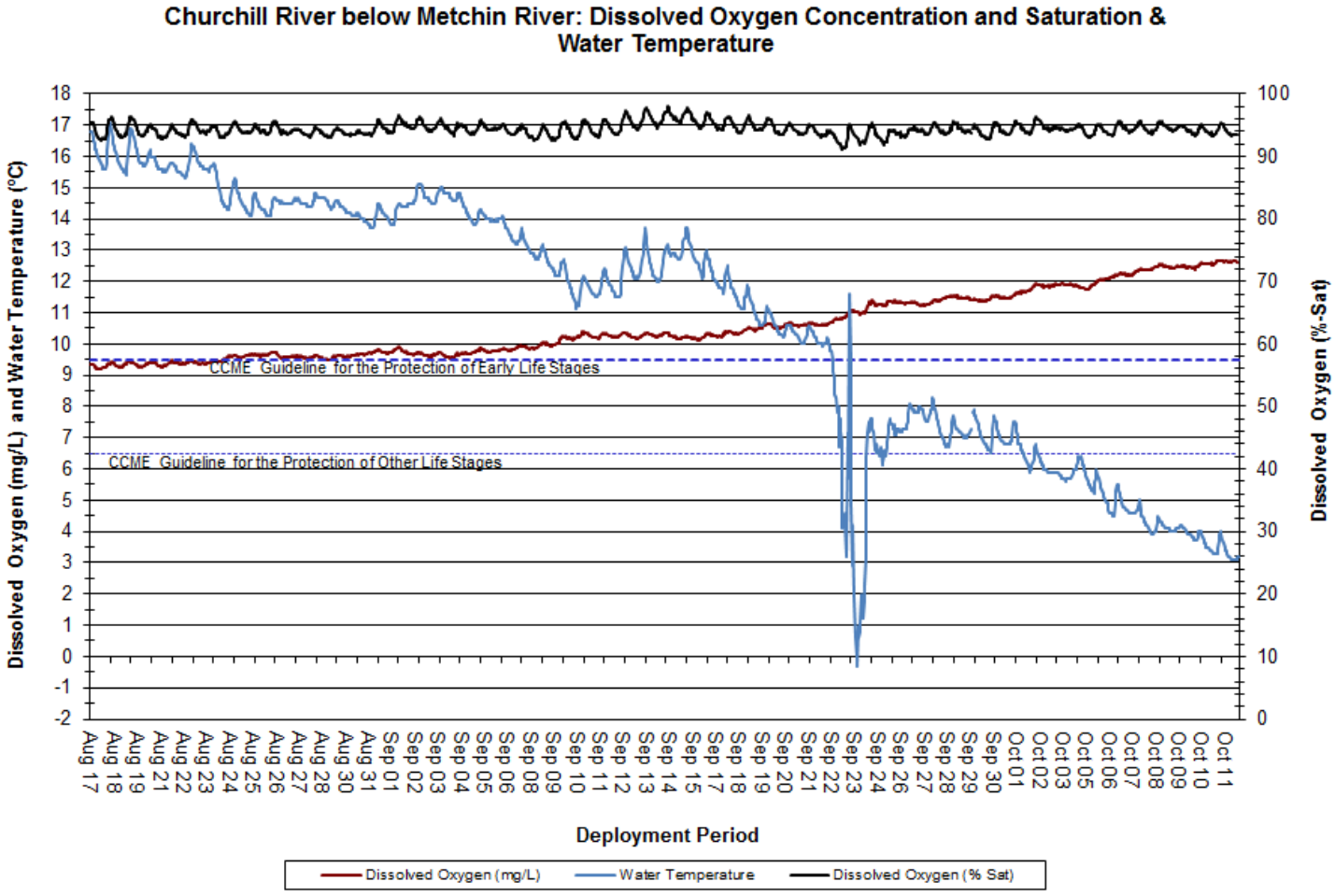

Figure 5: Dissolved Oxygen & Water Temperature at Churchill River below Metchin River

Turbidity

- Over the deployment period, turbidity ranged from 0.0NTU to 17.5NTU, 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.
- Many of the turbidity spikes correlate 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.

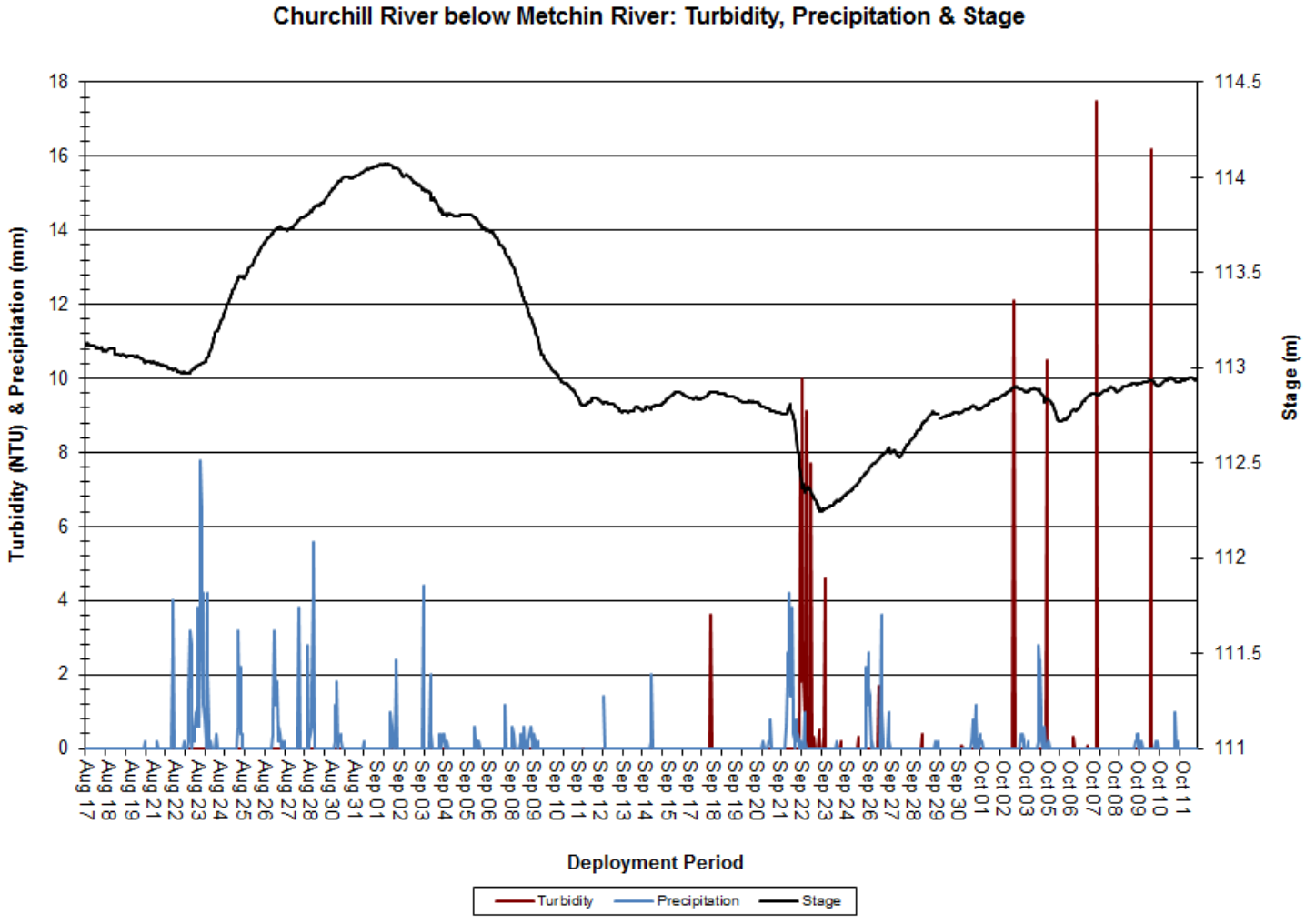

Figure 6: Turbidity, Precipitation & Stage at Churchill River below Metchin River

Stage and Flow

- Over the deployment period, stage levels ranged from 112.24m to 114.07m, with a median value of 112.90m. Flow ranged from 926.53m^3/s to 1540.06m^3/s, with a median value of 1204.19m^3/s (Figure 7). Precipitation data was obtained from the Metchin River near TLH Weather Station.
- Stage was slightly variable across the deployment period, with flow following a similar trend. Precipitation amounts across the same period are graphed below (Figure 8) to show that precipitation events often correlate with increases in both stage and flow. This is particularly evident from August 23rd through 28th.
- 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.

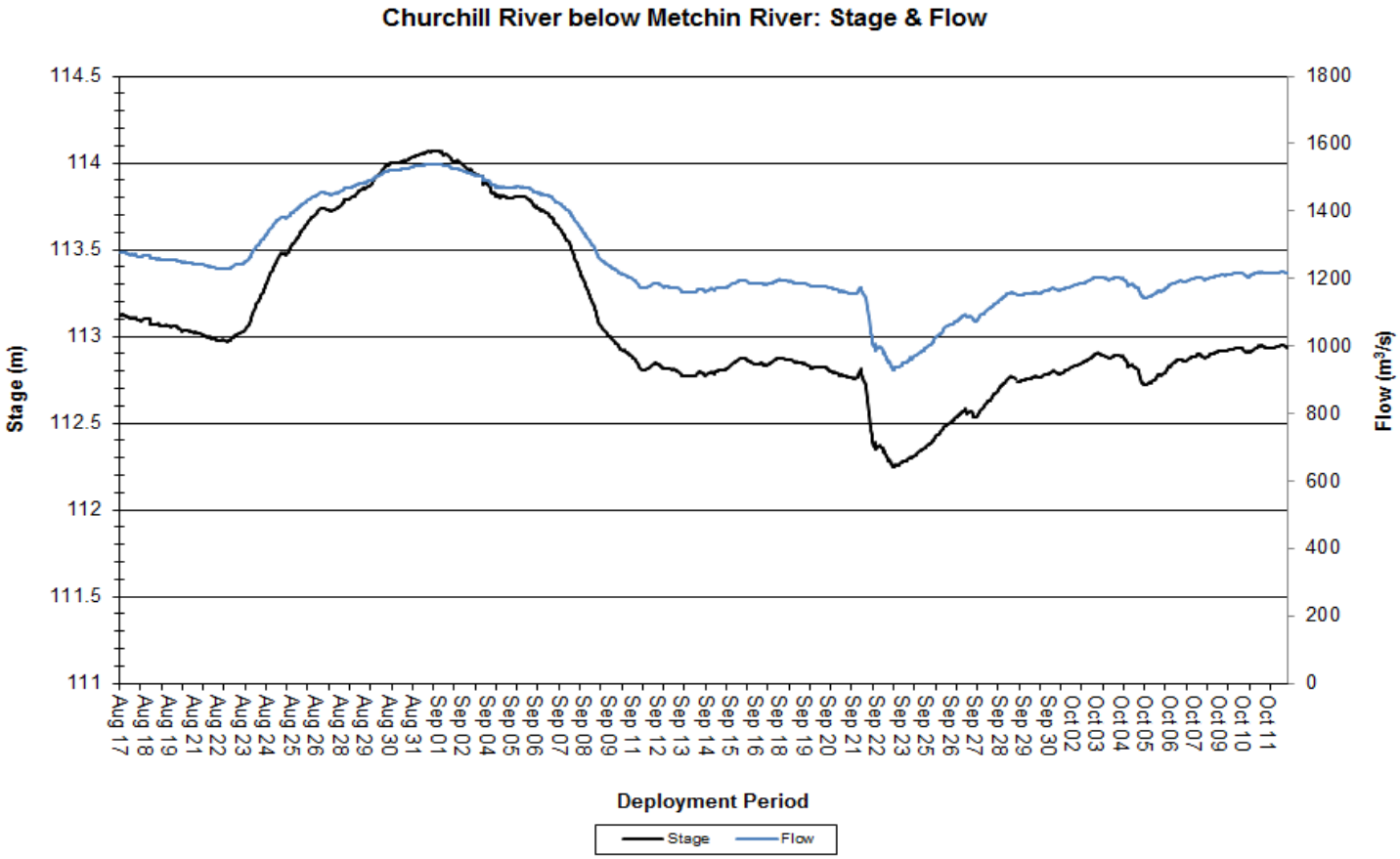

Figure 7: Stage & Flow at Churchill River below Metchin River

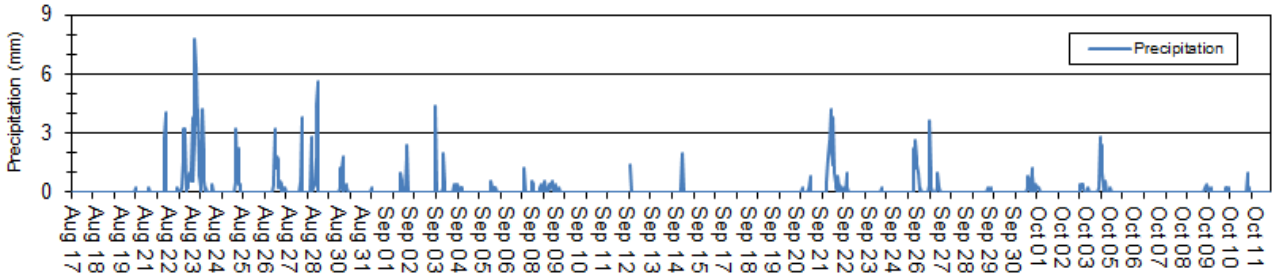

Figure 8: Precipitation at Churchill River below Metchin River

Churchill River above Grizzle Rapids

Water Temperature

- Over the deployment period, water temperature ranged from 5.70°C to 17.70°C, with a median value of 12.90°C (Figure 9). Air temperature data was obtained from the Muskrat Falls MET Station.
- Water temperature slowly decreased across the deployment period. This trend is to be expected as air temperatures also decreased through the late summer and fall seasons. 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.

