Real-Time Water Quality Deployment Report

Iron Ore Company of Canada
Labrador West Network

June 11 to
July 19, 2017

Newfoundland Labrador

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

Contents

General

- The Water Resources Management Division, in partnership with the Iron Ore Company of Canada (IOC) and Environment and Climate Change Canada (EC), 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 June 11th and 13th, 2017, real-time water quality monitoring instruments were deployed at the four IOC stations. The instruments were deployed for a period of 37 days at Dolomite Road, Dumbell Stream and Pumphouse Stream and 35 days at Julienne Narrows. The instruments were removed on July 18th and 19th. This was the first deployment for 2017.

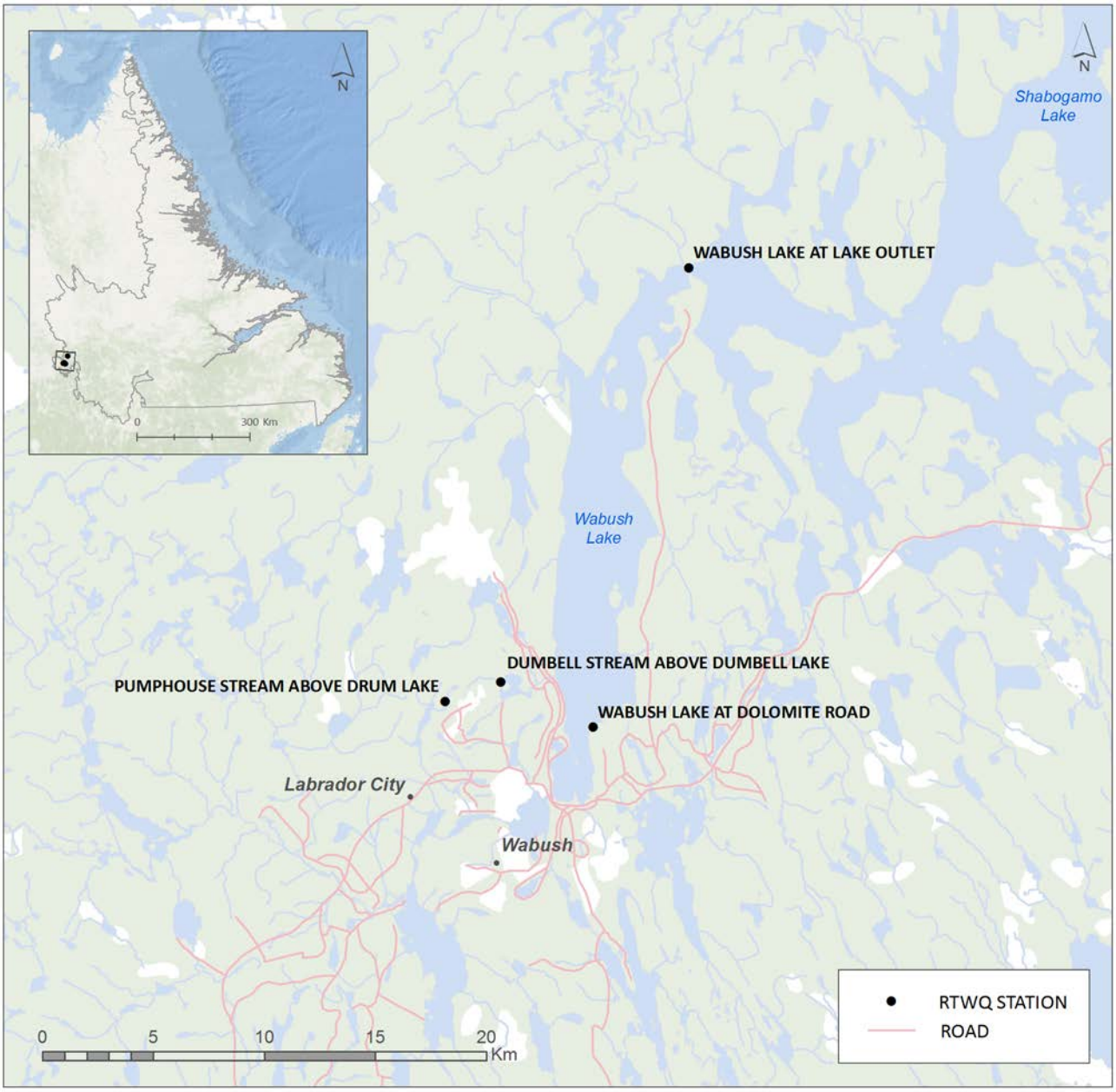

Figure 1: RTWQ Monitoring Stations in Labrador West

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

	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 > 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 11 and July 19, 2017 is summarized in Table 2.

Table 2: QA/QC comparison rankings for IOC stations between June 11 and July 19, 2017.

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Dolomite Road	June 11, 2017	Deployment	Good	Excellent	Excellent	Fair	Excellent
	July 18, 2017	Removal	Good	Good	Excellent	Good	N/A
Julienne Narrows	June 13, 2017	Deployment	Excellent	Excellent	Excellent	Fair	Good
	July 18, 2017	Removal	Good	Good	Good	Fair	Poor
Dumbell Stream	June 12, 2017	Deployment	Excellent	Excellent	Good	Good	Excellent
	July 19, 2017	Removal	Good	Excellent	Good	Excellent	Excellent
Pumphouse Stream	June 12, 2017	Deployment	Excellent	Excellent	Good	Good	Excellent
	July 19, 2017	Removal	Excellent	Good	Good	Excellent	Fair

- **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 10.05 mg/l, while the QA/QC instrument read a value of 9.28 mg/l.

  At removal, temperature, pH, conductivity and dissolved oxygen ranked either 'good' or 'excellent'. Turbidity was not ranked due to a power issue with the instrument, thus affecting the turbidity readings.

- **Julienne Narrows**

  At deployment, temperature, pH, conductivity and turbidity ranked either 'excellent' or 'good'. Dissolved oxygen ranked 'fair'. The field instrument read a value of 10.76 mg/l, while the QA/QC instrument read a value of 10.14 mg/l.

  At removal, temperature, pH and conductivity ranked 'good'. Dissolved oxygen ranked 'fair', the field instrument read a value of 8.92 mg/l, while the QA/QC instrument read a value of 8.38 mg/l. Turbidity ranked 'poor'. The field instrument read a value of 1.1 NTU, while the QA/QC instrument read a value of 20.6 NTU.

- **Dumbell Stream**

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

- **Pumphouse Stream**

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

  At removal, all parameters except turbidity ranked either 'excellent' or 'good'. Turbidity ranked 'fair'. The field instrument read a value of 5.2 NTU, while the QA/QC instrument read a value of 0.0 NTU.

- 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 of the sensors.

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from June 11, 2017 to July 19, 2017 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 10.30 to 18.50°C at Dolomite Road and 8.40 to 18.00°C at Julienne Narrows during this deployment period (Figure 2). Water temperature at Dolomite Road is slightly higher than at Julienne Narrows.

