



Real-Time Water Quality Deployment Report

Iron Ore Company of Canada
Lab West Network

June 7 to
July 20, 2016



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

Contents

General	3
Data Interpretation	6
Wabush Lake Network	6
Dumbell Stream	15
Conclusions	22
Appendix 1	23
Appendix 2 - Photos.....	24

General

- The Water Resources Management Division, in partnership with the Iron Ore Company of Canada (IOC) and Environment and Climate Change Canada, maintain two real-time water quality 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 Julianne 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, a new station was commissioned under this agreement. This station is located at *Dumbell Stream above Dumbell Lake*, hereafter referred to as Dumbell Stream.
- Water Resources Management Division staff monitors the real-time graphs regularly. They will inform IOC of any significant water quality events by email notification and by monthly deployment reports.
- Between June 7th and 11th, 2016, real-time water quality monitoring instruments were deployed at the three IOC stations. The instrument was deployed for a period of 43 days at Dolomite Road, 42 days at Dumbell Stream and 39 days at Julianne Narrows. The instruments were removed on July 20th, 2016. This was the first deployment for 2016.

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. 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 June 7 and July 20, 2016 is summarized in Table 2.

Table 2: Comparison rankings for IOC stations between June 7 and July 20, 2016.

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Dolomite Road	June 7, 2016	Deployment	Good	Excellent	Good	Fair	Excellent
	July 20, 2016	Removal	Good	Excellent	Fair	Fair	Excellent
Julienne Narrows	June 11, 2016	Deployment	Good	Excellent	Fair	Fair	Fair
	July 20, 2016	Removal	Excellent	Fair	Marginal	Excellent	Excellent
Dumbell Stream	June 8, 2016	Deployment	Good	Excellent	Excellent	Excellent	Excellent
	July 20, 2016	Removal	Good	Excellent	Fair	Poor	Excellent

- **Dolomite Road**

At deployment, temperature, pH, conductivity and turbidity ranked either 'good' or 'excellent'. Dissolved oxygen ranked 'fair'. The field instrument read a value of 9.53 mg/l, while the QA/QC instrument read a value of 10.24 mg/l.

At removal, temperature, pH and turbidity ranked either 'good' or 'excellent'. Conductivity ranked 'fair', the field instrument read a value of 52 μ s/cm and the QA/QC instrument read a value of 45.2 μ s/cm. Dissolved oxygen also ranked 'fair', the field instrument read a value of 7.84 mg/l and the QA/QC instrument read a value of 8.47 mg/l.

- **Julienne Narrows**

At deployment, temperature and pH ranked 'good' or 'excellent'. Conductivity ranked 'fair', the field sonde read a value of 114.3 μ s/cm, while the QA/QC instrument read a value of 98 μ s/cm. Dissolved oxygen ranked 'fair', the field instrument read a value of 11.11 mg/l, while the QA/QC instrument read a value of 11.65 mg/l. Turbidity ranked 'fair', the field instrument read a value of 2.7 NTU, while the QA/QC instrument read a value of 7.8 NTU.

At removal, temperature, dissolved oxygen and turbidity ranked either 'excellent'. pH ranked 'fair', the field instrument read a value of 8.44, while the QA/QC instrument read a value of 7.74. Specific conductivity ranked 'marginal', the field instrument read a value of 106.30 μ s/cm, while the QA/QC instrument read a value of 87.5 μ s/cm.

- **Dumbell Stream**

At deployment, all parameters ranked either 'good' or 'excellent'.

At removal, temperature, pH and turbidity ranked either 'good' or 'excellent'. Conductivity ranked 'fair', the field instrument read a value of 69 $\mu\text{s}/\text{cm}$, while the QA/QC instrument read a value of 61.4 $\mu\text{s}/\text{cm}$. Dissolved oxygen ranked 'poor'. The field instrument read a value of 9.86 mg/l, while the QA/QC instrument read a value of 11.33 mg/l. It was noted that at the time of removal, the DO sensor was fluctuating a lot.

- There are a few instances when less than ideal QA/QC rankings can 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 of the sensors.

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from June 7, 2016 to July 20, 2016 at Dolomite Road, Julianne Narrows and Dumbell Stream.
- 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 8.90 to 19.30°C at Dolomite Road and 5.00 to 19.80°C at Julianne Narrows during this deployment period (Figure 1). Water temperature at Dolomite Road is slightly higher than at Julianne Narrows.

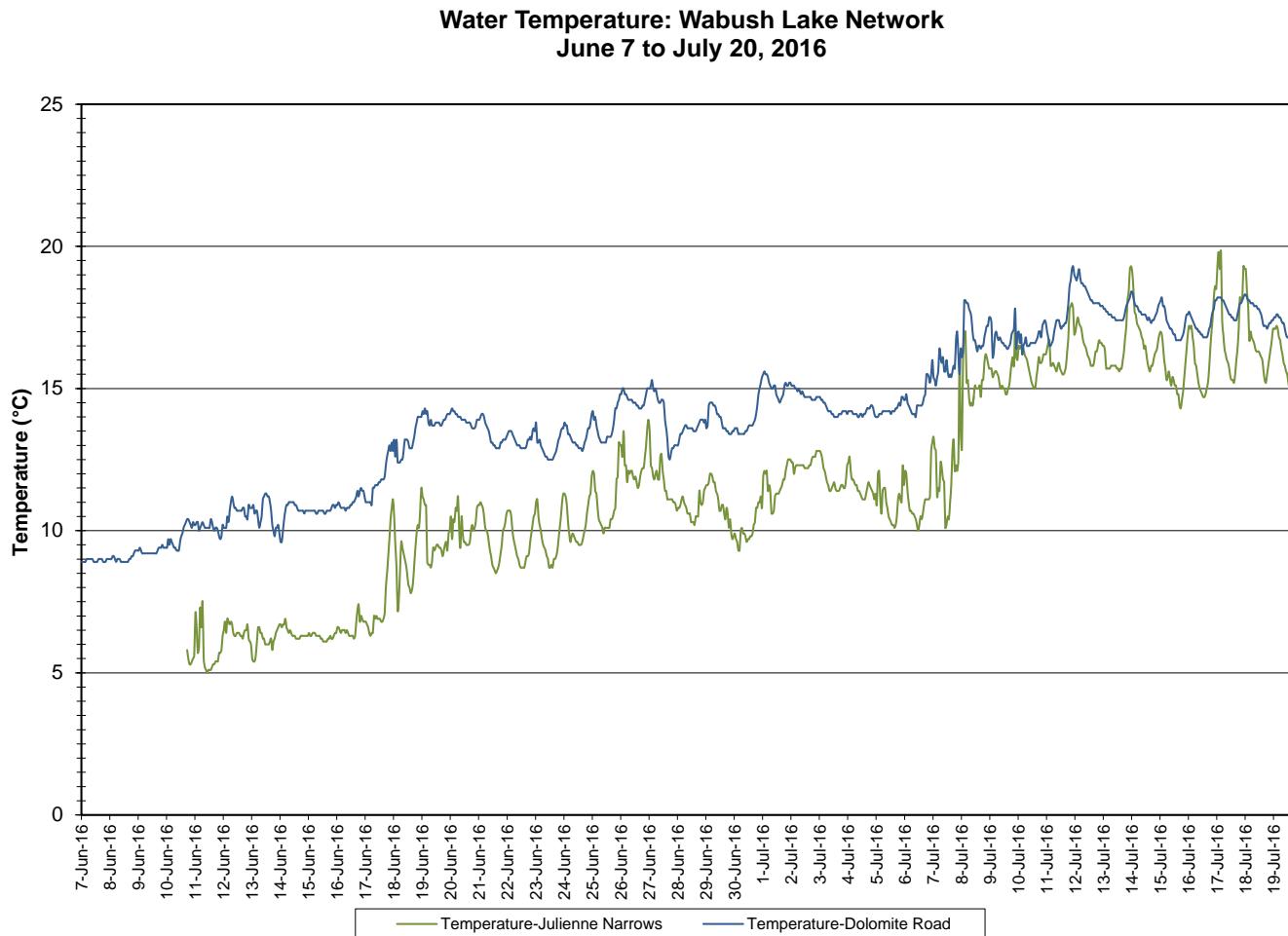


Figure 1: Water temperature - Wabush Lake network

- Water temperature increased during the deployment period, which corresponds with increasing ambient air temperature at this time (Figure 2).
- It is important to note that weather data was not available from the Wabush or Churchill Falls Airport. Therefore, weather data was collected from the Happy Valley – Goose Bay Airport, and this is over 500 km away.