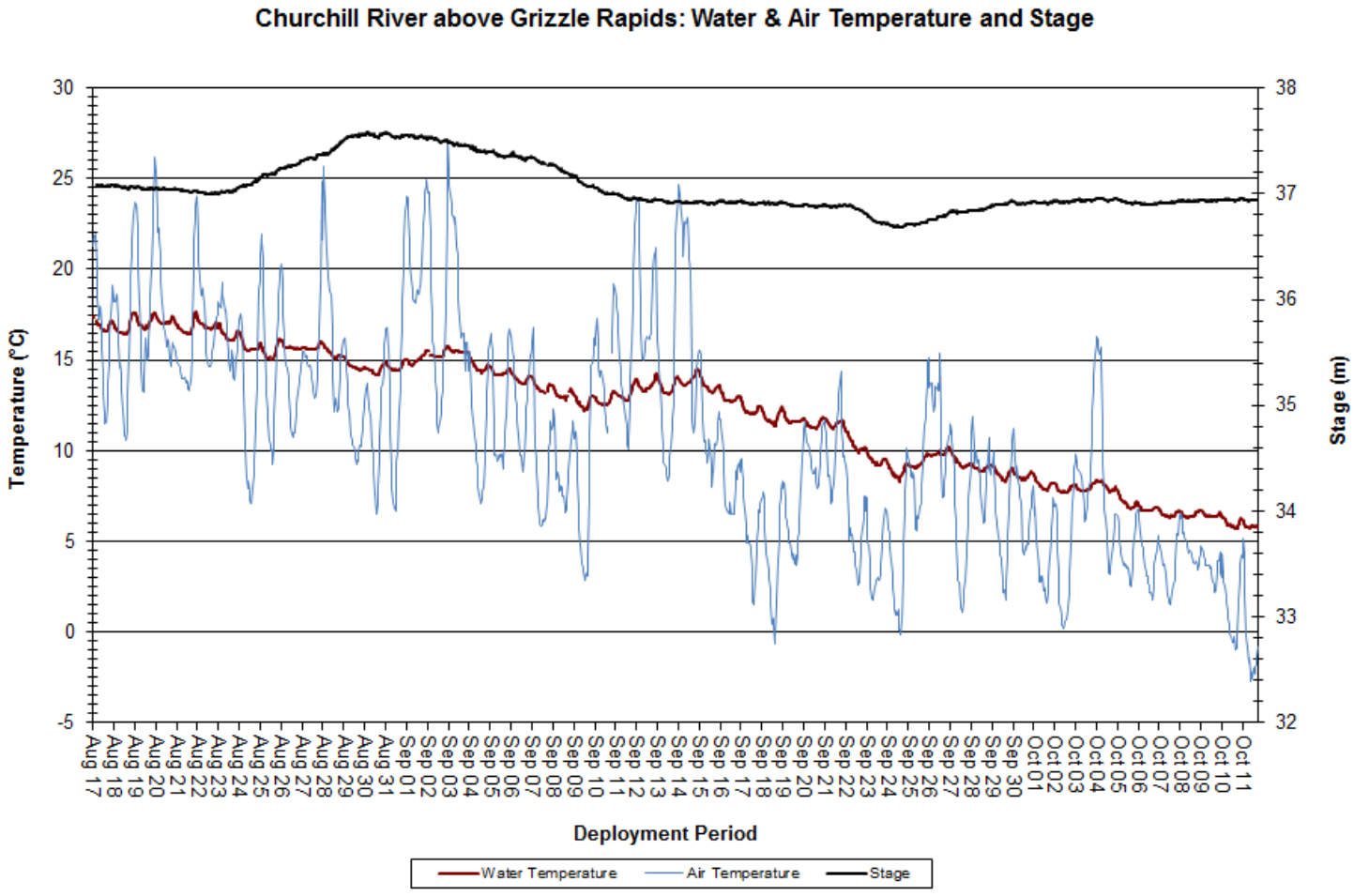

Figure 9: Water and Air Temperature & Stage at Churchill River above Grizzle Rapids

pH

- Over the deployment period, pH values ranged from 6.74 pH units to 7.00 pH units, with a median value of 6.83 (Figure 10).
- pH values were very stable and fell 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.

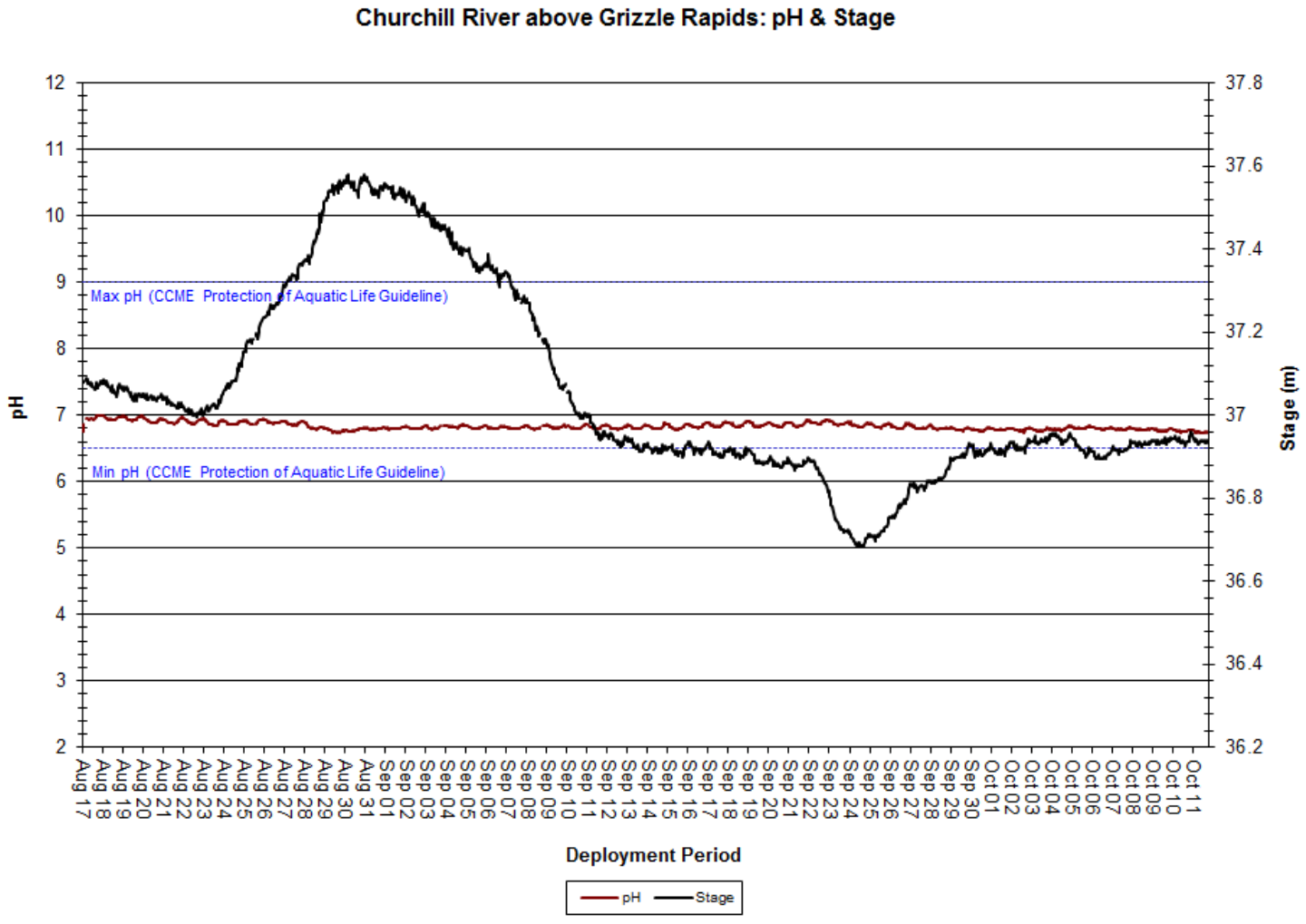

Figure 10: pH & Stage at Churchill River above Grizzle Rapids

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 16.8µS/cm to 19.2µS/cm, with a median of 18.0µS/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.
- 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.

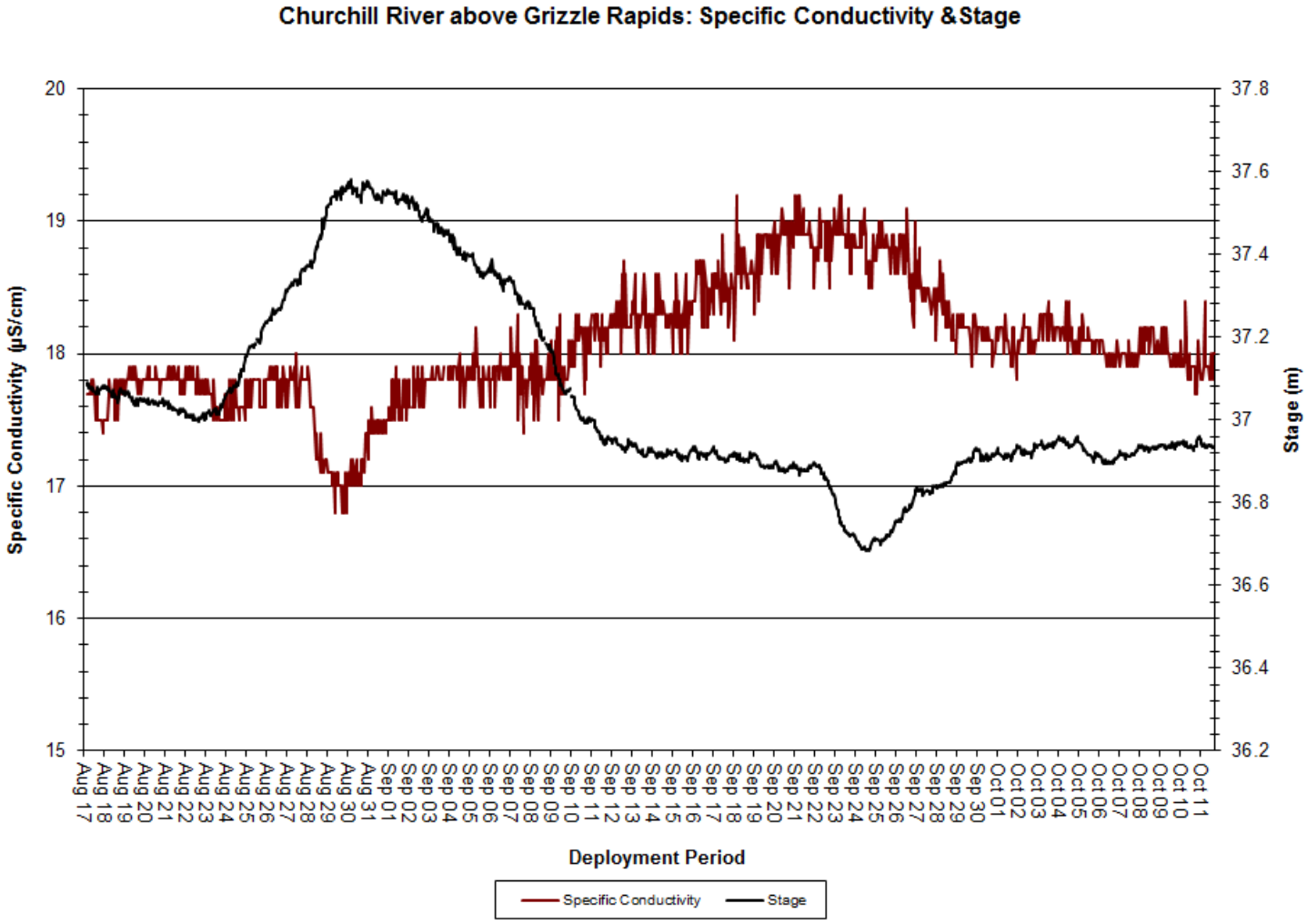

Figure 11: Specific Conductivity & Stage at Churchill River above Grizzle Rapids

Dissolved Oxygen

- Over the deployment period, dissolved oxygen content ranged from 9.26mg/L to 12.02mg/L, with a median value of 10.27mg/L. Saturation of dissolved oxygen ranged from 93.7% saturation to 99.5% saturation, with a median value of 96.3% (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 decreased through the late summer and fall seasons. 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 below the CCME's Guideline for the Protection of Early Life Stages until late August, after which levels remained above the CCME's Guideline for the remainder of deployment. This is to be expected given the lower water temperatures observed through September and October.