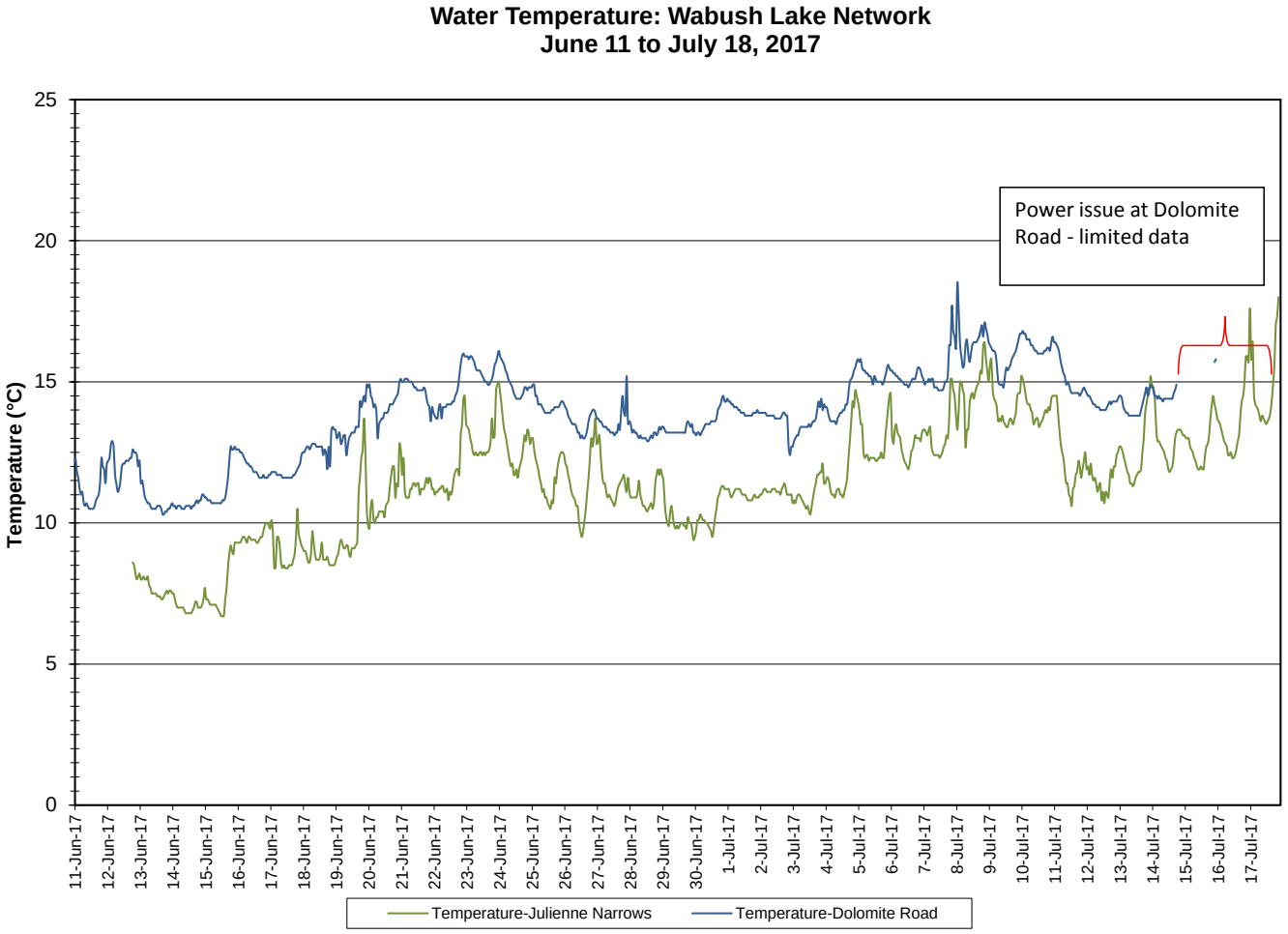

Figure 2: Water temperature - Wabush Lake network

- Water temperature increased during the deployment period, which corresponds with increasing ambient air temperature at this time (Figure 3).

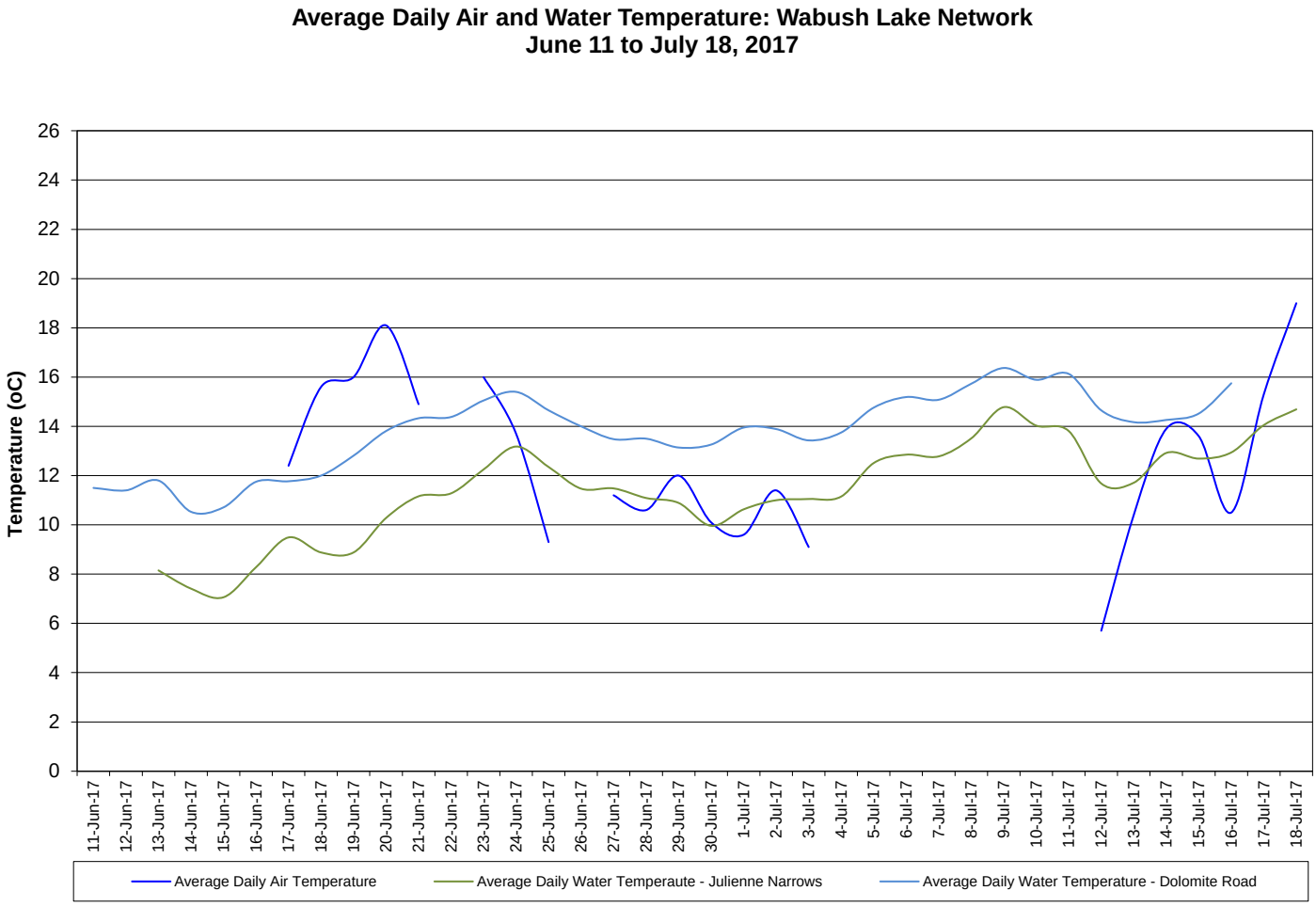

Figure 3: Average daily air and water temperatures – Wabush Lake network

- pH ranges from 7.37 to 7.87 pH units at Dolomite Road, and from 7.67 to 8.28 pH units at Julienne Narrows throughout the deployment period (Figure 4). The median pH is 7.64 and 7.90 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.
- A decrease in pH is noticeable at Dolomite Road on the 3rd of July, with a corresponding increase in stage. 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.

