

Real-Time Water Quality Deployment Report

Iron Ore Company of Canada
Labrador West Network

September 10 to
October 17, 2018



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

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General

- The Water Resources Management Division, in partnership with the Iron Ore Company of Canada (IOC) and Environment and Climate Change Canada (ECCC), maintain two real-time water quality (RTWQ) and water quantity stations at Wabush Lake.
- The official name of each station is *Wabush Lake at Dolomite Road* and *Wabush Lake at Lake Outlet*, hereafter referred to as the Dolomite Road station and the Julienne Narrows station.
- These stations are situated upstream (Dolomite Road) and downstream (Julienne Narrows) of the IOC tailings disposal area in Wabush Lake.
- On June 8th, 2016, an additional station was commissioned under this agreement. This station is located at *Dumbell Stream above Dumbell Lake*, hereafter referred to as Dumbell Stream.
- On June 12th, 2017 a new station was commissioned under this agreement. This station is located at *Pumphouse Stream above Drum Lake*, hereafter referred to as Pumphouse Stream.
- Water Resources Management Division staff monitor the real-time graphs regularly. They will inform IOC of any significant water quality events by email notification and by monthly deployment reports.
- Between September 10th and 12th, real-time water quality monitoring instruments were deployed at the four IOC stations. The instruments were deployed for a period of 36 days at Dolomite Road, 34 days at Dumbell Stream and Pumphouse Stream and 35 days at Julienne Narrows. The instruments were removed between October 16th and 17th. This was the final deployment period for this season. Instruments will be redeployed in the spring of 2019, when ice conditions permit.



Figure 1: RTWQ Monitoring Stations in Labrador West

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 each deployment period. The procedure is based on the approach used by the United States Geological Survey.

At deployment and removal, a QA/QC Sonde is temporarily deployed along side the Field Sonde. 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 Sonde and QA/QC Sonde at deployment and at removal, a qualitative statement is made on the data quality (Table 1).

Table 1: Ranking classifications for deployment and removal

Parameter	Rank				
	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 > 35 µS/cm (%)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Dissolved Oxygen (mg/L) (% Sat)	<=+/-0.3	>+/-0.3 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Turbidity <40 NTU (NTU)	<=+/-2	>+/-2 to 5	>+/-5 to 8	>+/-8 to 10	>+/-10
Turbidity > 40 NTU (%)	<=+/-5	>+/-5 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20

- It should be noted that the temperature sensor on any sonde is the most important. All other parameters can be broken down into three groups: temperature dependant, temperature compensated and temperature independent. Because the temperature sensor is not isolated from the rest of the sonde, the entire sonde 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 IOC water quality stations deployed between September 10-12 and October 16-17, 2018 are summarized in Table 2.

Table 2: QA/QC comparison rankings for IOC stations between September 10 and October 17, 2018.

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Dolomite Road	Sept 10, 2018	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	Oct 16, 2018	Removal	Excellent	Excellent	Good	Excellent	Excellent
Julienne Narrows	Sept 12, 2018	Deployment	Excellent	Excellent	Excellent	Good	Fair
	Oct 17, 2018	Removal	Excellent	Fair	Excellent	Fair	Poor
Dumbell Stream	Sept 12, 2018	Deployment	Good	Excellent	Excellent	Marginal	Excellent
	Oct 16, 2018	Removal	Good	Good	Good	Poor	Marginal
Pumphouse Stream	Sept 12, 2018	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	Oct 16, 2018	Removal	Excellent	Marginal	Excellent	Fair	Good

▪ **Dolomite Road**

At deployment and removal, all parameters ranked either ‘excellent’ or ‘good’.

▪ **Julienne Narrows**

At deployment, all parameters with the exception of turbidity ranked either ‘good’ or ‘excellent’. Turbidity ranked ‘fair’. The field instrument read a value of 0.7 NTU, while the QA/QC instrument read a value of 7.0 NTU. However, when compared to the QA/QC grab sample result of 1.6 NTU, turbidity ranked ‘excellent’.

At removal, temperature and conductivity ranked ‘excellent’. pH ranked ‘fair’. The field instrument read a value of 8.05, while the QA/QC instrument read a value of 7.52. Dissolved oxygen ranked ‘fair’. The field instrument read a value of 12.12 mg/l, while the QA/QC instrument read a value of 11.32 mg/l. Turbidity ranked ‘poor’. The field instrument read a value of 0.0 NTU, while the QA/QC instrument read a value of 19.5 NTU. However, when compared to the QA/QC grab sample result of 2.6 NTU, turbidity ranked ‘good’.

▪ **Dumbell Stream**

At deployment, all parameters except dissolved oxygen ranked either ‘good’ or ‘excellent’. Dissolved oxygen ranked ‘marginal’. The field instrument read a value of 12.71 mg/l, while the QA/QC instrument read a value of 11.91 mg/l.

At removal, temperature, pH and conductivity ranked ‘good’. Dissolved oxygen ranked ‘poor’. The field instrument read a value of 13.24 mg/l, while the QA/QC instrument read a value of 12.06 mg/l. Turbidity ranked ‘marginal’. The field instrument read a value of 0.0 NTU, while the QA/QC instrument read a value of 9.8 NTU. However, when compared to the QA/QC grab sample value of 0.1 NTU, turbidity ranked ‘excellent’.

▪ **Pumphouse Stream**

At deployment, all parameters ranked ‘excellent’.

At removal, temperature, conductivity and turbidity ranked either ‘good’ or ‘excellent’. pH ranked ‘marginal’. The field instrument read a value of 7.79, while the QA/QC instrument read a value of 6.89. However, when compared to the QA/QC grab sample value of 7.52, pH ranked ‘good’. Dissolved oxygen

ranked 'fair'. The field instrument read a value of 12.29 mg/l, while the QA/QC instrument read a value of 11.75 mg/l.

- There are a few circumstances which may cause less than ideal QA/QC rankings to be obtained. These include: the placement of the QA/QC sonde in relation to the field sonde, the amount of time each sonde was given to stabilize before readings were recorded; and deteriorating performance of one or more of the sensors.

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from September 10-12 to October 16-17, 2018 at the IOC RTWQ monitoring stations in Labrador West.
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

Wabush Lake Network

- Water temperature ranged from 2.8 to 14.1°C at Dolomite Road and 2.2 to 15.8°C at Julienne Narrows during this deployment period (Figure 2).
- Water temperature decreased during this deployment period, which corresponds with decreasing ambient air temperature into fall (Figure 2).

Water and Air Temperature : Wabush Lake Network
September 10 to October 17, 2018

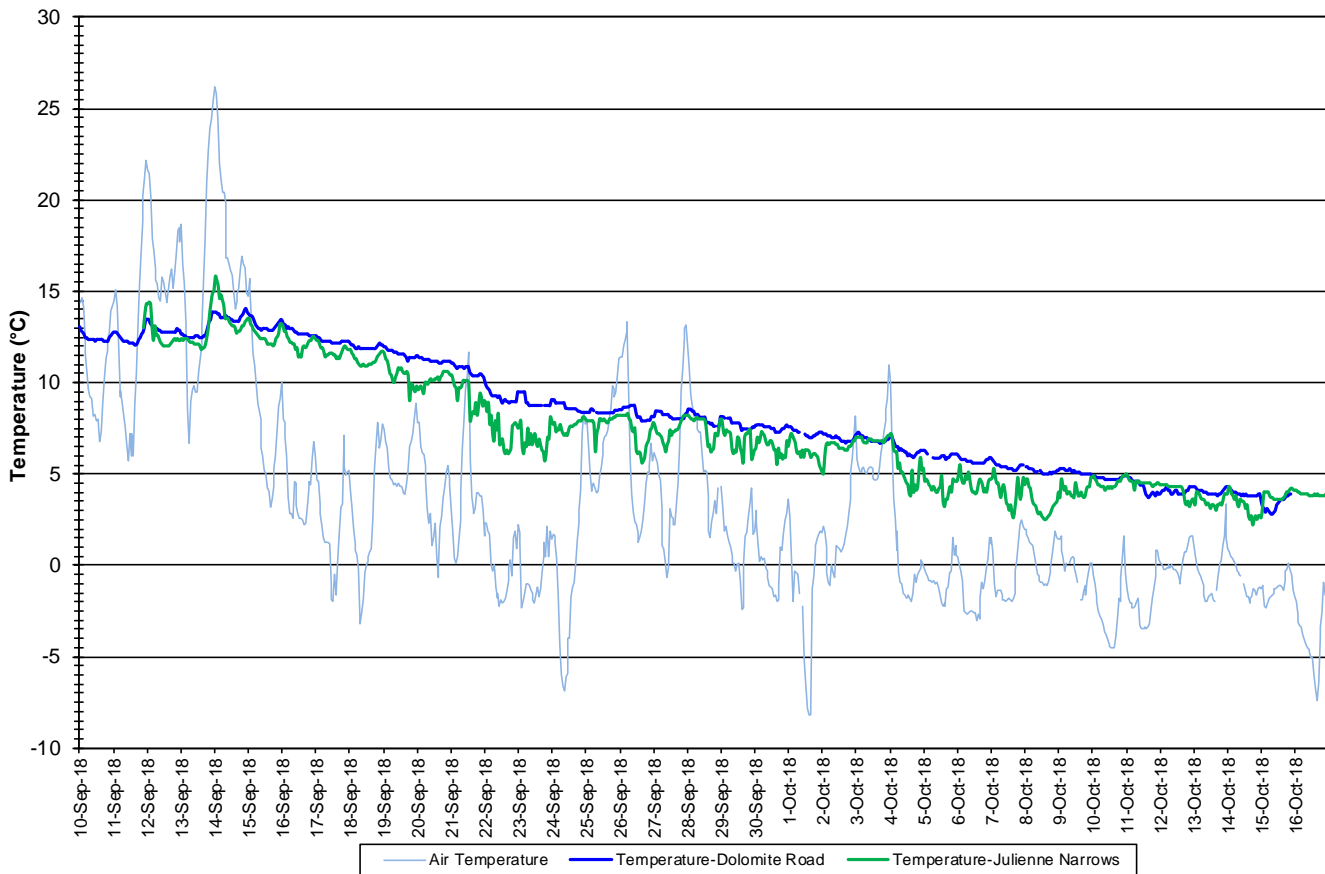


Figure 2: Water and Air Temperature - Wabush Lake network
(Weather data collected from climate station near Moosehead Lake)

