Real-Time Water Quality Deployment Report

Lower Churchill River Network

September 5/28 to
October 18/30, 2023

Newfoundland Labrador

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

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Real Time Water Quality Monitoring

- Staff with the Department of Environment and Climate Change monitor real-time water quality data on a regular basis.
- This deployment report discusses water quality related events occurring at four stations on the Lower Churchill River: Churchill River below Metchin River, Churchill River above Grizzle Rapids, Churchill River below Muskrat Falls and Churchill River at English Point.
- A real-time water quality monitoring instrument was deployed at Churchill River below Metchin River on September 5th. Instruments were deployed at Churchill River below Muskrat Falls and at English Point on September 28th.
- The instrument at Churchill River below Metchin River was removed on October 18th, for a deployment period of 43 days.
- The instruments at Churchill River below Muskrat Falls and at English Point were removed on October 30th, for a deployment period of 32 days.
- The instrument at Churchill River above Grizzle Rapids was not deployed on September 28th; 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 August 10th through October 30th. A deployment period of 32 days will be used for reporting purposes.

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 September 5/28 to October 18/30, 2023 are summarized in Table 2.

Table 2: Comparison rankings for Lower Churchill River stations September 5/28 to October 18/30, 2023

Churchill River Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Below Metchin River	September 5, 2023	Deployment	Good	Marginal	Excellent	Excellent	Excellent
	October 18, 2023	Removal	Good	Poor	Excellent	Excellent	Excellent
Above Grizzle Rapids	September 28, 2023	Deployment	N/A	N/A	N/A	N/A	N/A
	October 30, 2023	Removal	Excellent	Fair	Excellent	Good	Excellent
Below Muskrat Falls	September 28, 2023	Deployment	Fair	Good	Excellent	Excellent	Excellent
	October 30, 2023	Removal	Excellent	Excellent	Excellent	Good	Excellent
At English Point	September 28, 2023	Deployment	Excellent	Excellent	Excellent	Good	Excellent
	October 30, 2023	Removal	Excellent	Excellent	Fair	Fair	Good

- **Churchill River below Metchin River**
  - At deployment, all parameters ranked as either 'excellent' or 'good' with the exception of pH, which was 'marginal'.
  - At removal, all parameters ranked as either 'excellent' or 'good' with the exception of pH, which was 'poor'. Comparison rankings for pH that were less than 'good' at both deployment and removal suggest a calibration error. In this case, since comparison rankings for pH between the field sonde and grab sample at deployment were 'excellent', the calibration error may lie with the pH sensor on the QA/QC sonde.
- **Churchill River above Grizzle Rapids**
  - Comparison rankings are not available for deployment since this instrument was not physically deployed on the date in question.
  - At removal, all parameters ranked as either 'excellent' or 'good' with the exception of pH, which was 'fair'.
- **Churchill River below Muskrat Falls**
  - At deployment, all parameters ranked as either 'excellent' or 'good' with the exception of temperature, which was 'fair'.
  - At removal, all parameters ranked as either 'excellent' or 'good'.

- **Churchill River at English Point**
    - At deployment, all parameters ranked as either 'excellent' or 'good'.
    - At removal, all parameters again ranked as either 'excellent' or 'good' with the exception of conductivity and dissolved oxygen, which were 'fair'.

Data Interpretation

- The following graphs and discussion illustrate water quality related events occurring from September 5/28 to October 18/30, 2023 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.

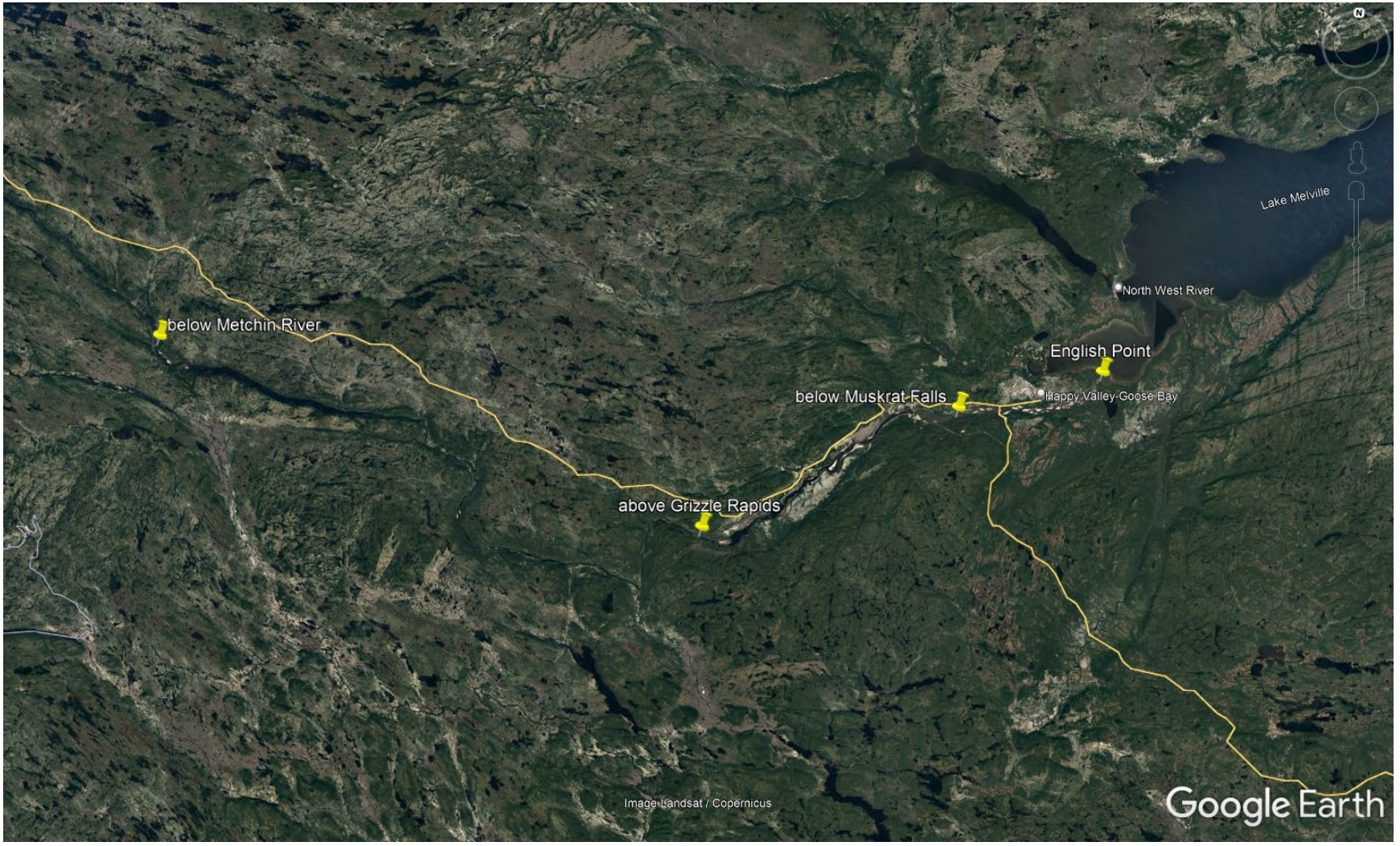

Figure 1: Lower Churchill Network of Real-Time Water Quality Stations

Churchill River below Metchin River

Water Temperature

- Over the deployment period, water temperature ranged from 8.7°C to 15.9°C, with a median value of 10.9°C (Figure 2). Air temperature data was obtained from the Metchin River near TLH Weather Station.
- Water temperature was slowly decreasing over the course of deployment, which is to be expected as air temperatures were also slowly decreasing through the fall season. Water temperature data exhibits a diurnal pattern as expected, and closely correlates with ambient air temperatures.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

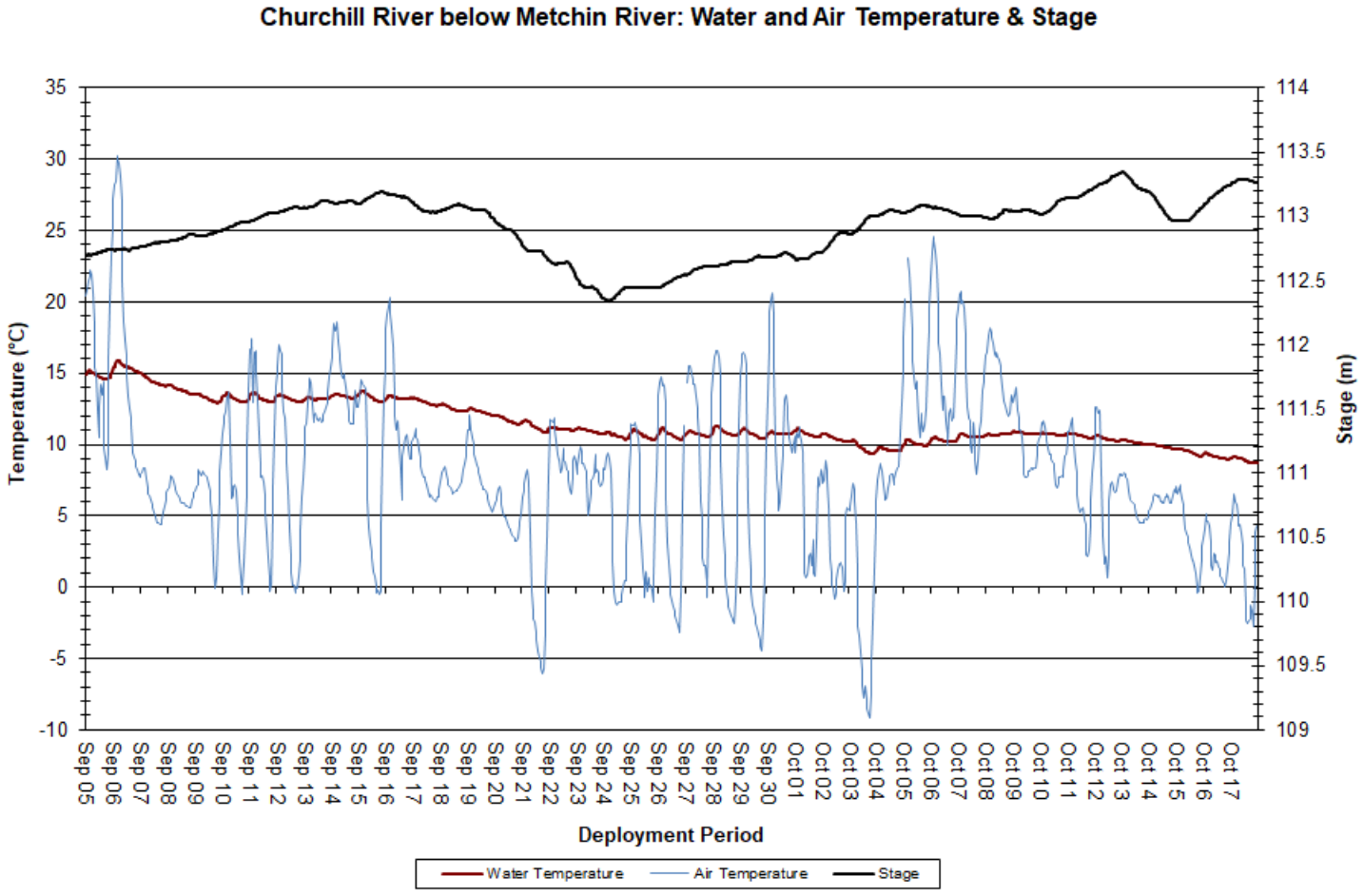

Figure 2: Water and Air Temperature & Stage at Churchill River below Metchin River

pH

- Over the deployment period, pH values ranged from 7.05 to 7.37 pH units, with a median value of 7.15 (Figure 3).
- pH values were relatively stable over the deployment period, remaining within the CCME's Guidelines for the Protection of Aquatic Life for the duration of deployment.
- Photosynthesis uses up hydrogen molecules; this causes the concentration of hydrogen ions to decrease, which in turn causes pH to increase. For this reason, pH may be higher during daylight hours and during the growing season when photosynthesis is at a maximum. This is illustrated by the diurnal fluctuations in pH values (Figure 3).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

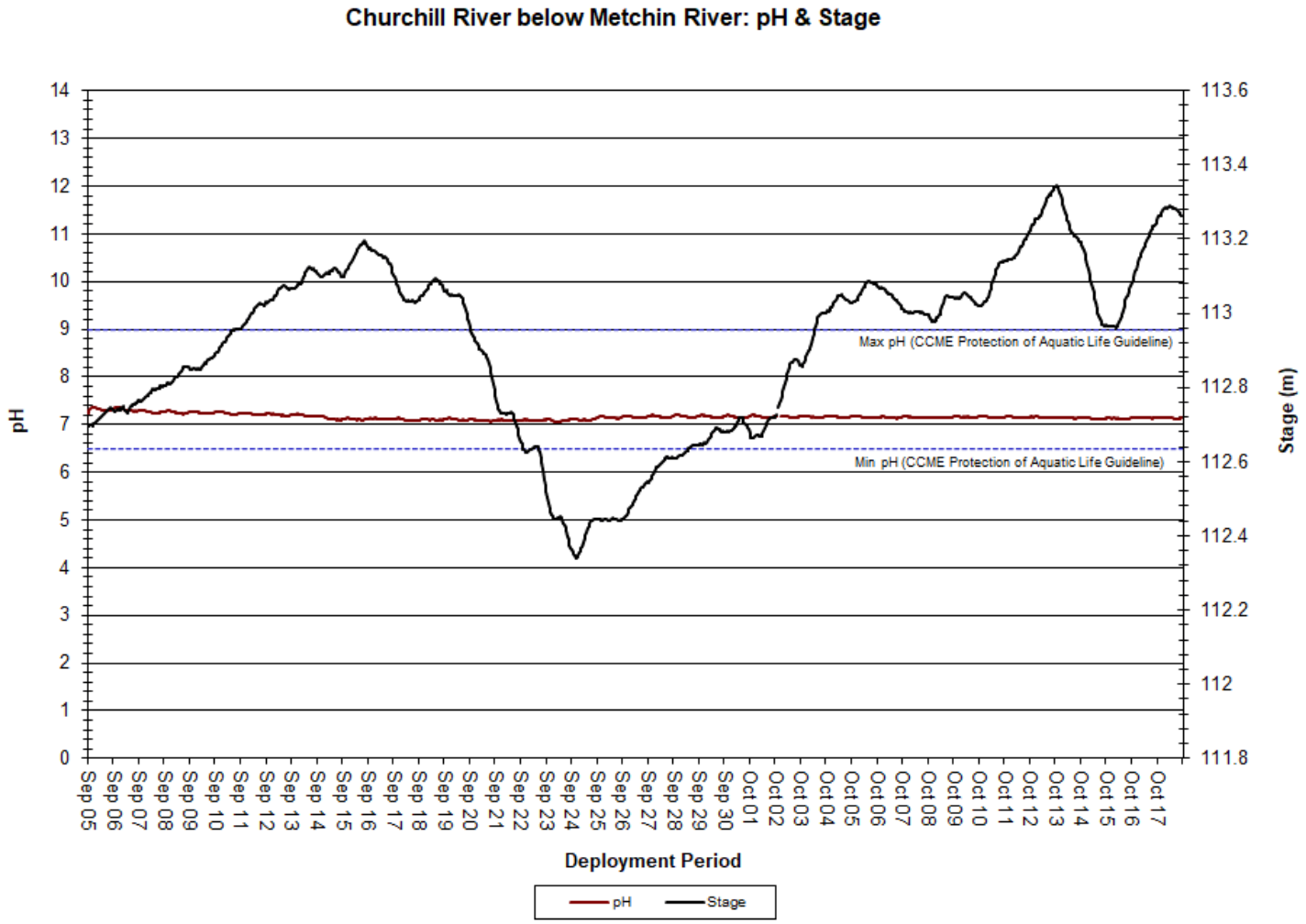

Figure 3: pH & Stage at Churchill River below Metchin River

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 20.2µS/cm to 40.5µS/cm, with a median value of 21.2µS/cm (Figure 4).
- The relationship between conductivity and stage is generally inversed. When stage levels increase, specific conductivity levels decrease as the increased amount of water in the river system dilutes solids that are present. This relationship is somewhat evident in the graph below (Figure 4).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