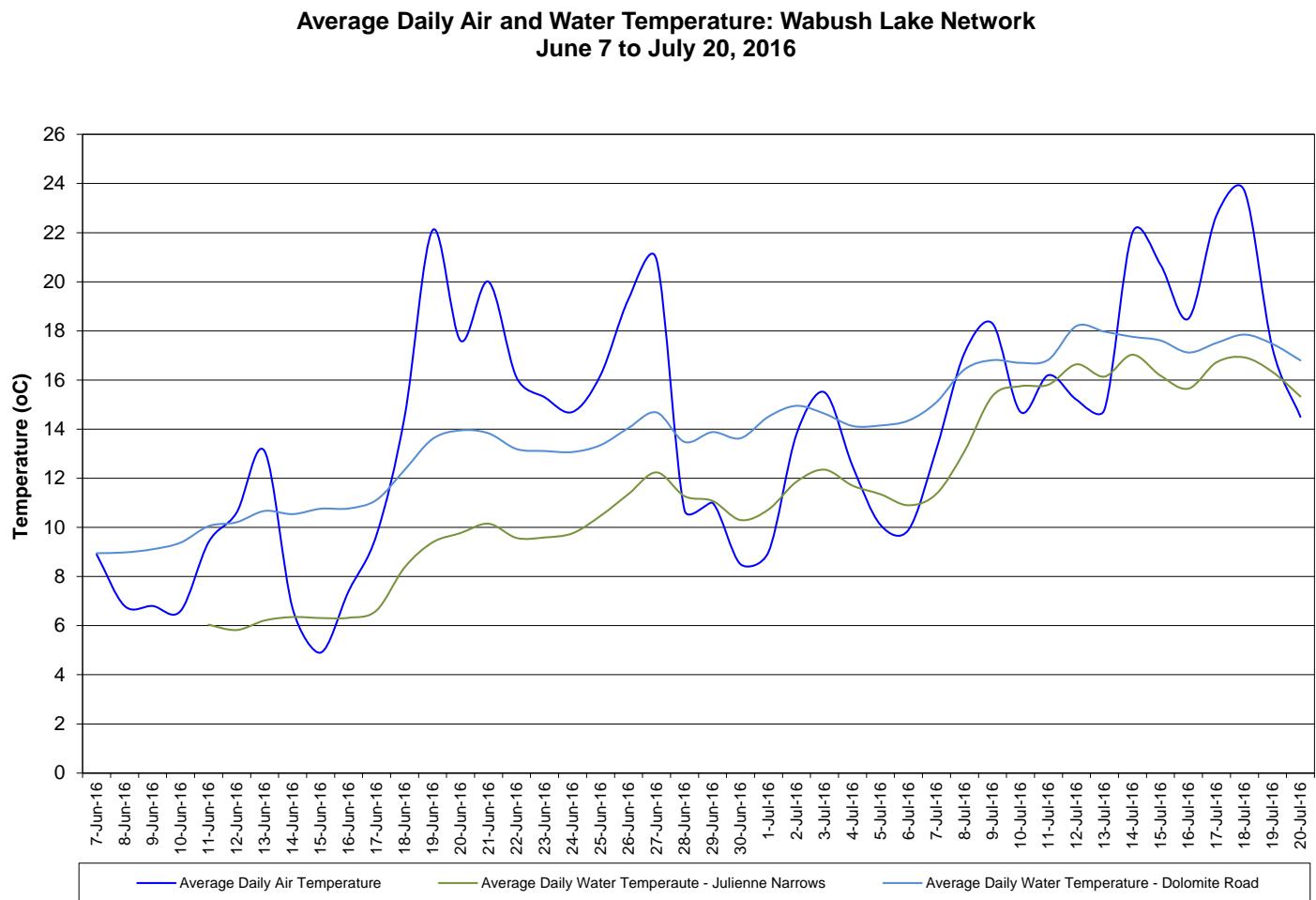


Figure 2: Average daily air and water temperatures – Wabush Lake network

(Weather data collected at Happy Valley – Goose Bay)

- pH ranges from 6.96 to 7.69 pH units at Dolomite Road, and from 7.89 to 8.71 pH units at Julianne Narrows, throughout the deployment period (Figure 3). The median pH is 7.45 and 8.21 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 during the day and night.
- A decrease in pH is noticeable at Dolomite Road on the 28th of June; you can also see that stage increases at this time, this may be caused by a precipitation event on the same day.
- 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.

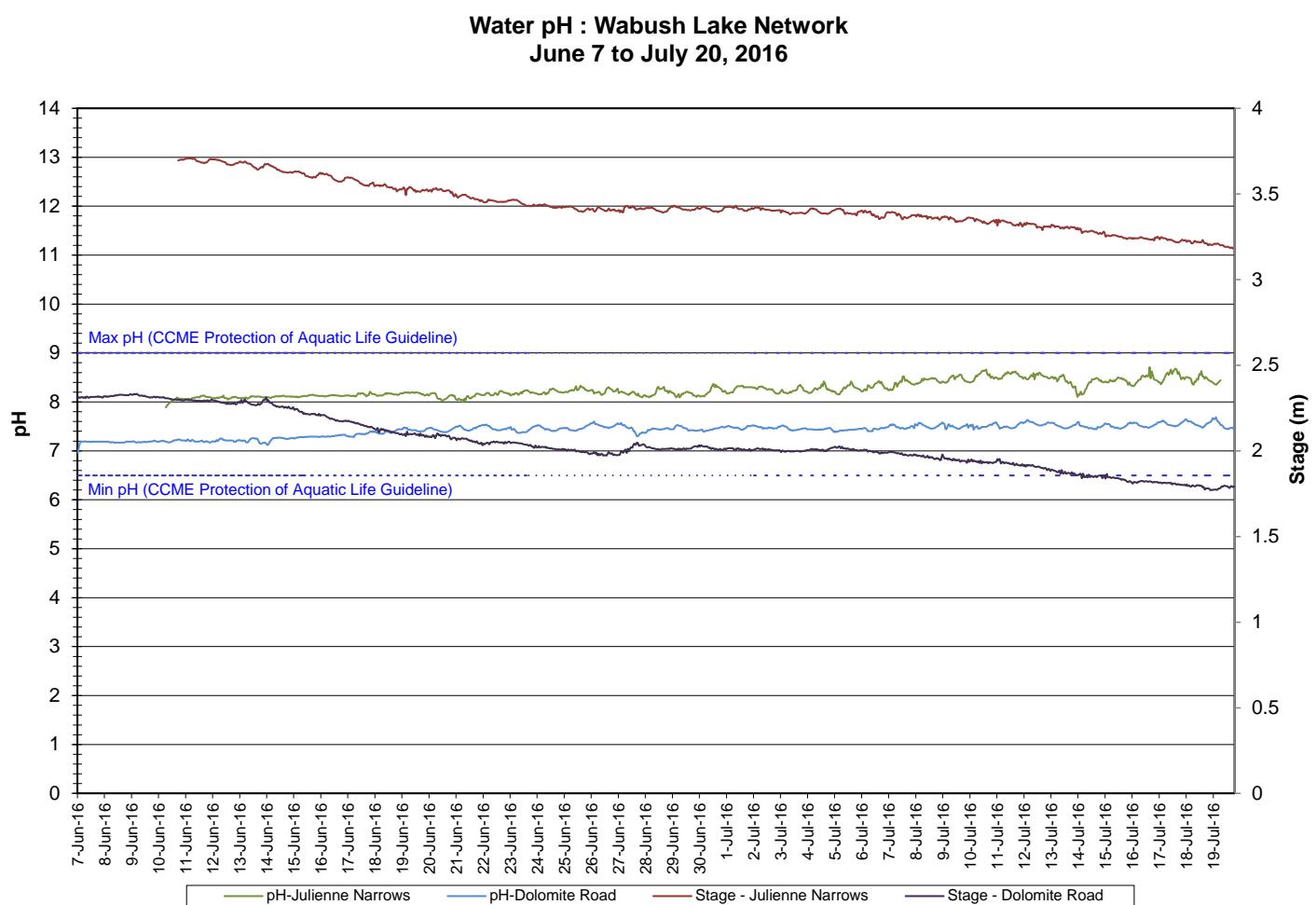


Figure 3: pH – Wabush Lake network

- Specific conductivity ranged from 36.4 to 57.6 $\mu\text{s}/\text{cm}$ at Dolomite Road and from 76.2 to 119.2 $\mu\text{s}/\text{cm}$ 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.
- There is a decrease in specific conductivity at Dolomite Road on the 28th of June; this can be attributed to the rise in stage from a rainfall event. This occurs when an increased amount of water is introduced to the system and the amount of solids is diluted. There is an increase in specific conductivity on the 15th of July, the cause of this is unknown.
- 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
June 7 to July 20, 2016