- pH ranges from 7.32 to 7.77 pH units at Dolomite Road, and from 7.75 to 8.18 pH units at Julienne Narrows throughout the deployment period (Figure 3). The median pH is 7.54 and 8.01 units respectively.
- All values during the deployment are within the CCME Guidelines for the Protection of Aquatic Life (between 6.5 and 9 pH units). pH fluctuates slightly throughout the day and night.
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

**Water pH and Stage: Wabush Lake Network
September 10 to October 17, 2018**

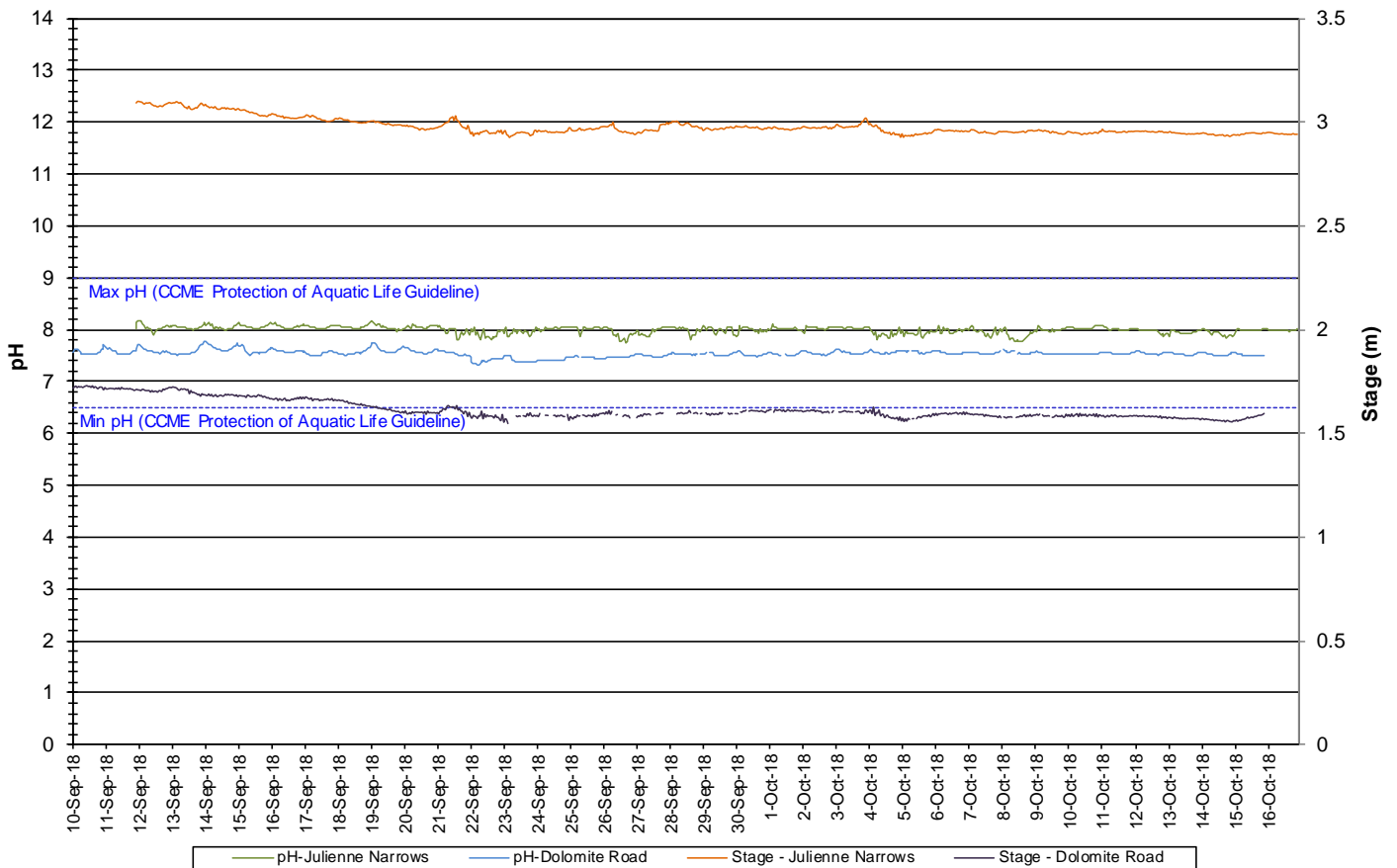


Figure 3: Water pH and stage– Wabush Lake network

- Specific conductivity ranged from 52.2 to 58.2 $\mu\text{S}/\text{cm}$ at Dolomite Road and from 66.7 to 105.4 $\mu\text{S}/\text{cm}$ at Julienne Narrows throughout the deployment period (Figure 4).
- Daily fluctuations are evident at the Julienne Narrows station. This can be attributed to varying contributions of iron ore tailings deposited into Wabush Lake upstream of Julienne Narrows and downstream of Dolomite Road. This can also explain the difference in specific conductivity levels between the two stations as conductance values are generally higher at Julienne Narrows.
- Specific conductance increases slightly at Dolomite Road during this deployment period.
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

Specific Conductivity and Stage: Wabush Lake Network
September 10 to October 17, 2018

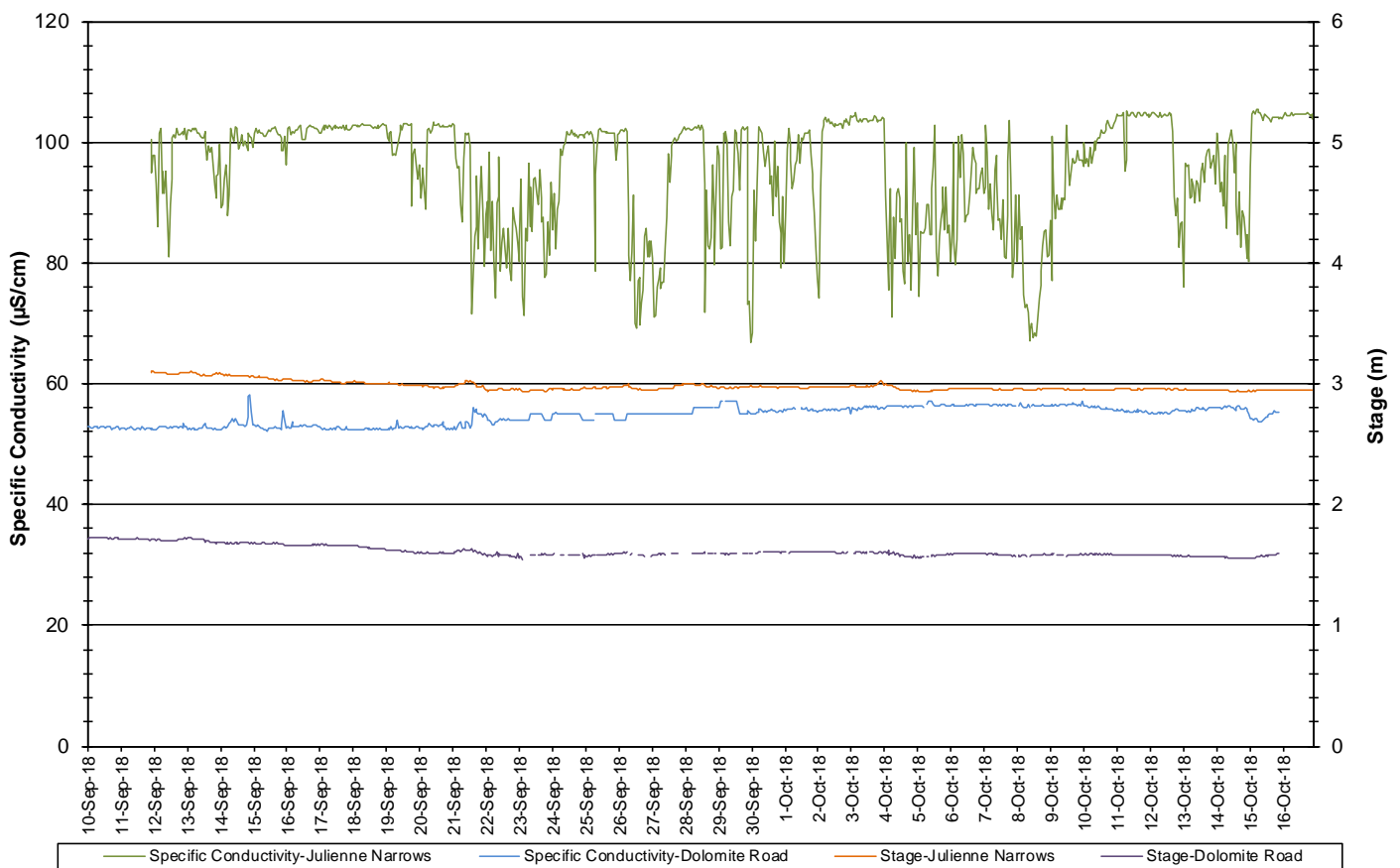


Figure 4: Specific conductivity and stage – Wabush Lake network

- At the Dolomite Road station, the saturation of dissolved oxygen ranged from 80.9 to 96.2% while the dissolved oxygen content ranged from 9.27 to 12.02 mg/l with a median value of 10.11 mg/l (Figure 5).
- At the Julienne Narrows station, the saturation of dissolved oxygen ranged from 90.5 to 103.4% while the dissolved oxygen content ranged from 9.84 to 13.05 mg/l with a median value of 11.44 mg/l (Figure 5).
- All values recorded at Julienne Narrows and Dolomite Road were above the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota of Other Life Stages of 6.5 mg/l.
- All of the values recorded at Julienne Narrows were above the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota of Early Life Stages of 9.5 mg/l, while the majority of values recorded at Dolomite Road were above the guideline. The guidelines are indicated in blue on Figure 5.
- Dissolved oxygen increased at both stations towards the end of this deployment period, as water temperature decreased. Dissolved oxygen fluctuated daily with decreases observed at night.