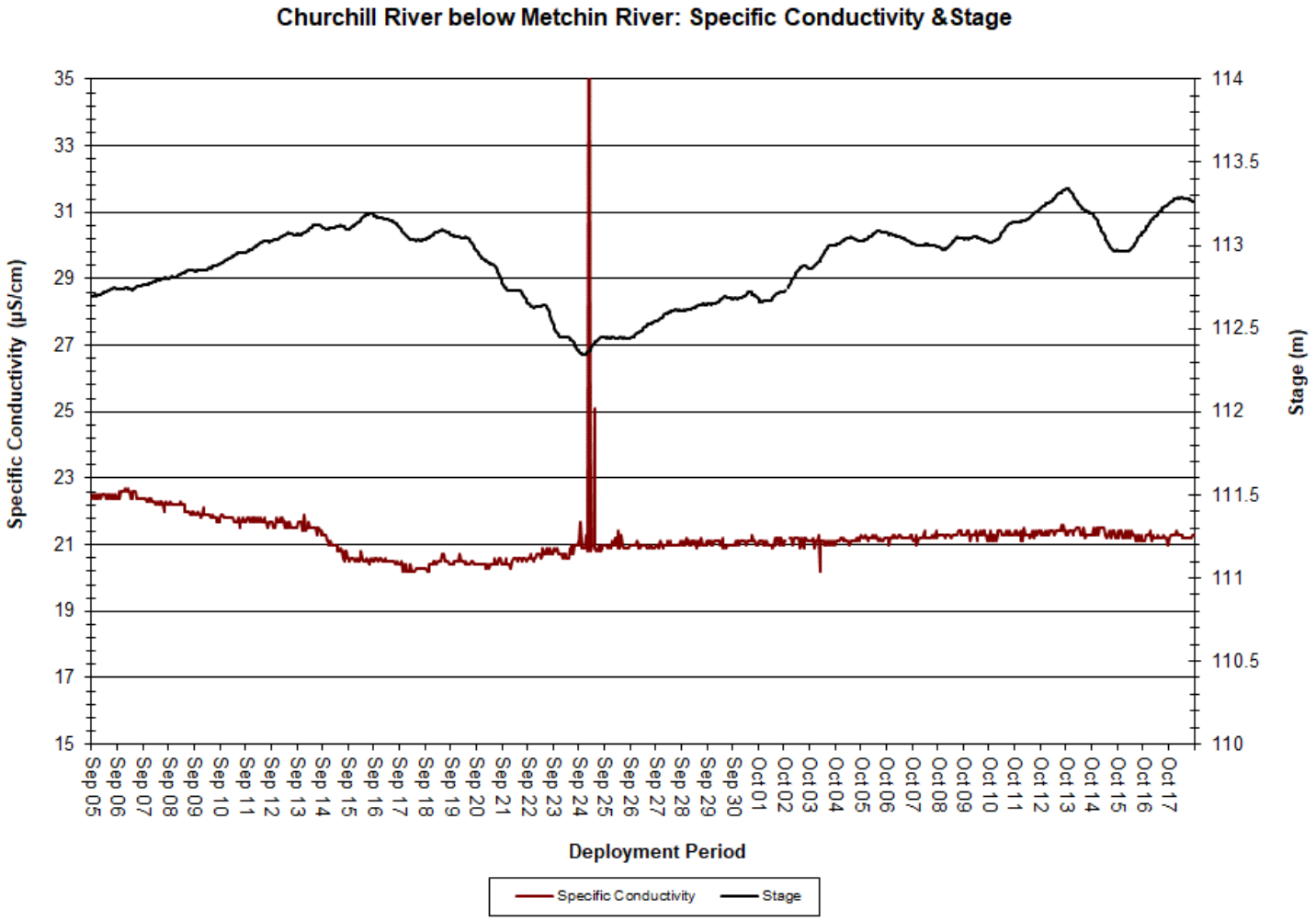

Figure 4: Specific Conductivity & Stage at Churchill River below Metchin River

Dissolved Oxygen

- Over the deployment period, dissolved oxygen content ranged from 9.83mg/L to 11.28mg/L, with a median value of 10.94mg/L. Saturation of dissolved oxygen ranged from 95.6% to 101.4%, with a median value of 98.1% (Figure 5).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period, dissolved oxygen levels were steadily increasing, as water temperatures were steadily decreasing. 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.

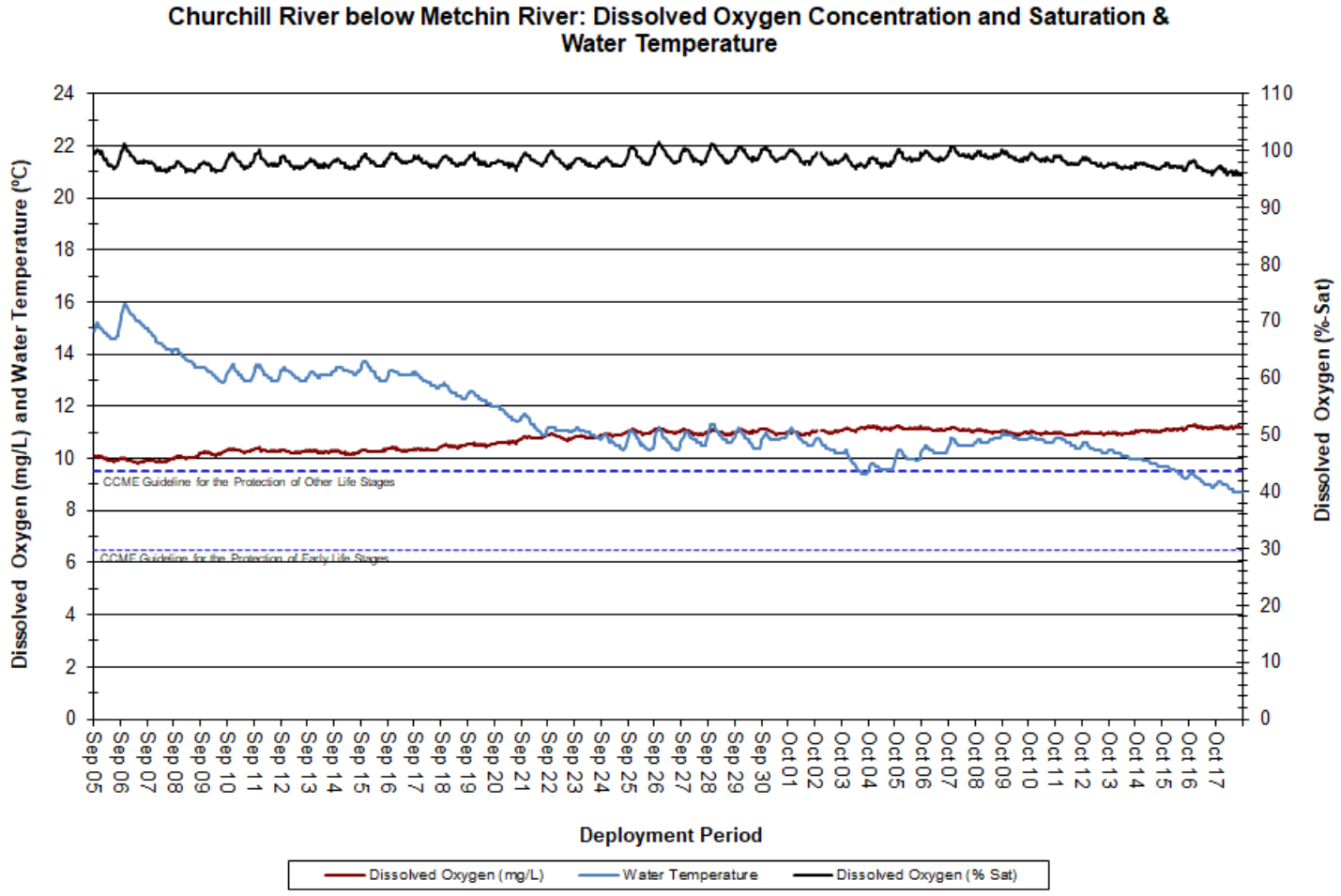

Figure 5: Dissolved Oxygen & Water Temperature at Churchill River below Metchin River

Turbidity

- Over the deployment period, turbidity ranged from 0.0NTU to 4.7NTU, 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.
- This station is located at a wide and deep section of the Churchill River and therefore turbidity levels are typically 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.

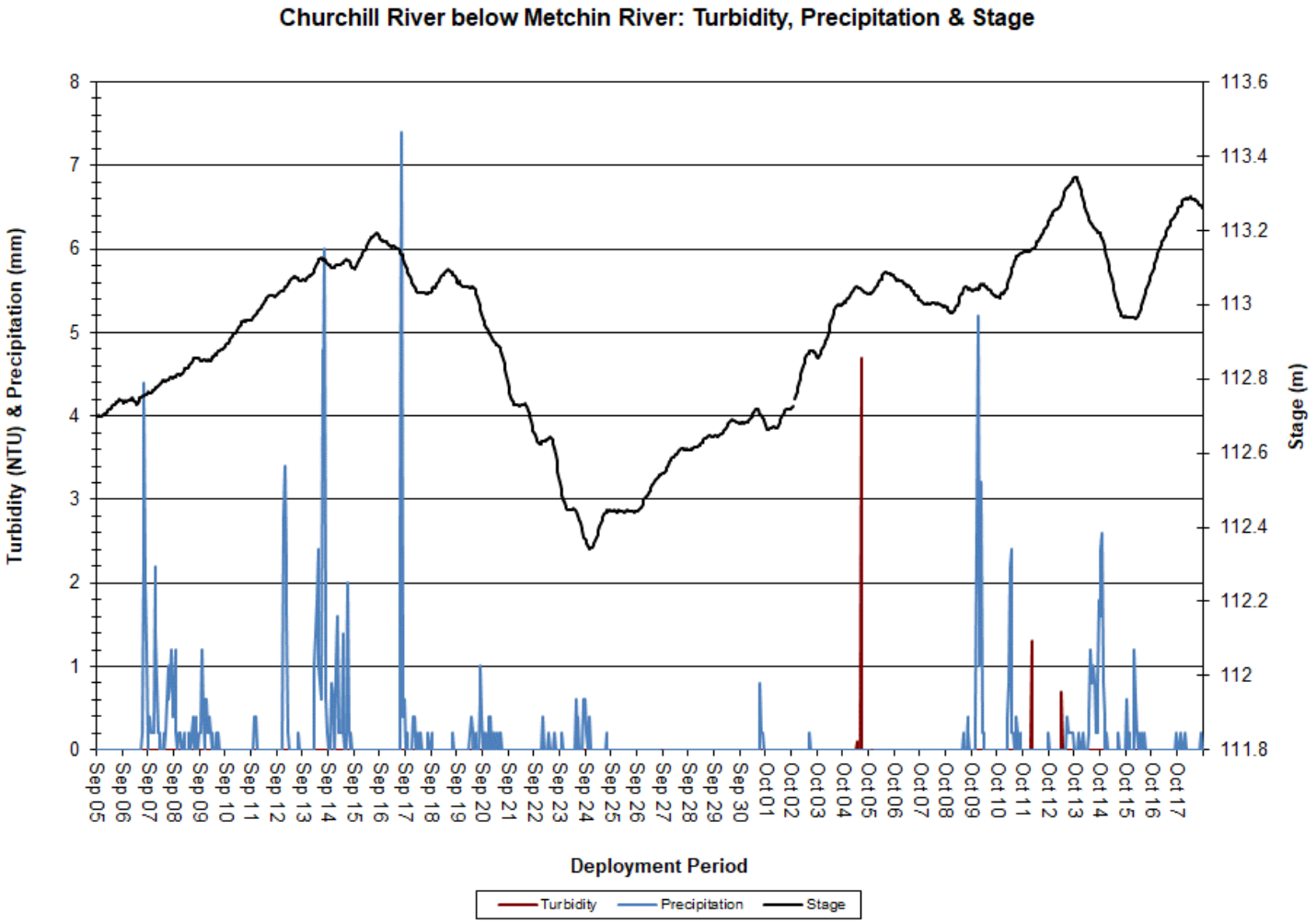

Figure 6: Turbidity, Precipitation & Stage at Churchill River below Metchin River

Stage and Flow

- Over the deployment period, stage levels ranged from 112.341m to 113.343m, with a median value of 112.994m. Flow ranged from 1040.07m^3/s to 1357.314m^3/s, with a median value of 1261.634m^3/s (Figure 7). Precipitation data was obtained from the Metchin River near TLH Weather Station.
- Stage and flow were relatively stable over the course of deployment. Precipitation events across the same period somewhat 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.