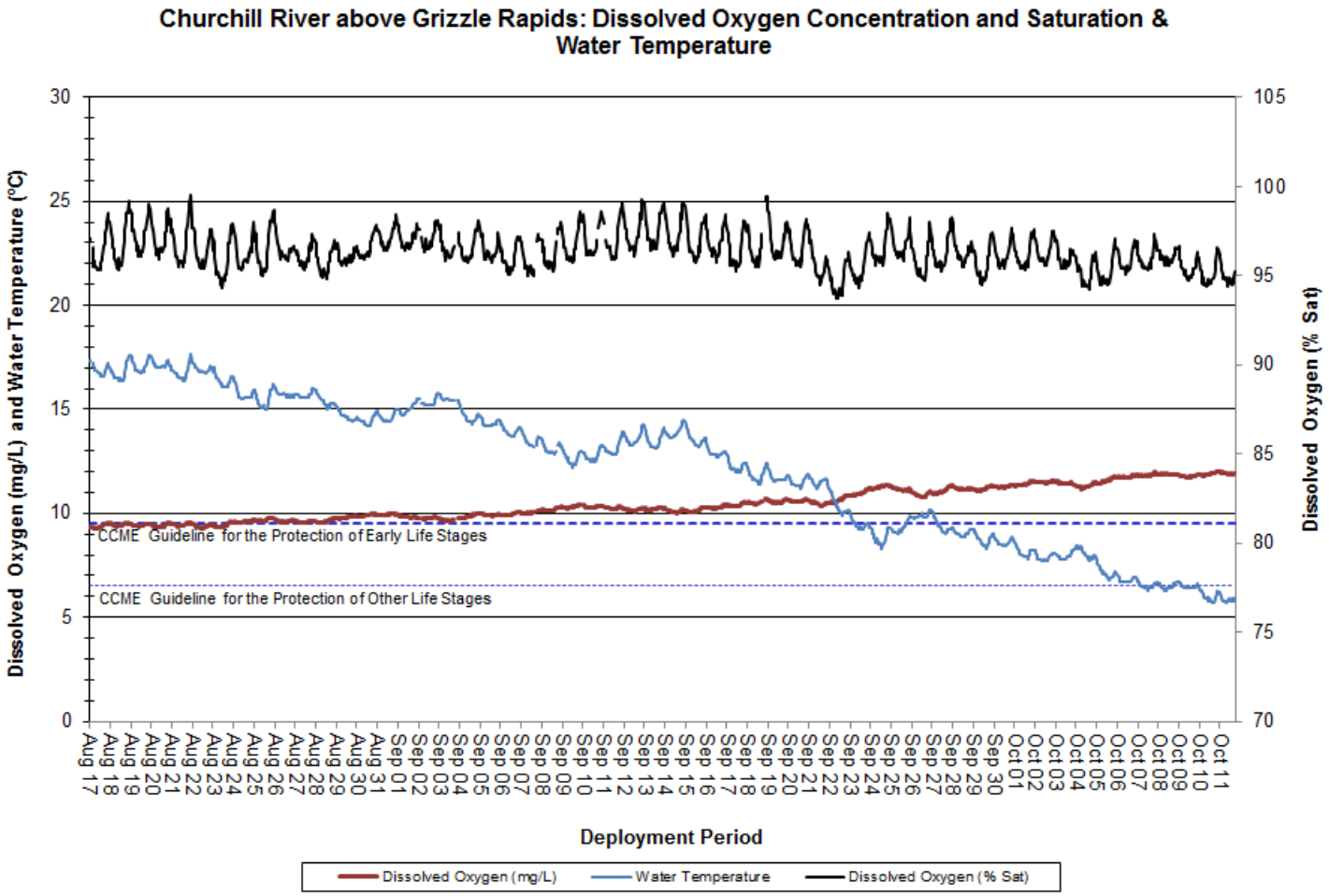

Figure 12: Dissolved Oxygen & Water Temperature at Churchill River above Grizzle Rapids

Turbidity

- Over the deployment period, turbidity ranged from 0.0NTU to 6.9 NTU, with a median value of 0.0NTU (Figure 13). A median value of 0.0NTU indicates a very low level of natural background turbidity in the waterbody; however, the very small range of turbidity values observed may indicate a slight error during calibration.
- The turbidity spikes observed over the deployment period generally correlate with increases in stage, which further correlate with precipitation events (Figure 13). 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.

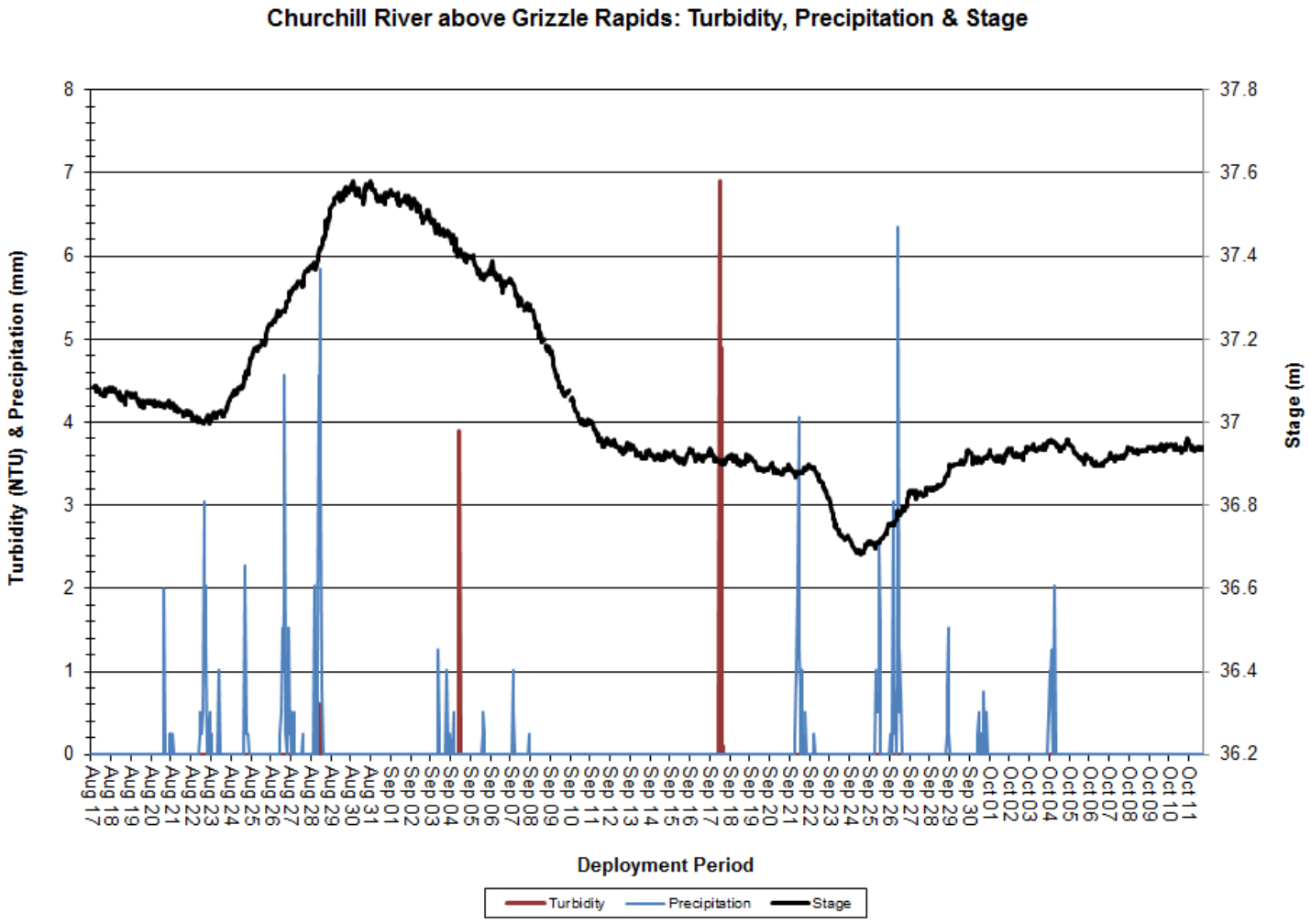

Figure 13: Turbidity, Precipitation & Stage at Churchill River above Grizzle Rapids

Stage & Flow

- Over the deployment period, stage ranged from 36.68m to 37.58m, with a median value of 36.94m (Figure 14). Flow ranged from 1082.18m^3/s to 2314.12m^3/s, with a median value of 1378.87m^3/s (Figure 14). Precipitation data was obtained from the Muskrat Falls MET Station.
- Stage and flow were variable across the course of deployment but followed a very similar trend. Precipitation across the same period is graphed below (Figure 15) to show that precipitation events often correlate with increases in both stage and flow. This is particularly evident from August 23rd through 28th.
- 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.