**Dissolved Oxygen : Wabush Lake Network
September 10 to October 17, 2018**

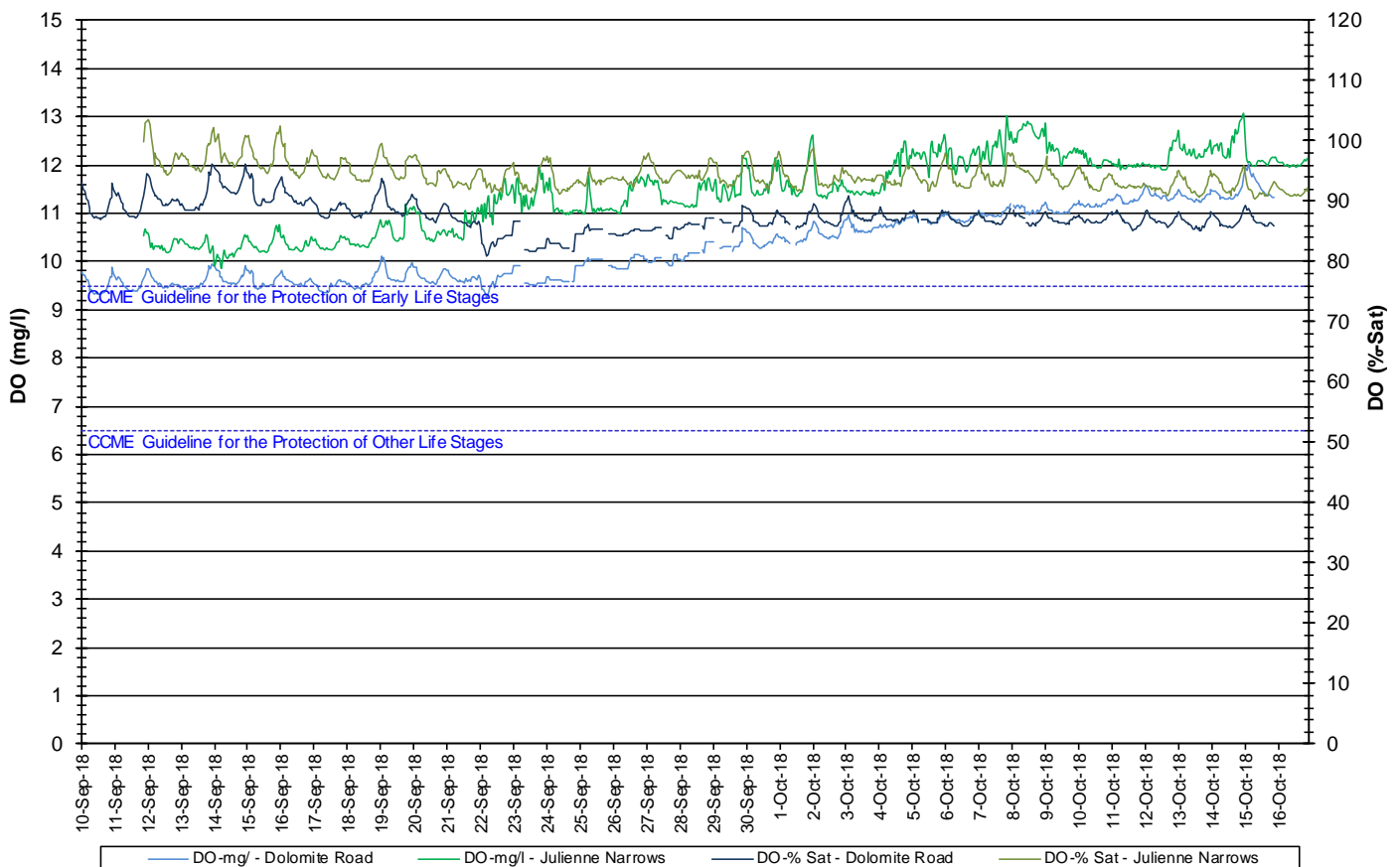
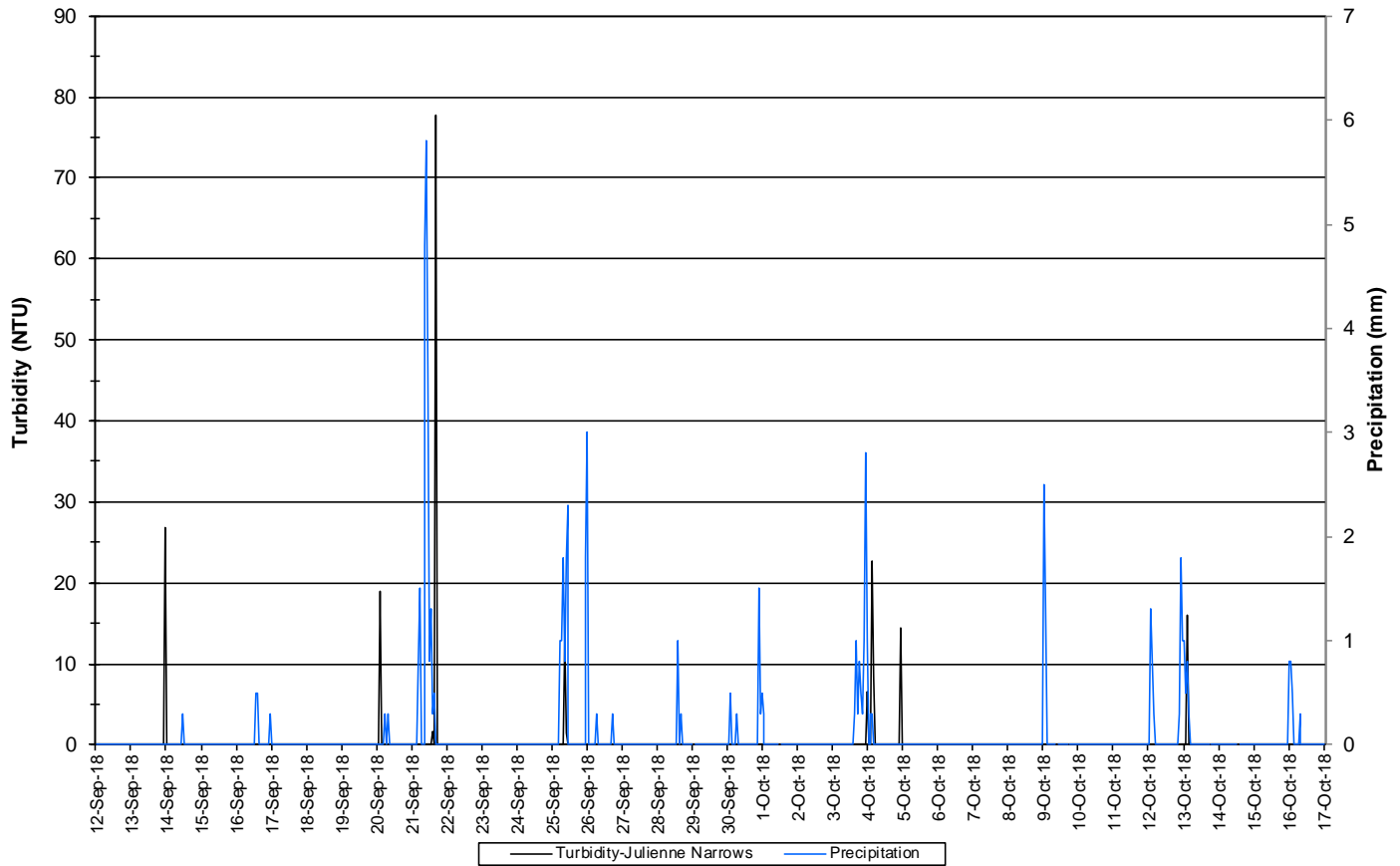


Figure 5: Dissolved oxygen and percent saturation – Wabush Lake Network

- At the Julienne Narrows station, turbidity values range from 0.0 to 77.7 NTU throughout the deployment period (Figure 6). The median value was 0.0 NTU.
- In some instances, turbidity spikes can be attributed to precipitation events.

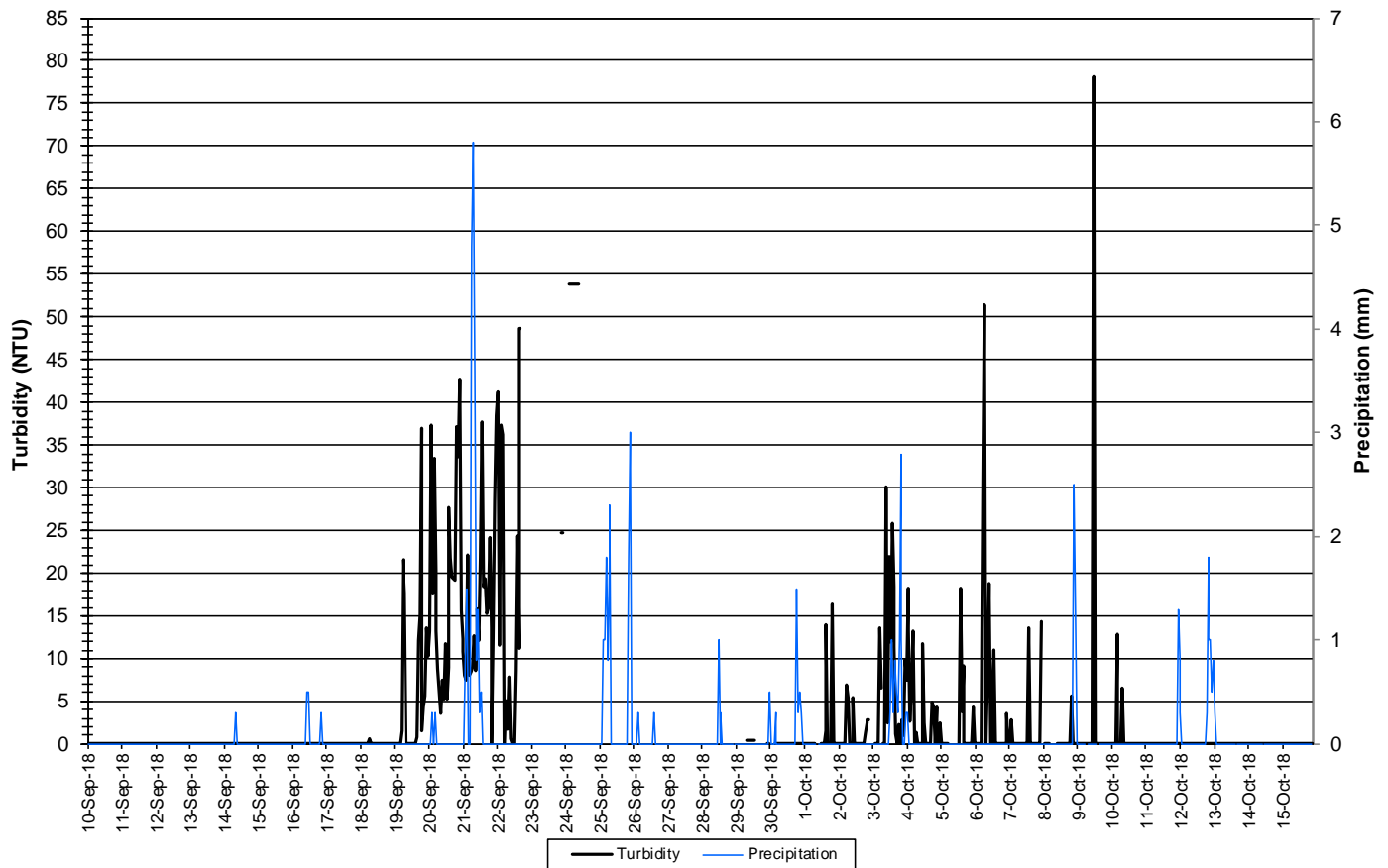
**Water Turbidity and Precipitation: Julienne Narrows
September 12 to October 17, 2018**



**Figure 6: Turbidity and precipitation – Julienne Narrows
(Weather data collected from climate station near Moosehead Lake)**

- At the Dolomite Road station, turbidity values ranged from 0.0 NTU to 78.2 NTU, throughout the deployment period (Figure 7). The median value was 0.0 NTU.
- High spikes in turbidity are unusual for this station. In some instances, turbidity spikes can be attributed to precipitation events.