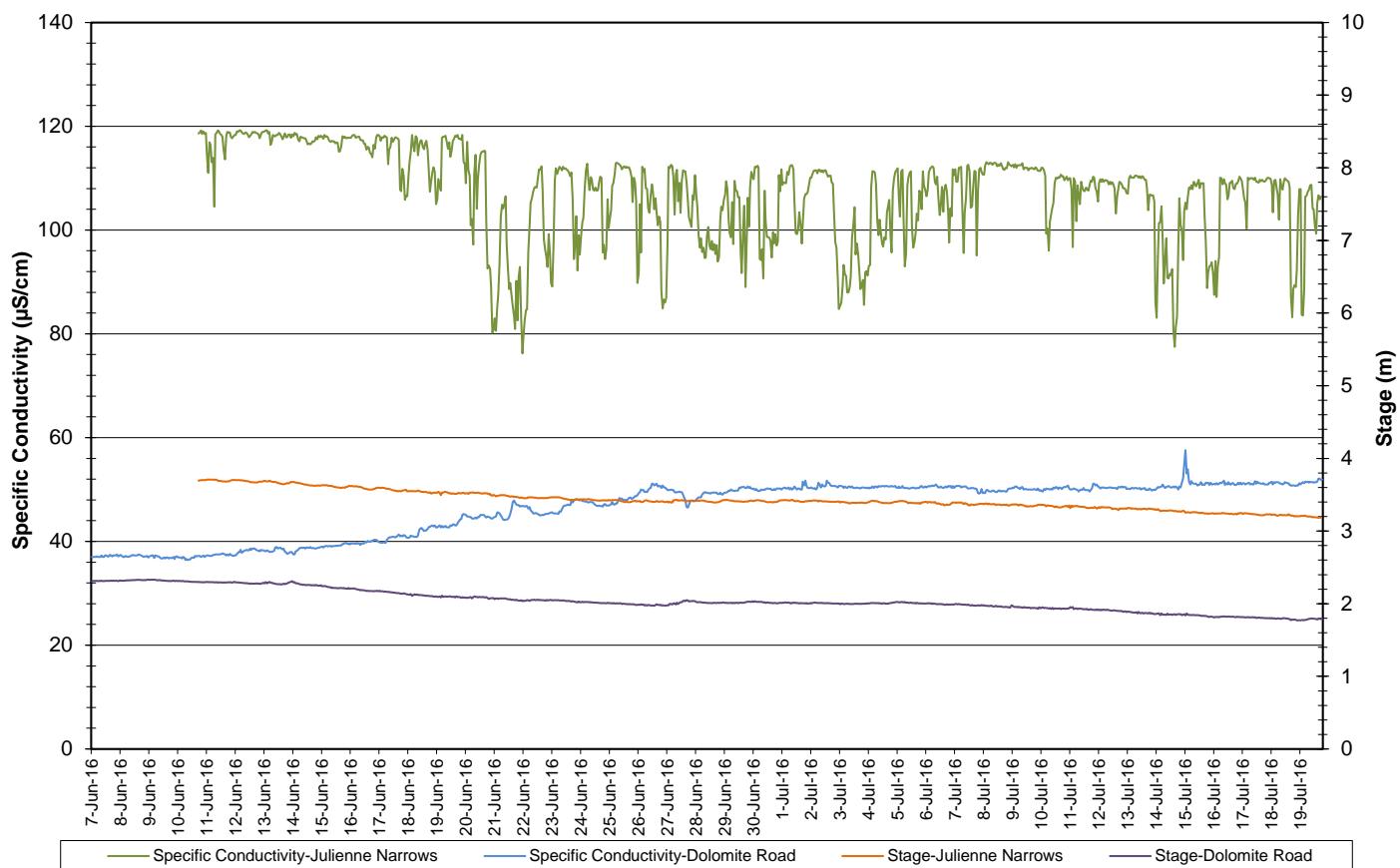


Figure 4: Specific conductivity – Wabush Lake network

- At the Dolomite Road station, the saturation of dissolved oxygen ranged from 78.8 to 90.4% and a range of 7.71 to 9.51 mg/l was found in the concentration of dissolved oxygen with a median value of 8.43 mg/l (Figure 5).
- At the Julianne Narrows station, the saturation of dissolved oxygen ranged from 86.7 to 104.0% and a range from 8.34 to 11.32 mg/l was found in the concentration of dissolved oxygen with a median value of 10.05 mg/l (Figure 5). There was a noticeable decrease in dissolved oxygen on the 15th of July, the reason for this is unknown.
- All values recorded at Julianne 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.
- Most values recorded at Julianne 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 most values recorded at Dolomite Road were below the guideline. The guidelines are indicated in blue on Figure 5.
- Dissolved oxygen fluctuated daily with decreases observed at night.

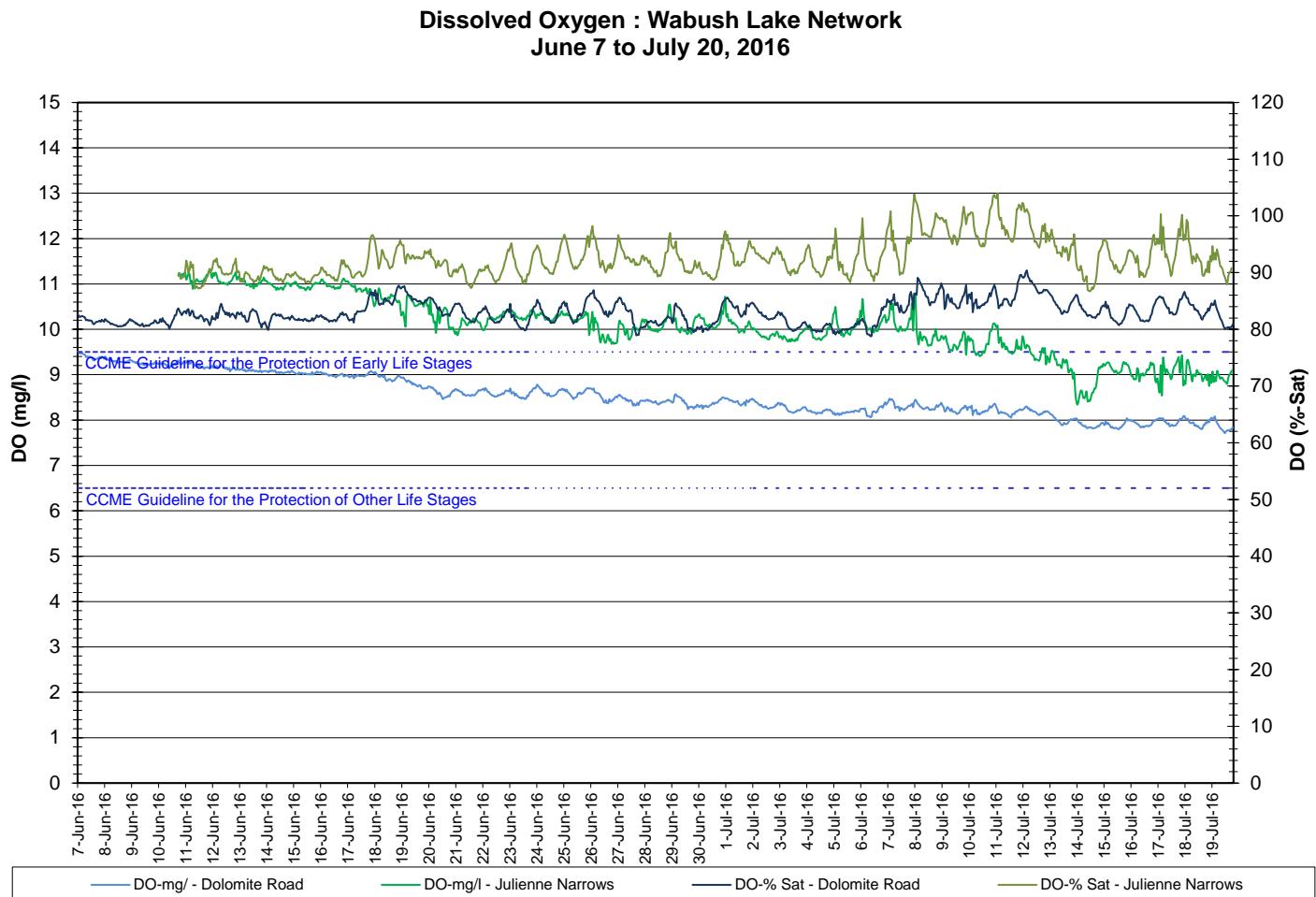


Figure 5: Dissolved oxygen and percent saturation – Wabush Lake Network

- At the Julienne Narrows station, turbidity values range from 0.0 to 502.00 NTU throughout the deployment period (Figure 6). The median value was 1.5 NTU.
- In some instances, turbidity spikes can be attributed to precipitation at the time (weather data collected at Happy Valley – Goose Bay). They are indicated on the graph in red.