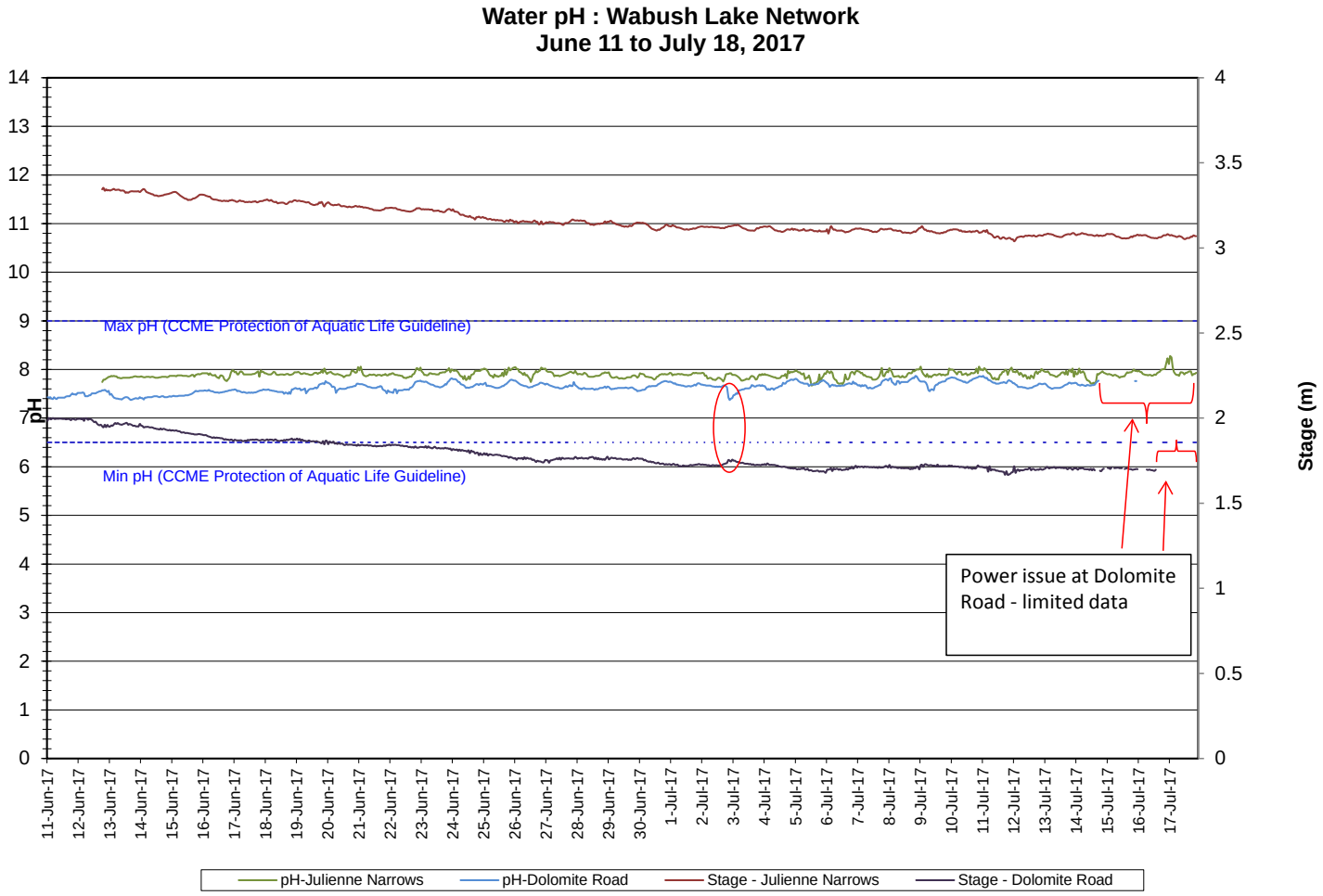

Figure 4: pH – Wabush Lake network

- Specific conductivity ranged from 44.0 to 60.5 µs/cm at Dolomite Road and from 58.1 to 118.0 µs/cm at Julienne Narrows throughout the deployment period (Figure 5).
- 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 3rd of July. This can be attributed to the rise in stage from a rainfall event. This occurs when an increased amount of water is introduced into the system and the amount of solids is diluted. Overall, conductivity increased at this station over the course of the 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.

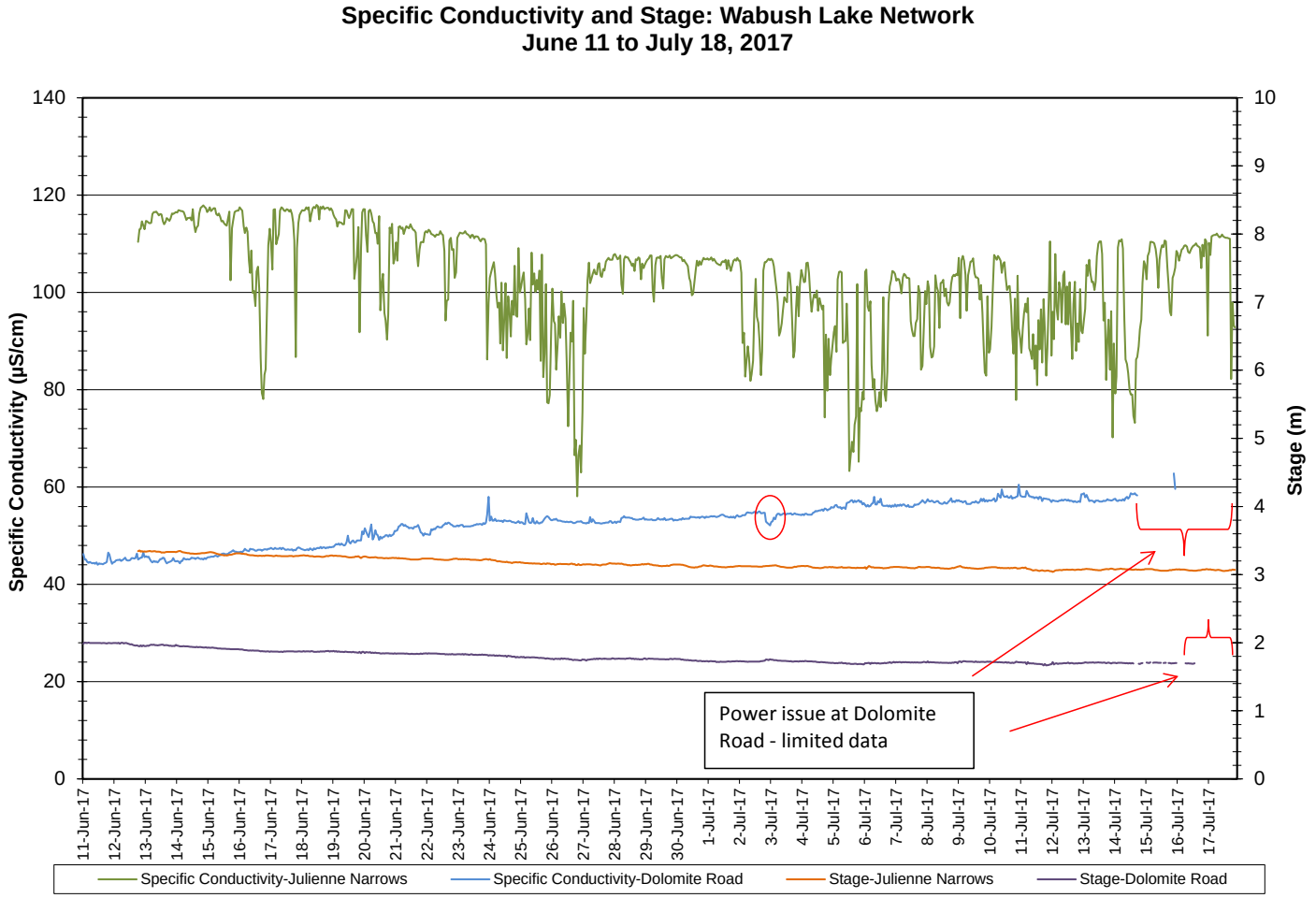

Figure 5: Specific conductivity – Wabush Lake network

- At the Dolomite Road station, the saturation of dissolved oxygen ranged from 85.3 to 100.8% while the dissolved oxygen content ranged from 8.96 to 10.26 mg/l with a median value of 9.47 mg/l (Figure 6).
- At the Julienne Narrows station, the saturation of dissolved oxygen ranged from 88.6 to 106.7% while the dizzolved oxygen content ranged from 8.92 to 10.92 mg/l with a median value of 9.99 mg/l (Figure 6).
- 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.
- Most 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 most values recorded at Dolomite Road were below the guideline. The guidelines are indicated in blue on Figure 6.
- Dissolved oxygen decreased at both stations over the course of this deployment period, as water warmed into summer. Dissolved oxygen fluctuated daily with decreases observed at night.