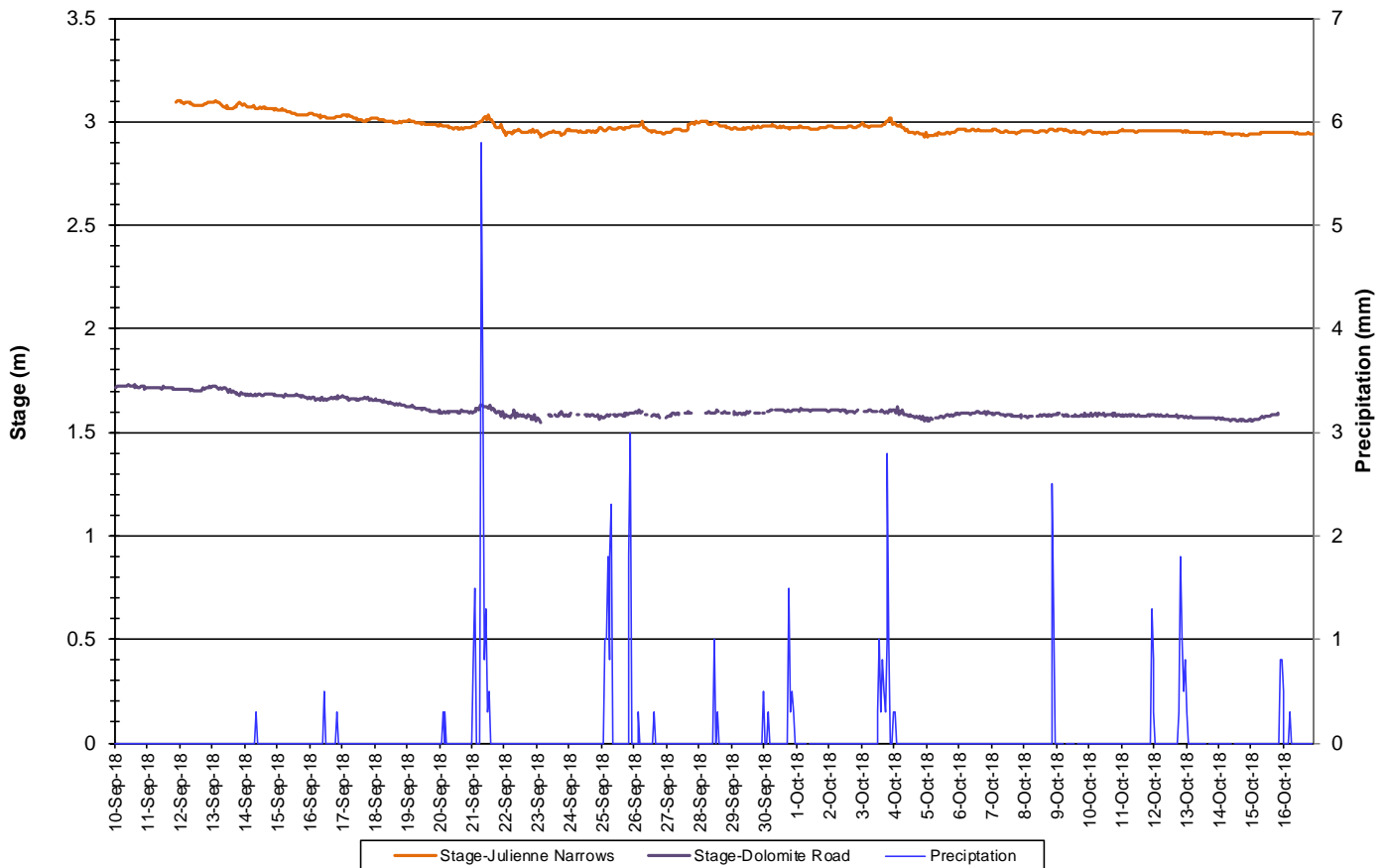
**Turbidity and Precipitation : Dolomite Road
September 10, 2018 to October 16, 2018**



**Figure 7: Turbidity and precipitation – Dolomite Road
(Weather data collected from climate station near Moosehead Lake)**

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Dolomite Road and Julienne Narrows (Figure 8).
- Overall, stage is relatively stable throughout the deployment period at both stations.
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

**Stage and Precipitation: Wabush Lake Network
September 10 to October 17, 2018**

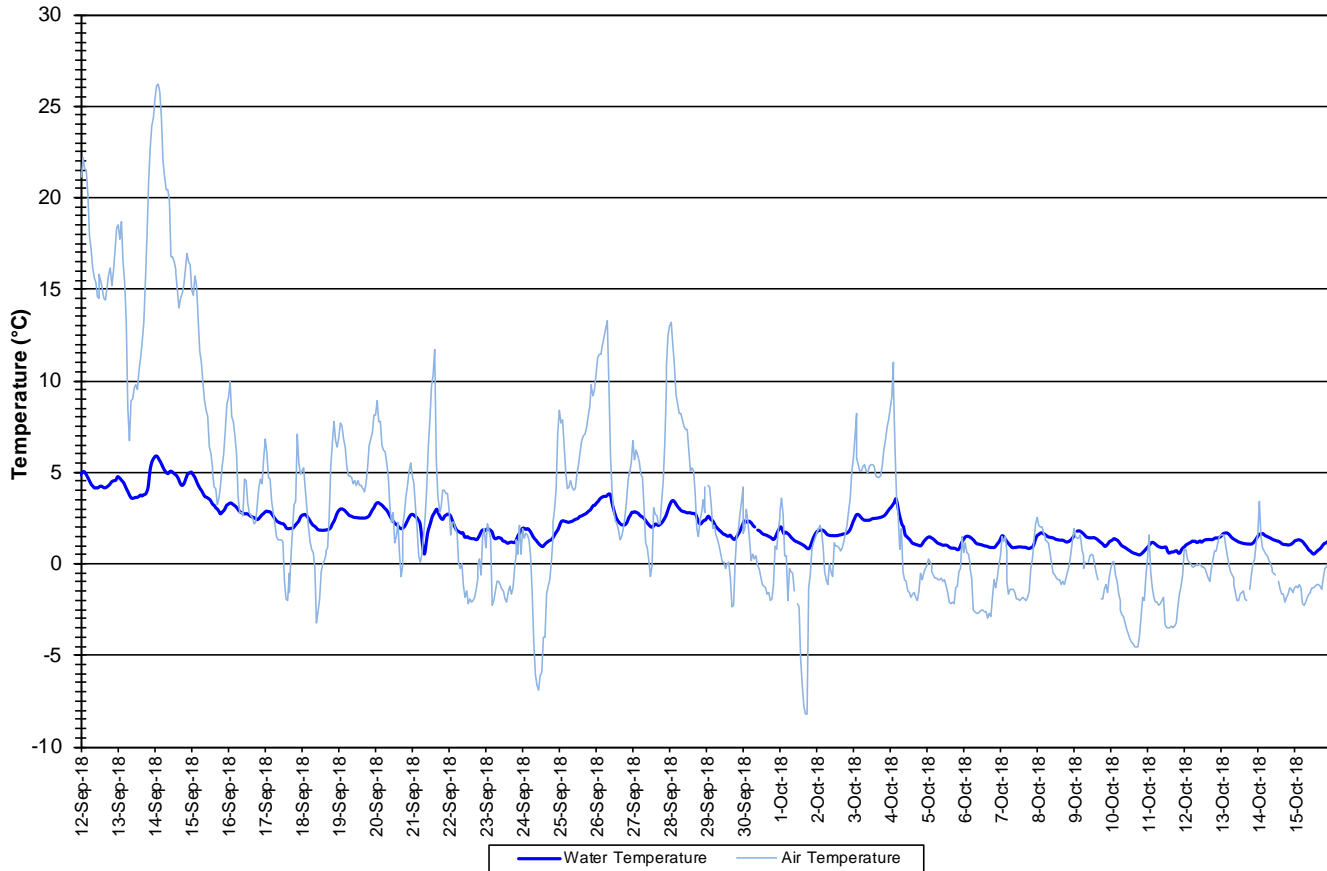


**Figure 8: Stage and precipitation – Wabush Lake Network
(Weather data collected at climate station located near Moosehead Lake)**

Dumbell Stream

- Water temperature ranged from 0.51 to 5.92°C during this deployment period (Figure 9).
- Water temperature generally fluctuated within this range for the deployment period. This area is very shaded. Temperature decreased slightly during the later portion of the deployment period due to decreasing air temperature into the fall season (Figure 9).