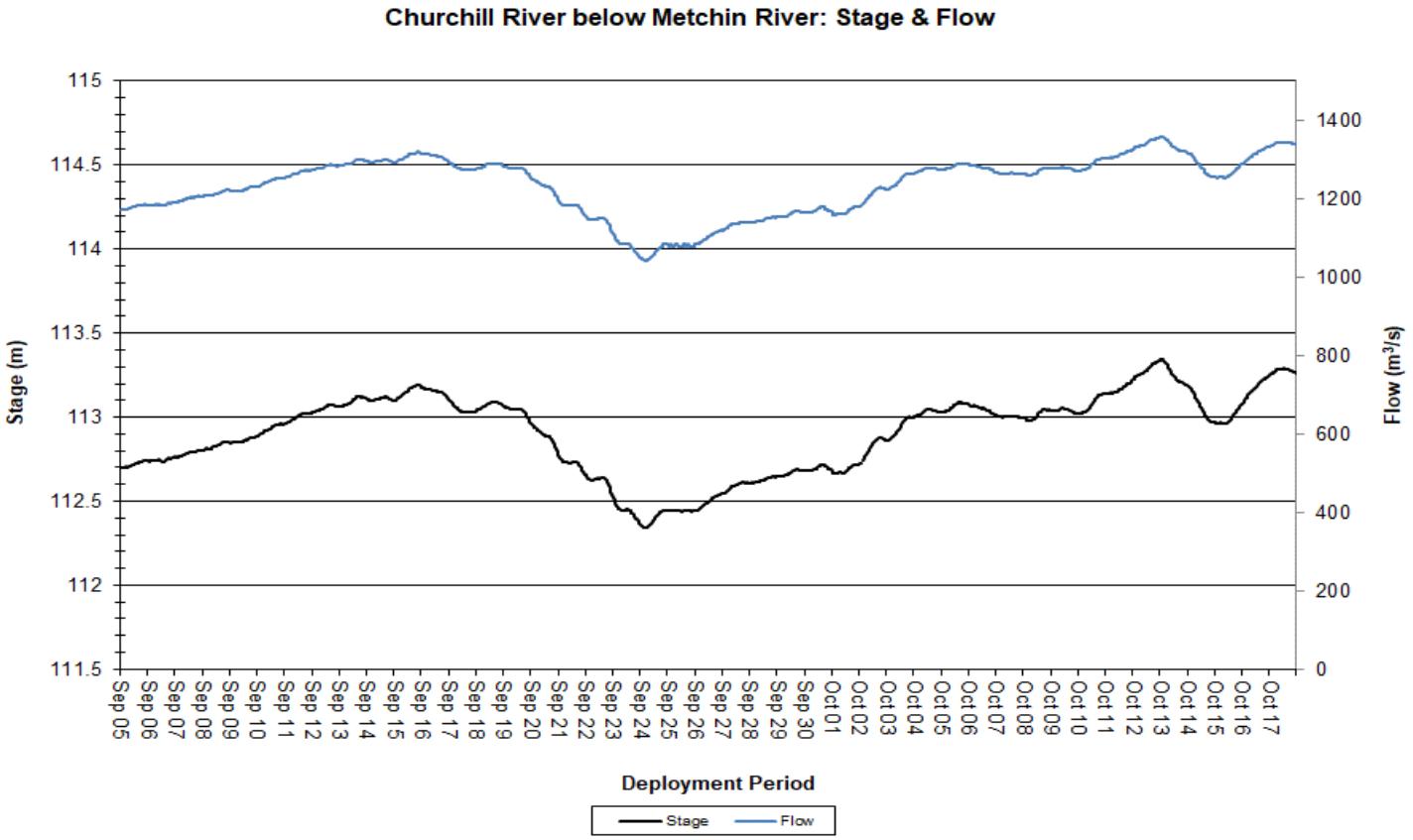

Figure 7: Stage & Flow at Churchill River below Metchin River

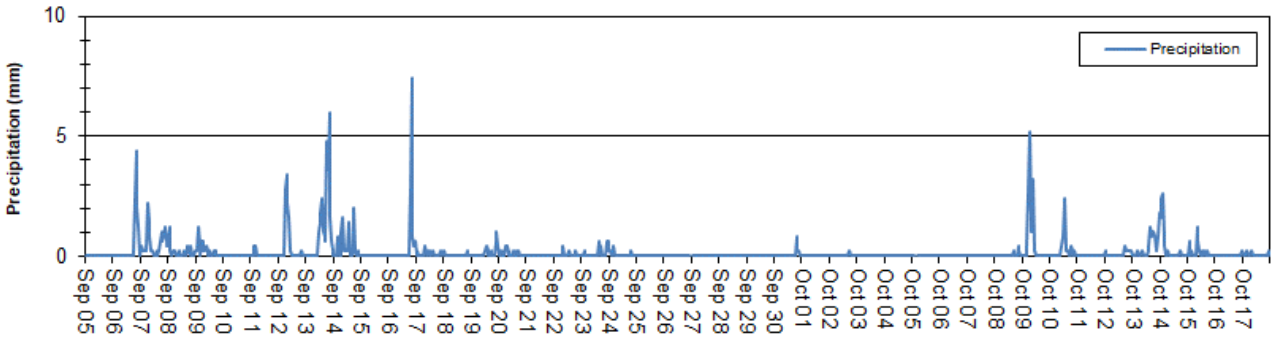

Figure 8: Precipitation at Churchill River below Metchin River

Churchill River above Grizzle Rapids

Water Temperature

- Over the deployment period, water temperature ranged from 6.6°C to 12.9°C, with a median value of 10.4°C (Figure 9). Air temperature data was obtained from the Metchin River near TLH Weather Station.
- Water temperature steadily 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.

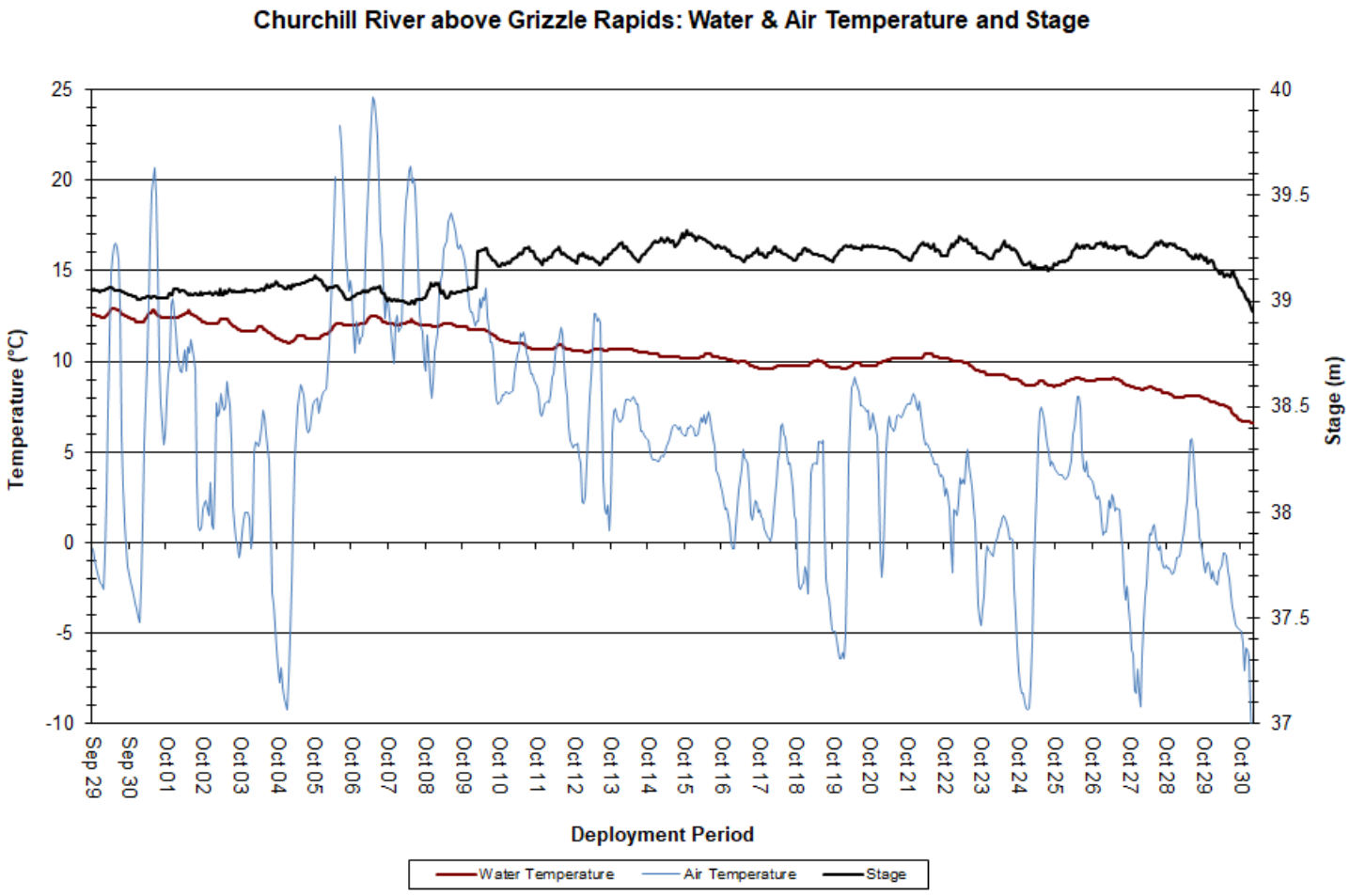

Figure 9: Water and Air Temperature & Stage at Churchill River above Grizzle Rapids

pH

- Over the deployment period, pH values ranged from 6.82 pH units to 6.94 pH units, with a median value of 6.87 (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.

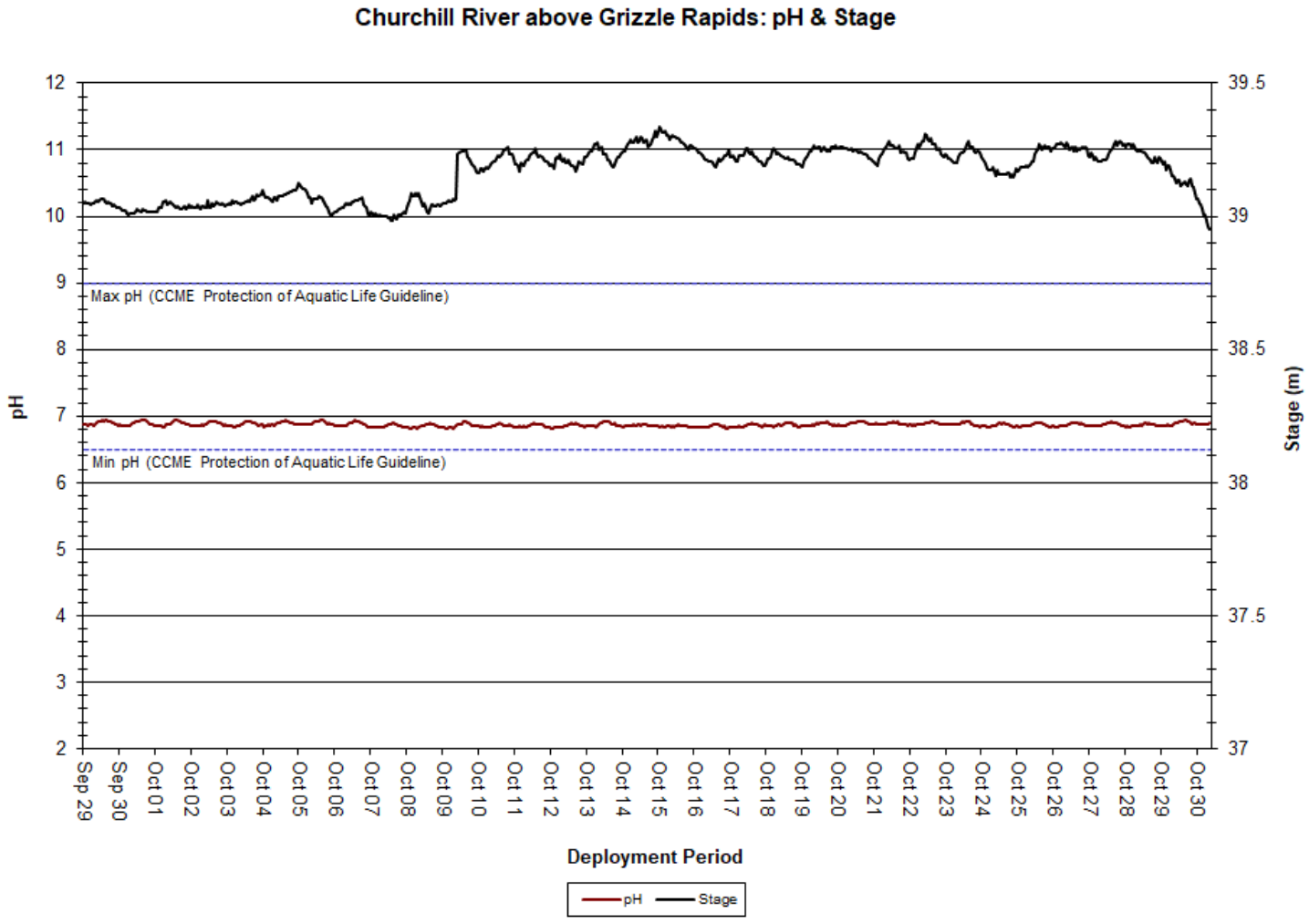

Figure 10: pH & Stage at Churchill River above Grizzle Rapids

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 19.1µS/cm to 21.2µS/cm, with a median of 19.6µS/cm (Figure 11).
- The relationship between conductivity and stage is generally inversed. When stage levels increase, specific conductivity levels generally decrease as the increased amount of water in the river system dilutes solids that are present. This relationship is only somewhat evident in the graph below, likely because this station is located at a deep and wide section of the Churchill River and other factors in the water column influence conductivity levels.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

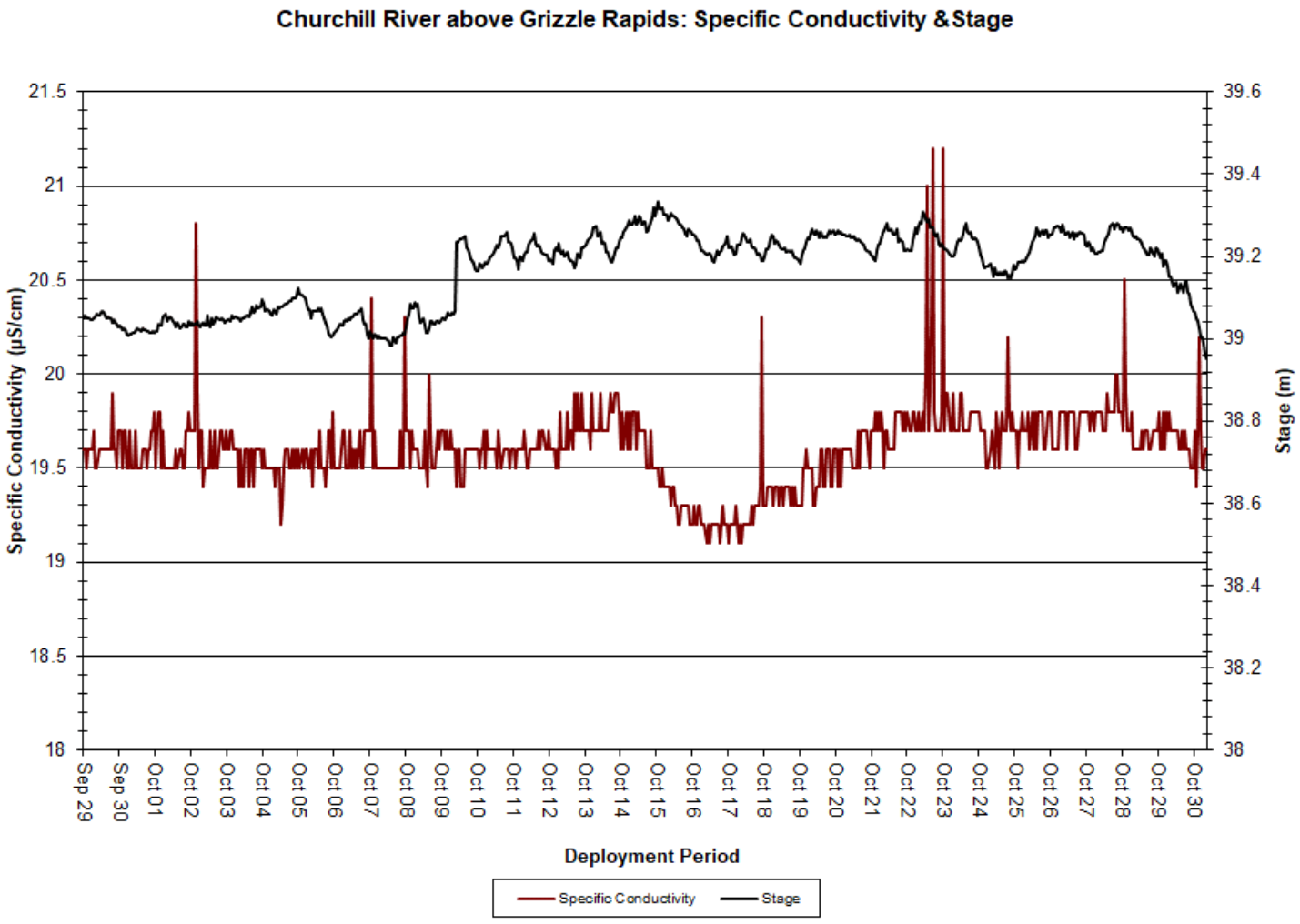

Figure 11: Specific Conductivity & Stage at Churchill River above Grizzle Rapids

Dissolved Oxygen

- Over the deployment period, dissolved oxygen content ranged from 10.34mg/L to 11.63mg/L, with a median value of 10.79mg/L. Saturation of dissolved oxygen ranged from 93.7% saturation to 99.5% saturation, with a median value of 96.5% (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 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.