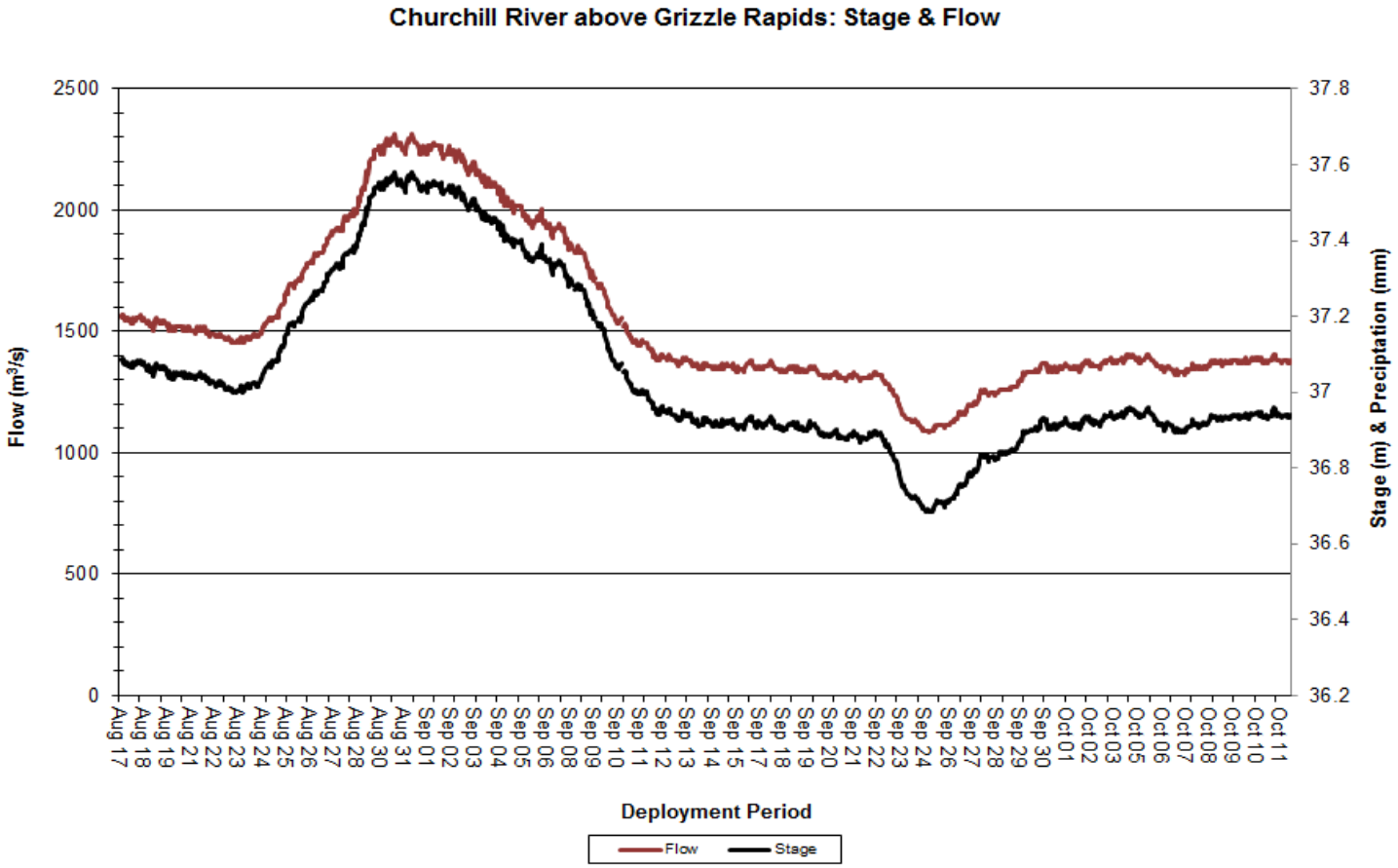

Figure 14: Stage & Flow at Churchill River above Grizzle Rapids

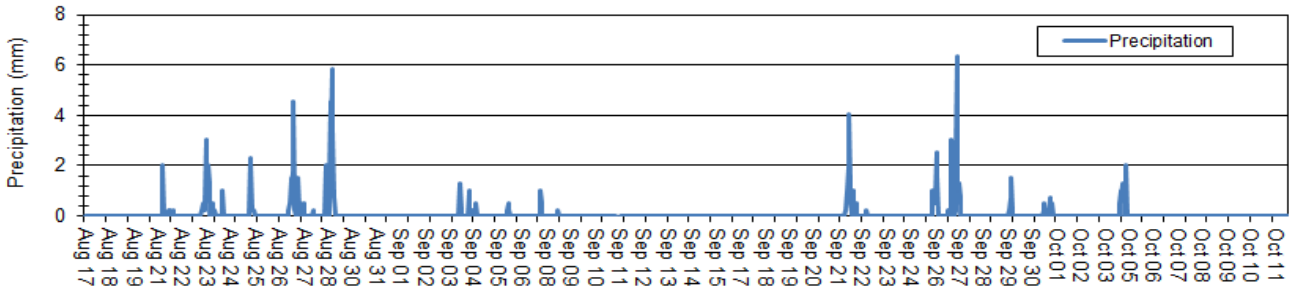

Figure 15: Precipitation at Churchill River above Grizzle Rapids

Churchill River below Muskrat Falls

Water Temperature

- Over the deployment period, water temperature ranged from 8.80°C to 16.30°C, with a median value of 13.60°C (Figure 16). Air temperature data was obtained from the Muskrat Falls MET Station.
- Water temperature slowly decreased over the course of the deployment period. This is to be expected as ambient air temperatures also decreased through September. 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.

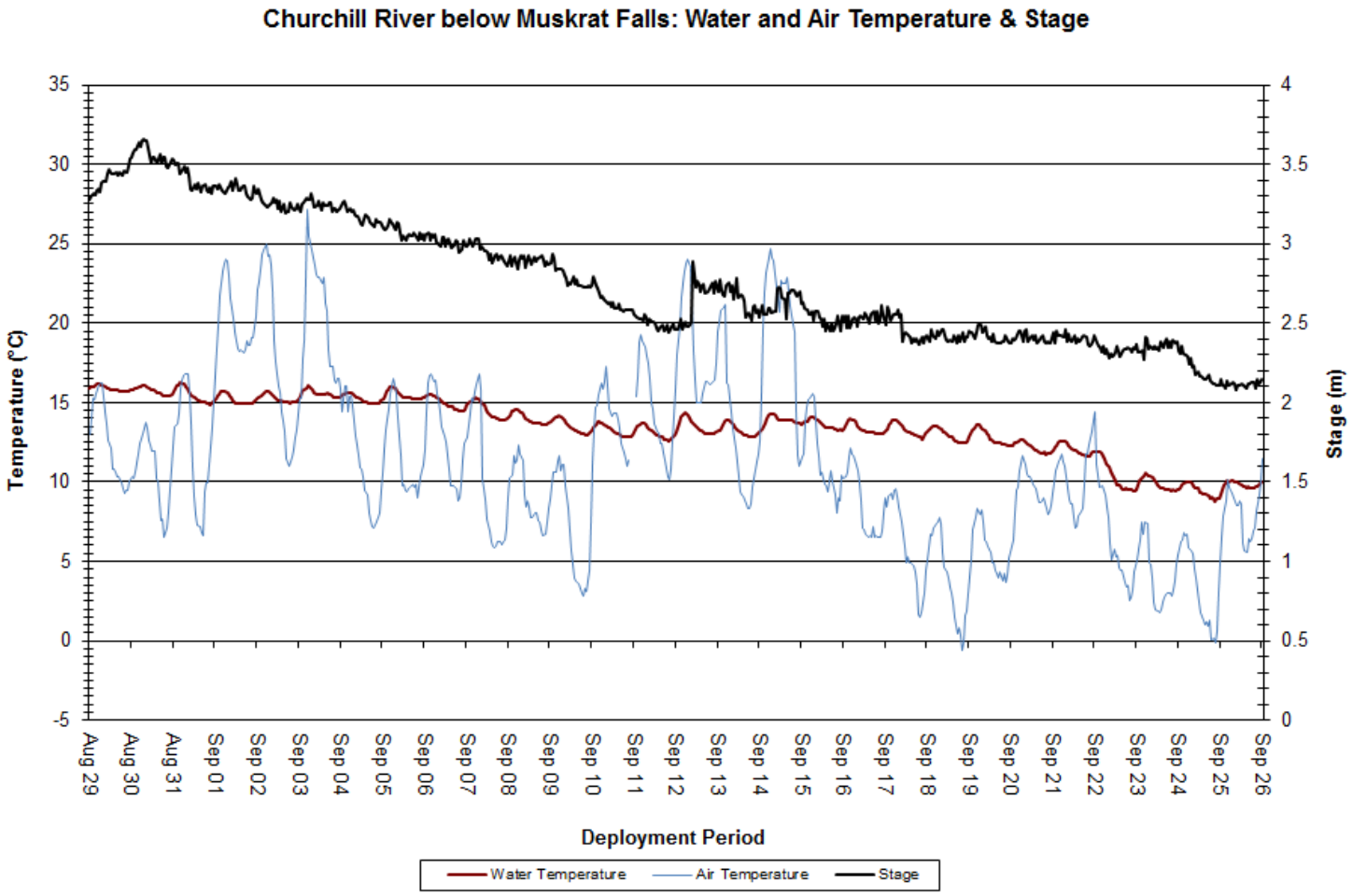

Figure 16: Water and Air Temperature & Stage at Churchill River below Muskrat Falls

pH

- Over the deployment period, pH ranged from 6.64 pH units to 7.17 pH units, with a median value of 6.77 (Figure 17).
- pH values were relatively stable over the course of deployment, and 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.

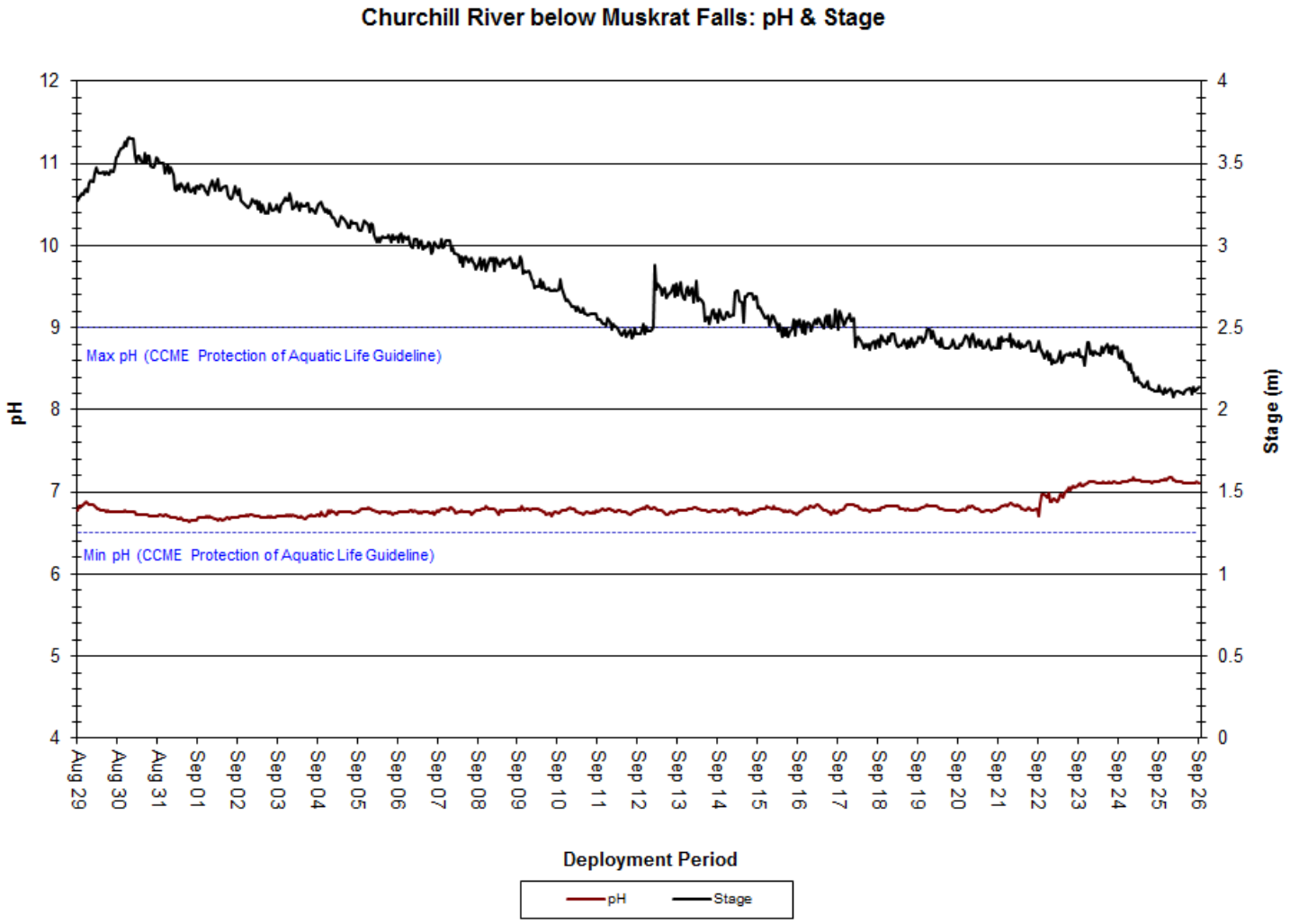

Figure 17: pH & Stage at Churchill River below Muskrat Falls

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 17.7µS/cm to 19.3µS/cm, with a median value of 18.6µS/cm (Figure 18).
- 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.

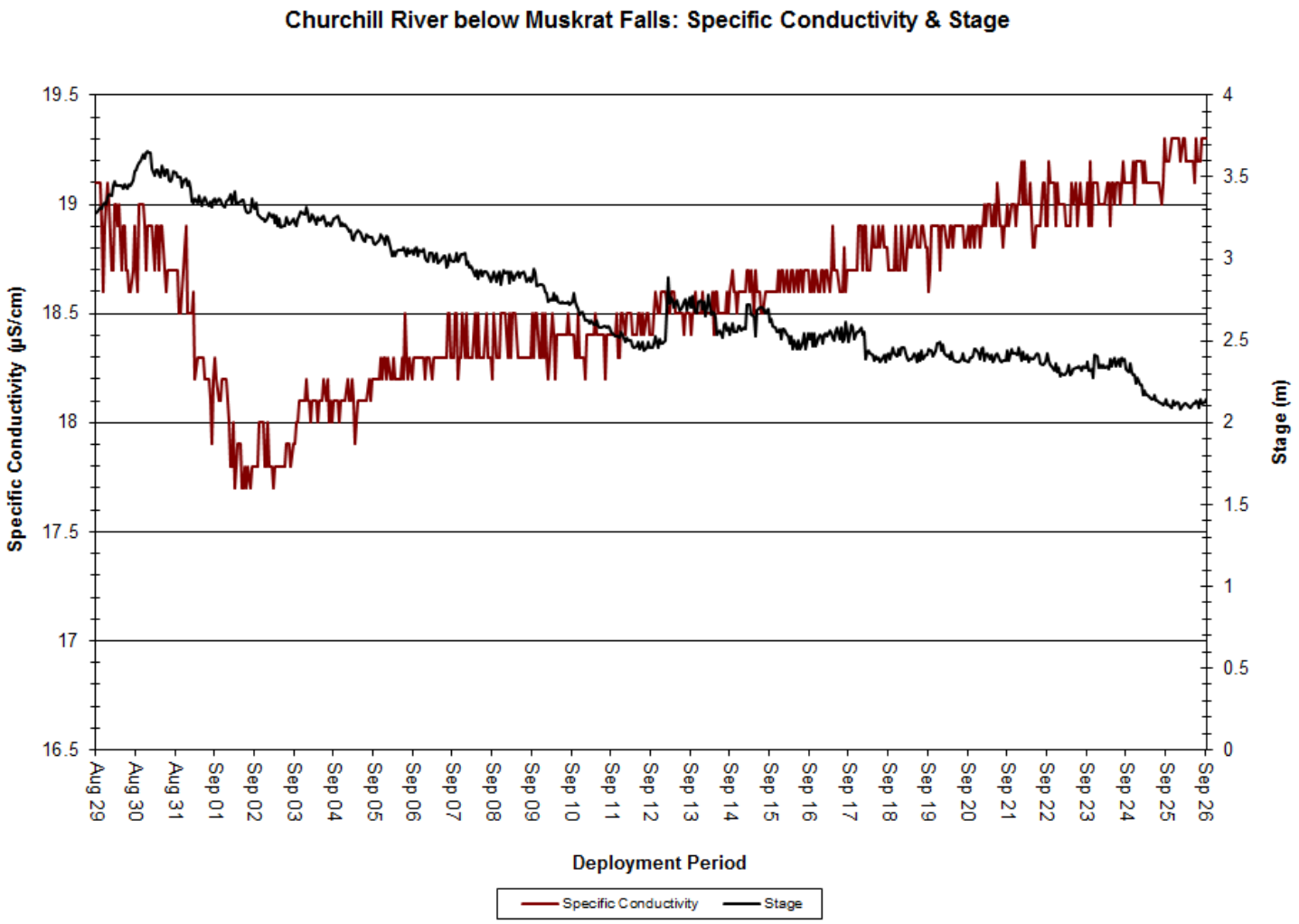

Figure 18: Specific Conductivity & Stage at Churchill River below Muskrat Falls

Dissolved Oxygen

- Over the deployment period, dissolved oxygen concentration ranged from 10.95mg/L to 12.41mg/L, with a median value of 11.98mg/L. Saturation of dissolved oxygen ranged from 99.0% to 125.2%, with a median value of 113.8% (Figure 19).
- Dissolved oxygen and water temperature exhibit an inverse relationship: as one parameter increases, the other decreases, and vice versa. Dissolved oxygen levels were relatively stable, with a slight increase at the very end of the deployment period. This is to be expected since water temperatures were also quite stable, with a slight decrease at the end of the deployment 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 Other and Early Life Stages for the duration of deployment.