**Water and Air Temperature : Dumbell Stream above Dumbell Lake
September 12 to October 16, 2018**



**Figure 9: Water and air temperature – Dumbell Stream
(Weather data collected from climate station near Moosehead Lake)**

- pH ranged from 7.72 to 7.89 pH units (Figure 10). The median pH was 7.78.
- All values during the deployment are within the CCME Guidelines for the Protection of Aquatic Life (between 6.5 and 9 pH units). pH fluctuates slightly throughout the day and night.
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

Water pH and Stage : Dumbell Stream above Dumbell Lake
September 12 to October 16, 2018



Figure 10: Water pH and stage – Dumbell Stream

- Specific conductivity ranged from 66.0 to 75.0 $\mu\text{S}/\text{cm}$, throughout the deployment period (Figure 11).
- Decreases in specific conductivity correspond to increases in stage. As more water is added to the system from precipitation, the solids in the water are diluted, decreasing conductivity. These decreases are indicated in red on Figure 11.
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

Specific Conductivity of Water and Stage: Dumbell Stream above Dumbell Lake
September 12 to October 16, 2018

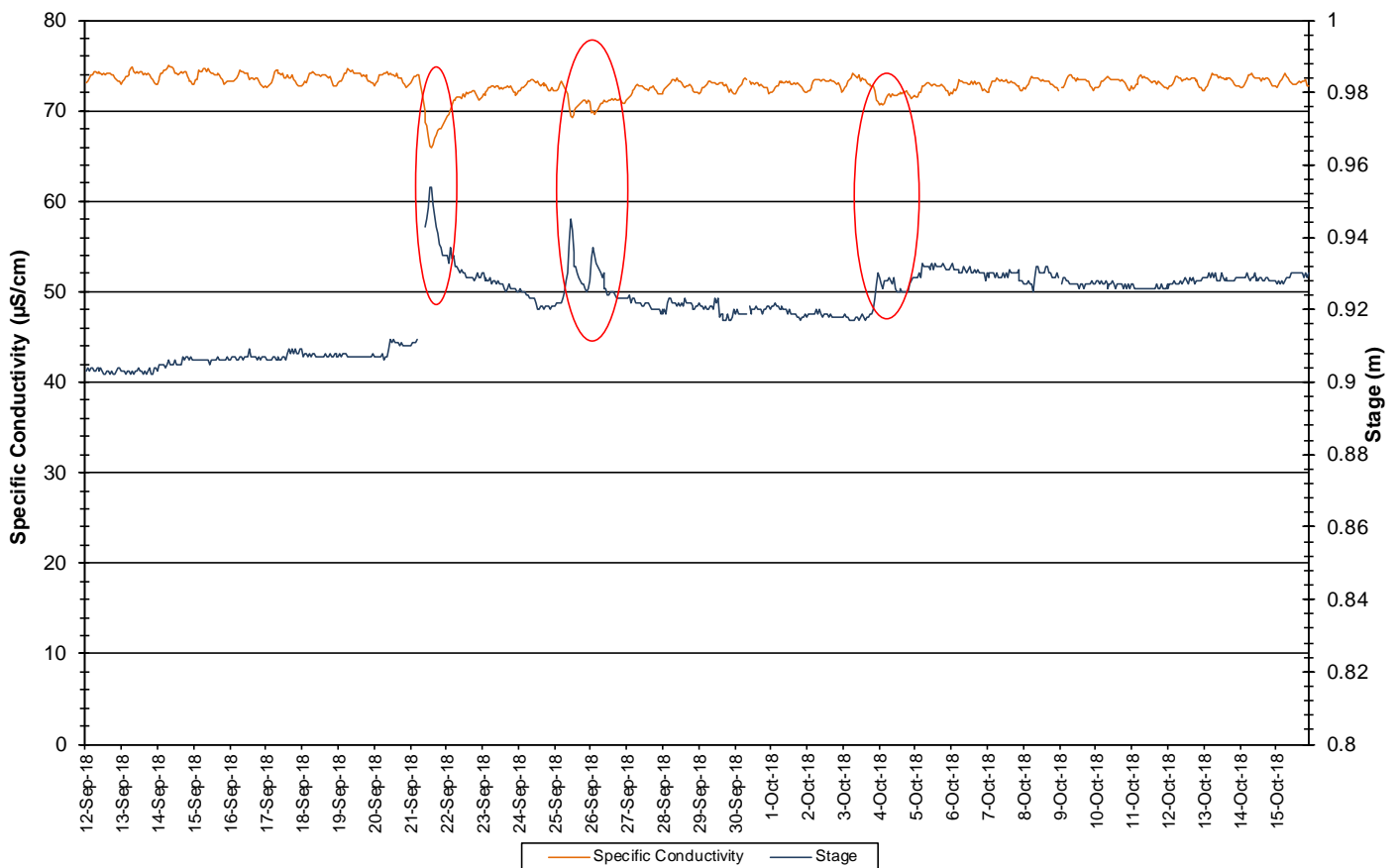


Figure 11: Specific conductivity and stage – Dumbell Stream

- The saturation of dissolved oxygen ranged from 92.0 to 98.4% while the dissolved oxygen content ranged from 12.05 to 13.88 mg/l with a median value of 13.29 mg/l (Figure 12).
- All values recorded at Dumbell Stream were above the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota of Other Life Stages of 6.5 mg/l and the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota of Early Life Stages of 9.5 mg/l. The guidelines are indicated in blue on Figure 12.
- Dissolved oxygen increased slightly during this deployment period as water temperature decreased.
- Dissolved oxygen fluctuated daily with decreases observed at night.

Dissolved Oxygen Concentration and Saturation : Dumbell Stream at Dumbell Lake
September 12 to October 16, 2018

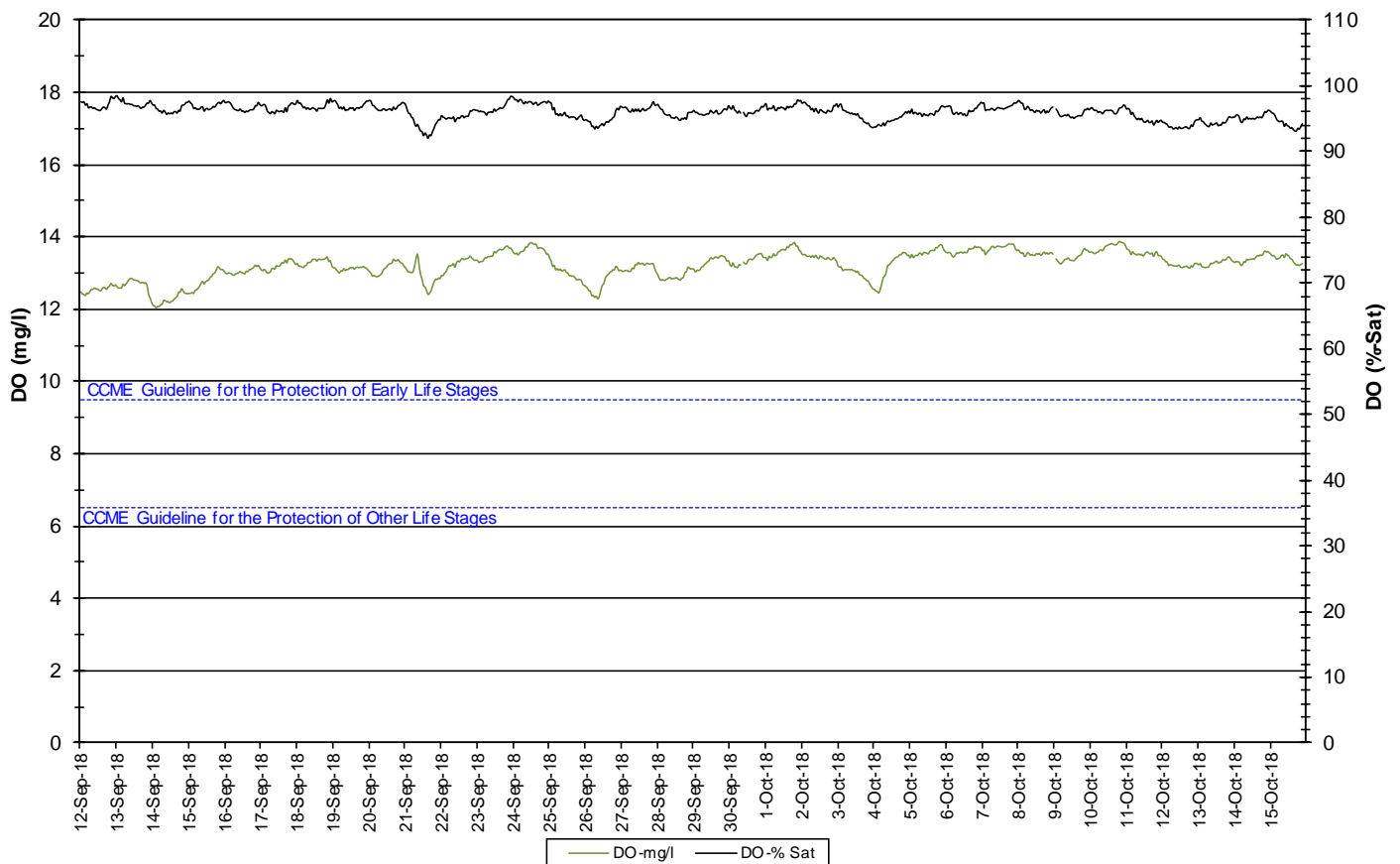
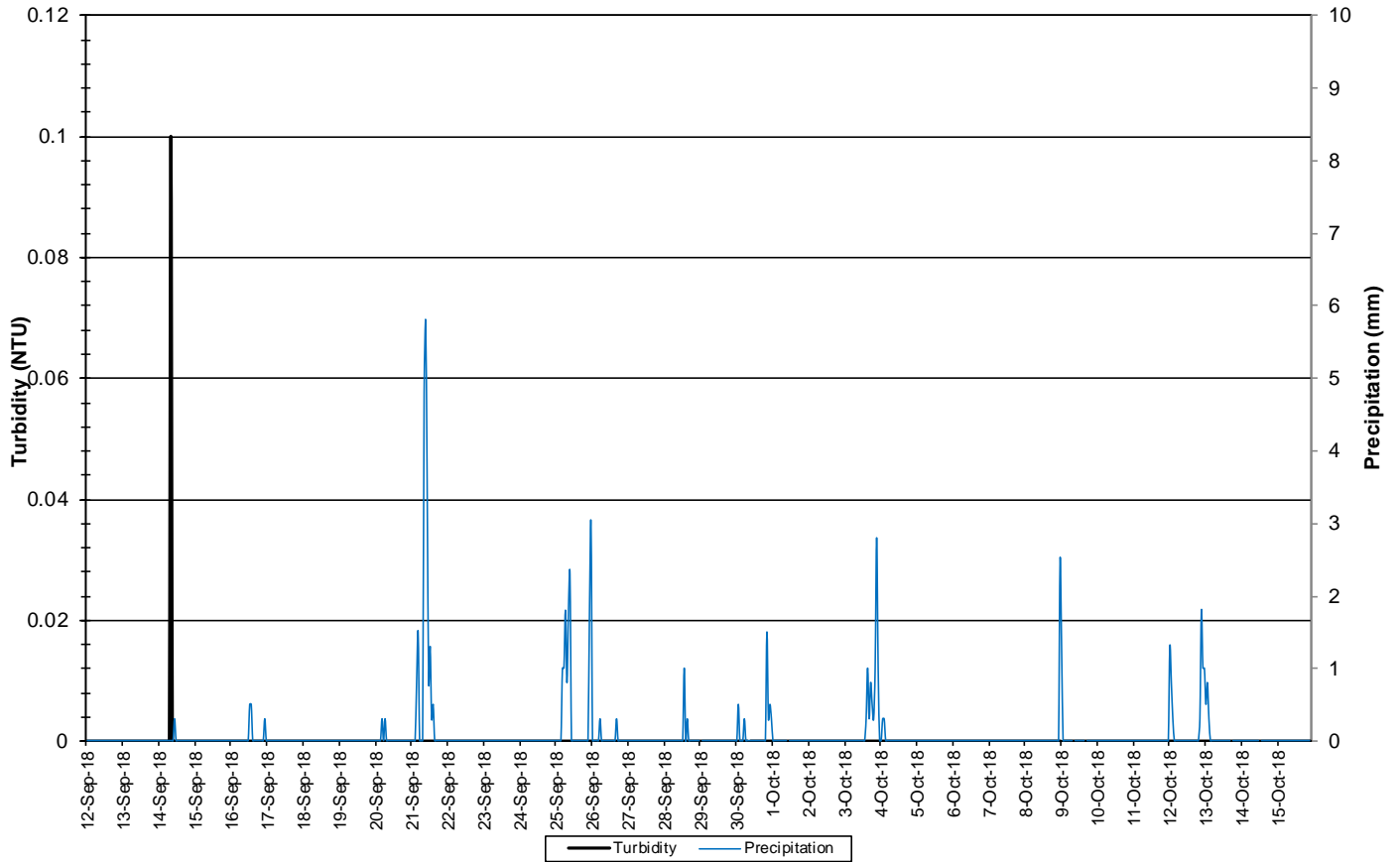