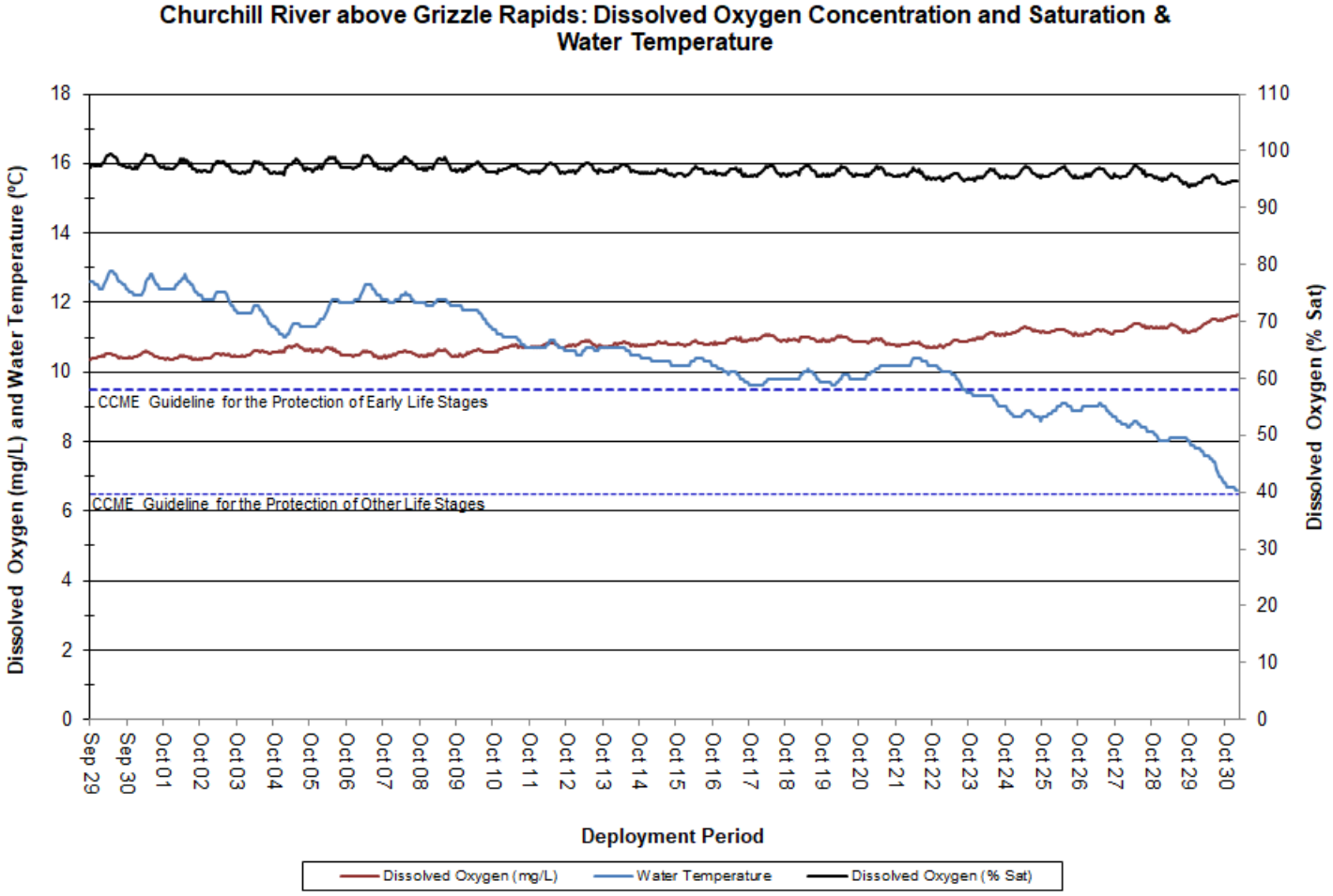

Figure 12: Dissolved Oxygen & Water Temperature at Churchill River above Grizzle Rapids

Turbidity

- Over the deployment period, turbidity ranged from 0.0NTU to 2.2NTU, 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. Precipitation data was obtained from the Metchin River near TLH Weather Station.
- A lone turbidity spike occurred during the deployment period and correlated with precipitation events (Figure 13). This station is located at a wide and deep section of the Churchill River and therefore turbidity levels are likely less susceptible to precipitation events as compared to other areas.
- 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.

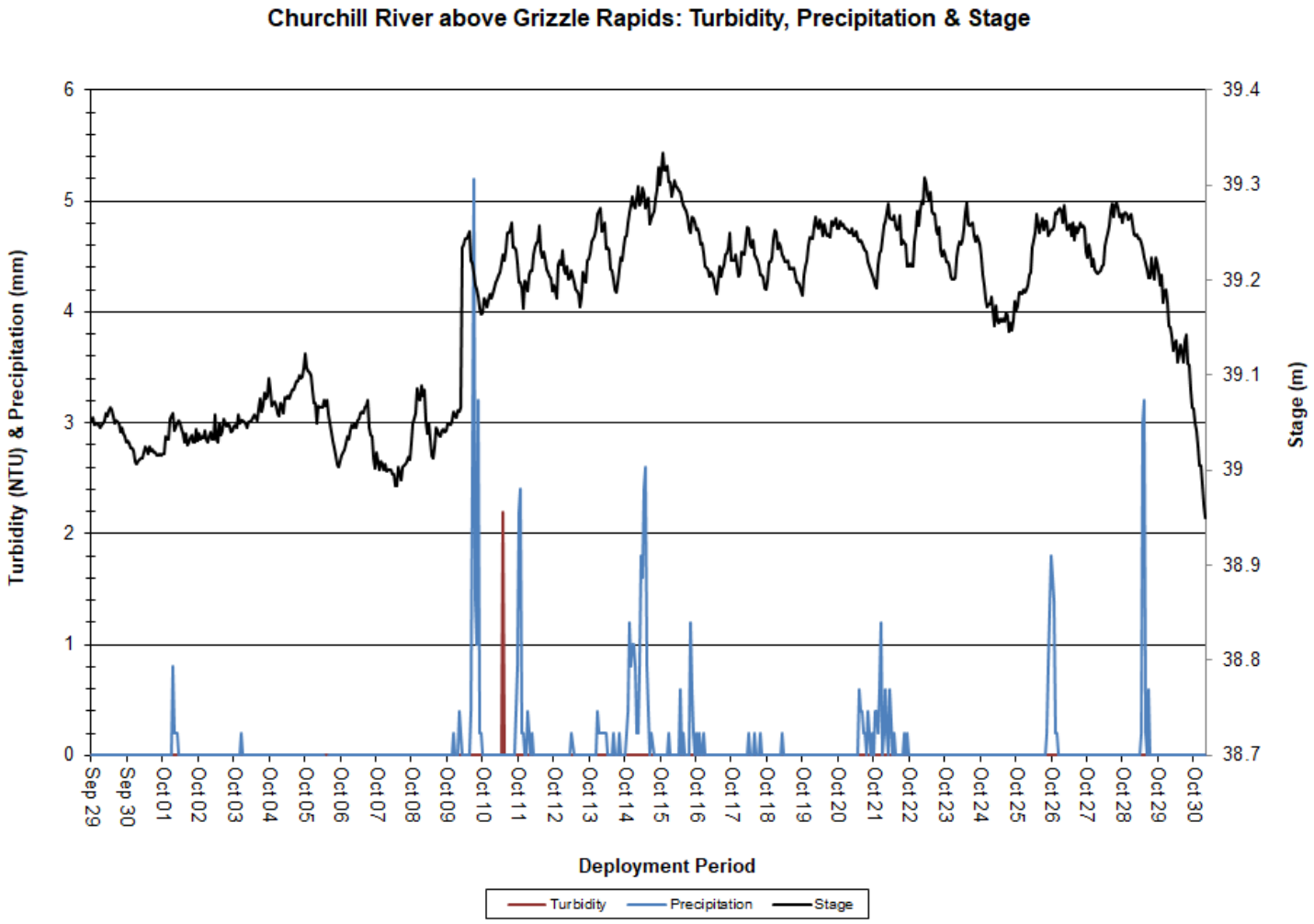

Figure 13: Turbidity, Precipitation & Stage at Churchill River above Grizzle Rapids

Stage

- Over the deployment period, stage ranged from 38.95m to 39.334m, with a median value of 39.204m (Figure 14). Precipitation data was obtained from the Metchin River near TLH Weather Station.
- Stage was quite stable across the deployment period, with precipitation events often correlating with slight increases in stage (Figure 14).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

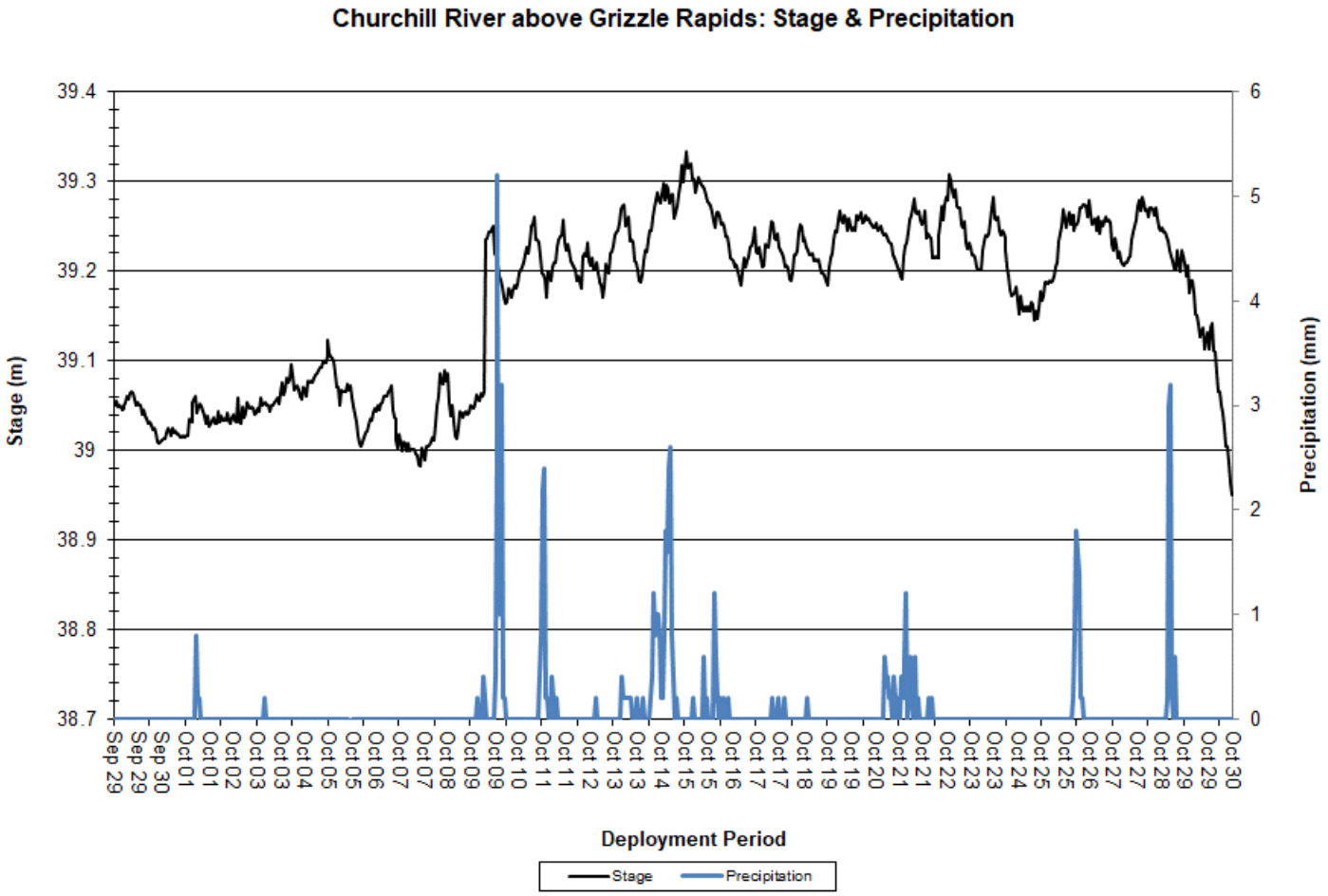

Figure 14: Stage & Precipitation at Churchill River above Grizzle Rapids

Churchill River below Muskrat Falls

Water Temperature

- Over the deployment period, water temperature ranged from 6.6°C to 13.6°C, with a median value of 11.3°C (Figure 15). 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 October.
- 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.

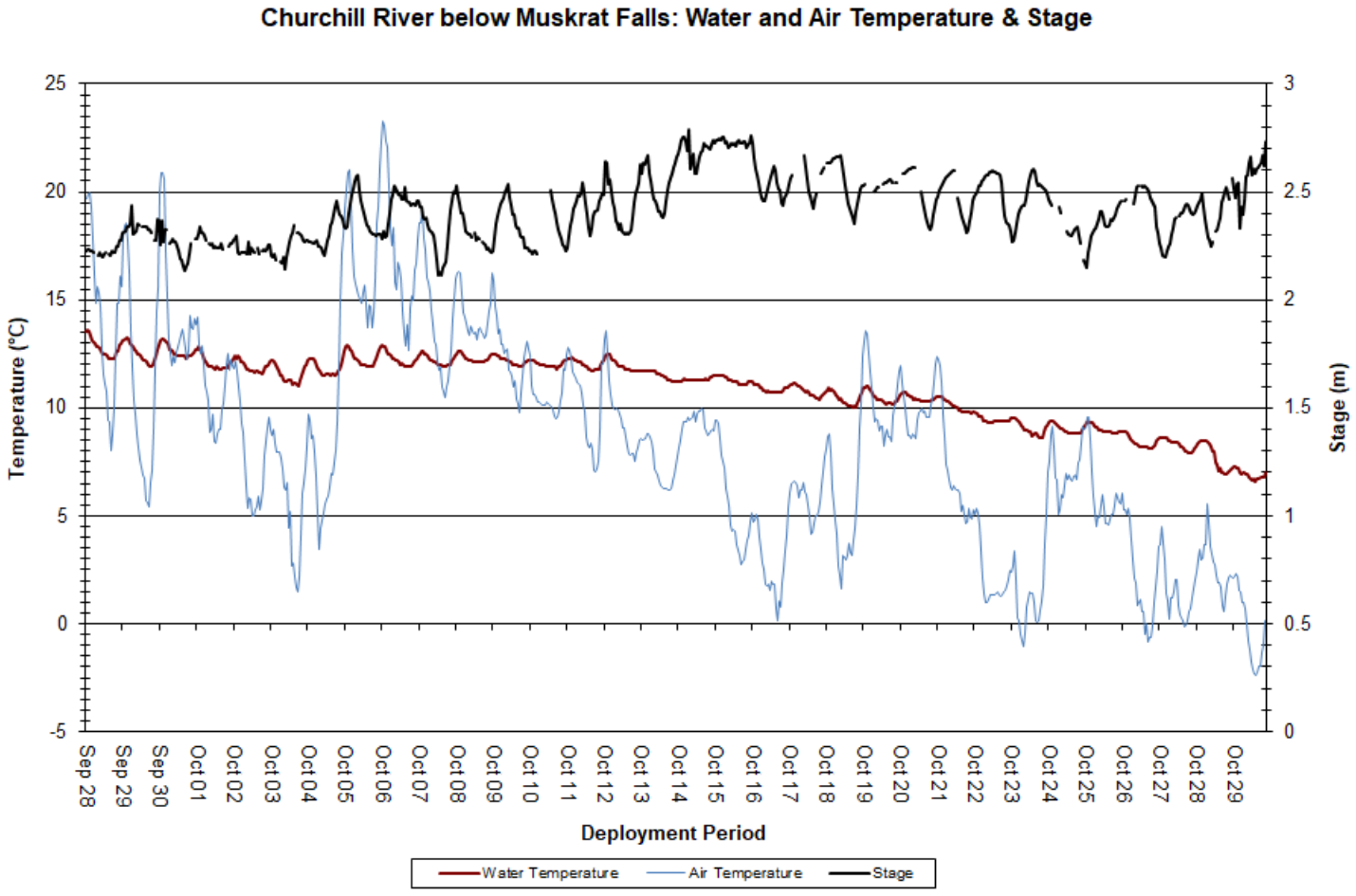

Figure 15: Water and Air Temperature & Stage at Churchill River below Muskrat Falls

pH

- Over the deployment period, pH ranged from 6.85 pH units to 7.06 pH units, with a median value of 6.92 (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 the deployment period (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.