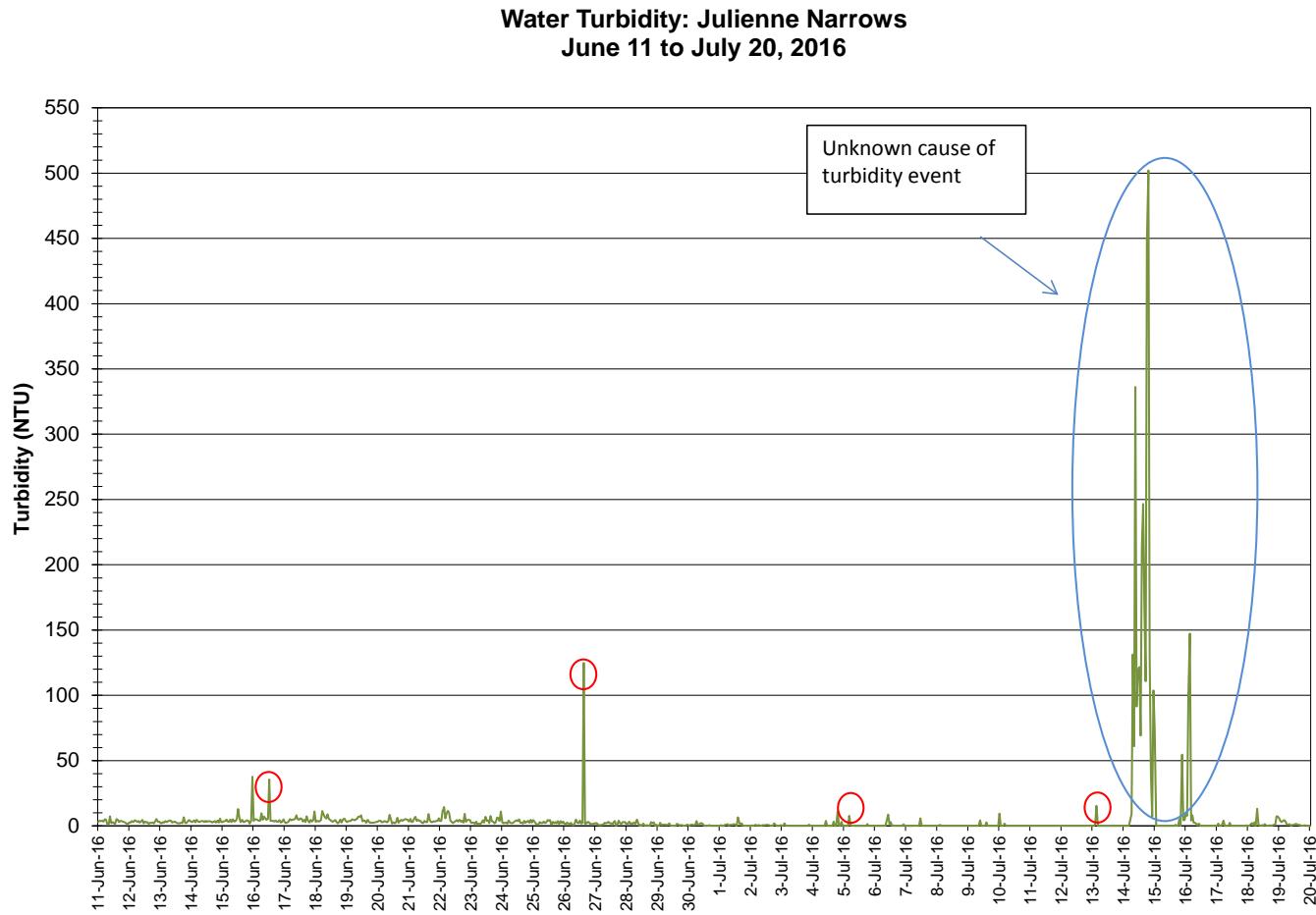


Figure 6: Turbidity – Julienne Narrows

- At the Dolomite Road station, turbidity values range from 0.0 to 9.9 NTU throughout the deployment period (Figure 7). The median value was 0.0 NTU.
- In some instances, turbidity spikes can be attributed to precipitation at the time (weather data collected at Happy Valley – Goose Bay). They are indicated on the graph in red.

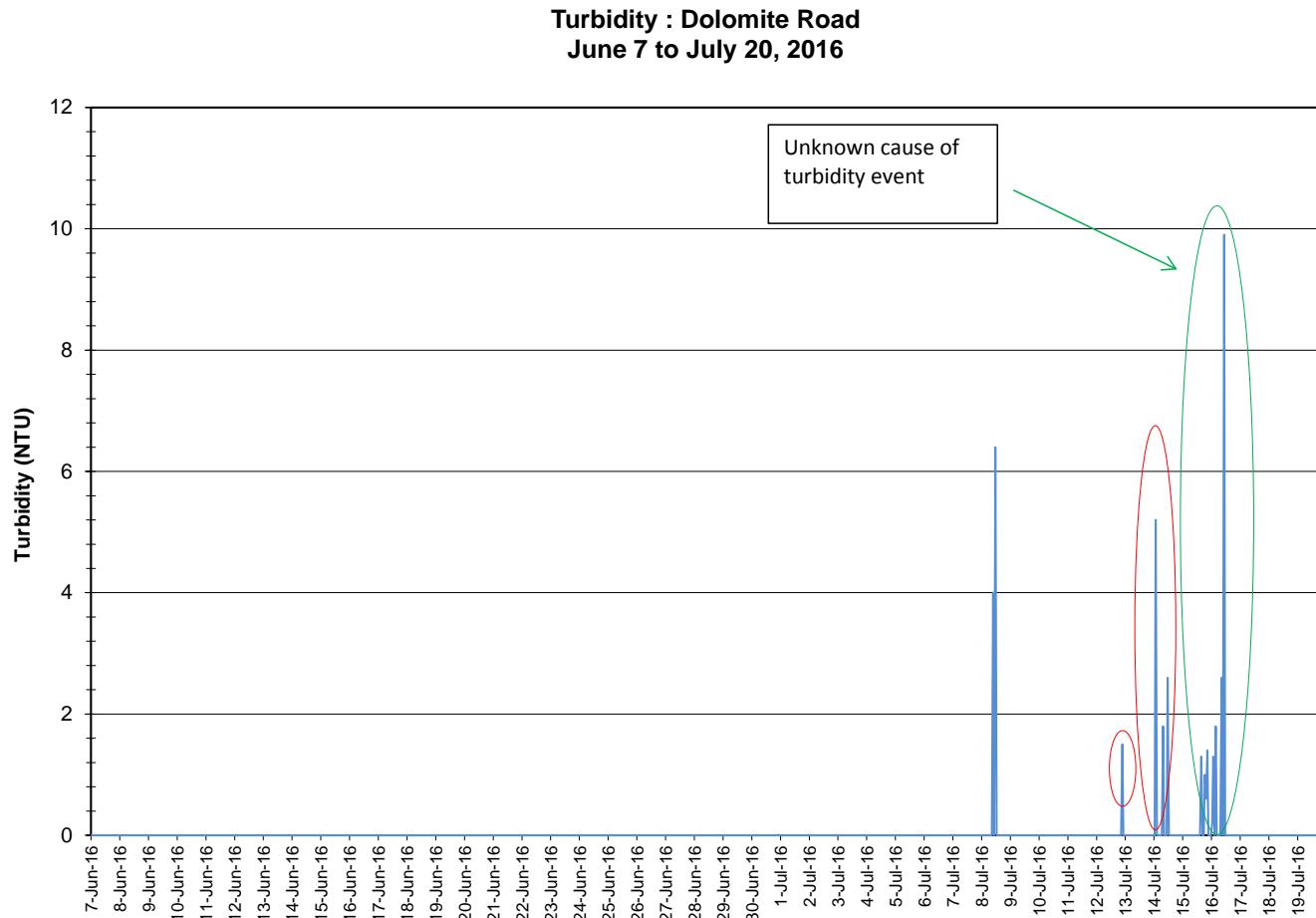


Figure 7: Turbidity – Dolomite Road

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Dolomite Road (Figure 8).
- Stage decreases throughout the deployment period with varying precipitation records.
- It is important to note that weather data was collected from Happy Valley – Goose Bay, ~500 km away. Data from the local area was not available for this 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.

Daily Precipitation and Average Daily Stage Level: Dolomite Road
June 7 to July 20, 2016

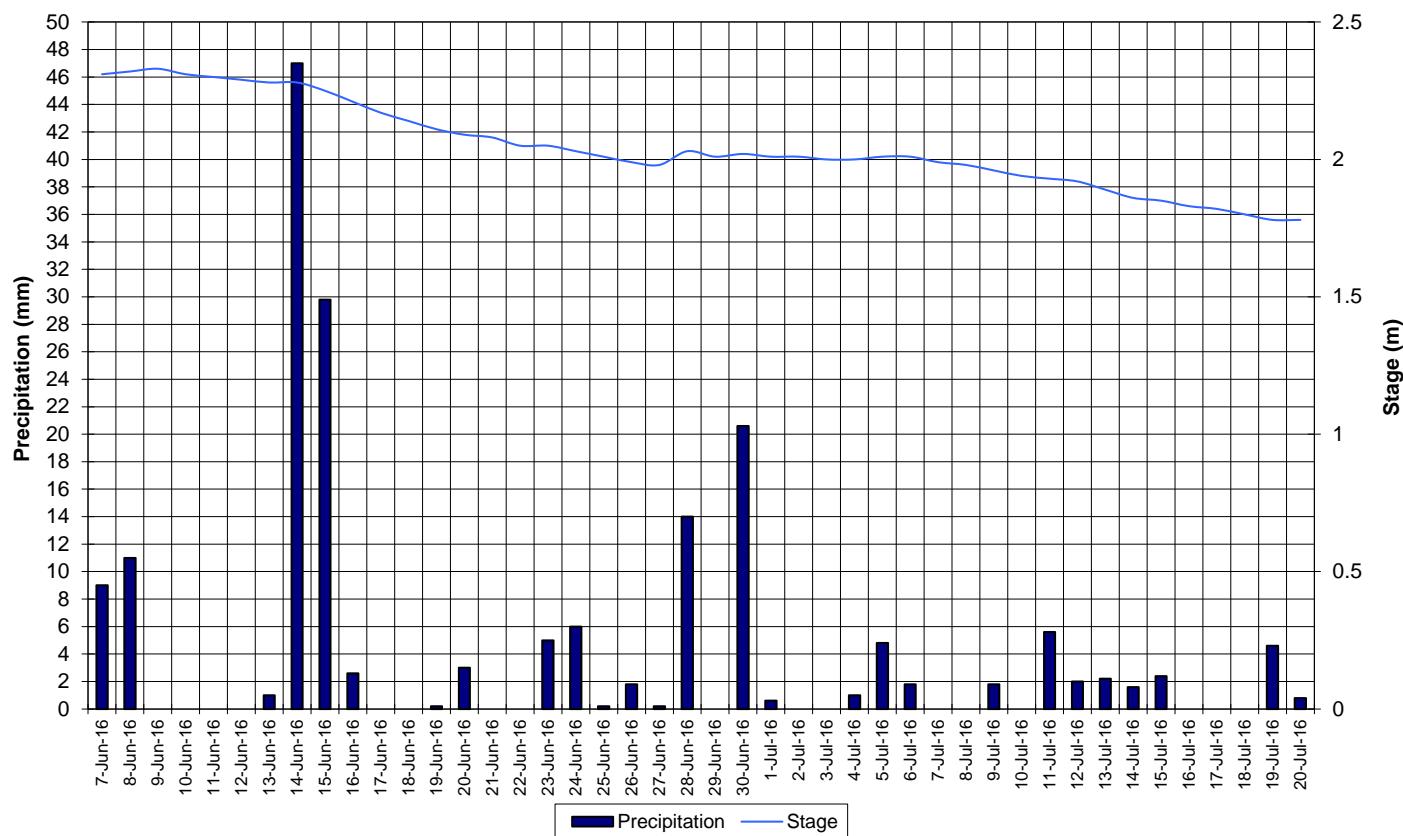


Figure 8: Precipitation and Stage –Dolomite Road

(Weather data collected at Happy Valley – Goose Bay)

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Julianne Narrows (Figure 9).
- Stage decreased throughout the deployment period, with varying precipitation records.
- It is important to note that weather data was collected from Happy Valley – Goose Bay, ~500 km away. Data from the local area was not available for this 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.