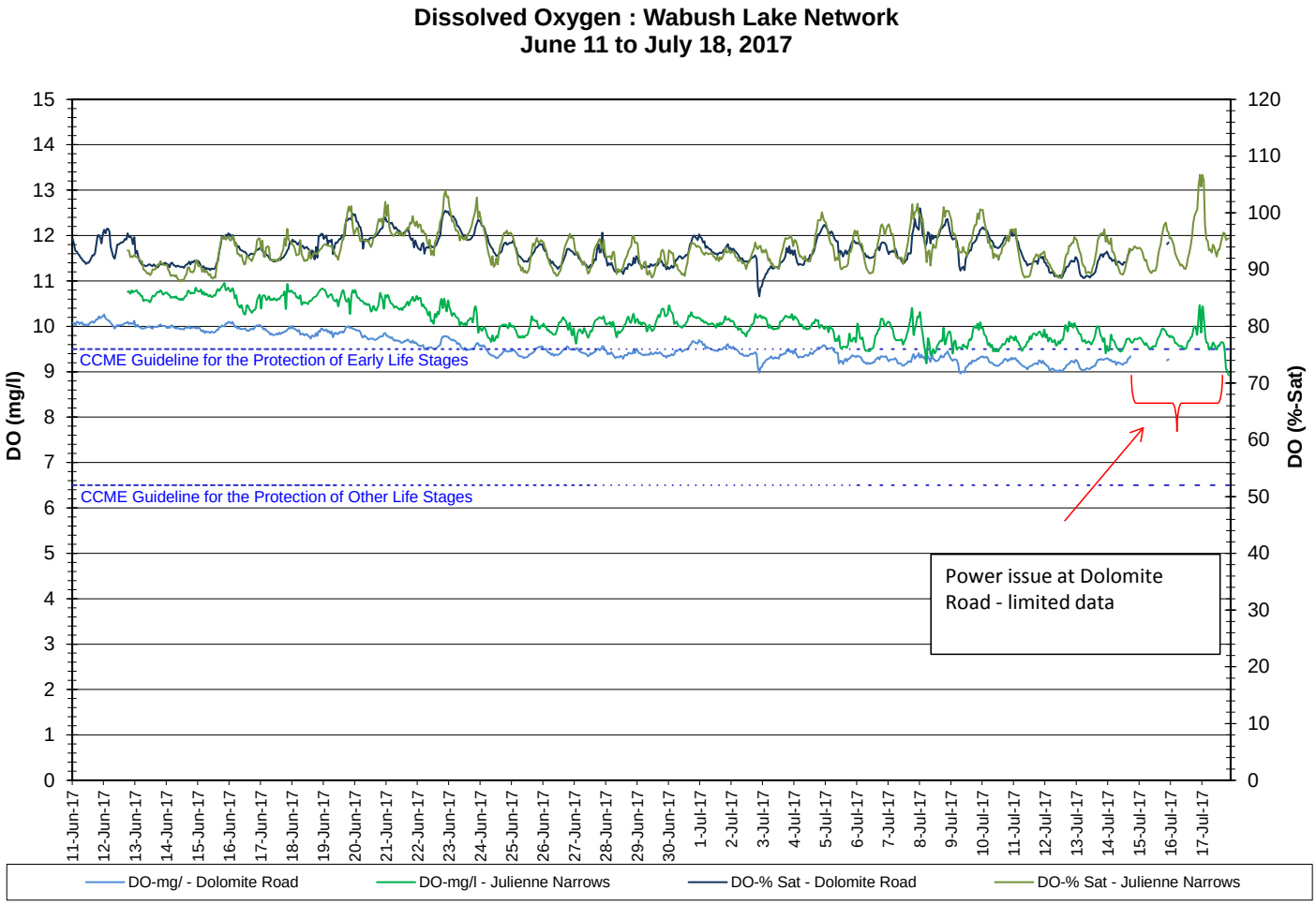

Figure 6: Dissolved oxygen and percent saturation – Wabush Lake Network

- At the Julienne Narrows station, turbidity values range from 0.0 to 134.4 NTU throughout the deployment period (Figure 7). The median value was 0.0 NTU.
- In some instances, turbidity spikes can be attributed to precipitation events. They are indicated on Figure 7 in red.

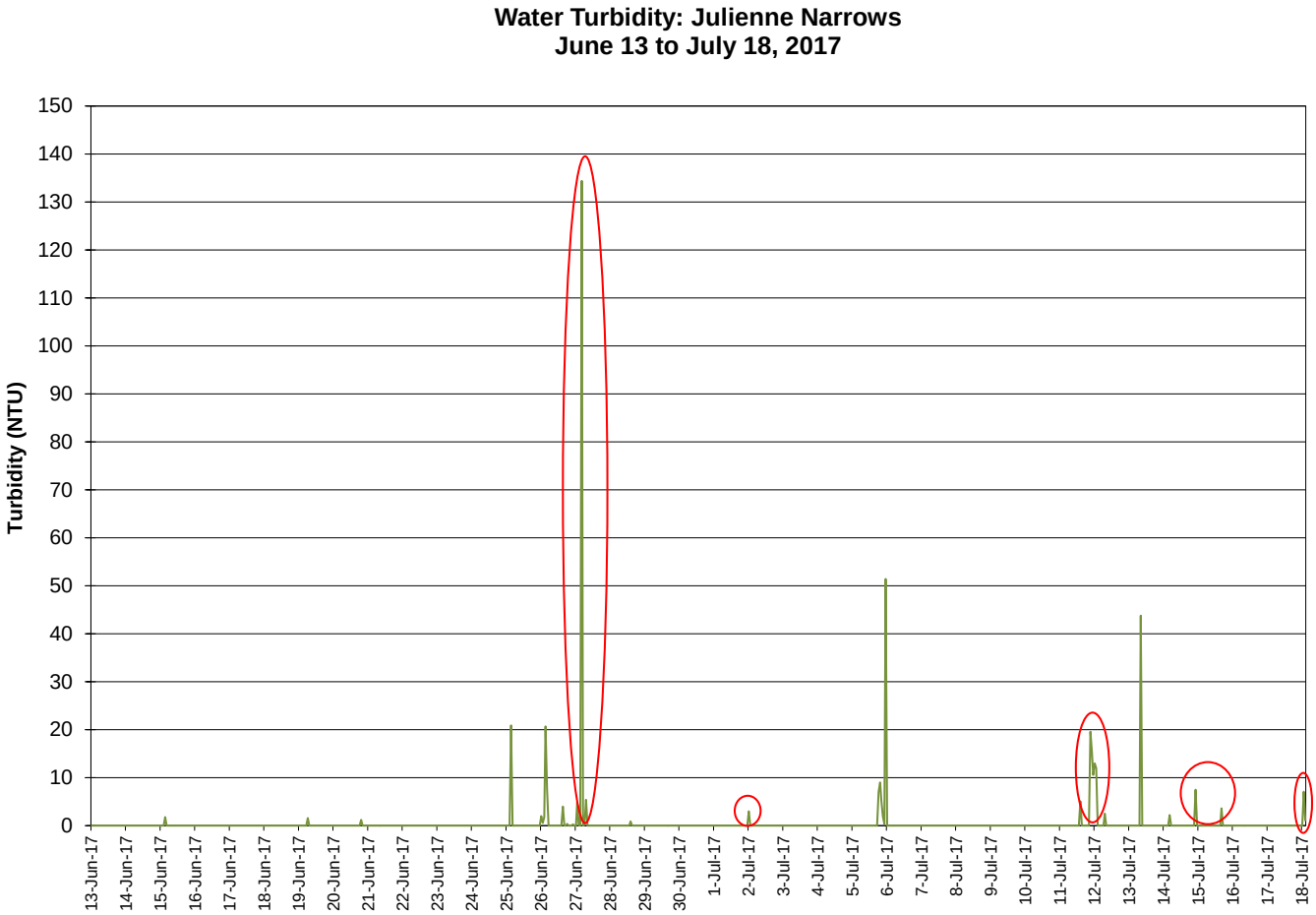

Figure 7: Turbidity – Julienne Narrows

- At the Dolomite Road station, turbidity values were 0.0 NTU throughout the deployment period (Figure 8).
- There was a power issue at this station during this deployment; a large portion of the turbidity data was removed.