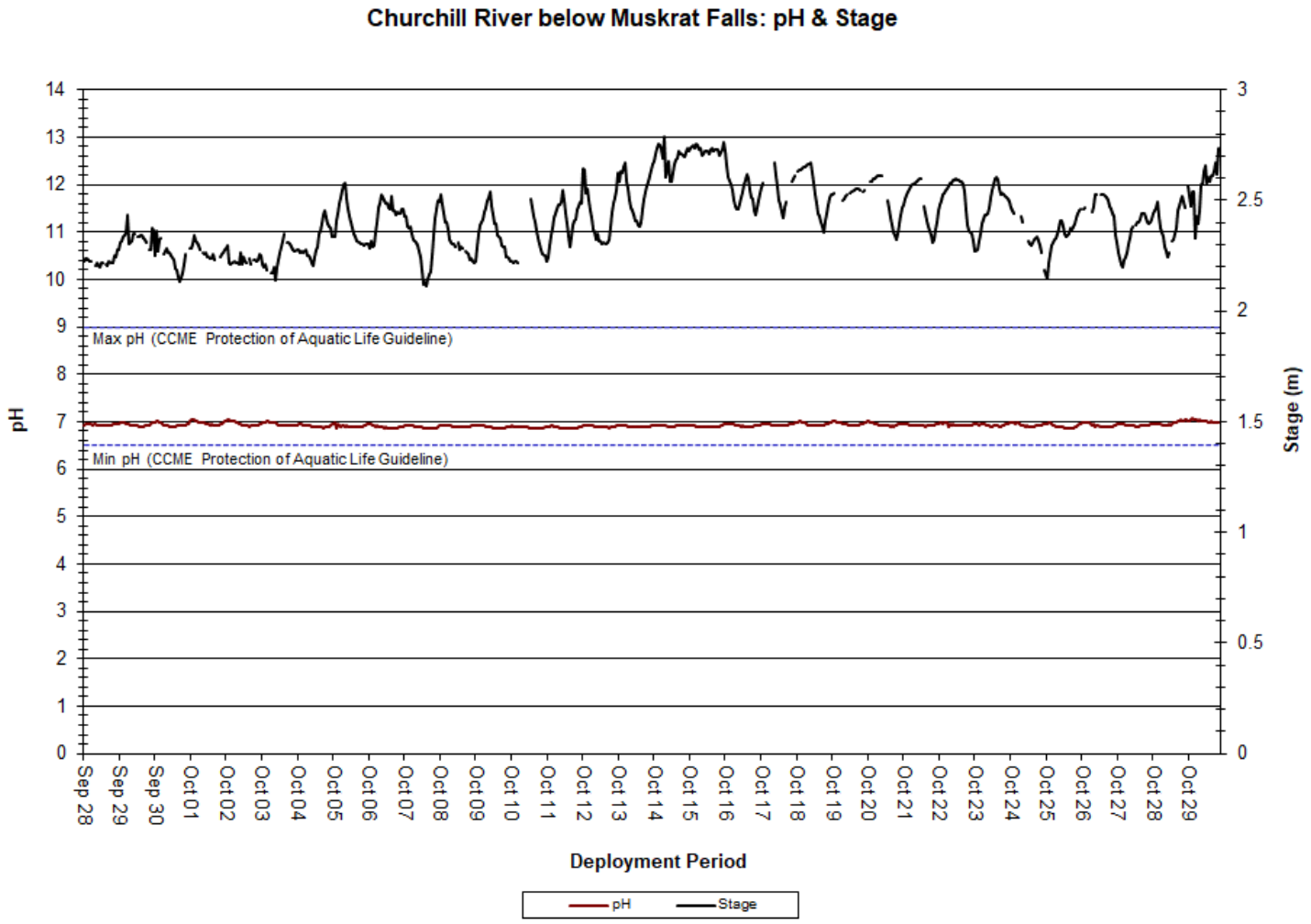

Figure 16: pH & Stage at Churchill River below Muskrat Falls

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 16.3µS/cm to 20.9µS/cm, with a median value of 19.1µS/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 only somewhat evident in the graph below, likely because this station is located at a deep and wide section of the Churchill River and other factors in the water column influence conductivity levels (Figure 17).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

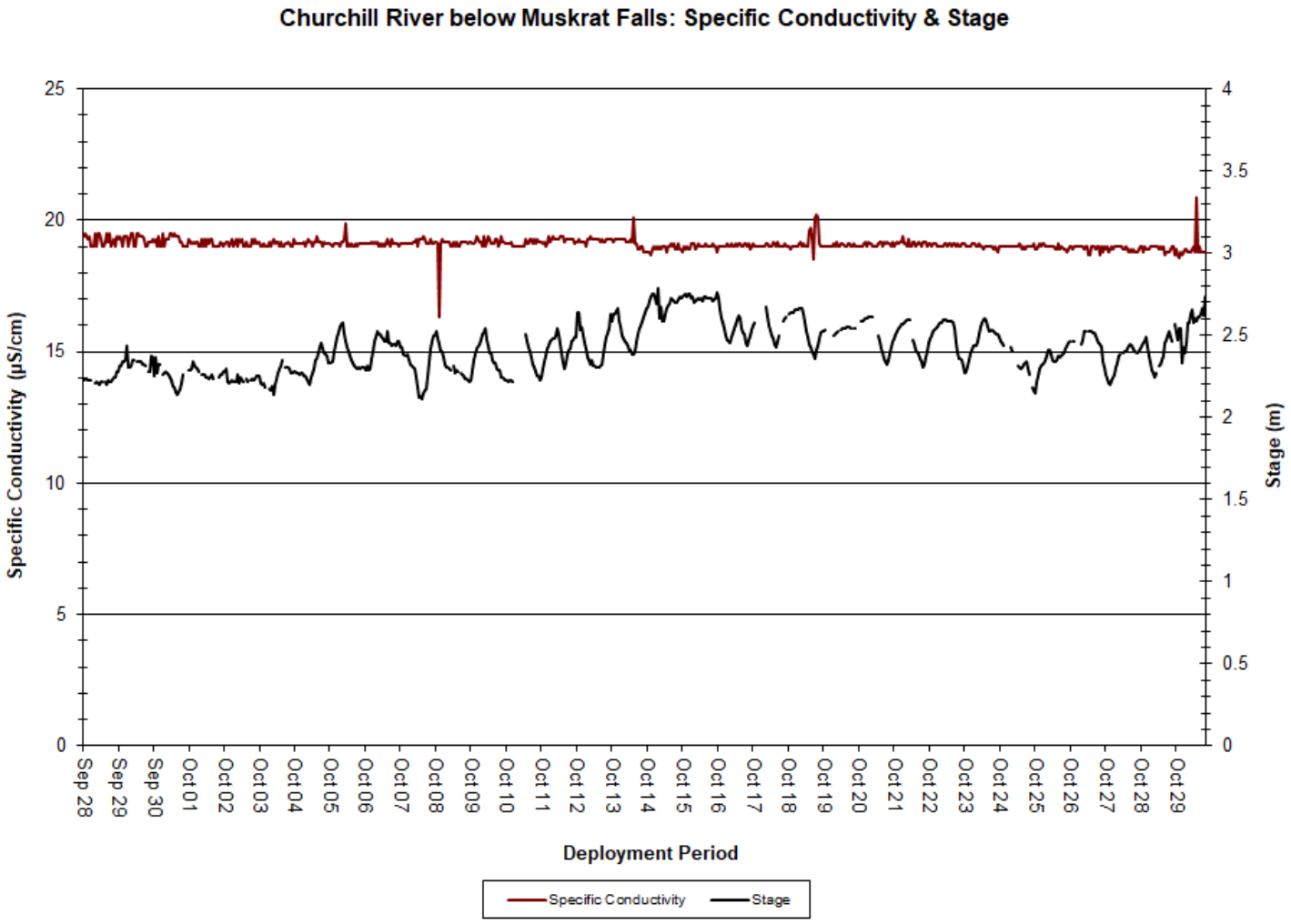

Figure 17: Specific Conductivity & Stage at Churchill River below Muskrat Falls

Dissolved Oxygen

- Over the deployment period, dissolved oxygen concentration ranged from 9.77mg/L to 11.68mg/L, with a median value of 10.32mg/L. Saturation of dissolved oxygen ranged from 91.3% to 97.9%, with a median value of 94.5% (Figure 18).
- Dissolved oxygen and water temperature exhibit an inverse relationship: as one parameter increases, the other decreases, and vice versa. Dissolved oxygen levels steadily increased over the course of deployment. This is to be expected since water temperatures were 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 were above the CCME's Guidelines for the Protection of Early and Other Life Stages for the duration of deployment.

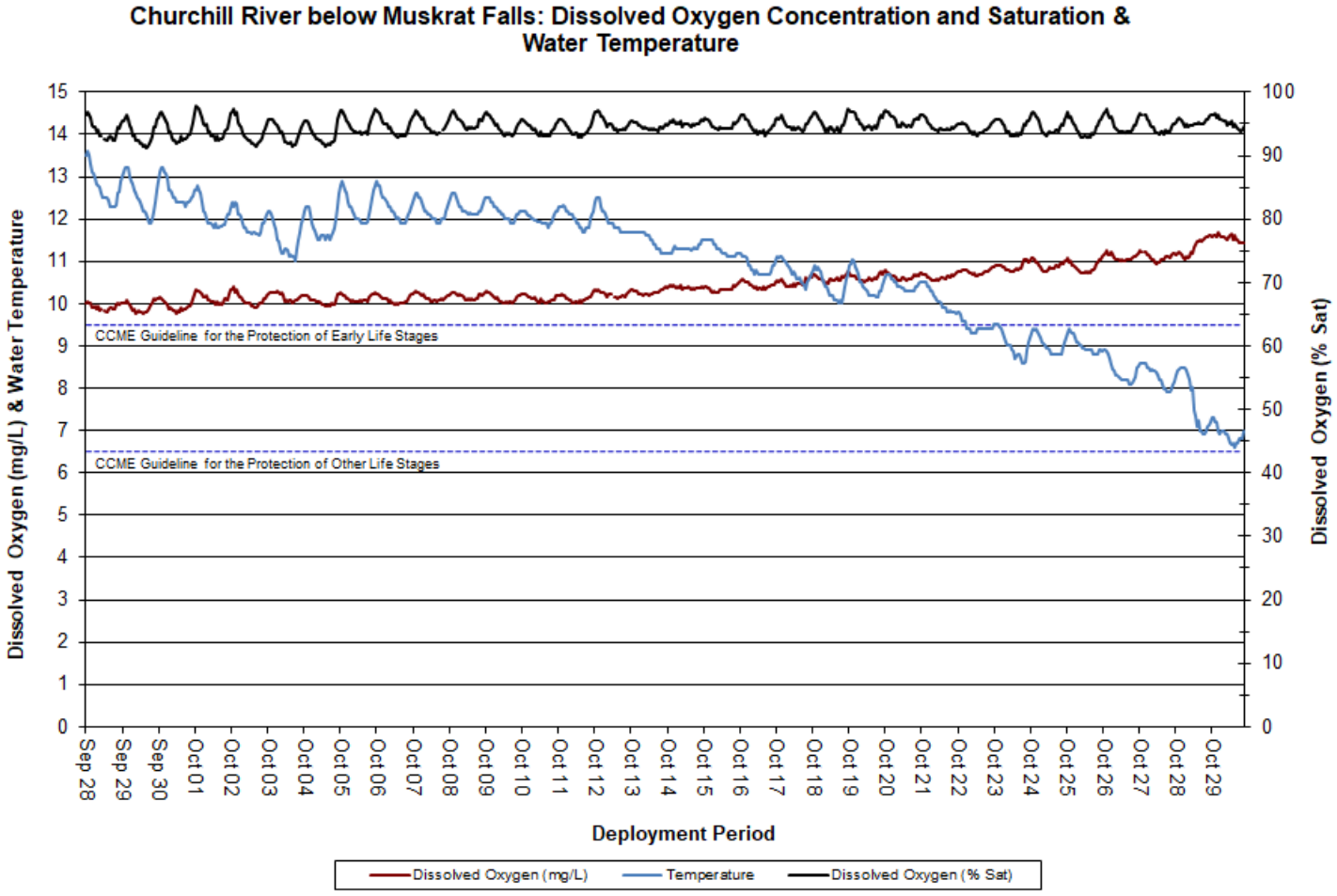

Figure 18: Dissolved Oxygen & Water Temperature at Churchill River below Muskrat Falls

Turbidity

- Over the deployment period, turbidity ranged from 0.6NTU to 85.3NTU, with a median value of 1.9NTU. A median value of 1.9NTU indicates a low level of natural background turbidity in the waterbody, which is typical of this station. Precipitation data was obtained from the Muskrat Falls MET Station.
- There was relatively good correlation between turbidity and precipitation events across the deployment period (Figure 19). Turbidity levels are often quite variable at this station, and do not always correlate with precipitation events given that this station is located on a wide and deep section of the Churchill River.
- 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.