Daily Precipitation and Average Daily Stage Level: Julianne Narrows
June 11 to July 20, 2016

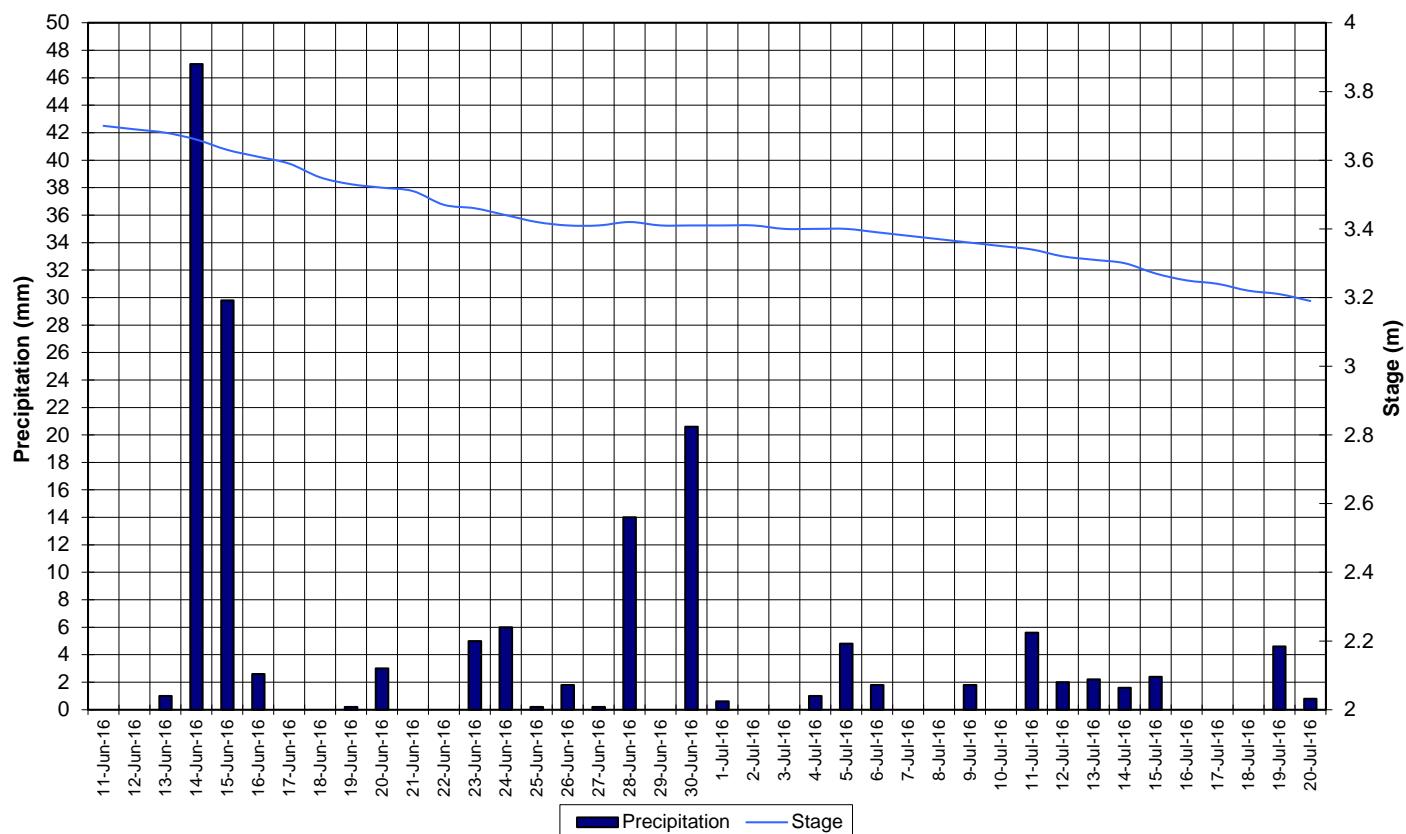


Figure 9: Precipitation and Stage – Julianne Narrows

(Weather data collected at Happy Valley – Goose Bay)

Dumbell Stream

- The instrument was deployed at Dumbell Stream on June 8th. However, there were a number of transmission issues, and therefore data was only available beginning on the 10th of June.
- Water temperature ranged from 2.49 to 6.57°C during this deployment period (Figure 10).
- Water temperature generally fluctuated within this range for the deployment period, this area is very shaded. It did not correspond with increasing ambient air temperature (Figure 11).