Figure 12: Dissolved oxygen – Dumbell Stream

- Turbidity values were 0.0 NTU throughout the deployment period, with the exception of one reading at 0.1 NTU (Figure 13).

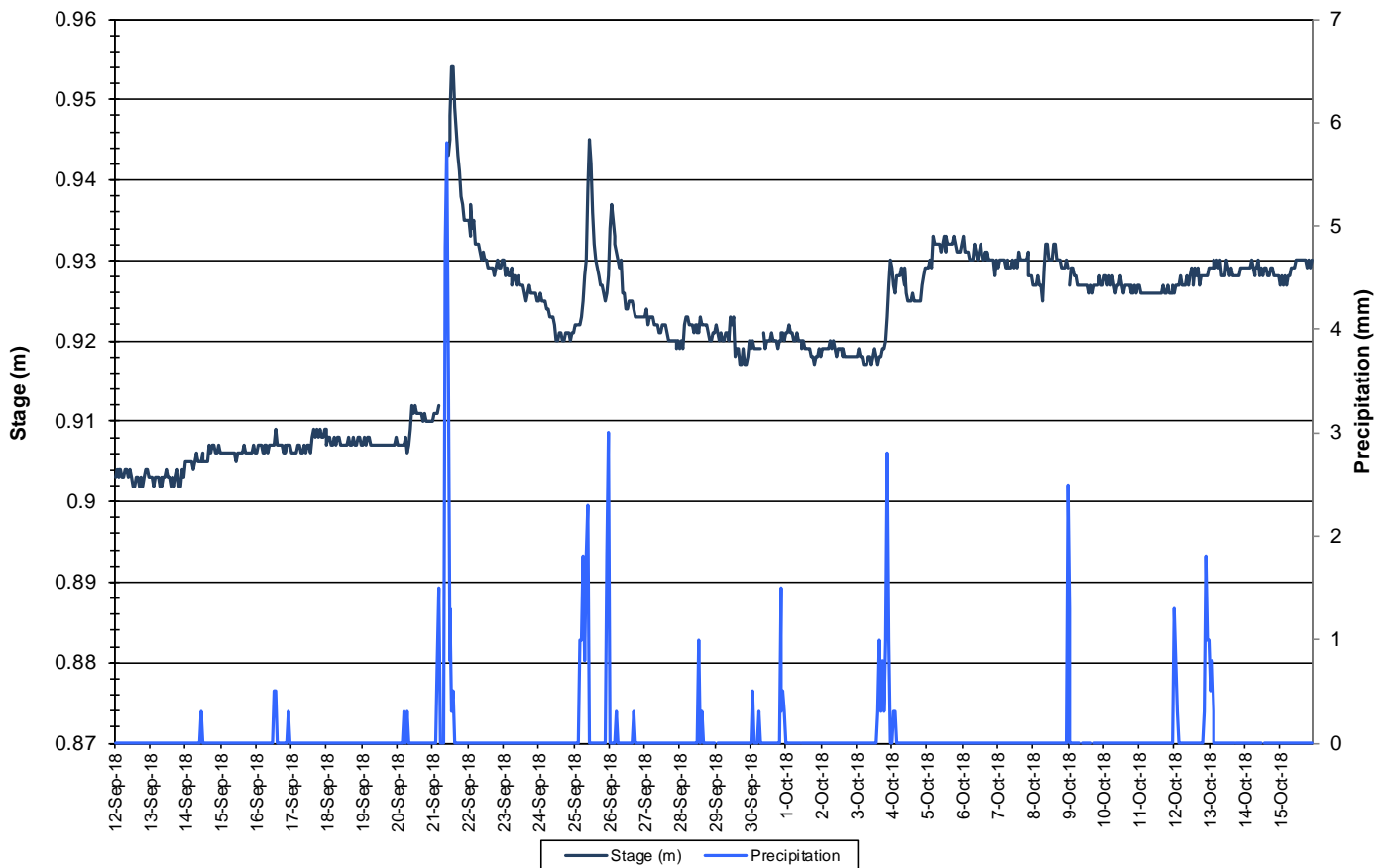
**Water Turbidity and Precipitation : Dumbell Stream above Dumbell Lake
September 12 to October 16, 2018**



**Figure 13: Turbidity and precipitation – Dumbell Stream
(Weather data collected from climate station near Moosehead Lake)**

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Dumbell Stream (Figure 14).
- Stage increases throughout the deployment period, with precipitation events causing periodic spikes.
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

**Stage and Precipitation: Dumbell Stream
September 12 to October 16, 2018**

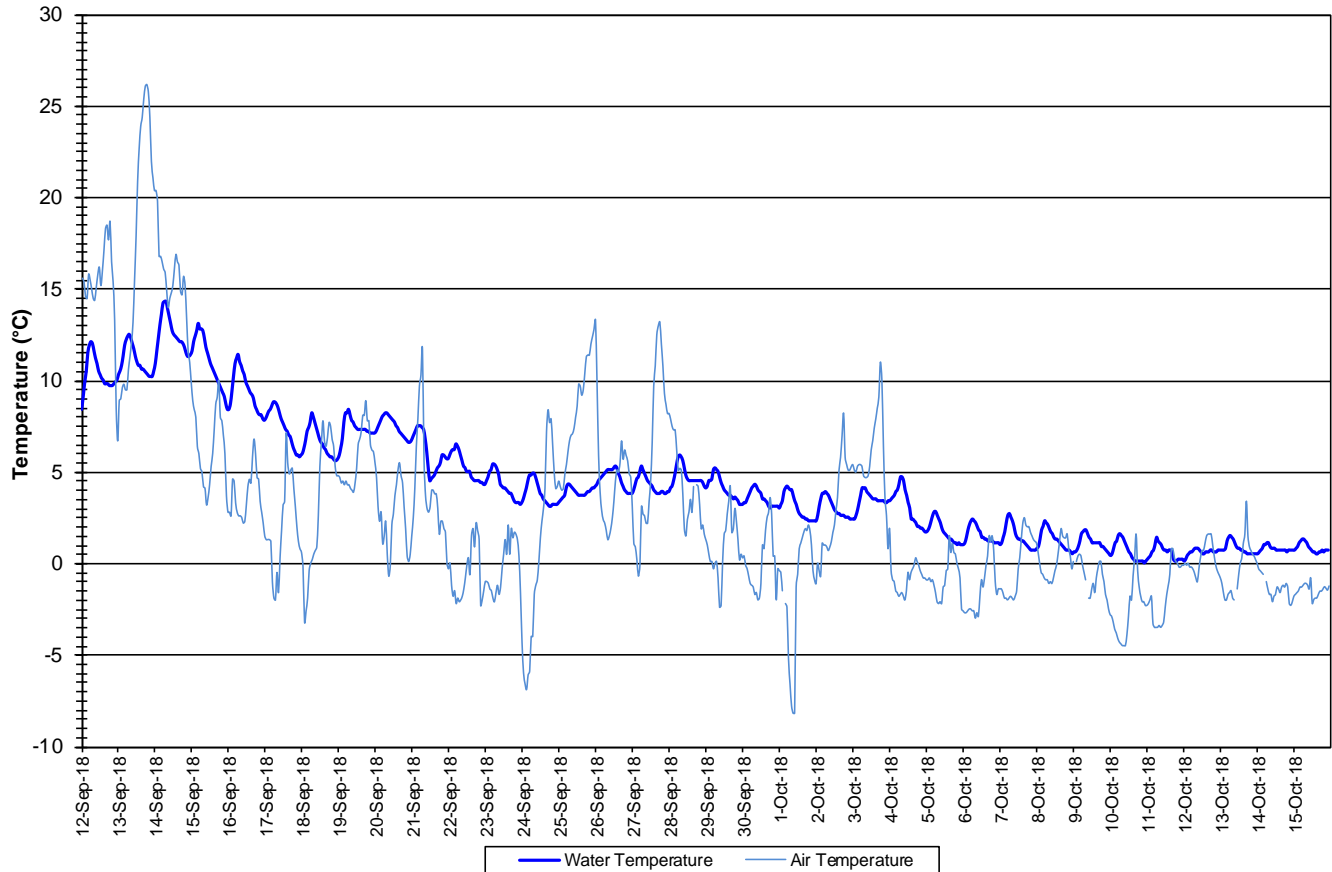


**Figure 14: Stage and precipitation – Dumbell Stream
(Weather data collected from climate station near Moosehead Lake)**

Pumphouse Stream

- Water temperature ranged from 0.00 to 14.30°C during this deployment period (Figure 15).
- Water temperature decreased over the course of this deployment period, corresponding to decreasing ambient air temperatures into fall (Figure 15).