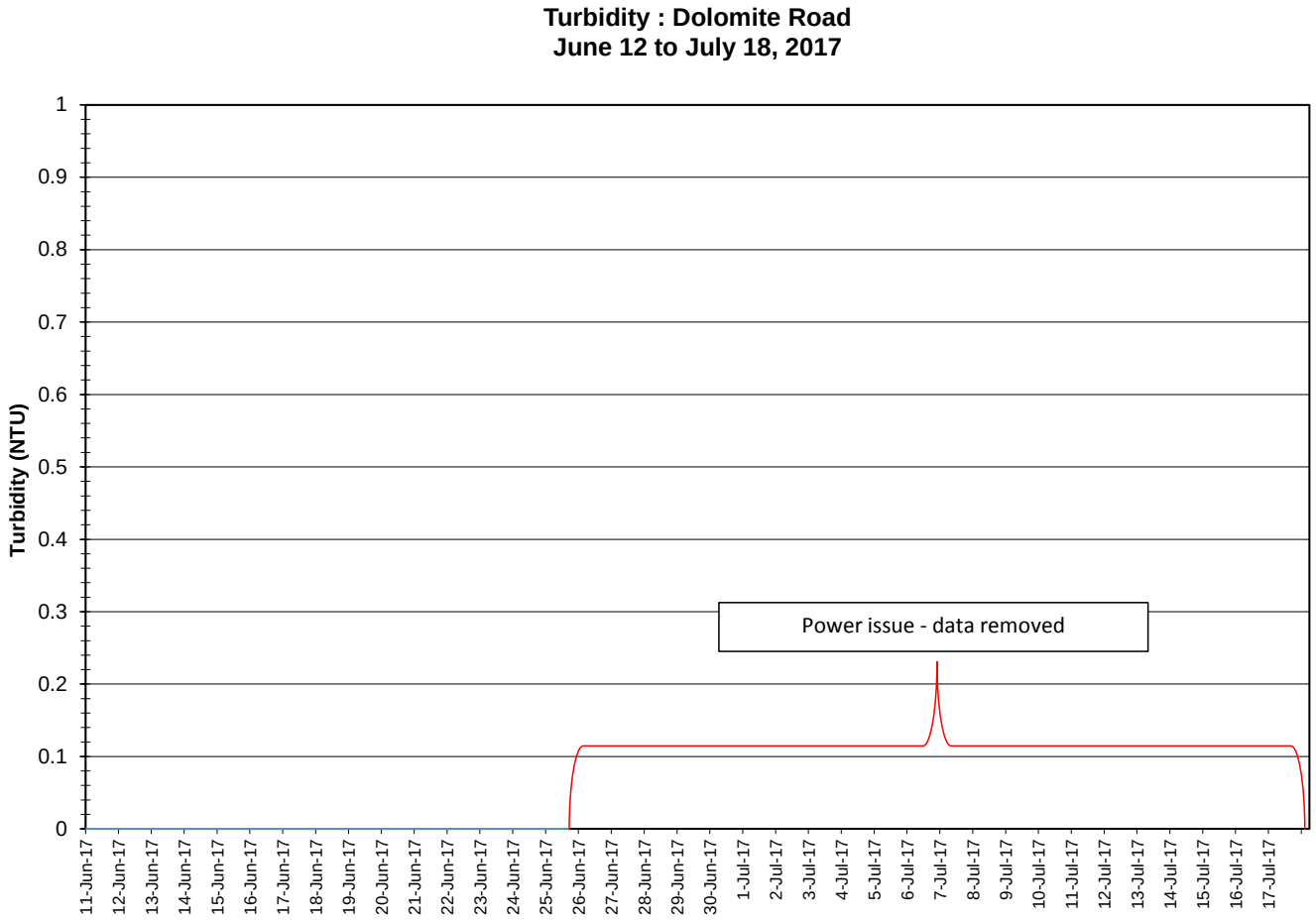

Figure 8: Turbidity – Dolomite Road

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Dolomite Road (Figure 9).
- Overall, stage decreases throughout the deployment period with precipitation events causing periodic increases in stage.
- 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.

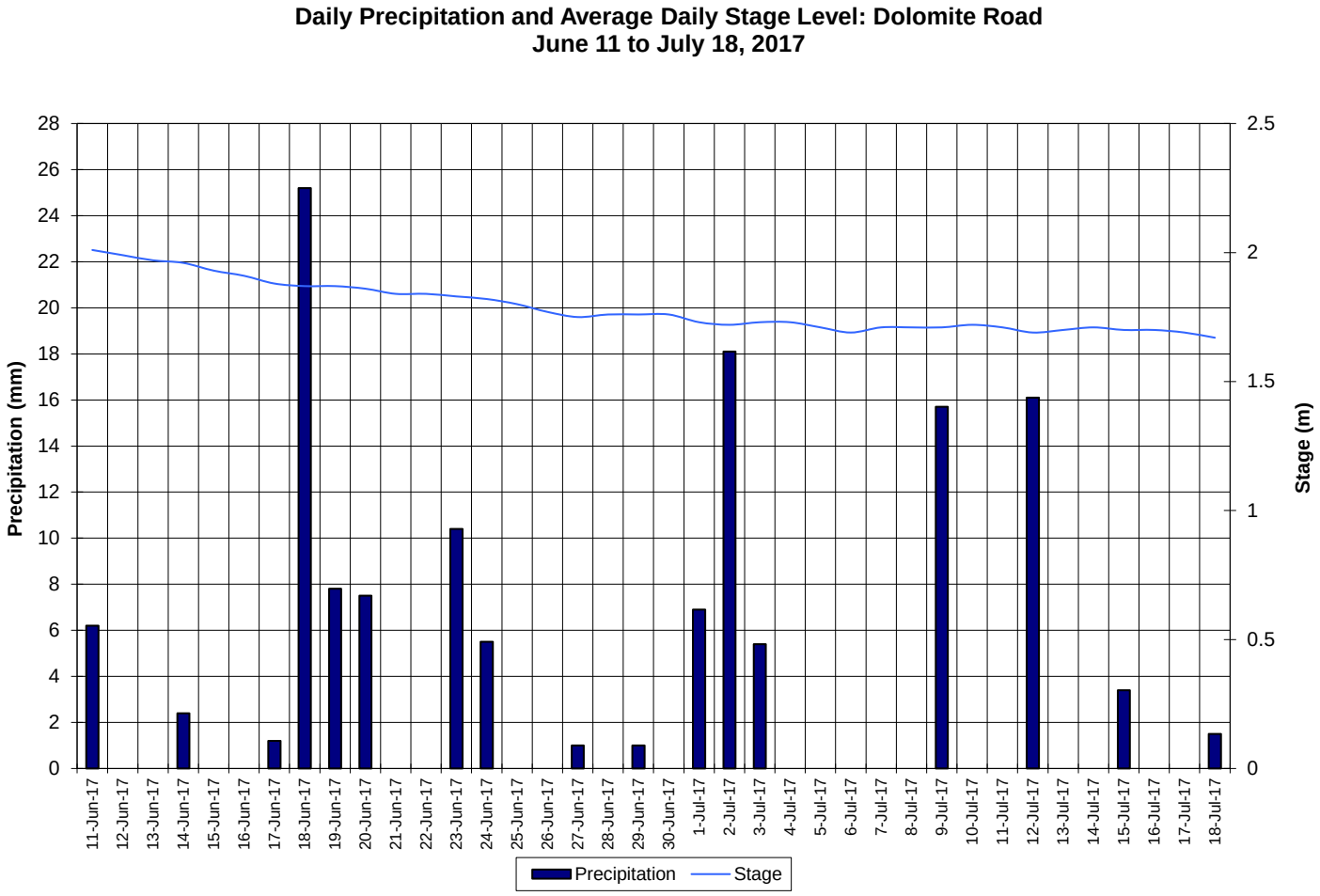

Figure 9: Precipitation and Stage –Dolomite Road

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Julienne Narrows (Figure 10).
- Overall, stage decreased throughout the deployment period, with precipitation events causing periodic increases in stage.
- There was a correction in stage by EC during the beginning of the deployment period. It is identified on Figure 10 in red.
- 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.