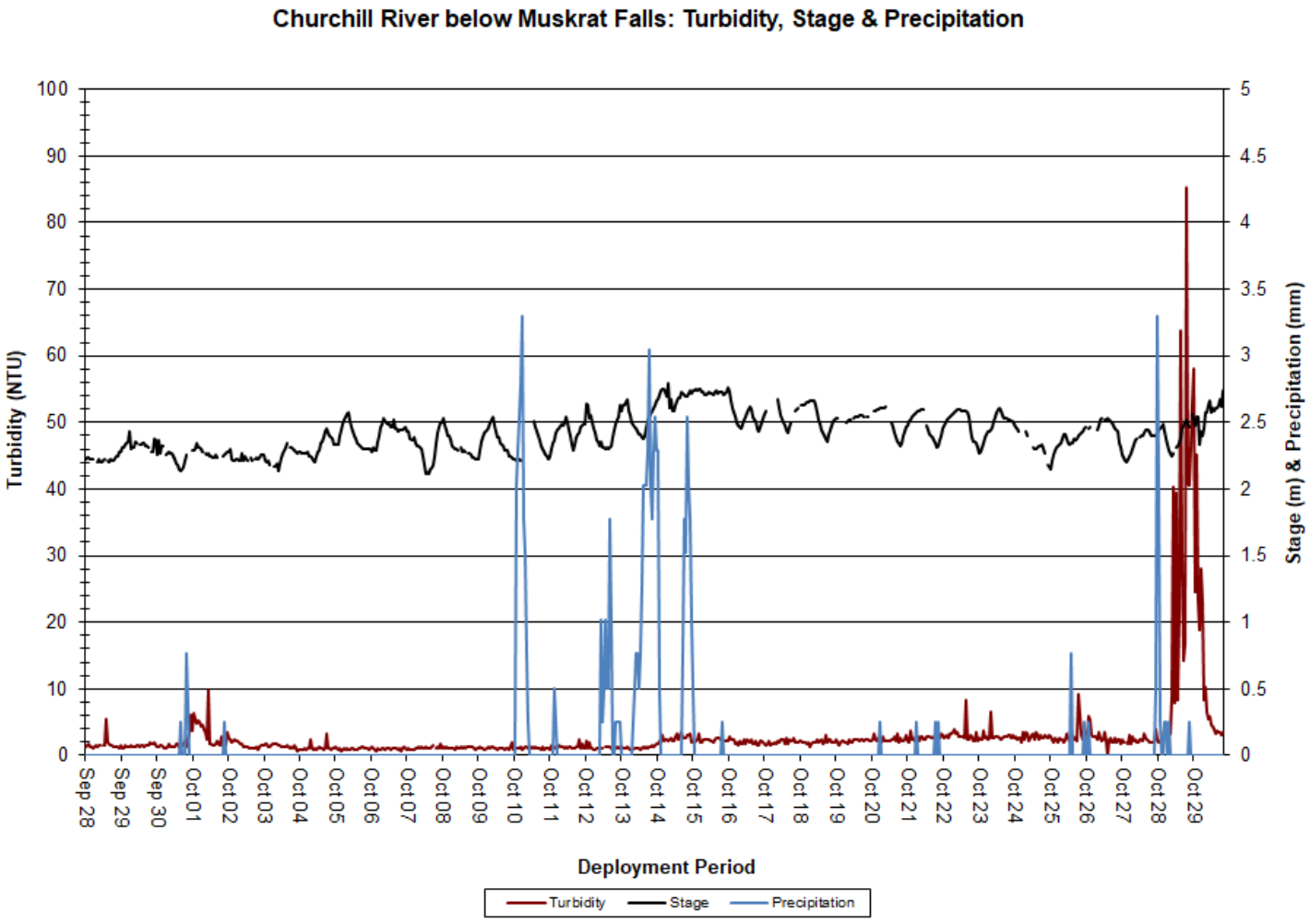

Figure 19: Turbidity, Precipitation & Stage at Churchill River below Muskrat Falls

Stage & Flow

- Over the deployment period, stage ranged from 2.115m to 2.79m, with a median value of 2.409m. Flow ranged from 1134.285m^3/s to 1776.057m^3/s, with a median value of 1398.412m^3/s (Figure 20). Precipitation data was obtained from the Muskrat Falls MET Station.
- Stage and flow were variable but somewhat increasing over the course of deployment, and often correlated with precipitation events. This is partly related to the fact that this station is located on a very wide section of the Churchill River and therefore is not as easily influenced by smaller precipitation events. Stage and flow at this station are also influenced by upstream activities at the Muskrat Falls hydroelectric project.
- 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.

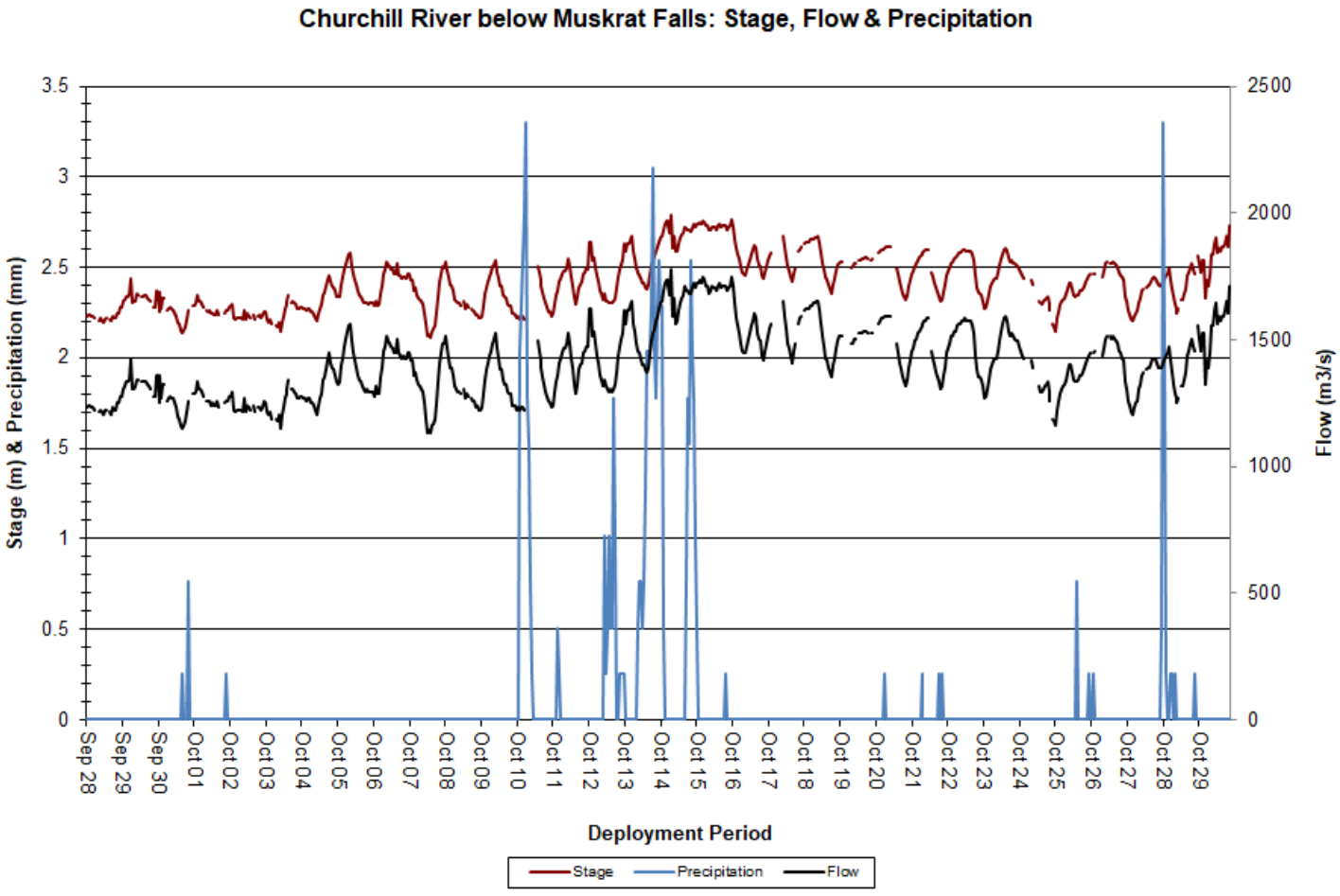

Figure 20: Stage, Flow & Precipitation at Churchill River below Muskrat Falls

Churchill River at English Point

Water Temperature

- Water temperature ranged from 4.6°C to 13.5C, with a median value of 10.7°C (Figure 21). Air temperature data was obtained from the Churchill River at End of Mud Lake Road Weather Station.
- Water temperature decreased steadily across the deployment period. Water temperatures closely correlated with ambient air temperatures, which followed a similar trend across the same period.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

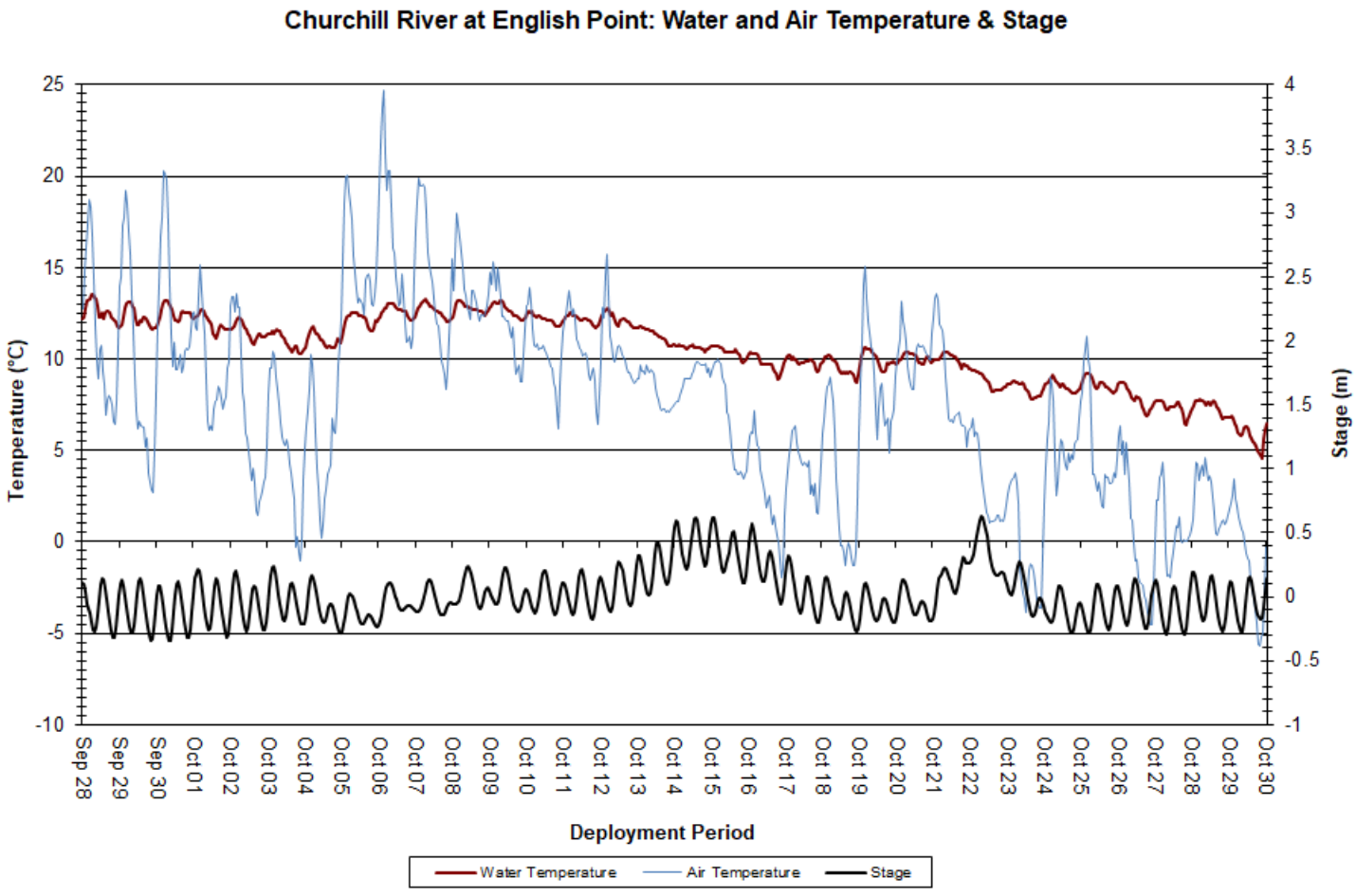

Figure 21: Water and Air Temperature & Stage at Churchill River at English Point

pH

- Over the deployment period, pH ranged from 5.56 pH units to 7.23 pH units, with a median value of 6.75 (Figure 22).
- pH values were relatively stable for the first half of deployment, after which they started to decrease. pH values were within the CCME's Guidelines for the Protection of Aquatic Life for the first half of deployment. From October 15th onwards, pH values were below the CCME's Minimum Guideline (Figure 22).
- 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.

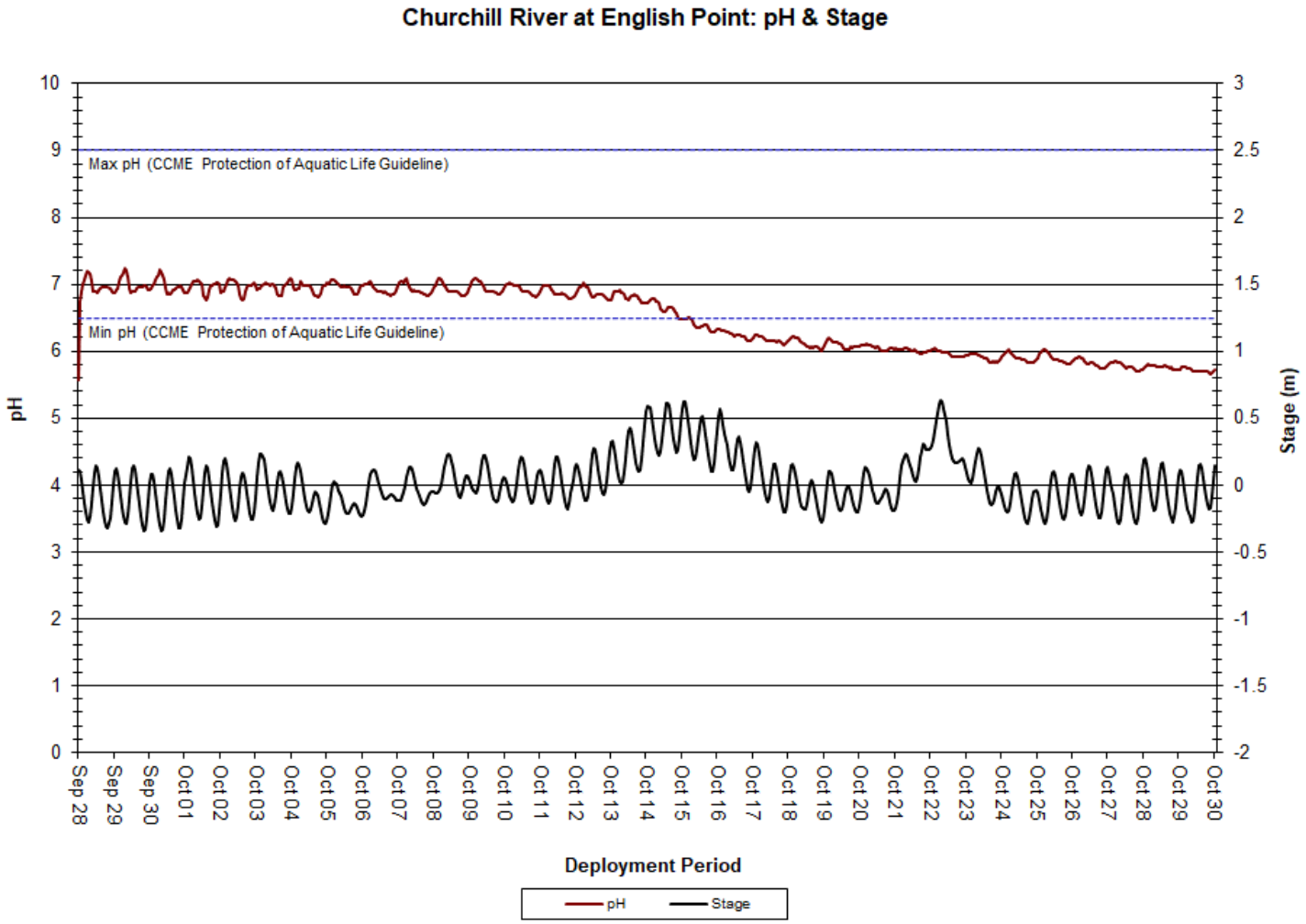

Figure 22: pH & Stage at Churchill River at English Point

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 19.3µS/cm to 45.2µs/cm, with a median value of 27.7µS/cm (Figure 23).
- Specific conductivity fluctuates considerably at this location due to the tidal influences of the Atlantic Ocean on Lake Melville. As the tide comes in, 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 23).
- 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.