Water Temperature : Dumbell Stream above Dumbell Lake
June 10 to July 20, 2016

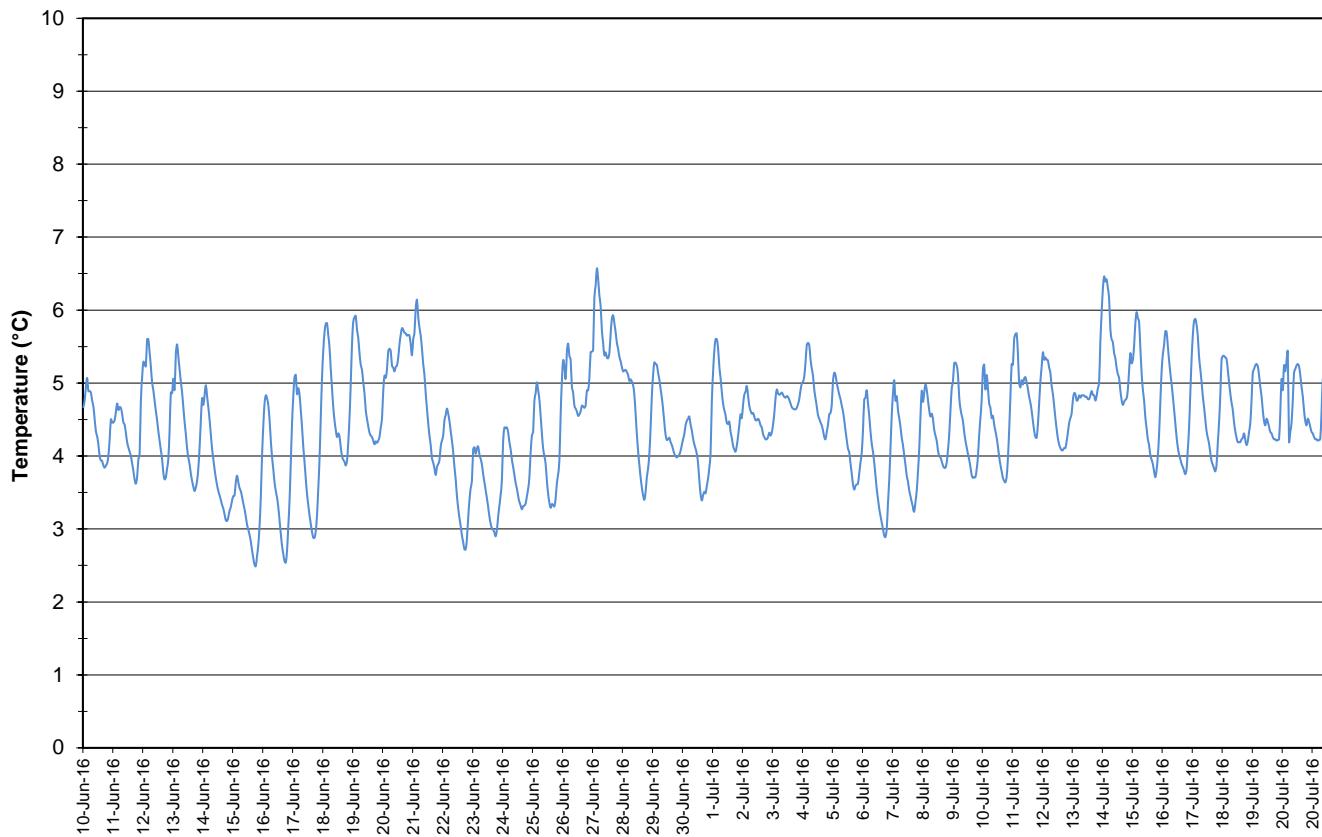


Figure 10: Water Temperature – Dumbell Stream

Average Daily Air and Water Temperature: Dumbell Stream
June 10 to July 20, 2016

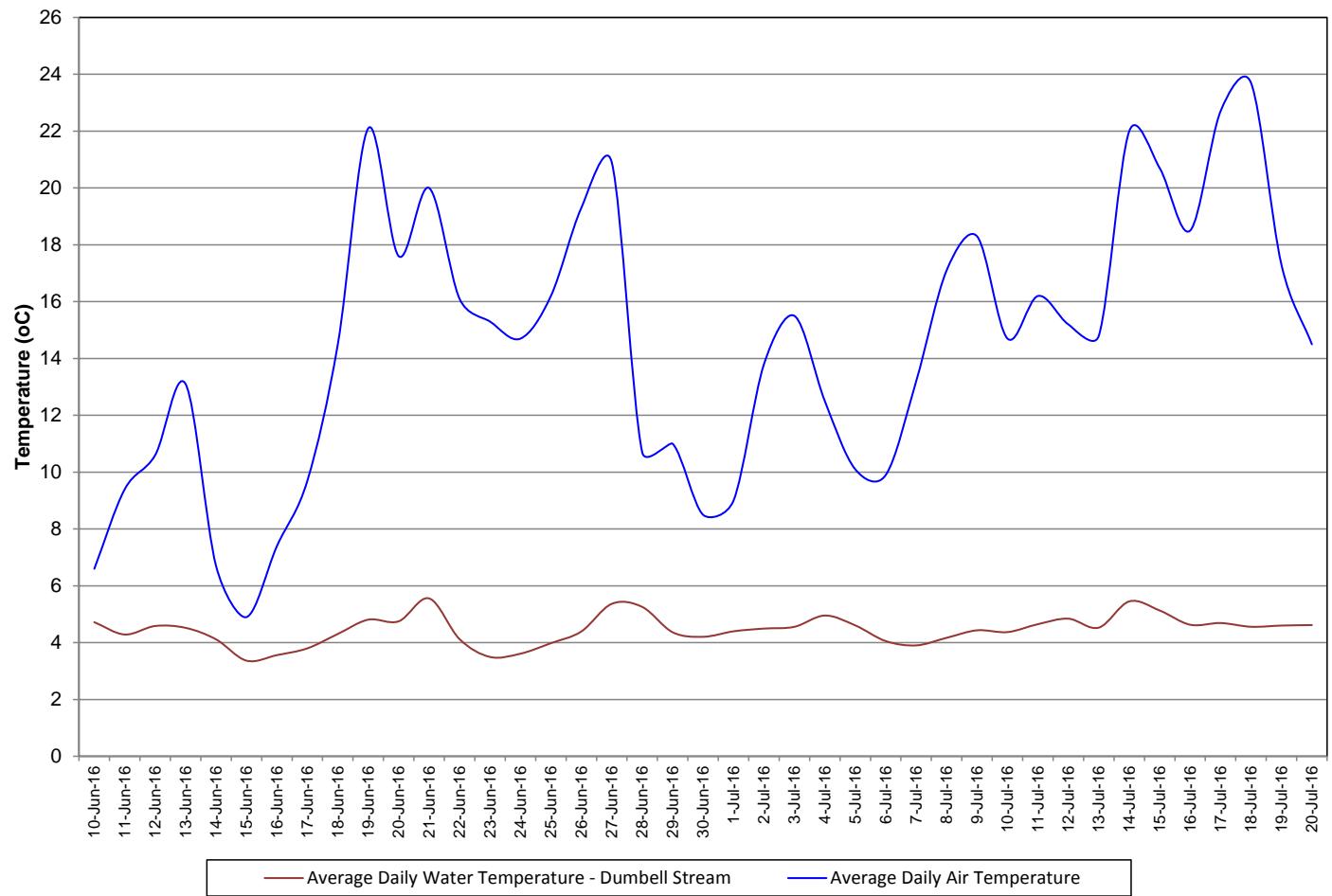


Figure 11: Average daily air and water temperatures – Dumbell Stream

(Weather data collected at Happy Valley – Goose Bay)

- pH ranged from 7.37 to 7.77 pH units (Figure 11). The median pH was 7.61.
- 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 during the day and night.

Water pH : Dumbell Stream above Dumbell Lake
June 10 to July 20, 2016

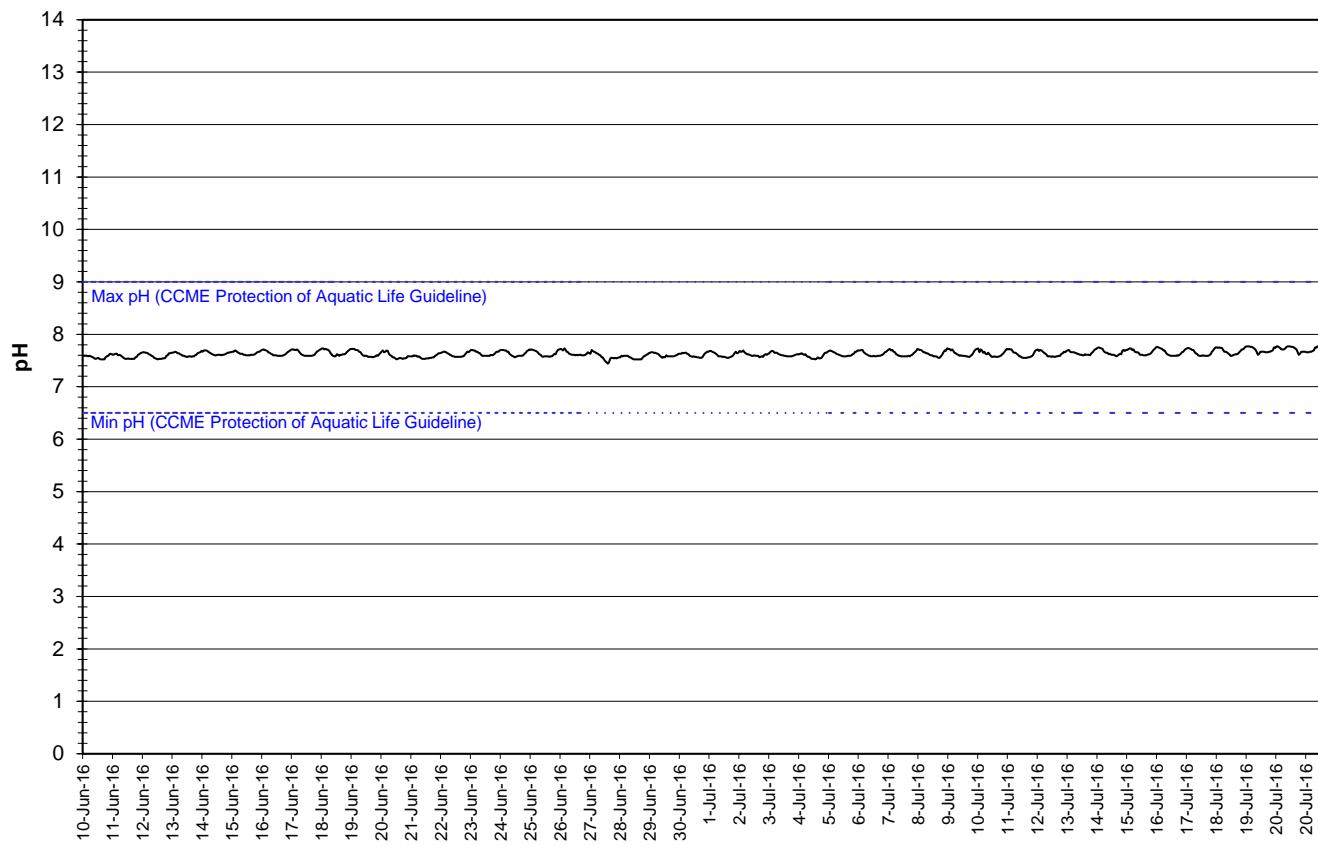


Figure 12: Water pH – Dumbell Stream

- Specific conductivity ranged from 47.0 to 74.0 $\mu\text{s}/\text{cm}$, throughout the deployment period (Figure 12).
- 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.

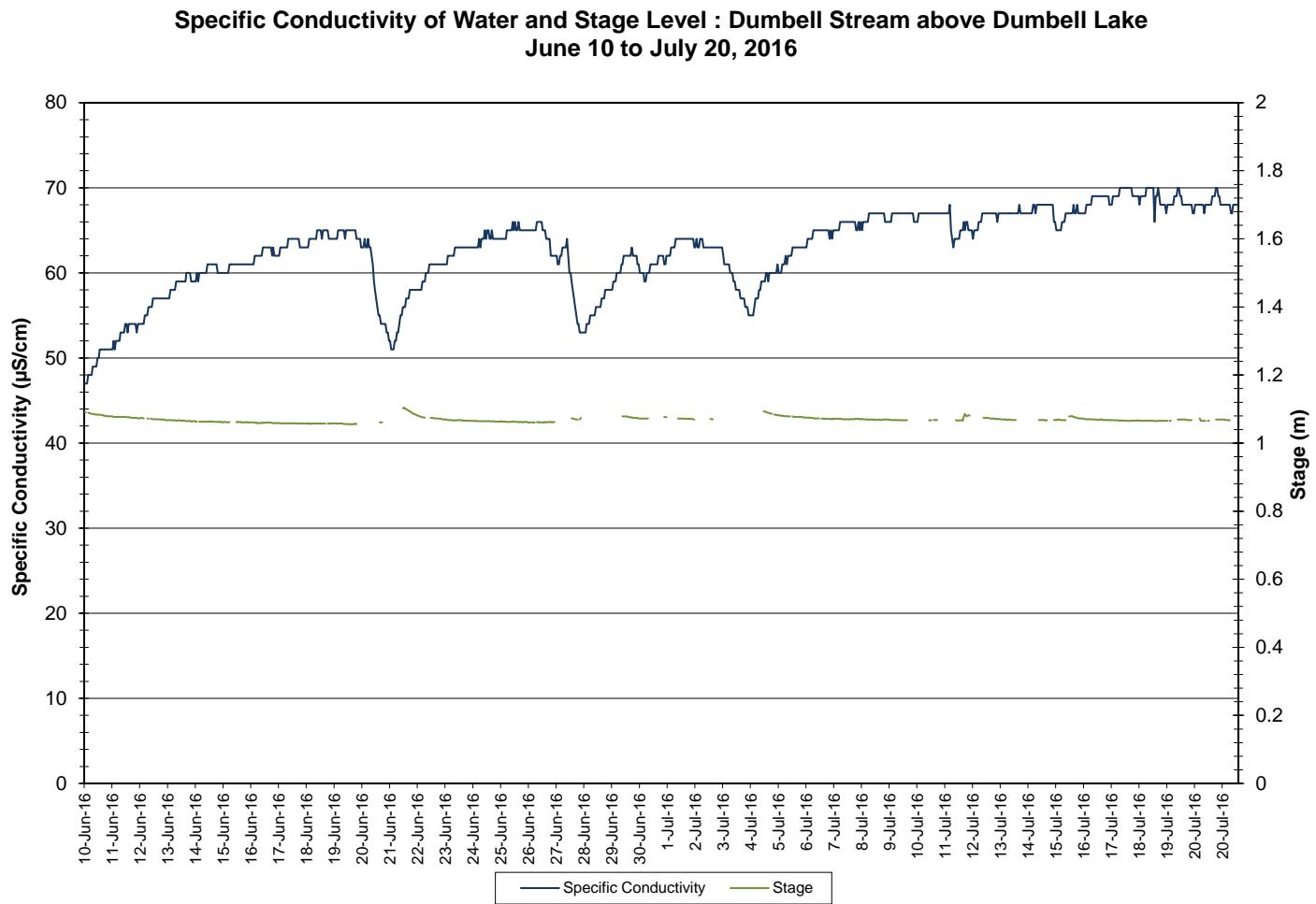


Figure 13: Specific Conductivity – Dumbell Stream

- The saturation of dissolved oxygen ranged from 81.4 to 95.5% and a range of 10.27 to 12.84 mg/l was found in the concentration of dissolved oxygen with a median value of 11.55 mg/l (Figure 5).
- 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 13.
- Dissolved oxygen fluctuated daily with decreases observed at night.