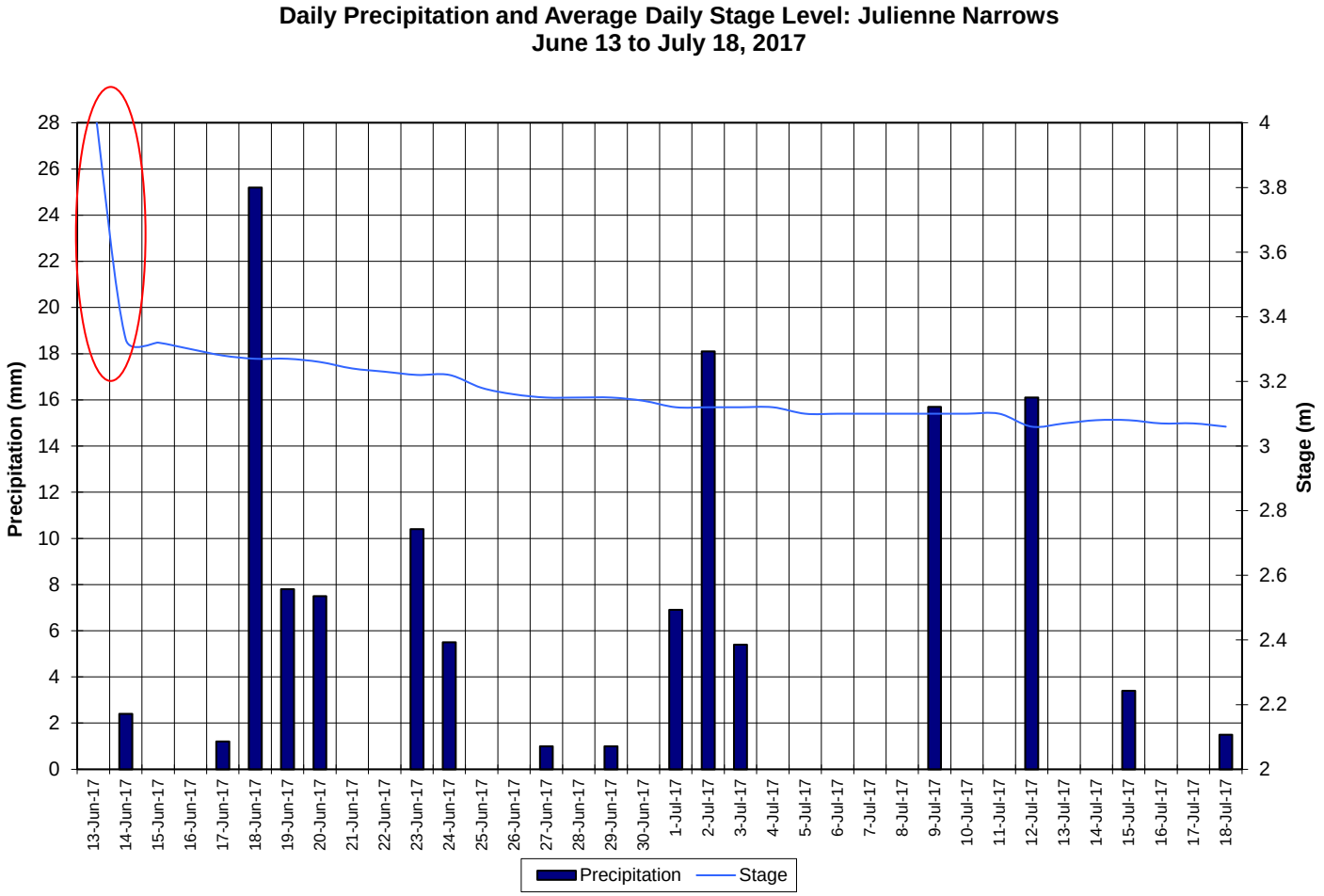

Figure 10: Precipitation and Stage –Julienne Narrows

Dumbell Stream

- Water temperature ranged from 2.01 to 7.22°C during this deployment period (Figure 11).
- Water temperature generally fluctuated within this range for the deployment period. This area is very shaded. Temperature did not correspond with increasing ambient air temperature (Figure 12).

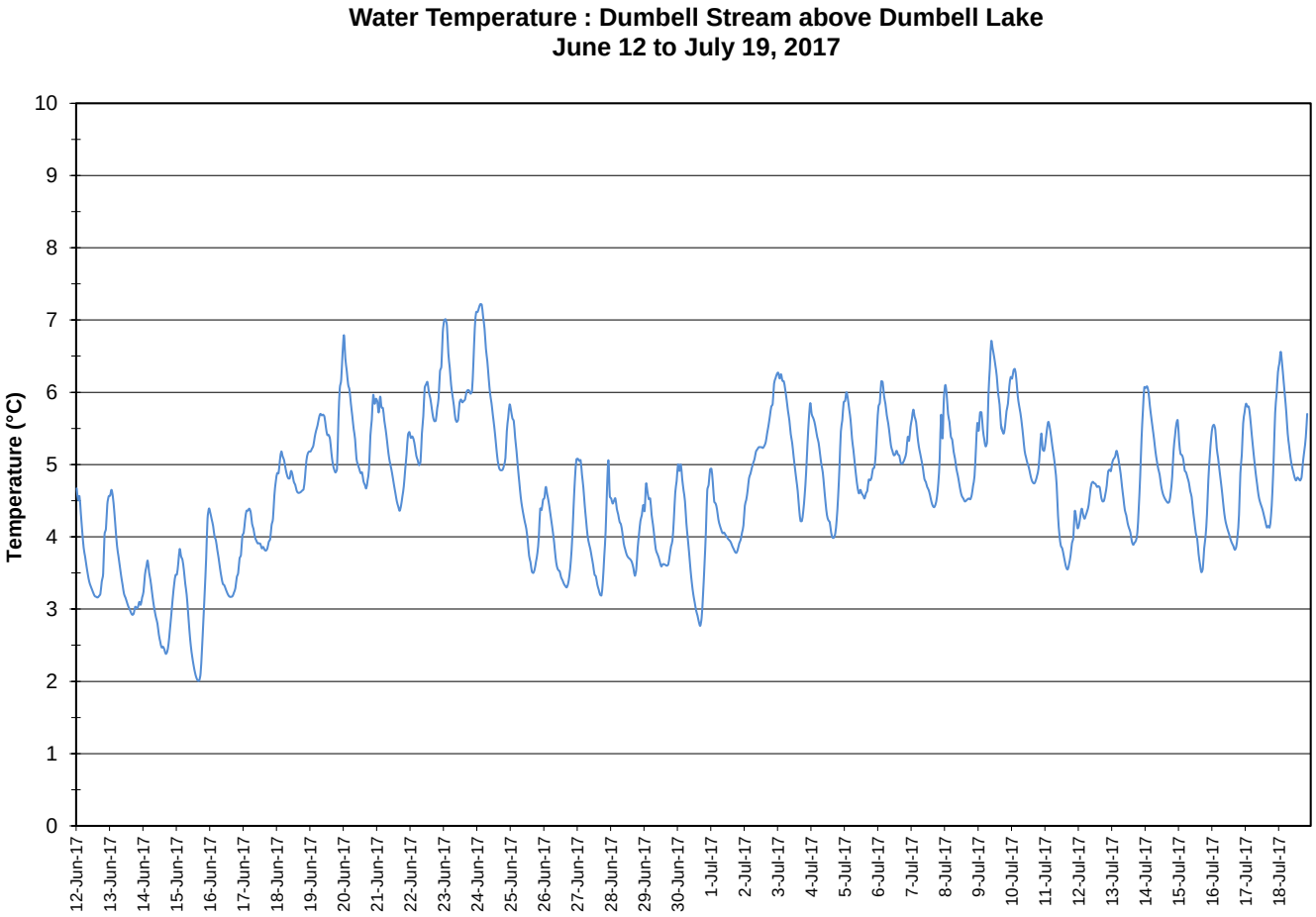

Figure 11: Water Temperature – Dumbell Stream

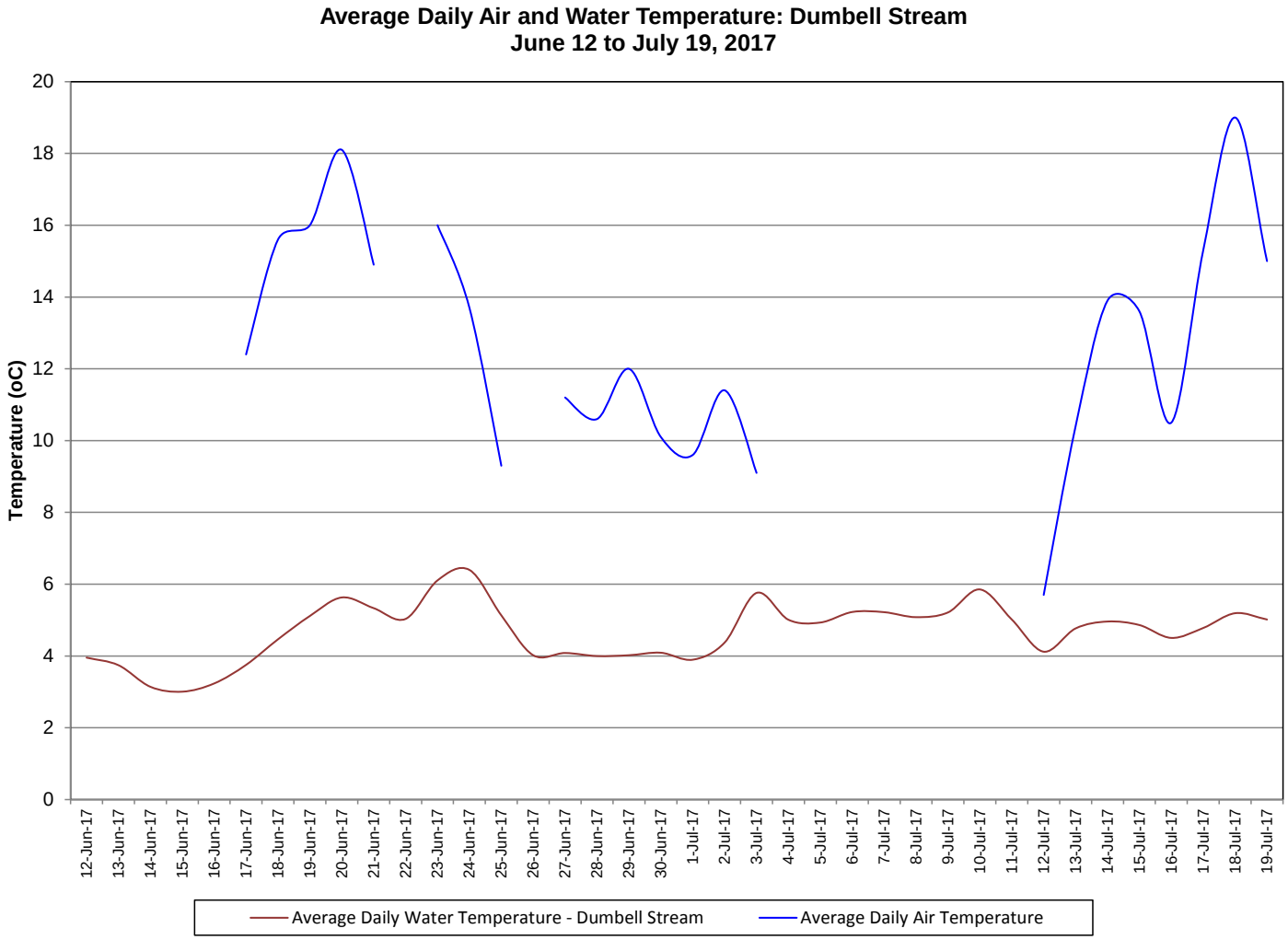

Figure 12: Average daily air and water temperatures – Dumbell Stream

- pH ranged from 7.45 to 7.72 pH units (Figure 13). The median pH was 7.60.
- 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.