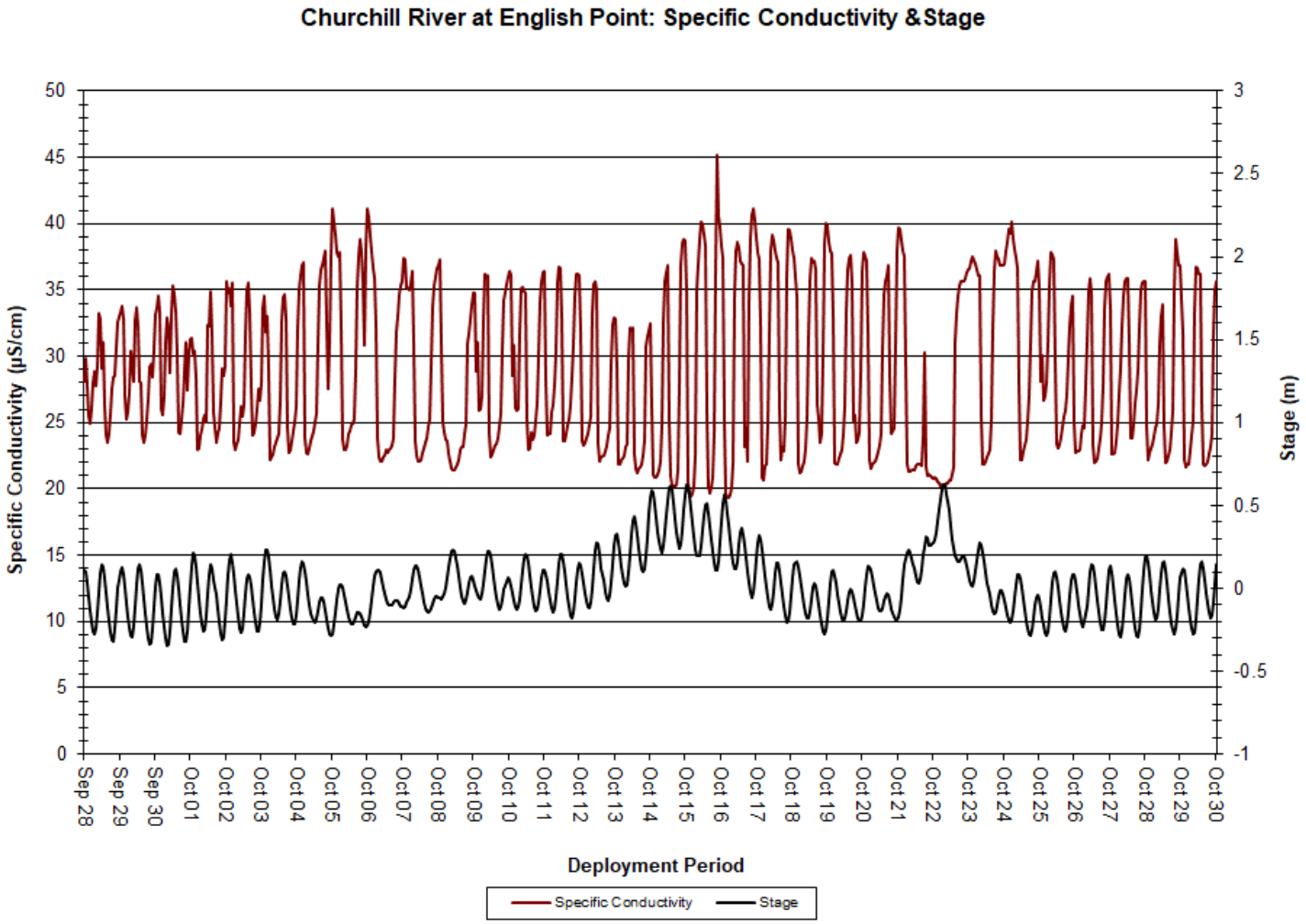

Figure 23: Specific Conductivity & Stage at Churchill River at English Point

Dissolved Oxygen

- Over the deployment period, dissolved oxygen concentration ranged from 9.66mg/L to 11.91mg/L, with a median value of 10.48mg/L. Saturation of dissolved oxygen ranged from 88.0% to 102.5% saturation, with a median value of 94.3% (Figure 24).
- There is an evident relationship between water temperature and dissolved oxygen. As water temperatures decreased over the deployment period, dissolved oxygen levels 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 were above the CCME's Guidelines for the Protection of Early and Other Life Stages for the duration of deployment (Figure 24).

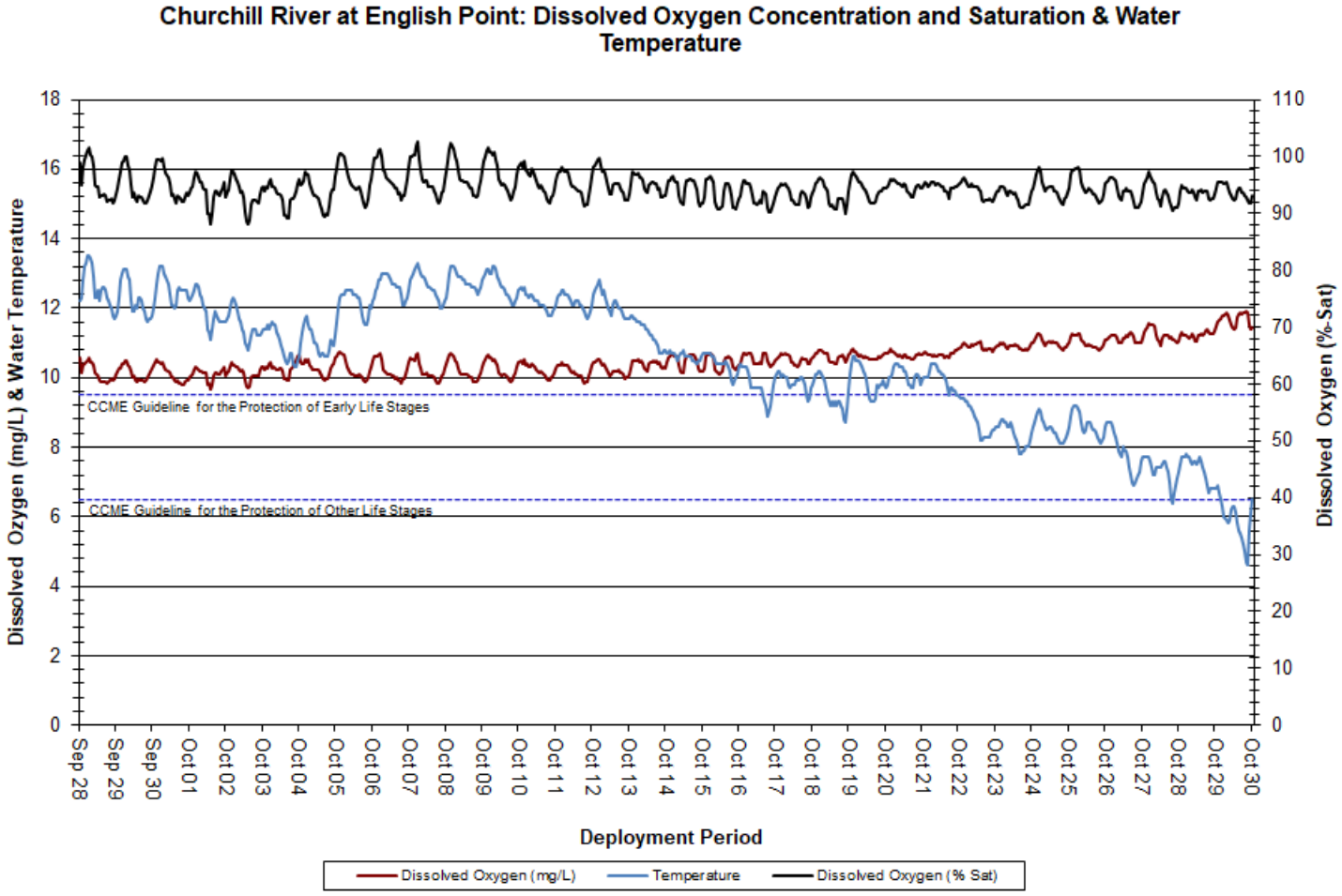

Figure 24: Dissolved Oxygen & Water Temperature at Churchill River at English Point

Turbidity

- Over the deployment period, turbidity ranged from 0 NTU to 77.2 NTU, with a median value of 0.8 NTU (Figure 25). A median value of 0.8 NTU indicates a low level of background turbidity; which is typical 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 often correlate with precipitation events, as these can increase the presence of suspended material in water. High winds and tidal influences also contribute to turbidity events at this station by disturbing sediment from the river bed (Figure 25). 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.

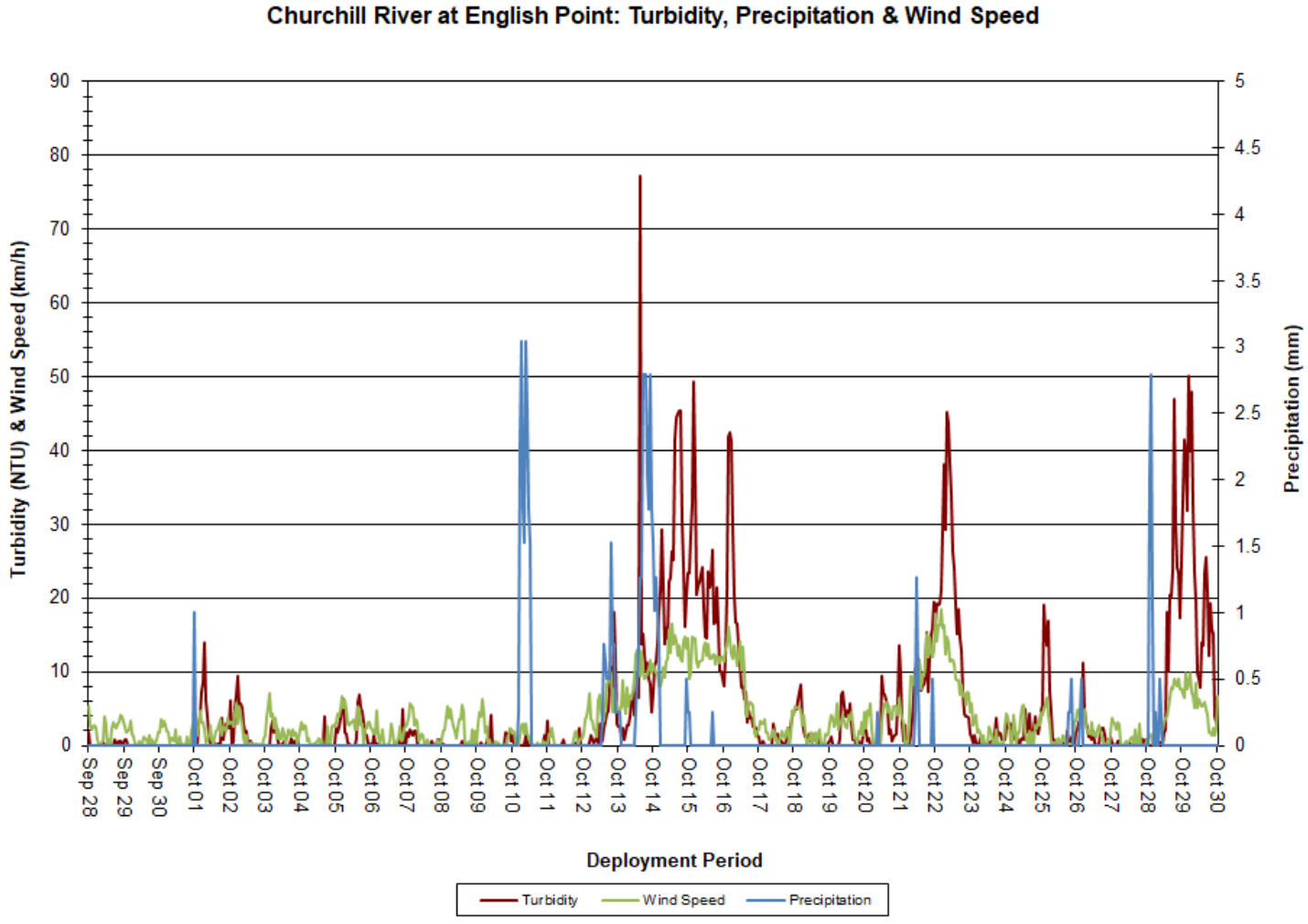

Figure 25: Turbidity, Precipitation & Wind Speed at Churchill River at English Point

Stage

- Over the deployment period, stage ranged from -0.346m to 0.629m, with a median value of -0.007m (Figure 26). 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.
- 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.

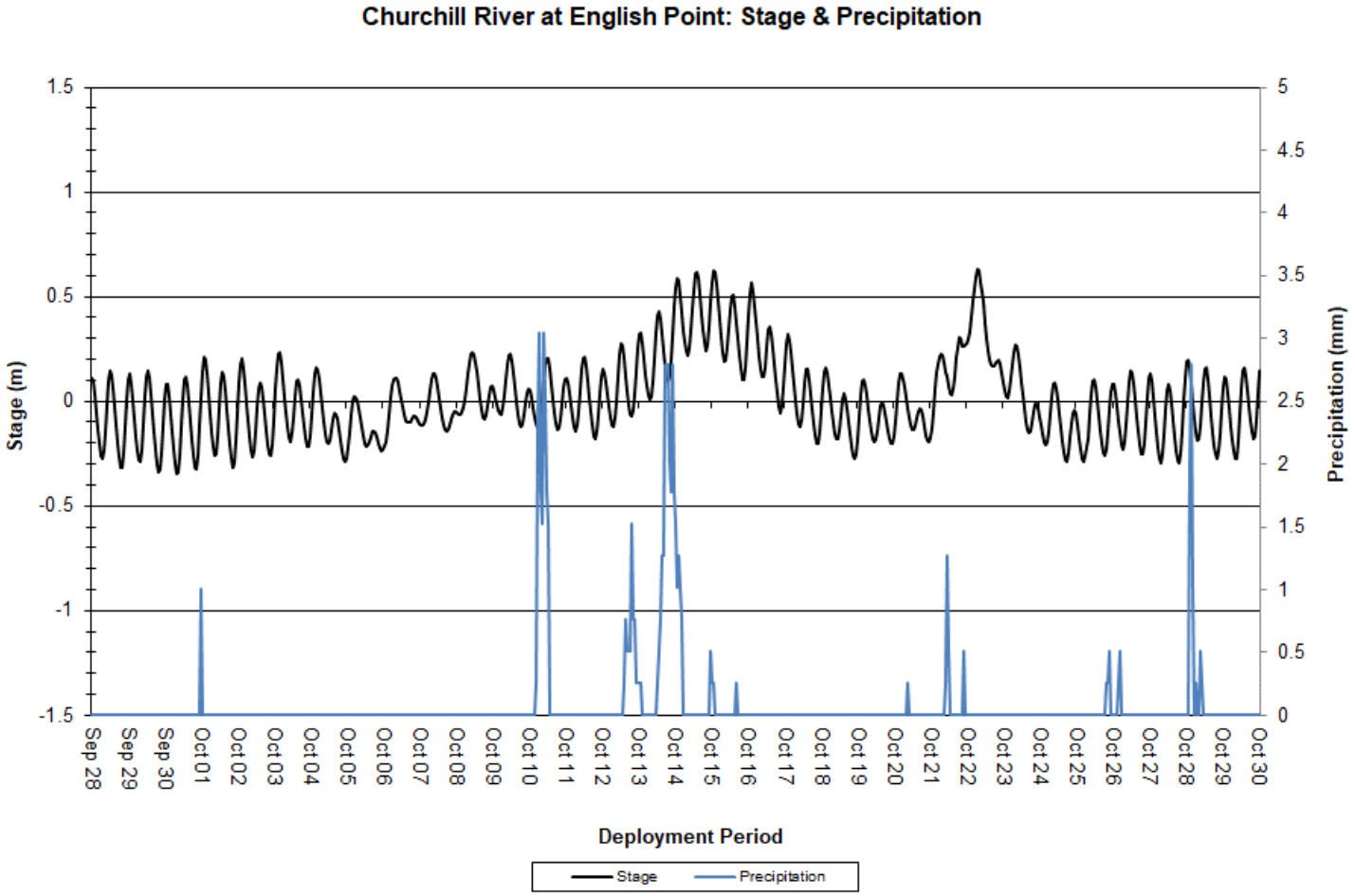

Figure 26: Stage & Precipitation at Churchill River at English Point

Conclusions

- Instruments at four water quality monitoring stations on the Lower Churchill River were deployed from September 5/28 through October 18/30, 2023.
- Water temperature decreased steadily at all stations over the course of deployment. This is to be expected based on ambient air temperature trends during the same period through September and 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 all stations, except for Churchill River at English Point.
- Specific conductivity was generally stable 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. Dissolved oxygen levels are generally higher in water at 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 at all stations.
- Turbidity events occurred at all stations and were somewhat related to precipitation, wind or tidal events.