**Water and Air Temperature: Pumphouse Stream above Drum Lake
September 12 to October 16, 2018**



**Figure 15: Water and air temperature – Pumphouse Stream
(Weather data collected from climate station near Moosehead Lake)**

- pH ranged from 7.42 to 8.05 pH units (Figure 16). The median pH was 7.73.
- All values during the deployment are within the CCME Guidelines for the Protection of Aquatic Life (between 6.5 and 9 pH units). pH fluctuates slightly throughout the day and night.
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

**Water pH and Stage: Pumphouse Stream above Drum Lake
September 12 to October 16, 2018**

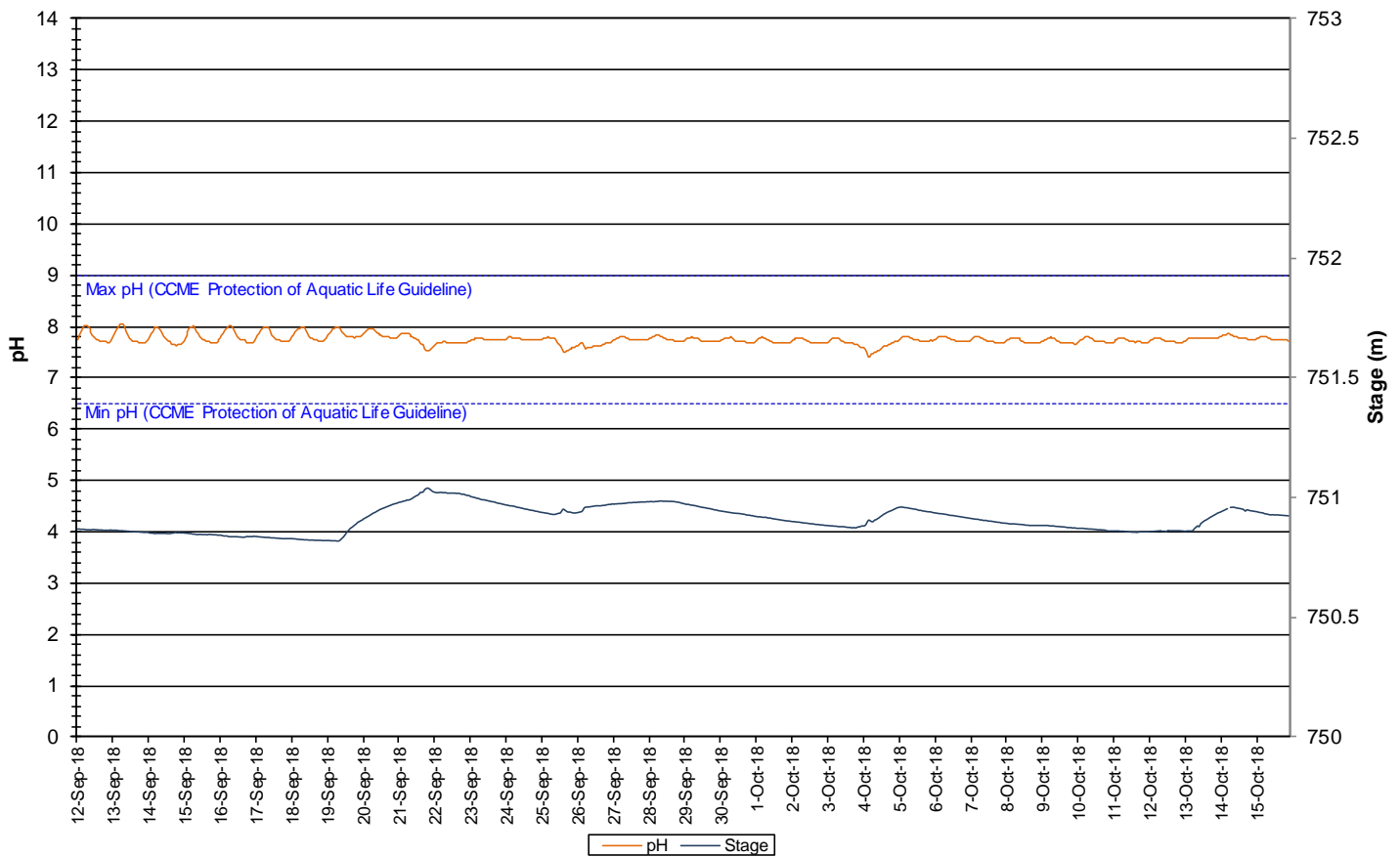


Figure 16: Water pH and stage – Pumphouse Stream

- Specific conductivity ranged from 130.6 to 161.8 $\mu\text{S}/\text{cm}$, throughout the deployment period (Figure 17).
- Some decreases in specific conductivity correspond to increases in stage. As more water is added to the system from precipitation, the solids in the water are diluted, decreasing conductivity.
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

**Specific Conductivity of Water and Stage: Pumphouse Stream above Drum Lake
September 12 to October 16, 2018**



Figure 17: Specific Conductivity and stage – Pumphouse Stream

- The saturation of dissolved oxygen ranged from 79.3 to 101.0% while the dissolved oxygen ranged from 8.82 to 12.81 mg/l with a median value of 11.40 mg/l (Figure 18).
- All values recorded at Pumphouse Stream were above the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota of Other Life Stages of 6.5 mg/l. The majority of values were above the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota of Early Life Stages of 9.5 mg/l. The guidelines are indicated in blue on Figure 18.
- Dissolved oxygen increased during this deployment period as water temperature decreased.
- Dissolved oxygen fluctuated daily with decreases observed at night.

**Dissolved Oxygen Concentration and Saturation: Pumphouse Stream above Drum Lake
September 12 to October 16, 2018**

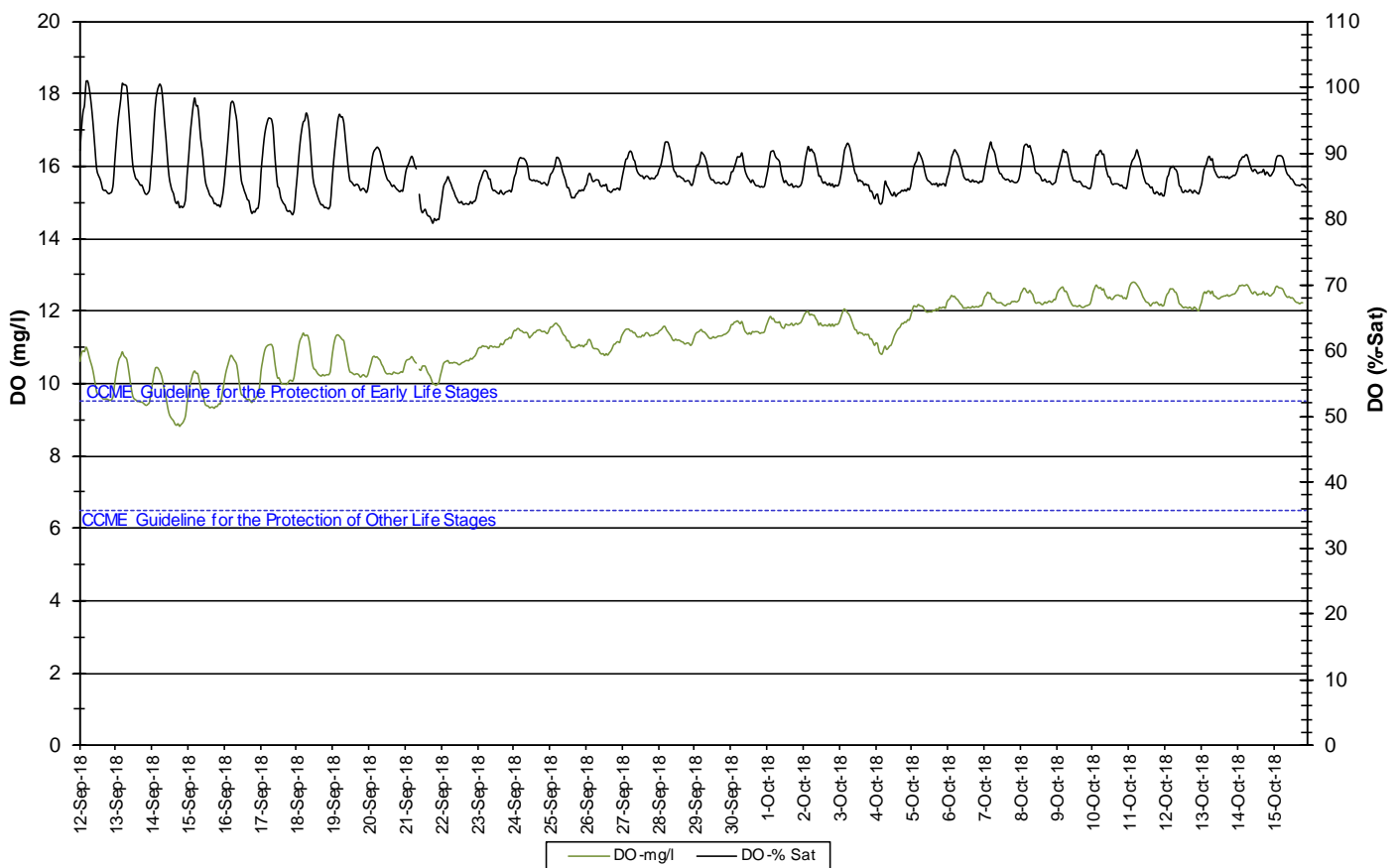
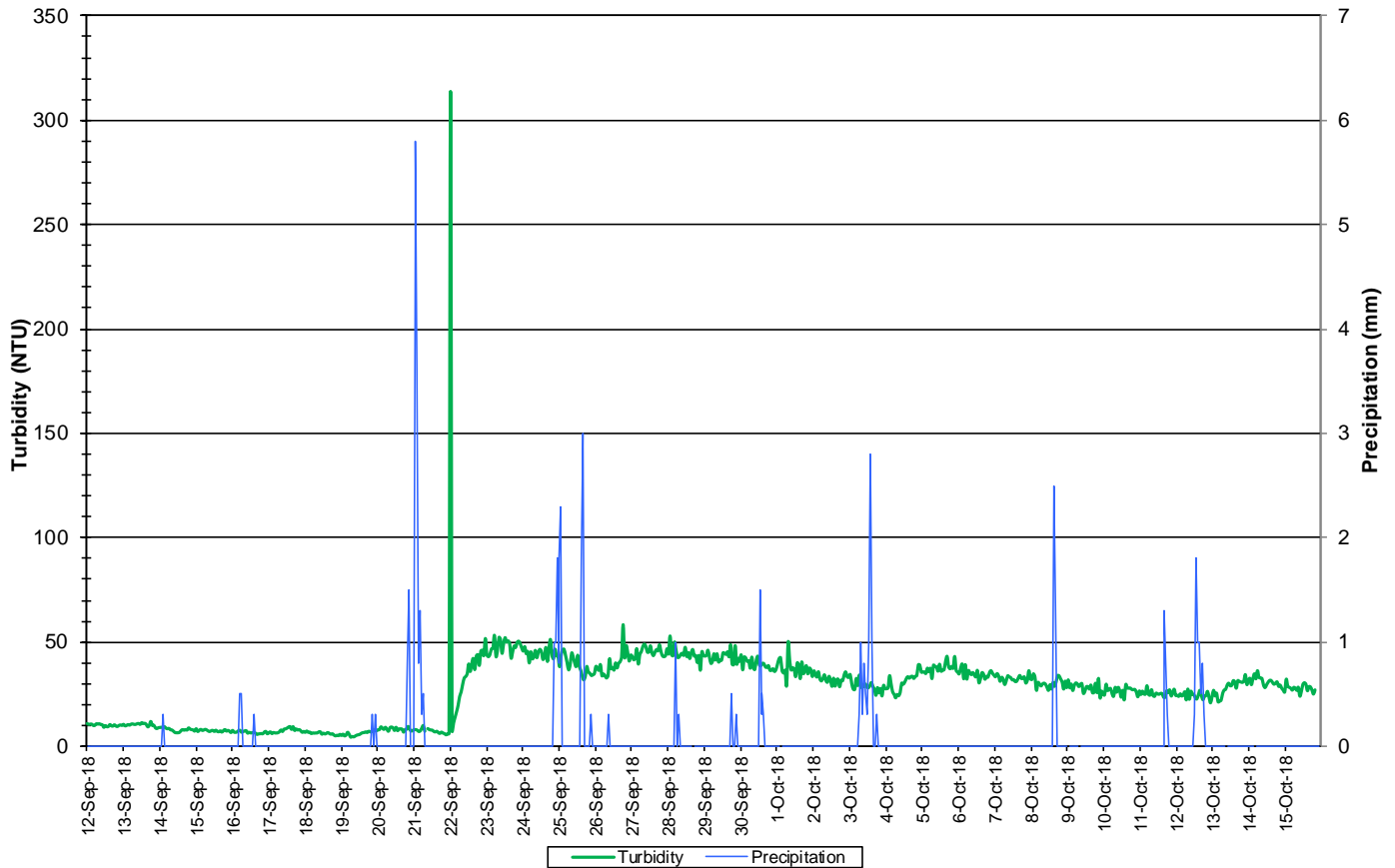