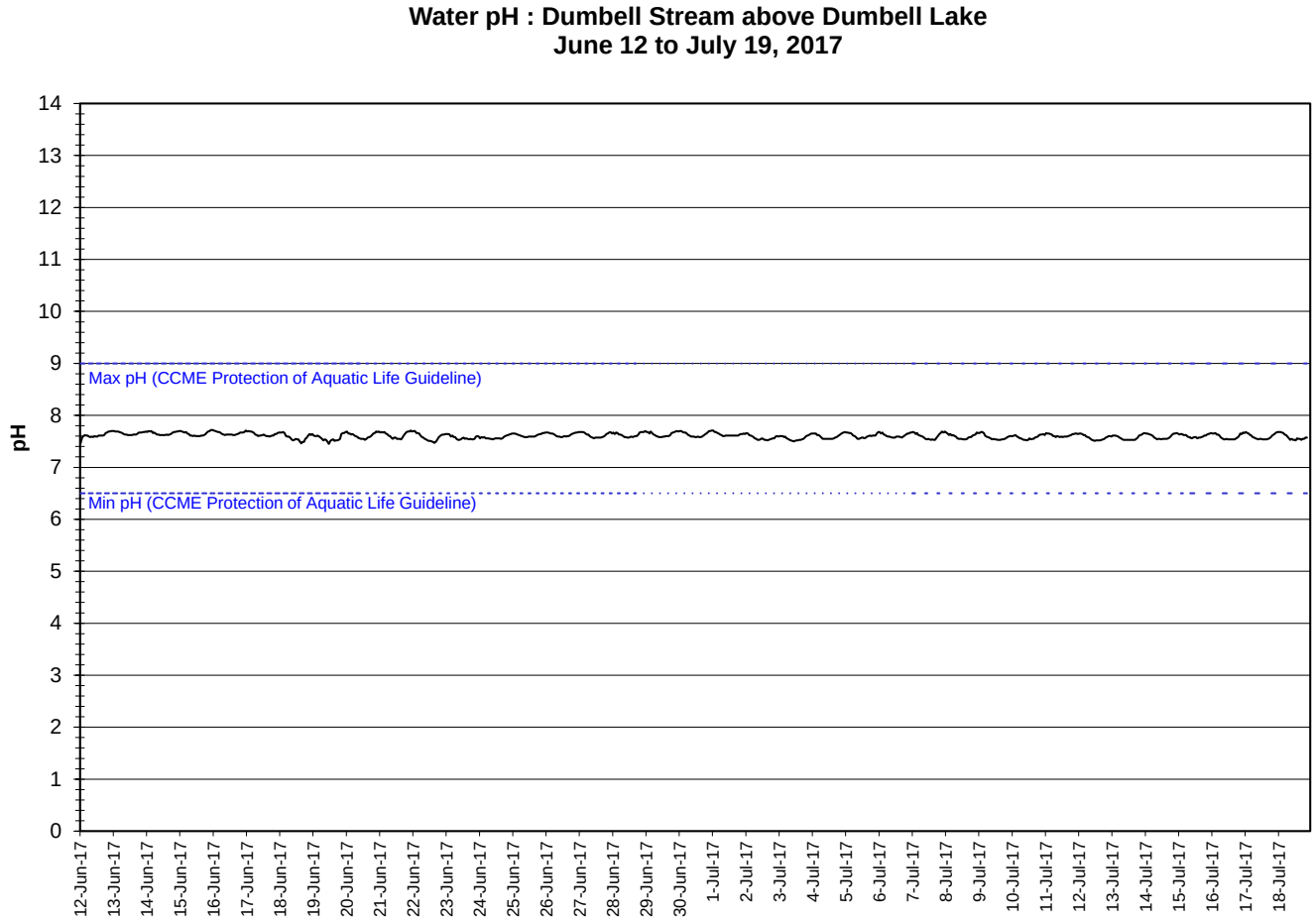

Figure 13: Water pH – Dumbell Stream

- Specific conductivity ranged from 53.5 to 70.9 µs/cm, throughout the deployment period (Figure 14).
- 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.

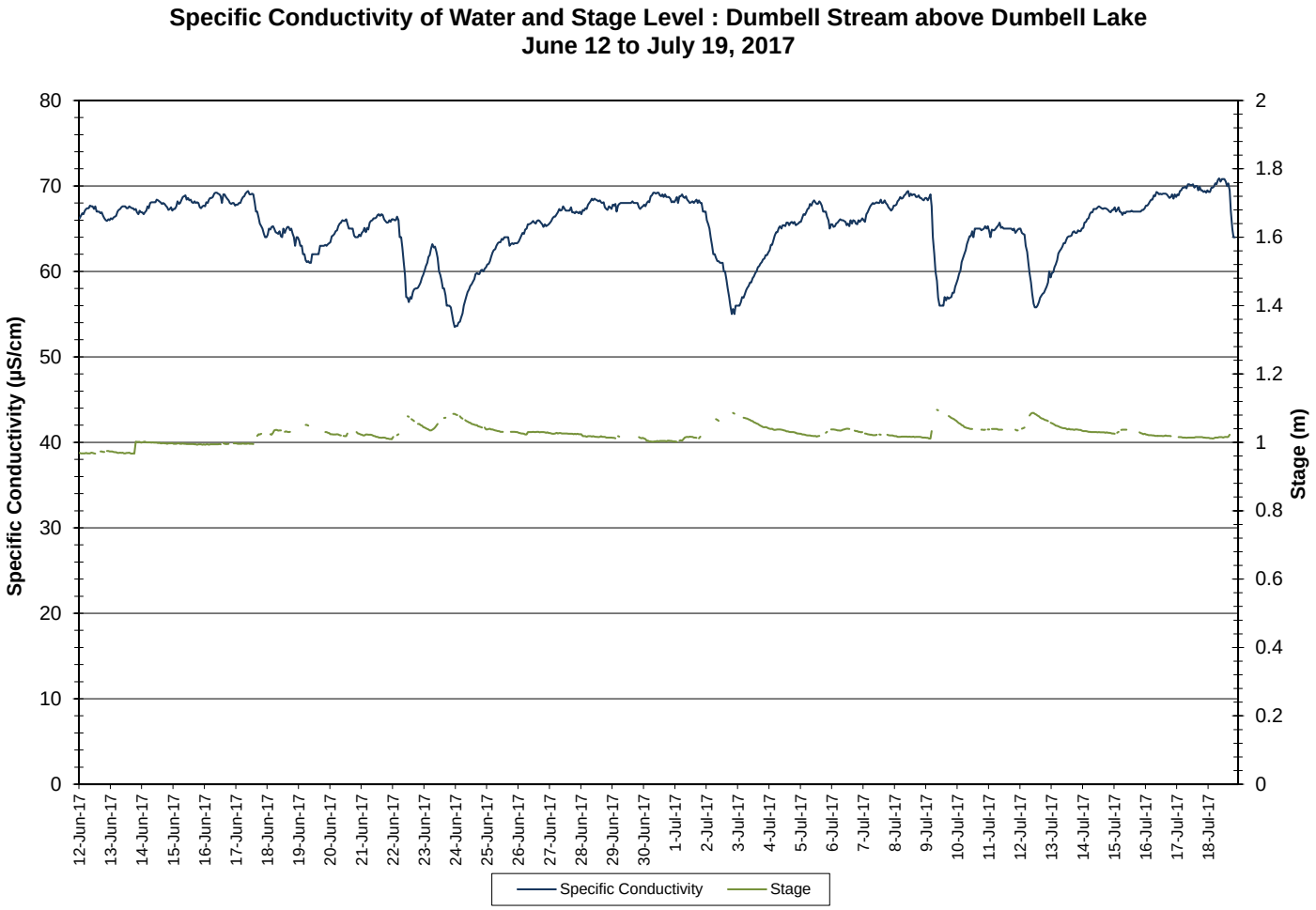

Figure 14: Specific Conductivity – Dumbell Stream

- The saturation of dissolved oxygen ranged from 87.1 to 90.5% while the dissolved oxygen content ranged from 10.43 to 12.19 mg/l with a median value of 11.22 mg/l (Figure 15).
- 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/. The guidelines are indicated in blue on Figure 15.
- Dissolved oxygen fluctuated daily with decreases observed at night.