Dissolved Oxygen Concentration and Saturation : Dumbell Stream at Dumbell Lake
June 10 to July 20, 2016

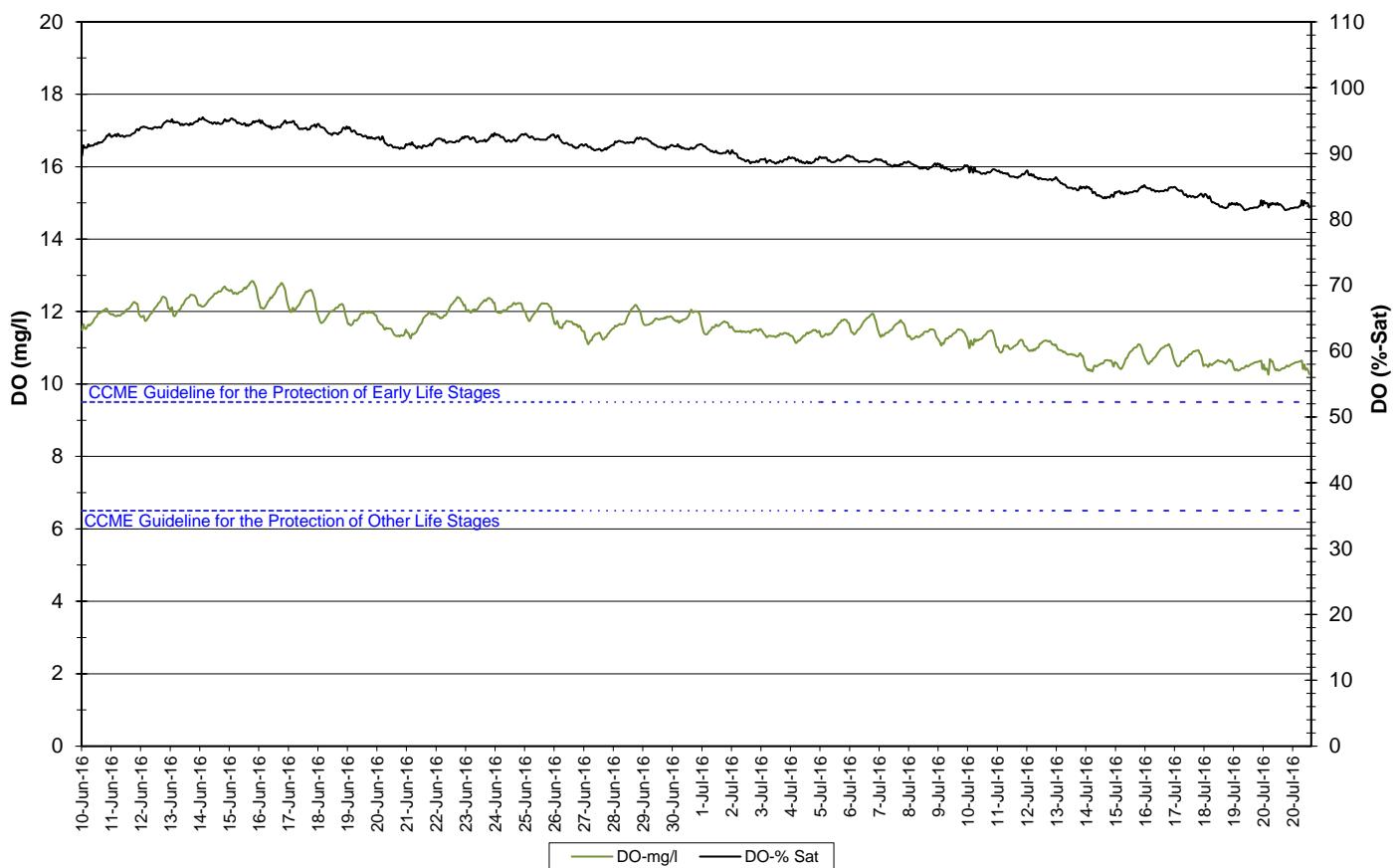


Figure 14: Dissolved Oxygen – Dumbell Stream

- Turbidity values range from 0.0 to 7.9 NTU throughout the deployment period (Figure 14). The median value was 0.0 NTU.
- There are numerous turbidity spikes at the end of the deployment period; the cause of this is unknown. It could be weather related as it is seen at all three stations.

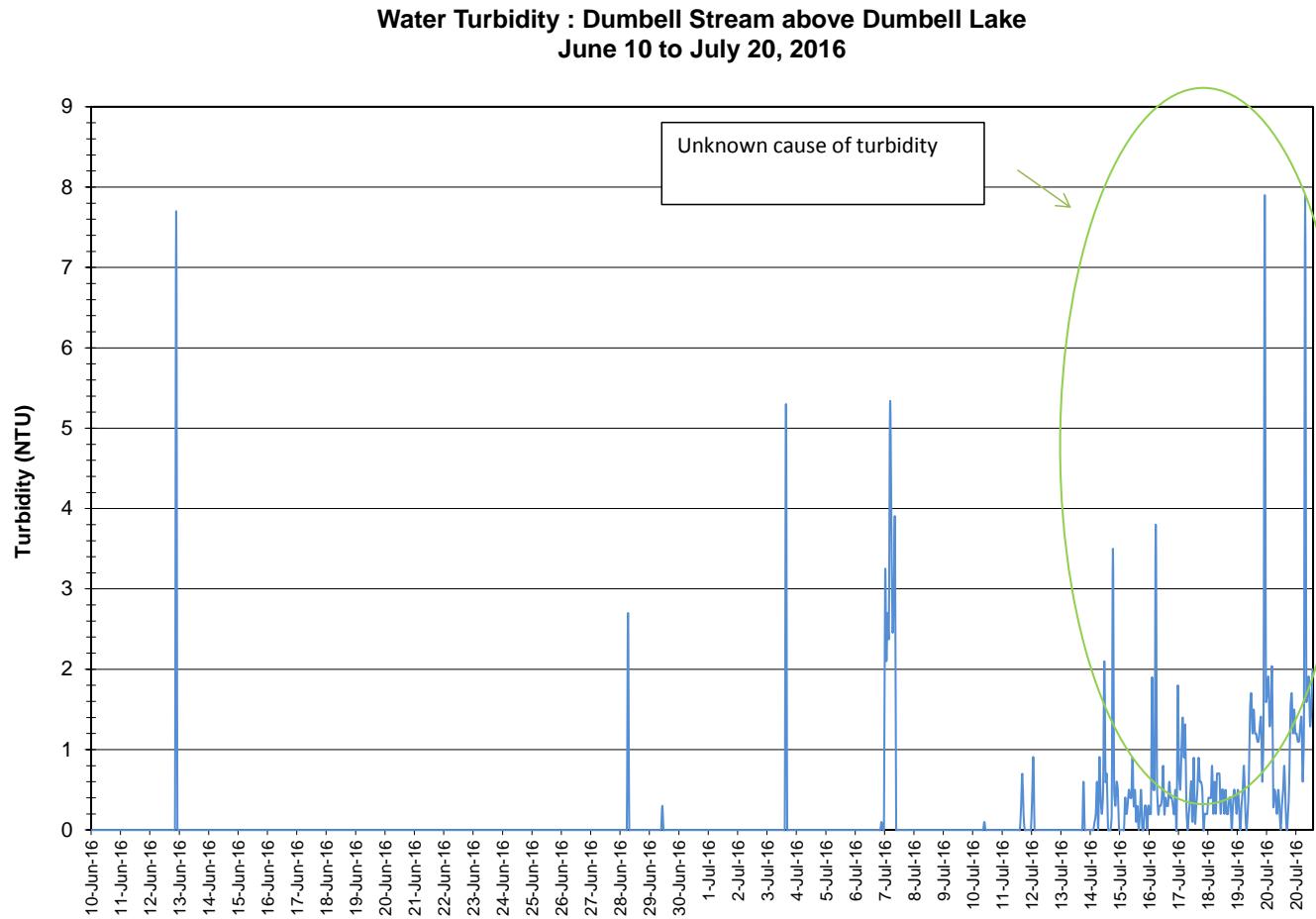


Figure 15: Turbidity – Dumbell Stream

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Dumbell Stream (Figure 16).
- Stage is relatively stable throughout the deployment period, with varying precipitation records.
- It is important to note that weather data was collected from Churchill Falls, ~200 km away. Data from the local area was not available for this 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.