Figure 18: Dissolved oxygen – Pumphouse Stream

- Turbidity values range from 4.8 to 313.8 NTU throughout the deployment period (Figure 19). The median value was 11.40 NTU.
- In some instances, turbidity spikes can be attributed to precipitation events.

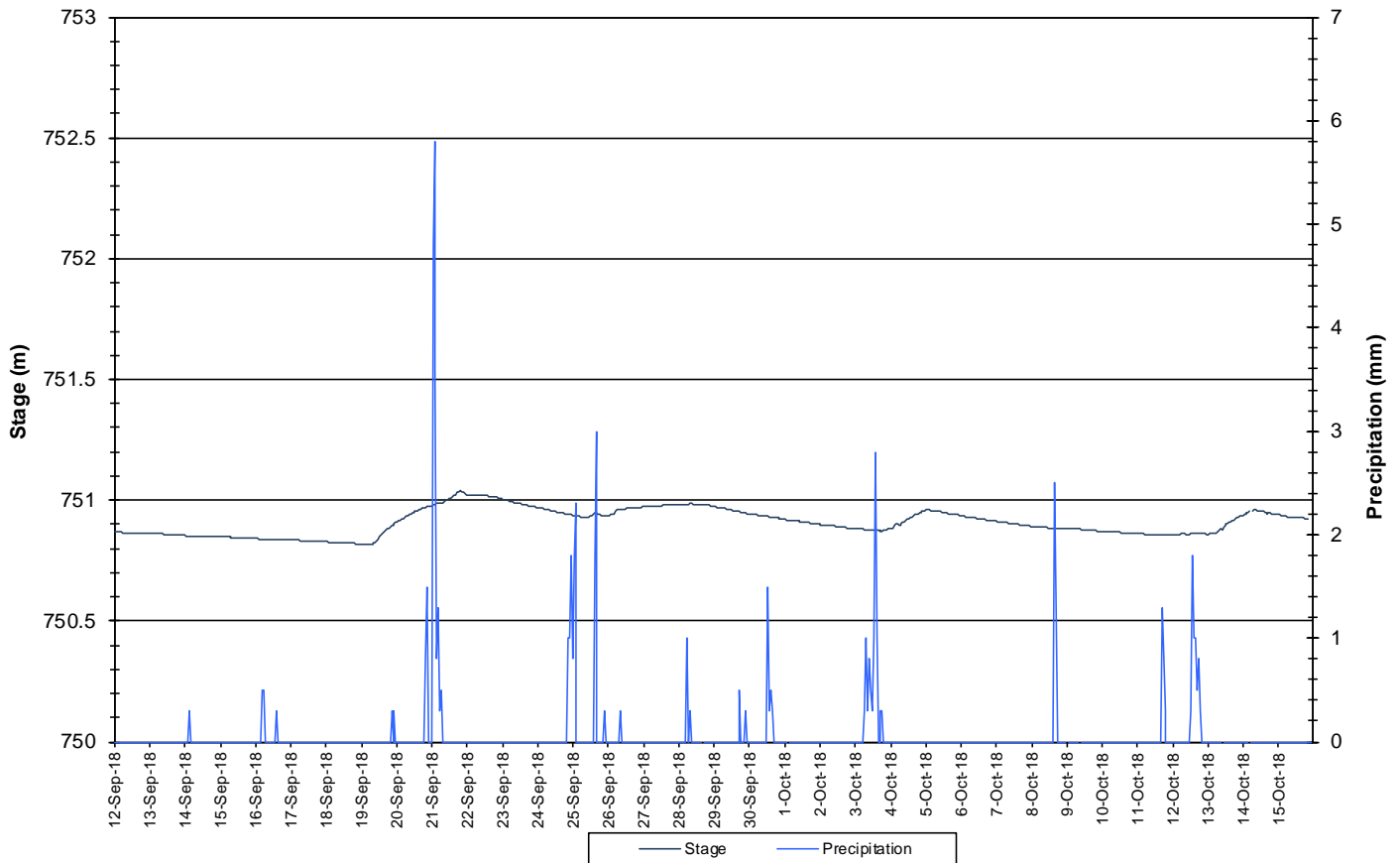
**Water Turbidity and Precipitation: Pumphouse Stream above Drum Lake
September 12 to October 16, 2018**



**Figure 19: Turbidity and precipitation – Pumphouse Stream
(Weather data collected from climate station near Moosehead Lake)**

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Pumphouse Stream (Figure 20).
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

**Stage and Precipitation: Pumphouse Stream above Drum Lake
September 12 to October 16, 2018**



**Figure 20: Stage and precipitation – Pumphouse Stream
(Weather data collected from climate station near Moosehead Lake)**

Conclusions

- Instruments were deployed between September 10th and 12th and removed by October 17th, 2018. This was the final deployment period for this season.
- In most cases, precipitation events or increase/decreases in water level could be used to explain the data fluctuations. Most values recorded were within ranges as suggested by the CCME Guidelines for the Protection of Aquatic Life for pH and dissolved oxygen.
- Water temperature corresponded with air temperature at all stations. Temperature typically ranged between 0.00 and 15.80°C, at these stations.
- All of the pH values were within the recommended CCME Guidelines for the Protection of Aquatic Life. pH ranged between 7.32 and 8.18. Fluctuations were noted between day and night.
- Specific conductivity differed between the two Wabush Lake stations. This can be attributed to varying concentrations of iron ore tailings deposited between the stations. Specific conductivity ranged from 52.2 µs/cm to 105.4 µs/cm at the Wabush Lake stations, 66.0 to 75.0 µs/cm at Dumbell Stream and 130.6 to 161.8 µs/cm at Pumphouse Stream.
- At all four stations, all dissolved oxygen values were above the minimum CCME Guideline for the Protection of Aquatic Life for Cold Water Biota at Other Life Stages of 6.5 mg/L. When dissolved oxygen values are compared to the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota at Early Life Stages of 9.5 mg/L, the majority of values were above this guideline.
- Turbidity at Dolomite Road fluctuated unusually during this deployment period. The median value was 0.0 NTU. Turbidity spikes at Julienne Narrows occurred but less frequently than at Dolomite Road.
- Turbidity at Dumbell Stream remained at 0.0 NTU for the entire development period with one spike of 0.1 NTU.
- Turbidity at Pumphouse Stream fluctuated throughout the deployment period with one high spike attributed to precipitation. The median value was 11.40 NTU.
- Stage was relatively stable at Dolomite Road and Julienne Narrows during the first half of the deployment period, and then decreased slightly. At Dumbell Stream, stage increased overall, with spikes noted after precipitation events. At Pumphouse Stream, stage fluctuated and showed increases after precipitation events.
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

Prepared by:
Maria Murphy
Department of Municipal Affairs and Environment
Water Resources Management Division
Phone: 709.896.7981

Appendix 1

Air Temperature and Precipitation: Moosehead Lake, NL September 10 to October 17, 2018