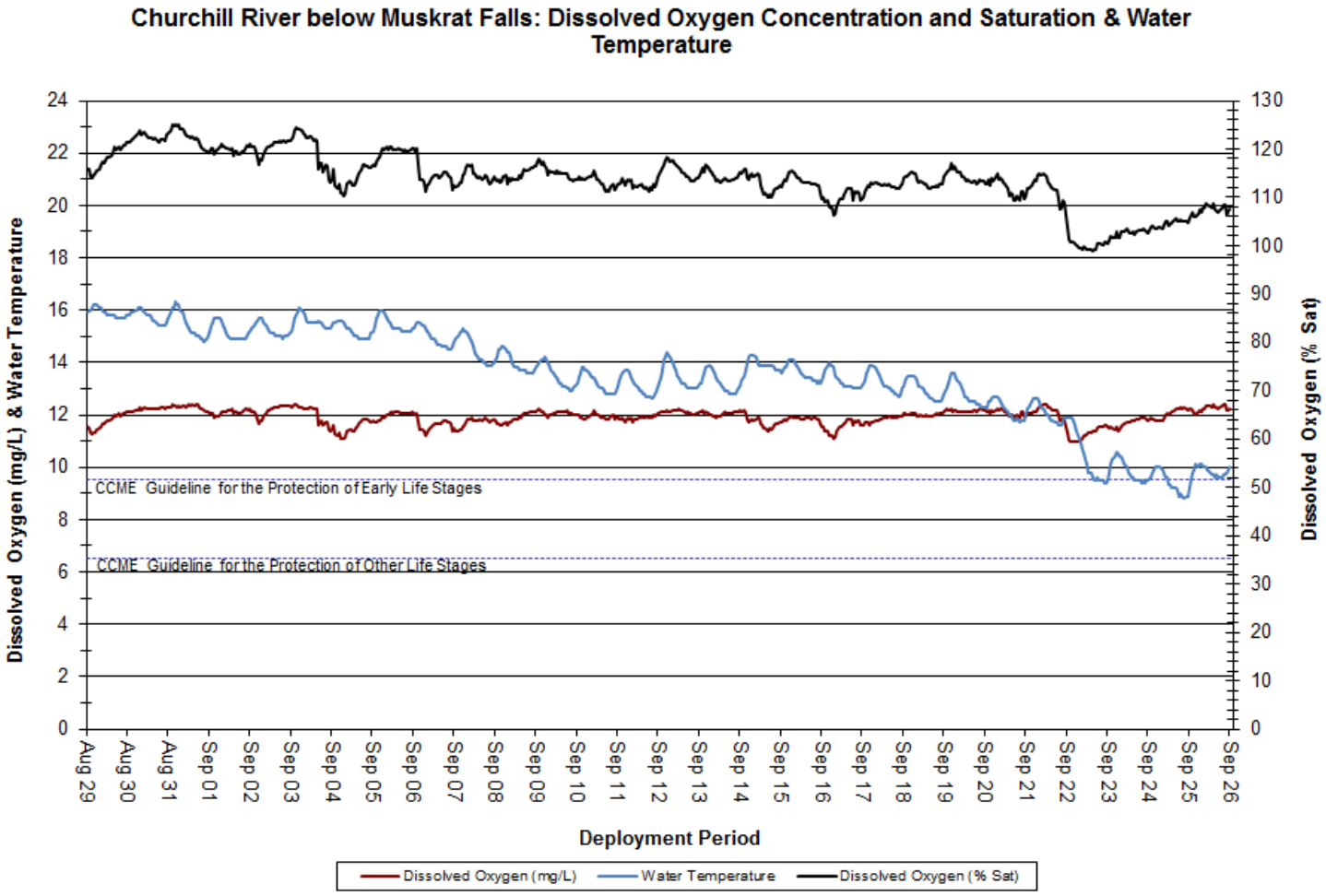

Figure 19: Dissolved Oxygen & Water Temperature at Churchill River below Muskrat Falls

Turbidity

- Over the deployment period, turbidity ranged from 0.0NTU to 185.2NTU, with a median value of 0.0NTU. A median value of 0.0NTU indicates a very low level of natural background turbidity in the waterbody. Precipitation data was obtained from the Muskrat Falls MET Station.
- Larger turbidity spikes observed over the deployment period correlated closely with precipitation events (Figure 20). 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.

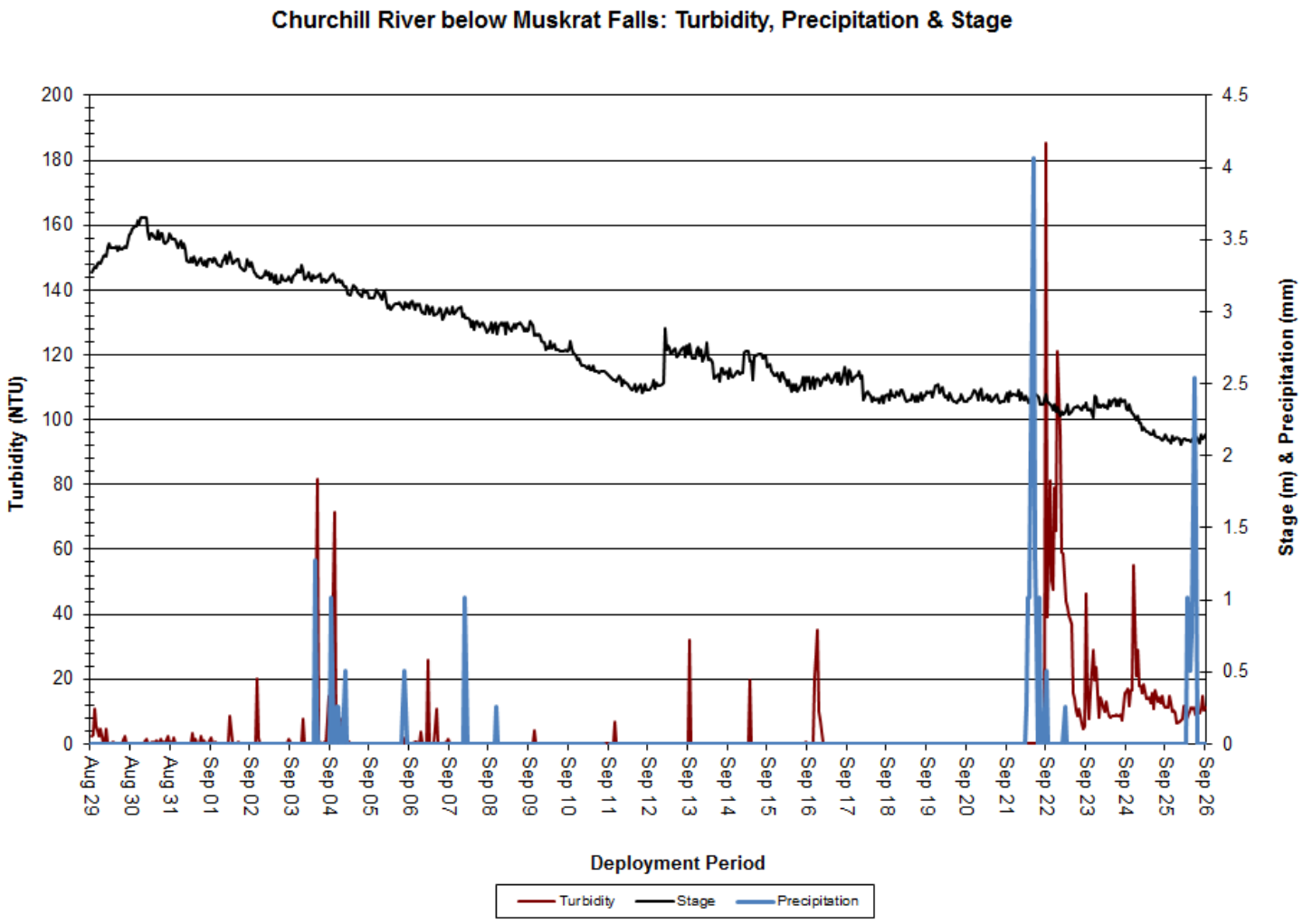

Figure 20: Turbidity, Precipitation & Stage at Churchill River below Muskrat Falls

Stage

- Over the deployment period, stage ranged from 2.08m to 3.66m, with a median value of 2.63m (Figure 21). Precipitation data was obtained from the Muskrat Falls MET Station.
- Stage decreased steadily over the course of deployment; however, correlation between stage and precipitation events is not particularly evident in the graph below. 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.

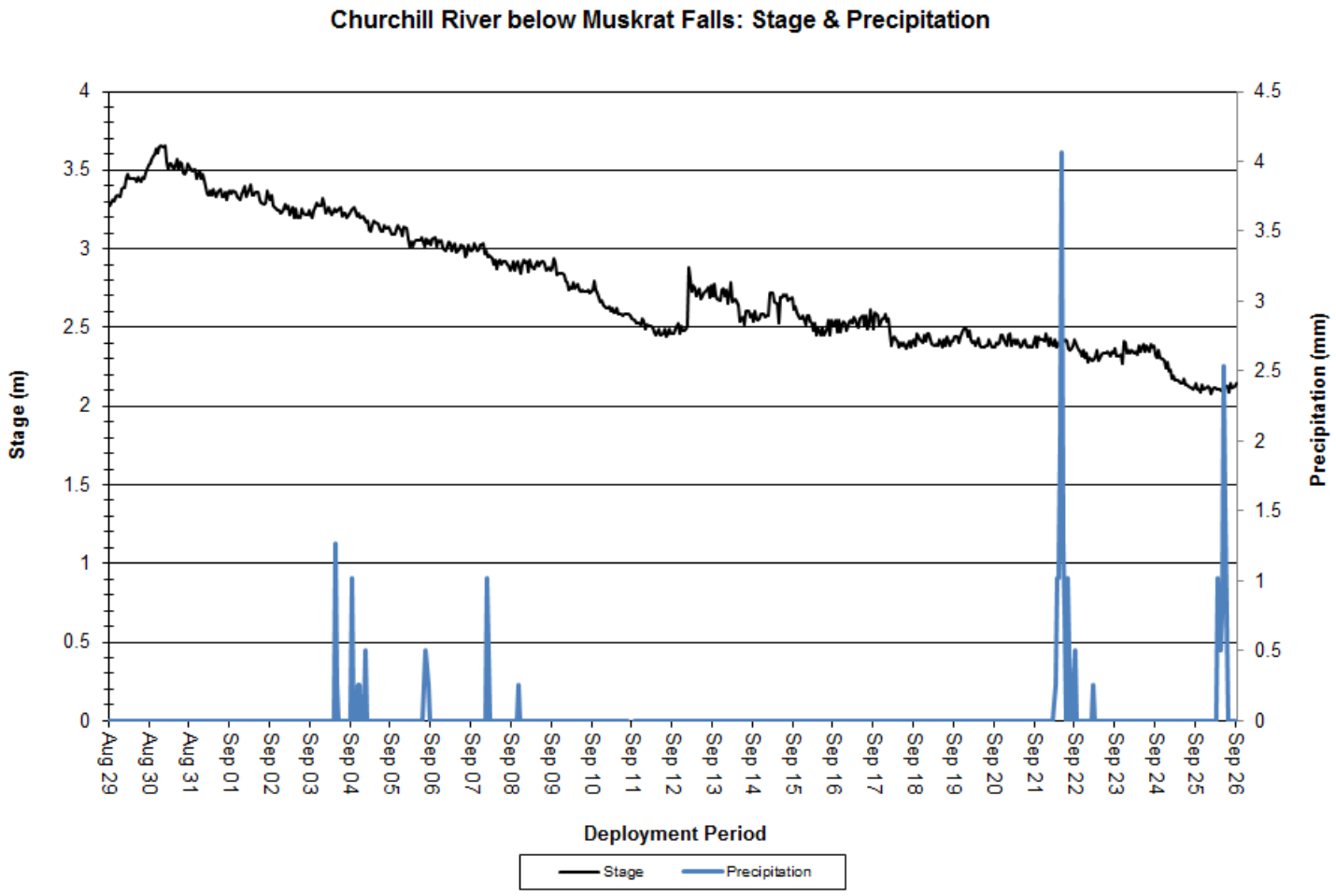

Figure 21: Stage & Precipitation at Churchill River below Muskrat Falls

Chlorophyll

- Over the deployment period, chlorophyll ranged from 1.89ug/L to 4.70ug/L, with a median value of 2.74ug/L (Figure 22).
- 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.