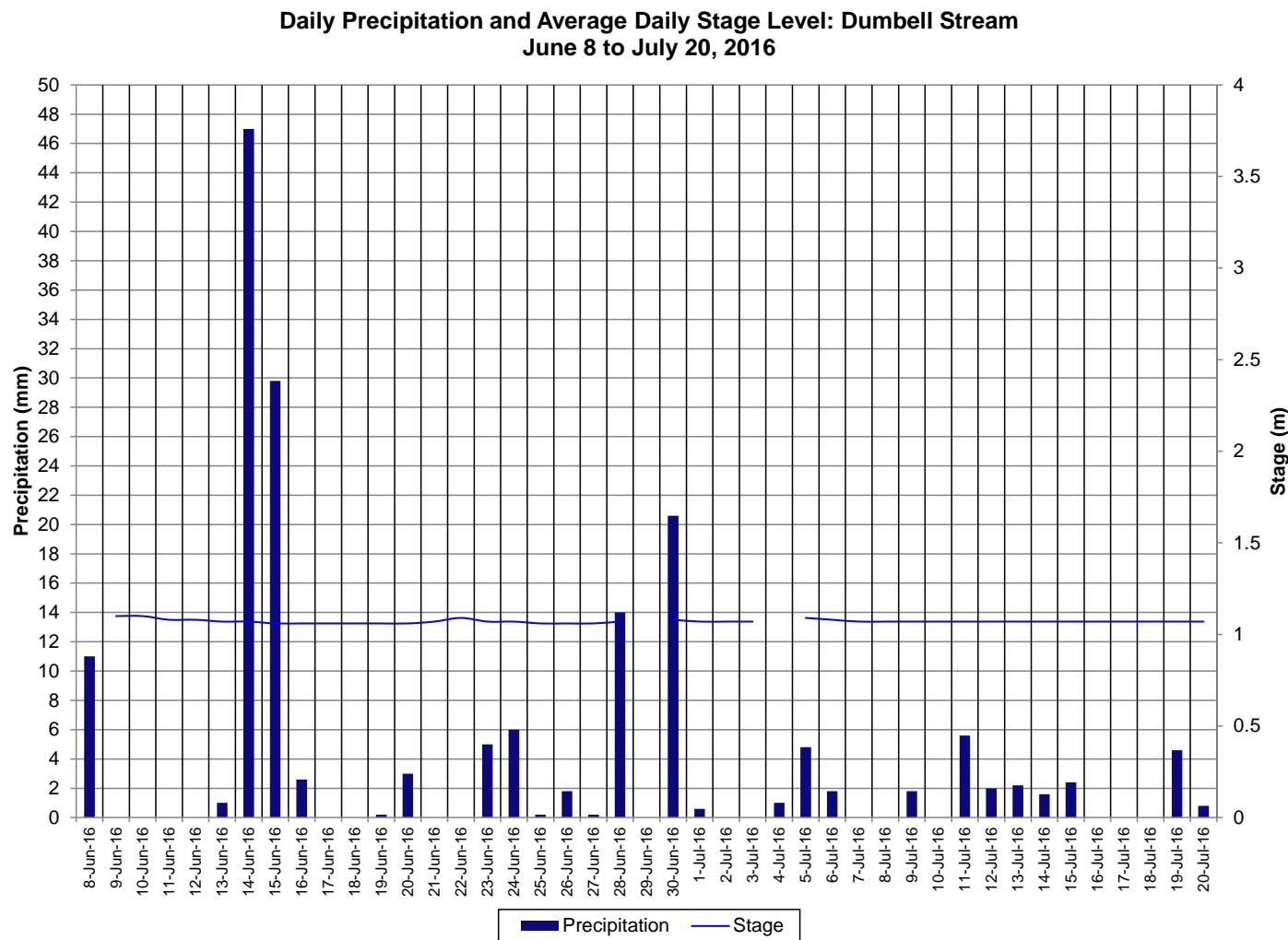


Figure 16: Precipitation and Stage –Dumbell Stream
(Weather data collected at Happy Valley – Goose Bay)

Conclusions

- Instruments were deployed starting June 7th and removed on July 20th, 2016.
- In most cases, weather related events or increase/decreases in water level could be used to explain the 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 Julianne Narrows and Dolomite Road. The temperature typically ranged between 2.49 and 19.80°C, at the three stations.
- pH values were all within the recommended CCME Guidelines for the Protection of Aquatic Life. pH ranged between 6.96 and 8.71. Fluctuations were noted between day and night. There was a noticeable decrease in pH on the 28th of June at Dolomite Road, this was due to precipitation.
- 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 36.4 µs/cm to 57.6 µs/cm. Specific conductivity at Dumbell Stream ranged from 47.0 to 74.0 µs/cm.
- At Dolomite Road, 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 and most values were below the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota at Early Life Stages of 9.5 mg/l.
- At Julianne Narrows, 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 and most values were above the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota at Early Life Stages of 9.5 mg/l.
- At Dumbell Stream, 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 and the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota at Early Life Stages of 9.5 mg/l.
- Turbidity values at Julianne Narrows were higher than at Dolomite Road, there were a few large spikes.
- Turbidity at Dolomite Road remained at 0.0 NTU for the majority of the deployment period but very small spikes did occur. The median value was 0.0 NTU.
- Turbidity at Dumbell Stream remained at 0.0 NTU for the majority of the deployment period there were a number of spikes towards the end of the deployment period. The median value was 0.0 NTU.
- Stage decreased at Dolomite Road and Julianne Narrows during this deployment period, and was stable at Dumbell Stream.
- 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

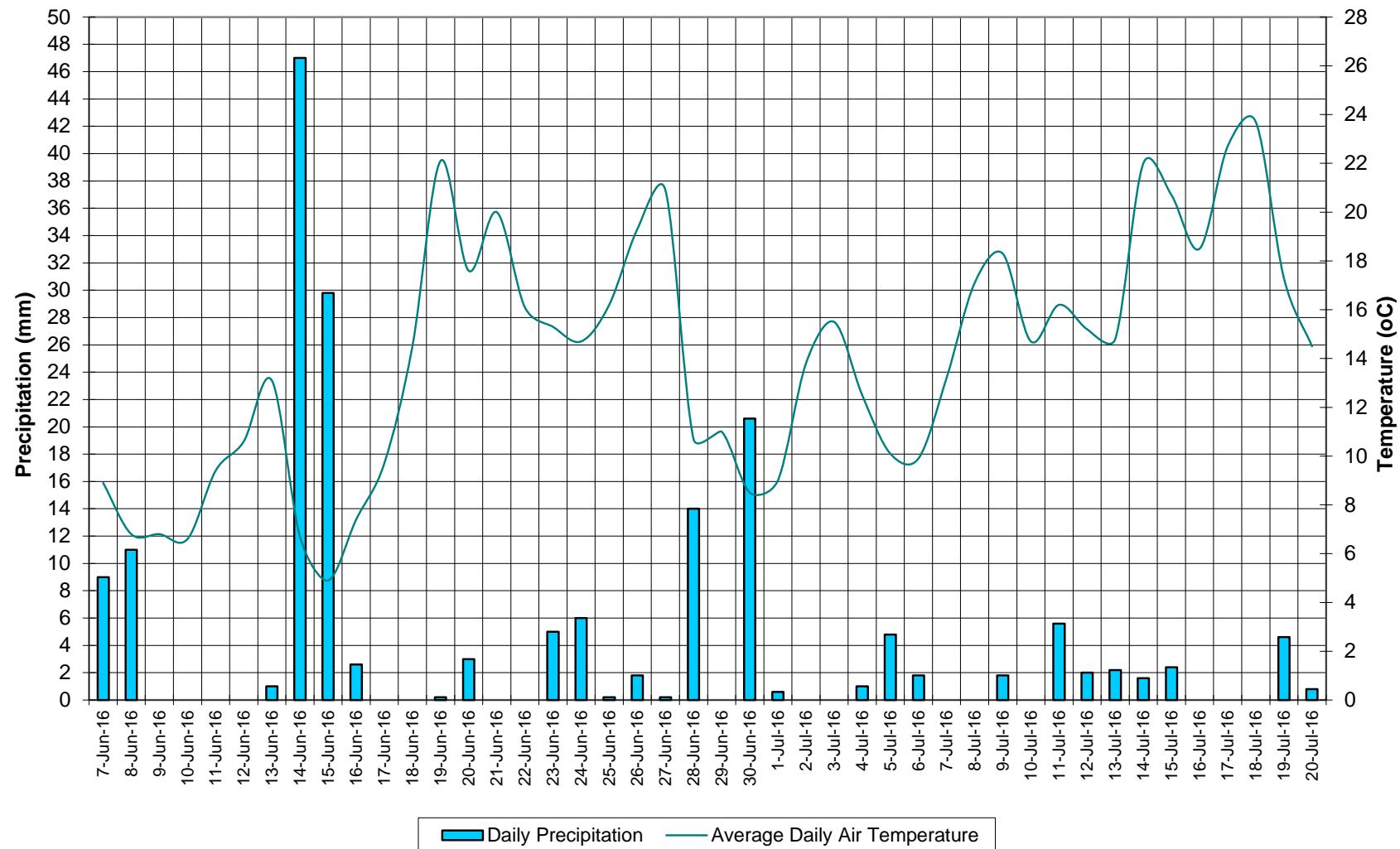
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Appendix 1

Average Daily Air Temperature and Daily Precipitation: Happy Valley - Goose Bay, NL June 7 to July 20, 2016



Appendix 2 - Photos



Photo 1: New Hut at Dumbell Stream



Photo 2: First Deployment at Dumbell Stream