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

Sample Details/Parameters	A	Result	RDL	UNITS	Extracted	Analyzed	By	Batch
WYN068 CR BELOW MR								
Sampling Date 2023/09/05 12:45								
Matrix W								
Sample # 2023-6321-00-SI-SP								
Registration # SA-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Hardness (CaCO3)	-	11	1.0	mg/L	N/A	2023/09/14		8910068
Nitrate (N)	-	ND	0.050	mg/L	N/A	2023/09/22		8910070
Total dissolved solids (calc., EC)	-	13	1.0	mg/L	N/A	2023/09/20		8910074
Inorganics								
Conductivity	-	24	1.0	uS/cm	N/A	2023/09/19	LJV	8925305
Chloride (Cl-)	-	ND	1.0	mg/L	N/A	2023/09/15	LKH	8917225
Bromide (Br-)	-	ND	1.0	mg/L	N/A	2023/09/15	LKH	8917225
Sulphate (SO4)	-	ND	1.0	mg/L	N/A	2023/09/15	LKH	8917225
Total Alkalinity (Total as CaCO3)	-	10	2.0	mg/L	N/A	2023/09/19	LJV	8925306
Colour	-	15	5.0	TCU	N/A	2023/09/22	HGV	8931412
Dissolved Fluoride (F-)	-	ND	0.10	mg/L	N/A	2023/09/19	LJV	8925307
Total Kjeldahl Nitrogen (TKN)	-	ND	0.10	mg/L	2023/09/15	2023/09/18	KJP	8921094
Nitrate + Nitrite (N)	-	ND	0.050	mg/L	N/A	2023/09/22	MCN	8931448
Nitrite (N)	-	ND	0.010	mg/L	N/A	2023/09/21	MCN	8931471
Nitrogen (Ammonia Nitrogen)	-	ND	0.050	mg/L	N/A	2023/09/21	HGV	8929676
Dissolved Organic Carbon (C)	-	3.2	0.50	mg/L	N/A	2023/09/20	ACK	8925785
Total Organic Carbon (C)	-	3.1	0.50	mg/L	N/A	2023/09/19	CPP	8925846
pH	-	7.21		pH	N/A	2023/09/19	LJV	8925302
Total Phosphorus	-	0.004	0.004	mg/L	2023/09/19	2023/09/20	SPC	8926617
Total Suspended Solids	-	ND	1.0	mg/L	2023/09/12	2023/09/19	RDM	8910356
Turbidity	-	0.69	0.10	NTU	N/A	2023/09/19	LJV	8925568
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	-	ND	0.000013	mg/L	2023/09/20	2023/09/22	SGK	8928182
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	-	0.020	0.0050	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Antimony (Sb)	-	ND	0.0010	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Arsenic (As)	-	ND	0.0010	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Barium (Ba)	-	0.0074	0.0010	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Boron (B)	-	ND	0.050	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Cadmium (Cd)	-	ND	0.000010	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Calcium (Ca)	-	2.9	0.10	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Chromium (Cr)	-	ND	0.0010	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Copper (Cu)	-	ND	0.00050	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Iron (Fe)	-	0.12	0.050	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Lead (Pb)	-	ND	0.00050	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Magnesium (Mg)	-	0.92	0.10	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Manganese (Mn)	-	0.023	0.0020	mg/L	2023/09/13	2023/09/14	MTZ	8913044

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Sample Details/Parameters	A	Result	RDL	UNITS	Extracted	Analyzed	By	Batch
WYN068 CR BELOW MR Sampling Date 2023/09/05 12:45 Matrix W Sample # 2023-6321-00-SI-SP Registration # SA-0000								
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Nickel (Ni)	-	ND	0.0020	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Phosphorus (P)	-	ND	0.10	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Potassium (K)	-	0.29	0.10	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Selenium (Se)	-	ND	0.00050	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Sodium (Na)	-	0.58	0.10	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Strontium (Sr)	-	0.012	0.0020	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Uranium (U)	-	ND	0.00010	mg/L	2023/09/13	2023/09/14	MTZ	8913044
Total Zinc (Zn)	-	ND	0.0050	mg/L	2023/09/13	2023/09/14	MTZ	8913044

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Bureau Veritas Job #: C3U6641
Report Date: 2023/10/25

NL Department of Environment, Climate Change and Municipalities
Site Location: LABRADOR
Your P.O. #: 220028978-9

Sample Details/Parameters	A	Result	RDL	UNITS	Extracted	Analyzed	By	Batch
XEK342 CR BELOW MF Sampling Date 2023/09/28 11:10 Matrix W Sample # 2023-6327-00-SI-SP Registration # SA-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Hardness (CaCO3)	-	9.5	1.0	mg/L	N/A	2023/10/25		8958939
Nitrate (N)	-	0.052	0.050	mg/L	N/A	2023/10/21		8960058
Total dissolved solids (calc., EC)	-	13	1.0	mg/L	N/A	2023/10/17		8959186
Inorganics								
Conductivity	-	24	1.0	uS/cm	N/A	2023/10/16	LJV	8979539
Chloride (Cl-)	-	ND	1.0	mg/L	N/A	2023/10/13	LKH	8974489
Bromide (Br-)	-	ND	1.0	mg/L	N/A	2023/10/13	LKH	8974489
Sulphate (SO4)	-	ND	1.0	mg/L	N/A	2023/10/13	LKH	8974489
Total Alkalinity (Total as CaCO3)	-	8.6	2.0	mg/L	N/A	2023/10/16	LJV	8979565
Colour	-	37	5.0	TCU	N/A	2023/10/21	MCN	8989818
Dissolved Fluoride (F-)	-	ND	0.10	mg/L	N/A	2023/10/16	LJV	8979575
Total Kjeldahl Nitrogen (TKN)	-	0.10	0.10	mg/L	2023/10/12	2023/10/16	RTY	8976193
Nitrate + Nitrite (N)	-	0.052	0.050	mg/L	N/A	2023/10/20	MCN	8989816
Nitrite (N)	-	ND	0.010	mg/L	N/A	2023/10/20	MCN	8989481
Nitrogen (Ammonia Nitrogen)	-	ND	0.050	mg/L	N/A	2023/10/13	MCN	8975618
Dissolved Organic Carbon (C)	-	4.9	0.50	mg/L	N/A	2023/10/13	CPP	8979060
Total Organic Carbon (C)	-	4.8	0.50	mg/L	N/A	2023/10/13	CPP	8976328
pH	-	7.18		pH	N/A	2023/10/16	LJV	8979522
Total Phosphorus	-	0.022	0.004	mg/L	2023/10/12	2023/10/17	SSV	8976345
Total Suspended Solids	-	16	1.0	mg/L	2023/10/05	2023/10/06	CAC	8962772
Turbidity	-	1.6	0.10	NTU	N/A	2023/10/16	LJV	8979812
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	-	ND	0.000013	mg/L	2023/10/17	2023/10/18	SGK	8986054
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	-	0.27	0.0050	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Antimony (Sb)	-	ND	0.0010	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Arsenic (As)	-	ND	0.0010	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Barium (Ba)	-	0.0096	0.0010	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Boron (B)	-	ND	0.050	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Cadmium (Cd)	-	ND	0.000010	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Calcium (Ca)	-	2.4	0.10	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Chromium (Cr)	-	ND	0.0010	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Copper (Cu)	-	0.00085	0.00050	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Iron (Fe)	-	0.44	0.050	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Lead (Pb)	-	ND	0.00050	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Magnesium (Mg)	-	0.85	0.10	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Manganese (Mn)	-	0.020	0.0020	mg/L	2023/10/23	2023/10/25	MTZ	8998849

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Sample Details/Parameters	A	Result	RDL	UNITS	Extracted	Analyzed	By	Batch
XEK342 CR BELOW MF Sampling Date 2023/09/28 11:10 Matrix W Sample # 2023-6327-00-SI-SP Registration # SA-0000								
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Nickel (Ni)	-	ND	0.0020	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Phosphorus (P)	-	ND	0.10	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Potassium (K)	-	0.34	0.10	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Selenium (Se)	-	ND	0.00050	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Sodium (Na)	-	0.66	0.10	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Strontium (Sr)	-	0.013	0.0020	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Uranium (U)	-	ND	0.00010	mg/L	2023/10/23	2023/10/25	MTZ	8998849
Total Zinc (Zn)	-	ND	0.0050	mg/L	2023/10/23	2023/10/25	MTZ	8998849

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Sample Details/Parameters	A	Result	RDL	UNITS	Extracted	Analyzed	By	Batch
XEK343 CR @ EP Sampling Date 2023/09/28 12:00 Matrix W Sample # 2023-6328-00-SI-SP Registration # SA-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Hardness (CaCO3)	-	10	1.0	mg/L	N/A	2023/10/23		8958939
Nitrate (N)	-	0.057	0.050	mg/L	N/A	2023/10/21		8960058
Total dissolved solids (calc., EC)	-	16	1.0	mg/L	N/A	2023/10/19		8959186
Inorganics								
Conductivity	-	30	1.0	uS/cm	N/A	2023/10/18	LJV	8986557
Chloride (Cl-)	-	3.2	1.0	mg/L	N/A	2023/10/13	LKH	8974489
Bromide (Br-)	-	ND	1.0	mg/L	N/A	2023/10/13	LKH	8974489
Sulphate (SO4)	-	ND	1.0	mg/L	N/A	2023/10/13	LKH	8974489
Total Alkalinity (Total as CaCO3)	-	8.4	2.0	mg/L	N/A	2023/10/18	LJV	8986560
Colour	-	61	25	TCU	N/A	2023/10/21	MCN	8989818
Dissolved Fluoride (F-)	-	ND	0.10	mg/L	N/A	2023/10/18	LJV	8986561
Total Kjeldahl Nitrogen (TKN)	-	0.13	0.10	mg/L	2023/10/12	2023/10/16	RTY	8976193
Nitrate + Nitrite (N)	-	0.057	0.050	mg/L	N/A	2023/10/20	MCN	8989816
Nitrite (N)	-	ND	0.010	mg/L	N/A	2023/10/20	MCN	8989481
Nitrogen (Ammonia Nitrogen)	-	ND	0.050	mg/L	N/A	2023/10/13	MCN	8975618
Dissolved Organic Carbon (C)	-	5.9	0.50	mg/L	N/A	2023/10/18	CPP	8986257
Total Organic Carbon (C)	-	6.3	0.50	mg/L	N/A	2023/10/13	CPP	8976272
pH	-	7.03		pH	N/A	2023/10/18	LJV	8986545
Total Phosphorus	-	0.014	0.004	mg/L	2023/10/12	2023/10/17	SSV	8976345
Total Suspended Solids	-	16	1.0	mg/L	2023/10/05	2023/10/06	CAC	8962772
Turbidity	-	2.6	0.10	NTU	N/A	2023/10/19	LJV	8986355
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	-	ND	0.000013	mg/L	2023/10/17	2023/10/18	SGK	8986054
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	-	0.19	0.0050	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Aluminum (Al)	-	0.19	0.0050	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Antimony (Sb)	-	ND	0.0010	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Antimony (Sb)	-	ND	0.0010	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Arsenic (As)	-	ND	0.0010	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Arsenic (As)	-	ND	0.0010	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Barium (Ba)	-	0.010	0.0010	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Barium (Ba)	-	0.0093	0.0010	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Boron (B)	-	ND	0.050	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Boron (B)	-	ND	0.050	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Cadmium (Cd)	-	ND	0.000010	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Cadmium (Cd)	-	ND	0.000010	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Calcium (Ca)	-	2.5	0.10	mg/L	2023/10/20	2023/10/23	JHY	8994803

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Sample Details/Parameters	A	Result	RDL	UNITS	Extracted	Analyzed	By	Batch
XEK343 CR @ EP Sampling Date 2023/09/28 12:00 Matrix W Sample # 2023-6328-00-SI-SP Registration # SA-0000								
ELEMENTS BY ICP/MS (WATER)								
Metals								
Dup.Total Calcium (Ca)	-	2.4	0.10	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Chromium (Cr)	-	ND	0.0010	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Chromium (Cr)	-	ND	0.0010	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Copper (Cu)	-	0.00086	0.00050	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Copper (Cu)	-	0.00081	0.00050	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Iron (Fe)	-	0.44	0.050	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Iron (Fe)	-	0.44	0.050	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Lead (Pb)	-	ND	0.00050	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Lead (Pb)	-	ND	0.00050	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Magnesium (Mg)	-	1.0	0.10	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Magnesium (Mg)	-	1.0	0.10	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Manganese (Mn)	-	0.014	0.0020	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Manganese (Mn)	-	0.014	0.0020	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Nickel (Ni)	-	ND	0.0020	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Nickel (Ni)	-	ND	0.0020	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Phosphorus (P)	-	ND	0.10	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Phosphorus (P)	-	ND	0.10	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Potassium (K)	-	0.47	0.10	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Potassium (K)	-	0.43	0.10	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Selenium (Se)	-	ND	0.00050	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Selenium (Se)	-	ND	0.00050	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Sodium (Na)	-	3.0	0.10	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Sodium (Na)	-	2.8	0.10	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Strontium (Sr)	-	0.017	0.0020	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Strontium (Sr)	-	0.017	0.0020	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Uranium (U)	-	ND	0.00010	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Uranium (U)	-	ND	0.00010	mg/L	2023/10/20	2023/10/24	JHY	8994803
Total Zinc (Zn)	-	ND	0.0050	mg/L	2023/10/20	2023/10/23	JHY	8994803
Dup.Total Zinc (Zn)	-	ND	0.0050	mg/L	2023/10/20	2023/10/24	JHY	8994803

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