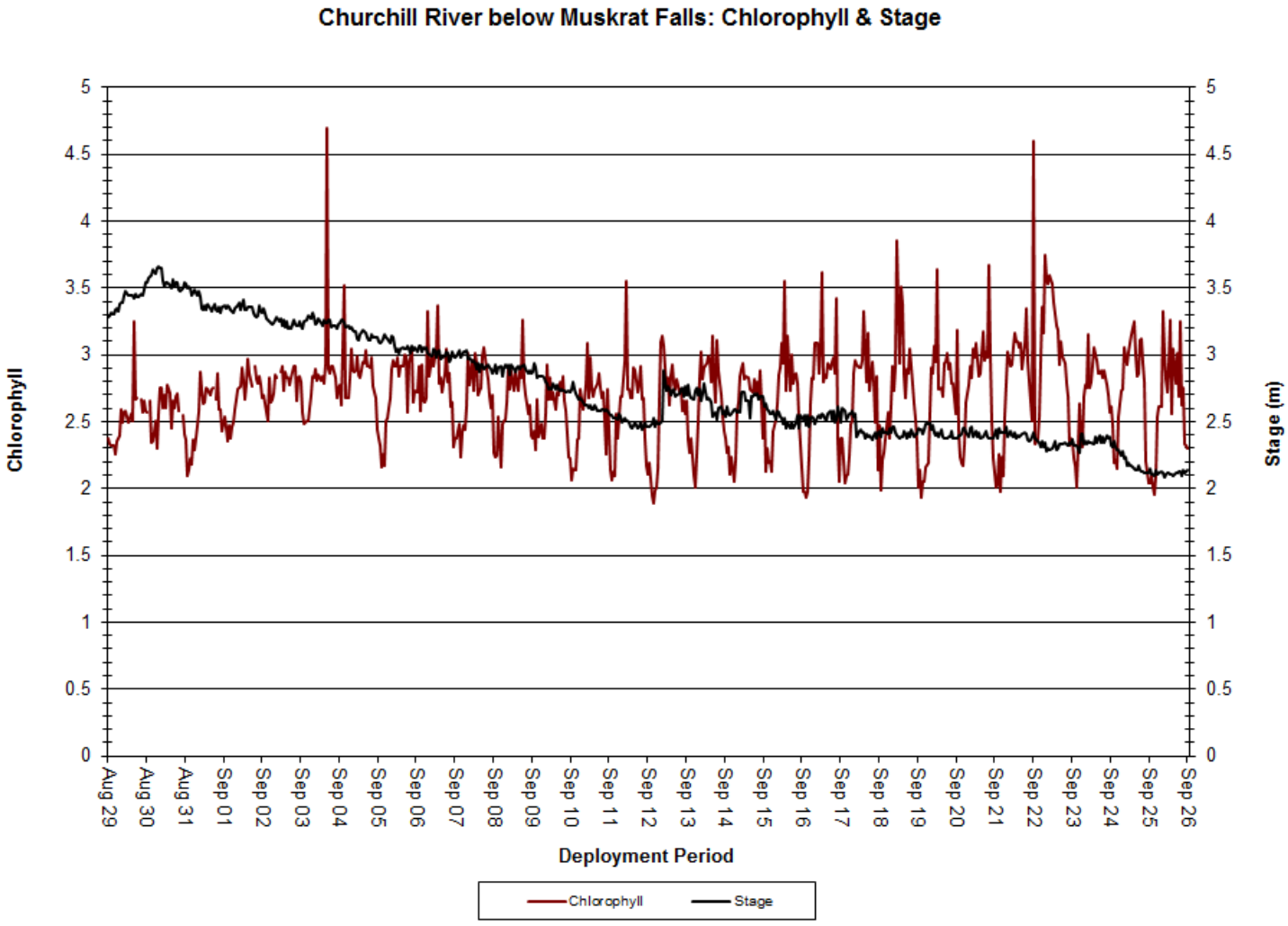

Figure 22: Chlorophyll & Stage at Churchill River below Muskrat Falls

Churchill River at English Point

Water Temperature

- Water temperature ranged from 7.04°C to 17.70°C, with a median value of 13.60°C (Figure 23). Air temperature data was obtained from the Muskrat Falls MET 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.

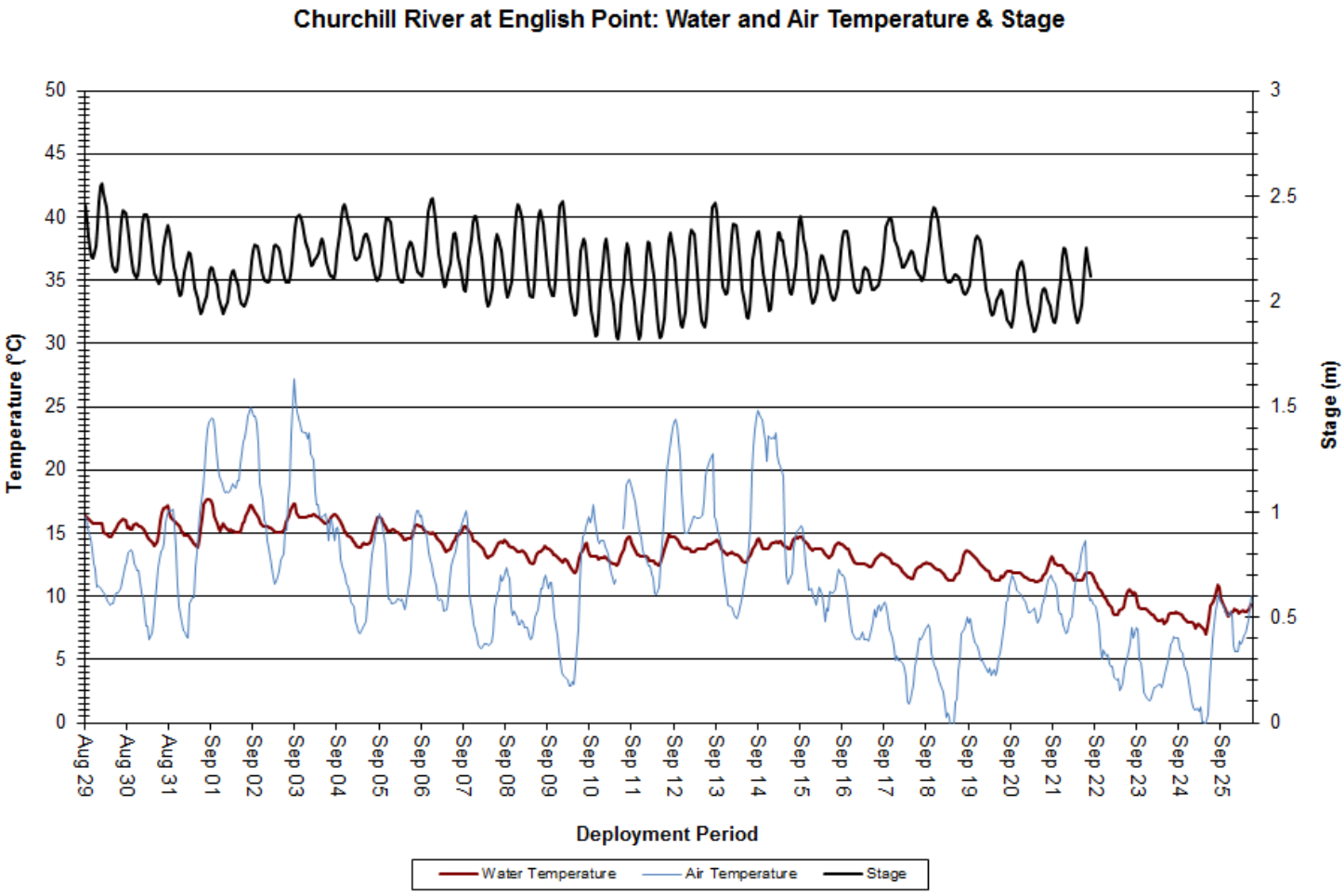

Figure 23: Water and Air Temperature & Stage at Churchill River at English Point

pH

- Over the deployment period, pH ranged from 6.54 pH units to 7.33 pH units, with a median value of 6.94 (Figure 24).
- pH values were relatively stable and 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.

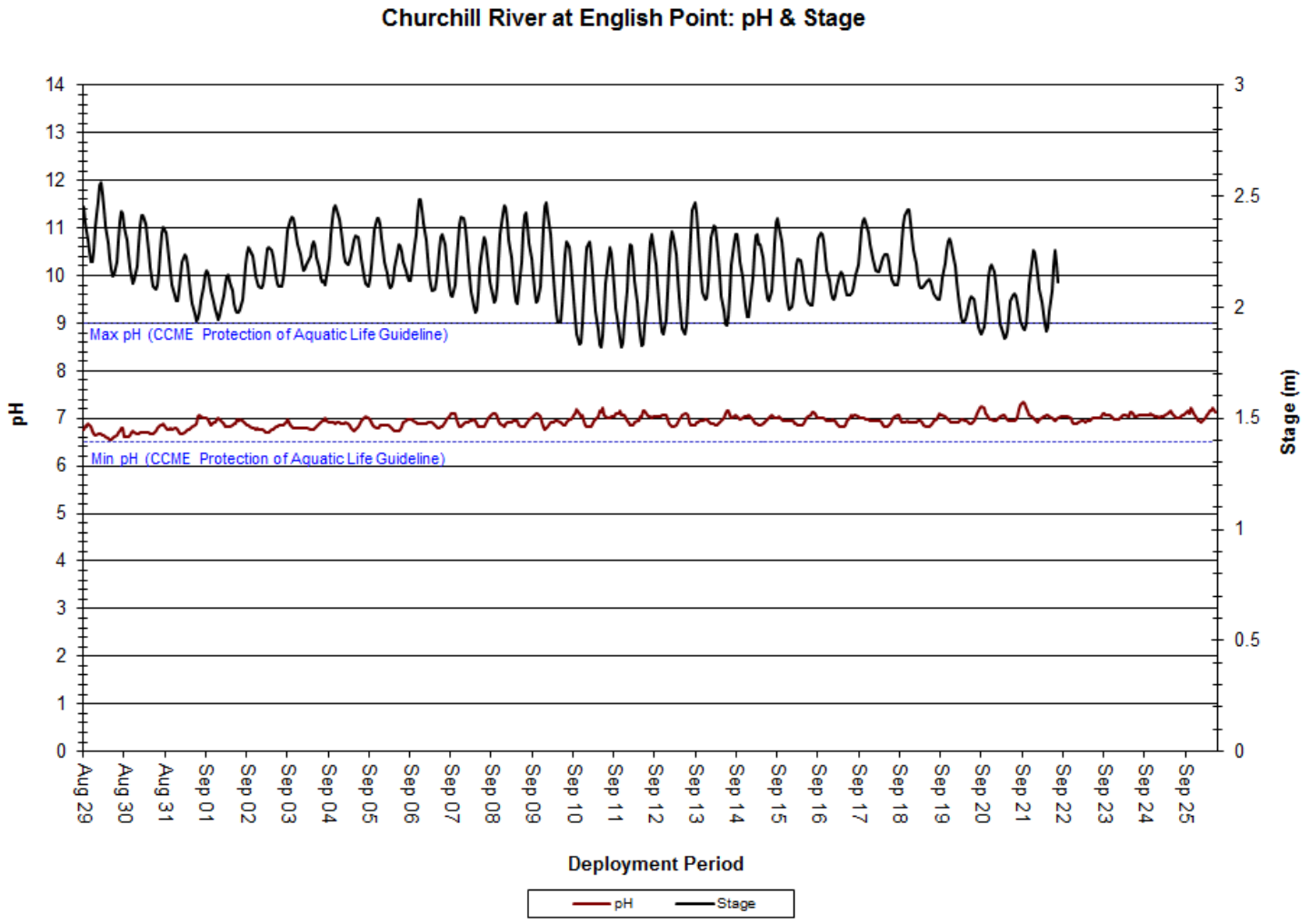

Figure 24: pH & Stage at Churchill River at English Point

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 19.2µS/cm to 58.0µs/cm, with a median value of 30.5µS/cm (Figure 25).
- 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 25).
- 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.

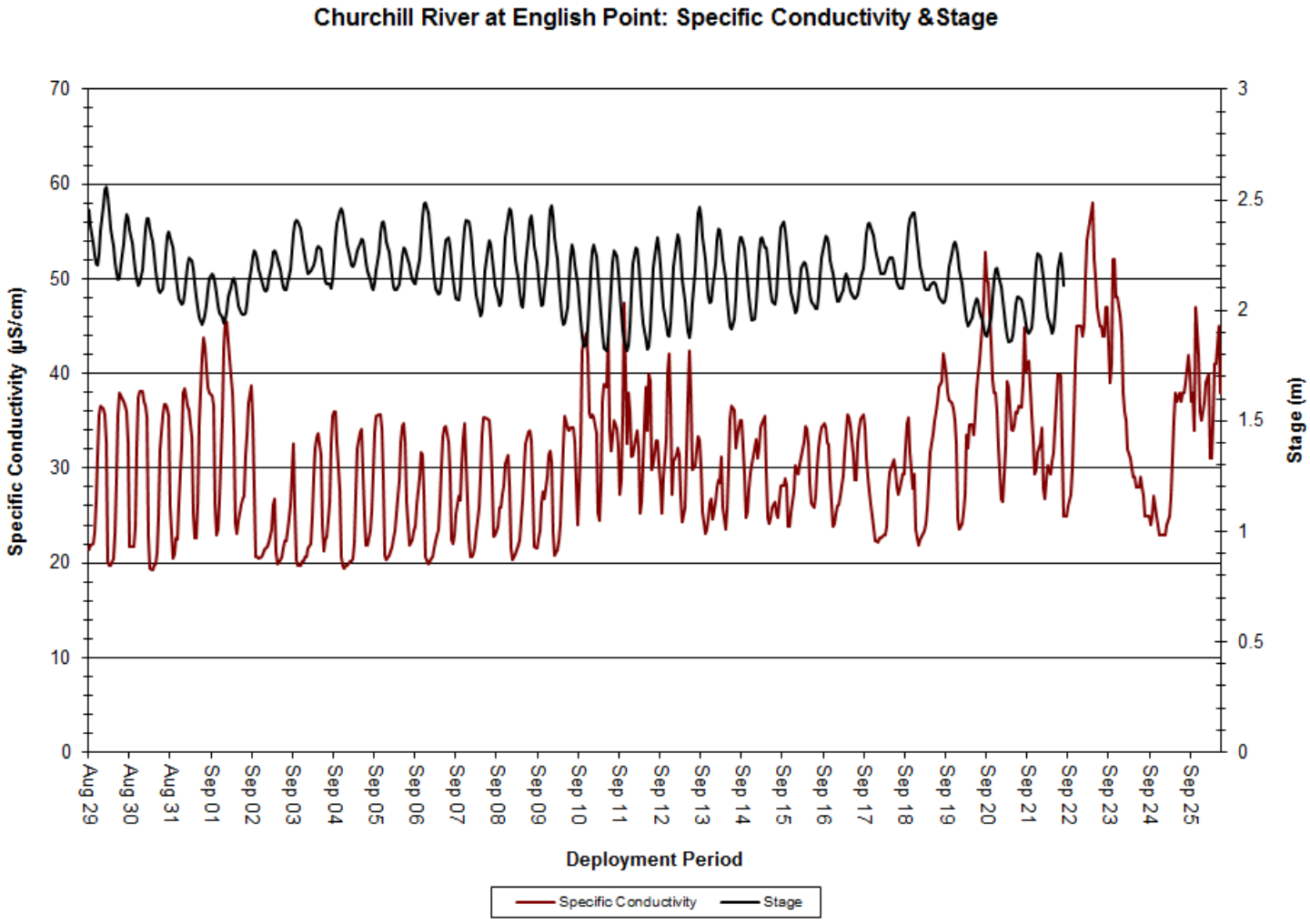

Figure 25: Specific Conductivity & Stage at Churchill River at English Point

Dissolved Oxygen

- Over the deployment period, dissolved oxygen concentration ranged from 9.21mg/L to 11.90mg/L, with a median value of 10.76mg/L. Saturation of dissolved oxygen ranged from 90.8% to 114.1% saturation, with a median value of 101.5% (Figure 26).
- There is an evident relationship between water temperature and dissolved oxygen. As water temperatures decreased over the deployment period, dissolved oxygen levels slowly 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 fell below the CCME's Guideline for the Protection of Early Life Stages on four brief occasions at the start of deployment; however, levels were above the CCME's Guideline for the remainder of deployment (Figure 26). This is not surprising considering the warmer water temperatures present at the start of deployment.

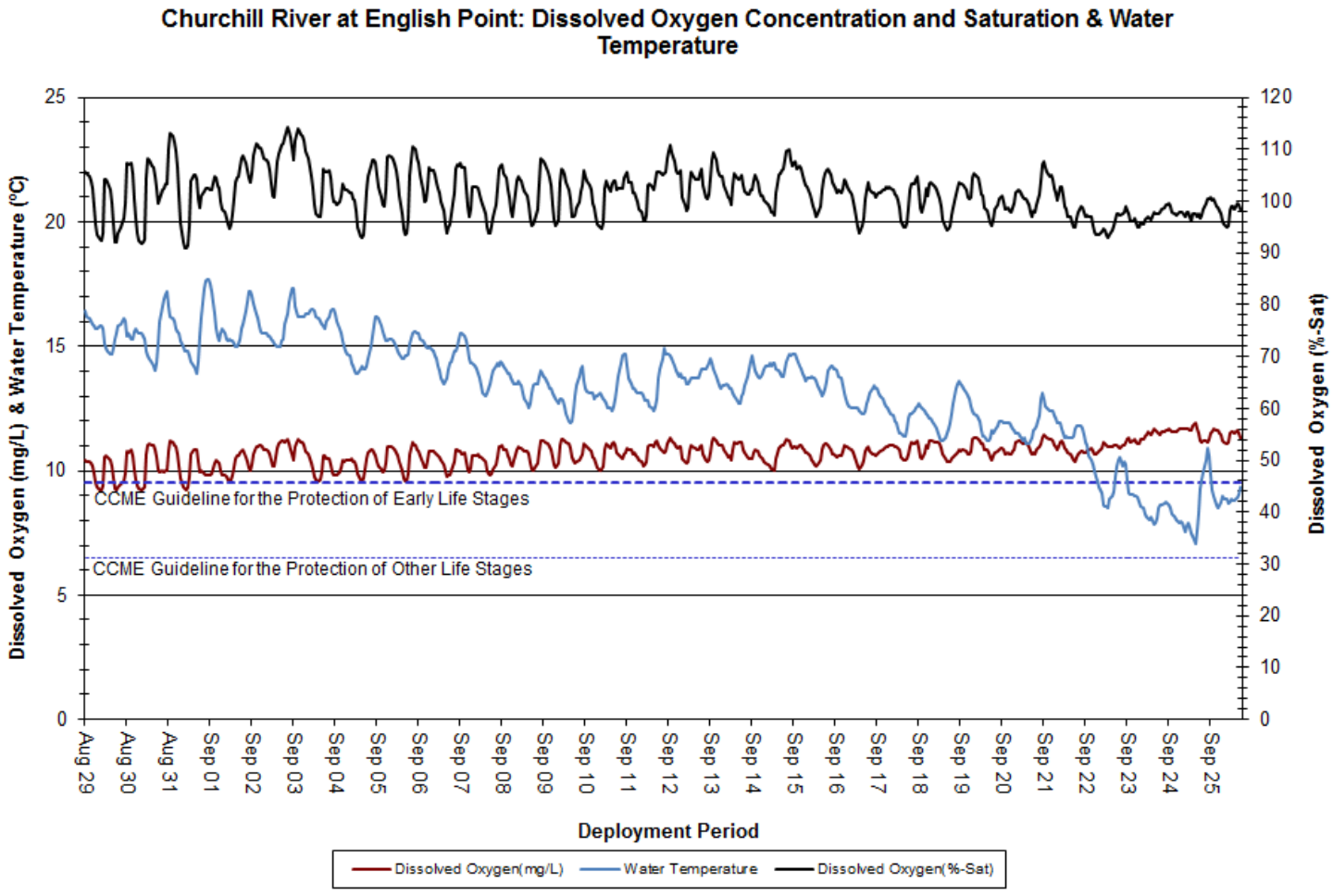

Figure 26: Dissolved Oxygen & Water Temperature at Churchill River at English Point

Turbidity

- Over the deployment period, turbidity ranged from 0.9NTU to 132.4NTU, with a median value of 7.6NTU (Figure 27). A median value of 7.6NTU 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 Muskrat Falls MET Station.
- Turbidity events generally correlate with increases in stage and precipitation events, as these can increase the presence of suspended material in water (Figure 27). High winds can also contribute to turbidity events at this station by disturbing sediment from the river bed.
- 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.

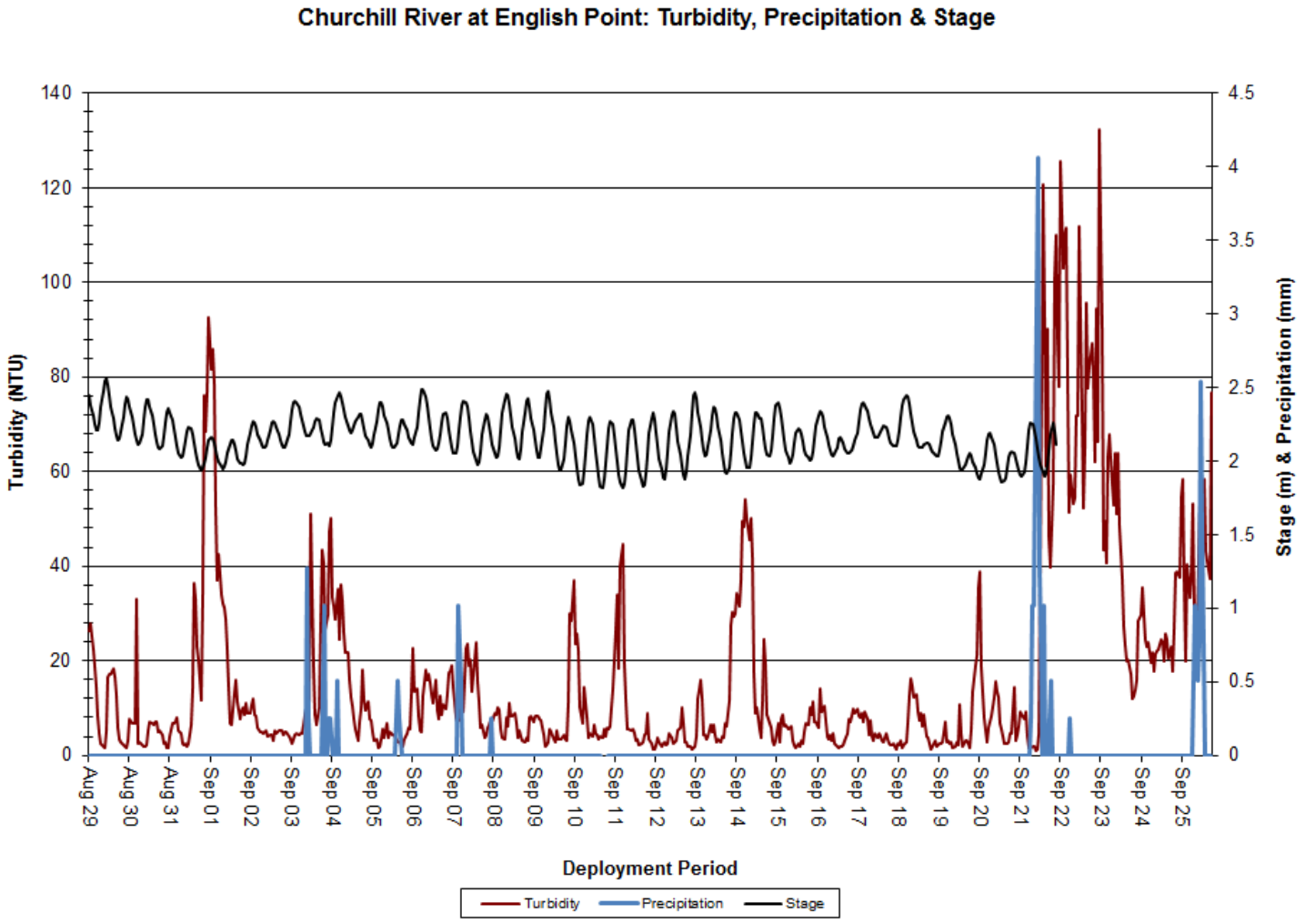

Figure 27: Turbidity, Precipitation & Stage at Churchill River at English Point

Stage

- Over the deployment period, stage ranged from 1.82m to 2.56m, with a median value of 2.16m (Figure 28). Precipitation data was obtained from the Muskrat Falls MET 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.

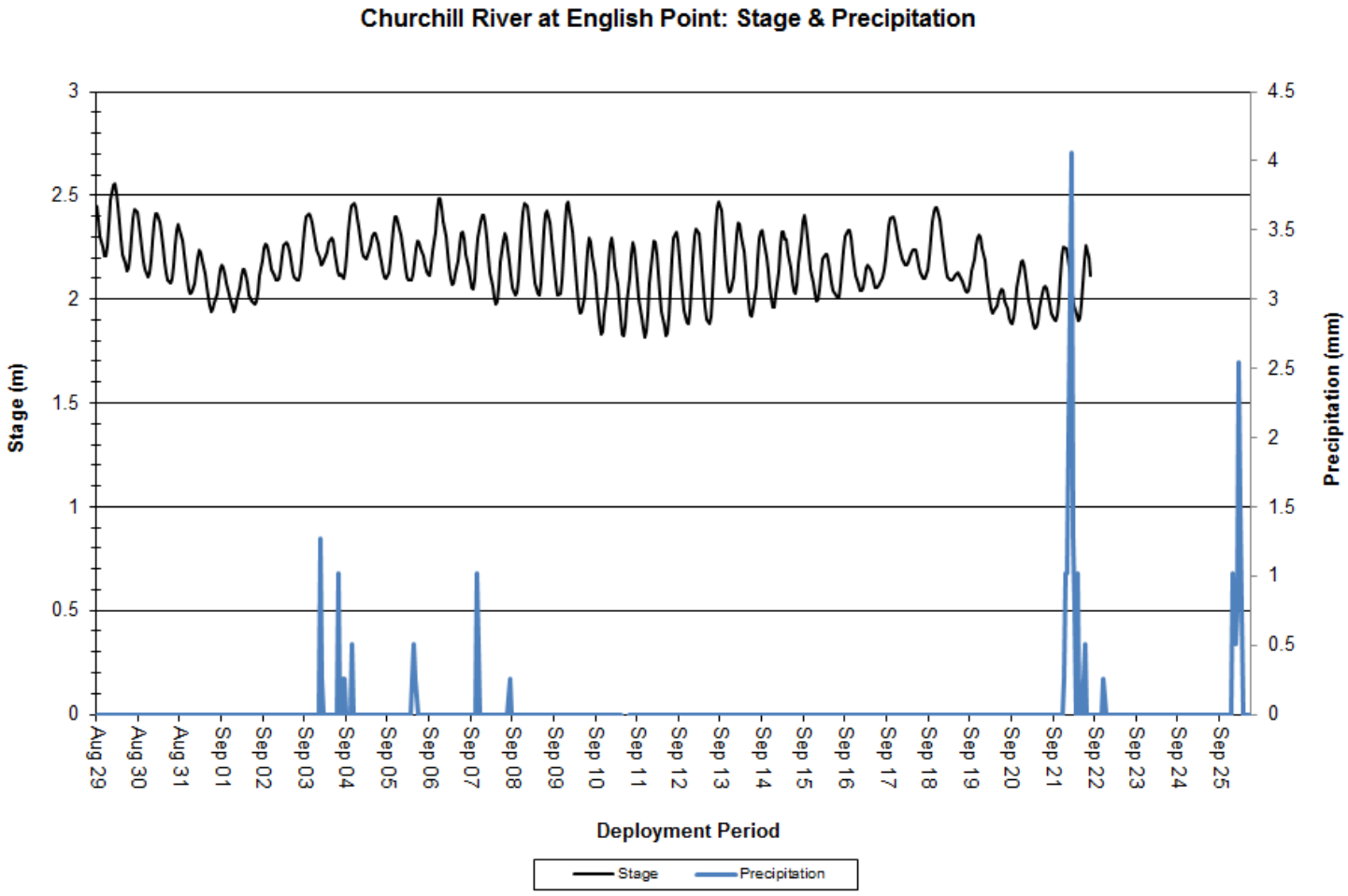

Figure 28: Stage & Precipitation at Churchill River at English Point

Conclusions

- Instruments at four water quality monitoring stations on the Lower Churchill River were deployed from August 17/29 through September 26/October 12, 2018.
- 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.
- pH was relatively stable at all stations over the course of deployment. pH fell within the CCME's Guidelines for the Protection of Aquatic Life for the duration of deployment at all stations, with a single exception at Churchill River below Metchin River associated with a significant increase in stage.
- 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 increased over the course of deployment at all stations as water temperatures decreased into the fall season. Dissolved oxygen levels are generally higher in water at cooler temperatures. Dissolved oxygen levels remained above the CCME's Guideline for the Protection of Early Life Stages for the duration of deployment at Churchill River below Muskrat Falls. Dissolved oxygen levels at the other three stations started deployment below the CCME's Guideline for the Protection of Early Life Stages, but quickly rose above the Guideline and remained there for the remainder of the deployment period.
- 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

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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: **1815079**

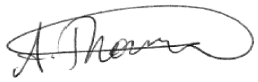
Cient:	Department of Environment	**COC Number:**	834917
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-09-04
Client Project:		**Date Submitted:**	2018-08-22
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1382504	WS-S-0000 CR below Metchin River	2018-6317-00-SI-SP	2018-08-17	Alkalinity as CaCO3	mg/L	5	9
				Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	<1
				Colour	TCU	2	26
				Conductivity	uS/cm	5	22
				Dissolved Organic Carbon	mg/L	0.5	3.7
				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	5
				N-NH3 (Ammonia)	mg/L	0.05	<0.05
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	7.10
				Sulphate	mg/L	1	2
				Total Dissolved Solids (COND - CALC)	mg/L	1	14
				Total Kjeldahl Nitrogen	mg/L	0.1	0.1
				Total Organic Carbon	mg/L	0.5	3.7
				Turbidity	NTU	0.1	0.7
				Aluminum	mg/L	0.01	0.03

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: 

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: **1815079**

Cient:	Department of Environment	**COC Number:**	834917
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-09-04
Client Project:		**Date Submitted:**	2018-08-22
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1382504	WS-S-0000	2018-6317-00-SI-SP	2018-08-17	Antimony	mg/L	0.0005	<0.0005
	CR below Metchin River			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	0.10
				Lead	mg/L	0.001	<0.001
				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	0.02
				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	0.012

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: A. Thomas

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: **1815079**

Cient:	Department of Environment	**COC Number:**	834917
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-09-04
Client Project:		**Date Submitted:**	2018-08-22
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1382504	WS-S-0000	2018-6317-00-SI-SP	2018-08-17	Uranium	mg/L	0.001	<0.001
	CR below Metchin River			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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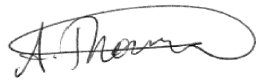
APPROVAL: 

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: **1815079**

Cient:	Department of Environment	**COC Number:**	834917
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-09-04
Client Project:		**Date Submitted:**	2018-08-22
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1382505	WS-S-0000 CR above Grizzle Rapids	2018-6318-00-SI-SP	2018-08-17	Alkalinity as CaCO3	mg/L	5	6
				Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	<1
				Colour	TCU	2	30
				Conductivity	uS/cm	5	25
				Dissolved Organic Carbon	mg/L	0.5	4.1
				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	5
				N-NH3 (Ammonia)	mg/L	0.05	<0.05
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	6.92
				Sulphate	mg/L	1	4
				Total Dissolved Solids (COND - CALC)	mg/L	1	16
				Total Kjeldahl Nitrogen	mg/L	0.1	0.1
				Total Organic Carbon	mg/L	0.5	4.1
				Turbidity	NTU	0.1	0.9
				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.
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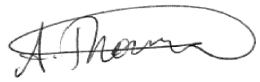
APPROVAL: 

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: **1815079**

Cient:	Department of Environment	**COC Number:**	834917
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-09-04
Client Project:		**Date Submitted:**	2018-08-22
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1382505	WS-S-0000	2018-6318-00-SI-SP	2018-08-17	Antimony	mg/L	0.0005	<0.0005
	CR above Grizzle Rapids			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	0.10
				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	0.012

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: **1815079**

Cient:	Department of Environment	**COC Number:**	834917
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-09-04
Client Project:		**Date Submitted:**	2018-08-22
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1382505	WS-S-0000	2018-6318-00-SI-SP	2018-08-17	Uranium	mg/L	0.001	<0.001
	CR above Grizzle Rapids			Zinc	mg/L	0.01	<0.01
				Phosphorus	mg/L	0.002	0.004
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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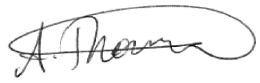
APPROVAL: 

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: **1816065**

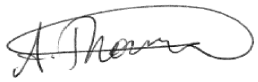
Cient:	Department of Environment	**COC Number:**	835479
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-09-14
Client Project:		**Date Submitted:**	2018-09-06
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1385683	WS-S-0000 CR below Muskrat Falls	2018-6320-00-SI-SP	2018-08-29	Alkalinity as CaCO3	mg/L	5	28
				Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	1
				Colour	TCU	2	34
				Conductivity	uS/cm	5	32
				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	0.05	<0.05
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	7.45
				Sulphate	mg/L	1	6
				Total Dissolved Solids (COND - CALC)	mg/L	1	21
				Total Kjeldahl Nitrogen	mg/L	0.1	0.2
				Total Organic Carbon	mg/L	0.5	4.4
				Turbidity	NTU	0.1	4.1
				Aluminum	mg/L	0.01	0.15

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: 

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: **1816065**

Cient:	Department of Environment	**COC Number:**	835479
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-09-14
Client Project:		**Date Submitted:**	2018-09-06
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1385683	WS-S-0000	2018-6320-00-SI-SP	2018-08-29	Antimony	mg/L	0.0005	<0.0005
	CR below Muskrat Falls			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	0.24
				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: A. Thomas

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: **1816065**

Cient:	Department of Environment	**COC Number:**	835479
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-09-14
Client Project:		**Date Submitted:**	2018-09-06
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1385683	WS-S-0000	2018-6320-00-SI-SP	2018-08-29	Uranium	mg/L	0.001	<0.001
	CR below Muskrat Falls			Zinc	mg/L	0.01	<0.01
				Phosphorus	mg/L	0.002	0.006
Sample comment:				Total Suspended Solids	mg/L	2	6

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: A. Thomas

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: **1816065**

Cient:	Department of Environment	**COC Number:**	835479
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-09-14
Client Project:		**Date Submitted:**	2018-09-06
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1385685	WS-S-0000 CR at English Point	2018-6322-00-SI-SP	2018-08-29	Alkalinity as CaCO3	mg/L	5	8
				Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	2
				Colour	TCU	2	66
				Conductivity	uS/cm	5	29
				Dissolved Organic Carbon	mg/L	0.5	5.3
				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	78
				N-NH3 (Ammonia)	mg/L	0.05	<0.05
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	7.00
				Sulphate	mg/L	1	1
				Total Dissolved Solids (COND - CALC)	mg/L	1	19
				Total Kjeldahl Nitrogen	mg/L	0.1	0.2
				Total Organic Carbon	mg/L	0.5	5.3
				Turbidity	NTU	0.1	23.2
				Aluminum	mg/L	0.01	0.74

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: Addrine Thomas

REPORT OF ANALYSIS

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Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1385685	WS-S-0000 CR at English Point	2018-6322-00-SI-SP	2018-08-29	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	13
				Cadmium	mg/L	0.0001	<0.0001
				Chromium	mg/L	0.001	0.001
				Copper	mg/L	0.001	0.002
				Iron	mg/L	0.03	1.25
				Lead	mg/L	0.001	<0.001
				Magnesium	mg/L	1	11
				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	10
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	11
				Strontium	mg/L	0.001	0.016

Sample comment:

Report comment:

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APPROVAL: A. Thomas

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: **1816065**

Cient:	Department of Environment	**COC Number:**	835479
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-09-14
Client Project:		**Date Submitted:**	2018-09-06
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1385685	WS-S-0000	2018-6322-00-SI-SP	2018-08-29	Uranium	mg/L	0.001	<0.001
	CR at English Point			Zinc	mg/L	0.01	<0.01
				Phosphorus	mg/L	0.002	0.067
Sample comment:				Total Suspended Solids	mg/L	2	56

Report comment:

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APPROVAL: A. Thomas

Addrine Thomas