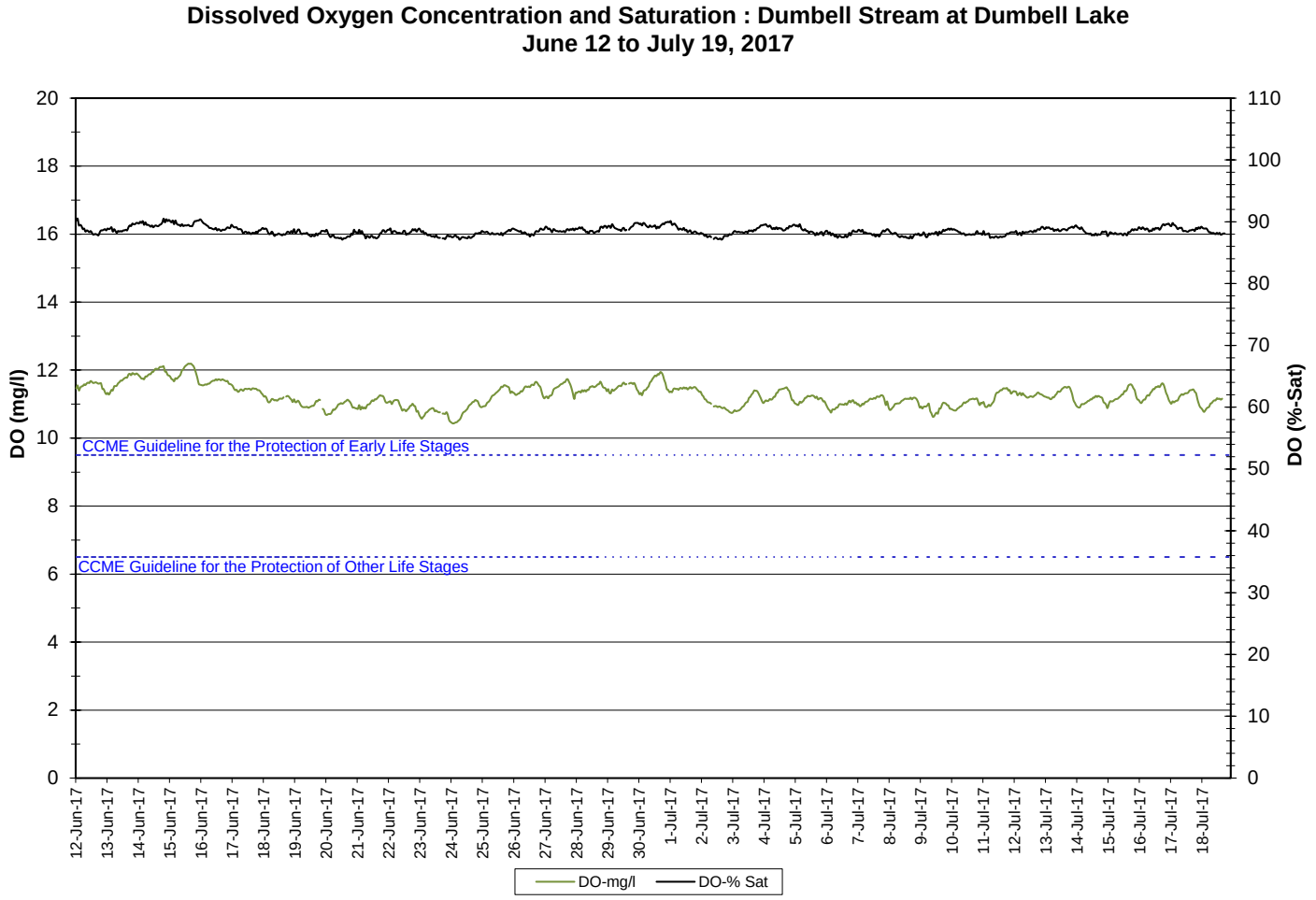

Figure 15: Dissolved Oxygen – Dumbell Stream

- Turbidity values range from 0.0 to 107.6 NTU throughout the deployment period (Figure 16). The median value was 0.0 NTU.
- In some instances, turbidity spikes can be attributed to precipitation events. They are indicated on the Figure 16 in red.

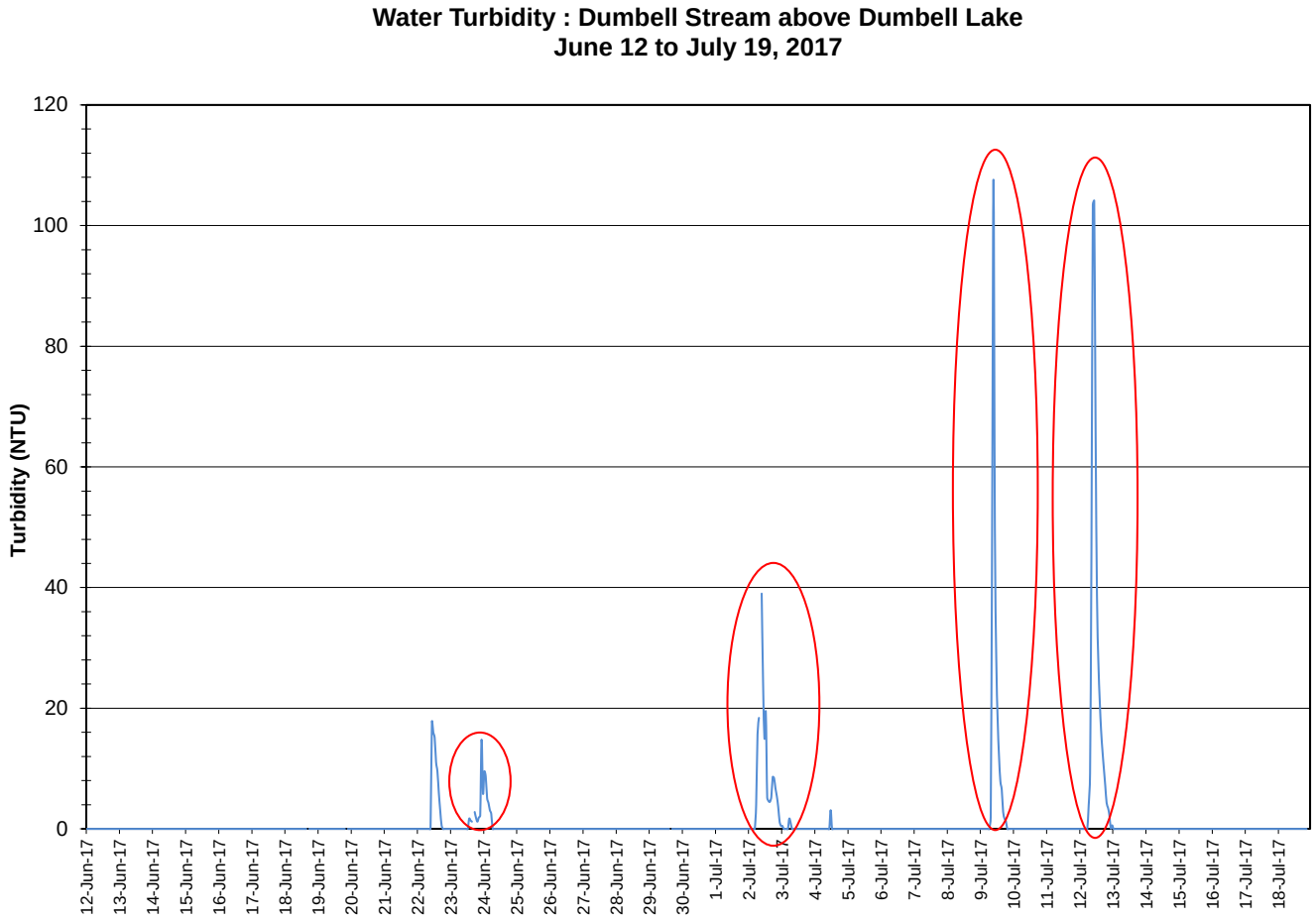

Figure 16: Turbidity – Dumbell Stream

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Dumbell Stream (Figure 17).
- Overall, stage is relatively stable throughout the deployment period, with precipitation events causing periodic increases in stage.
- 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.

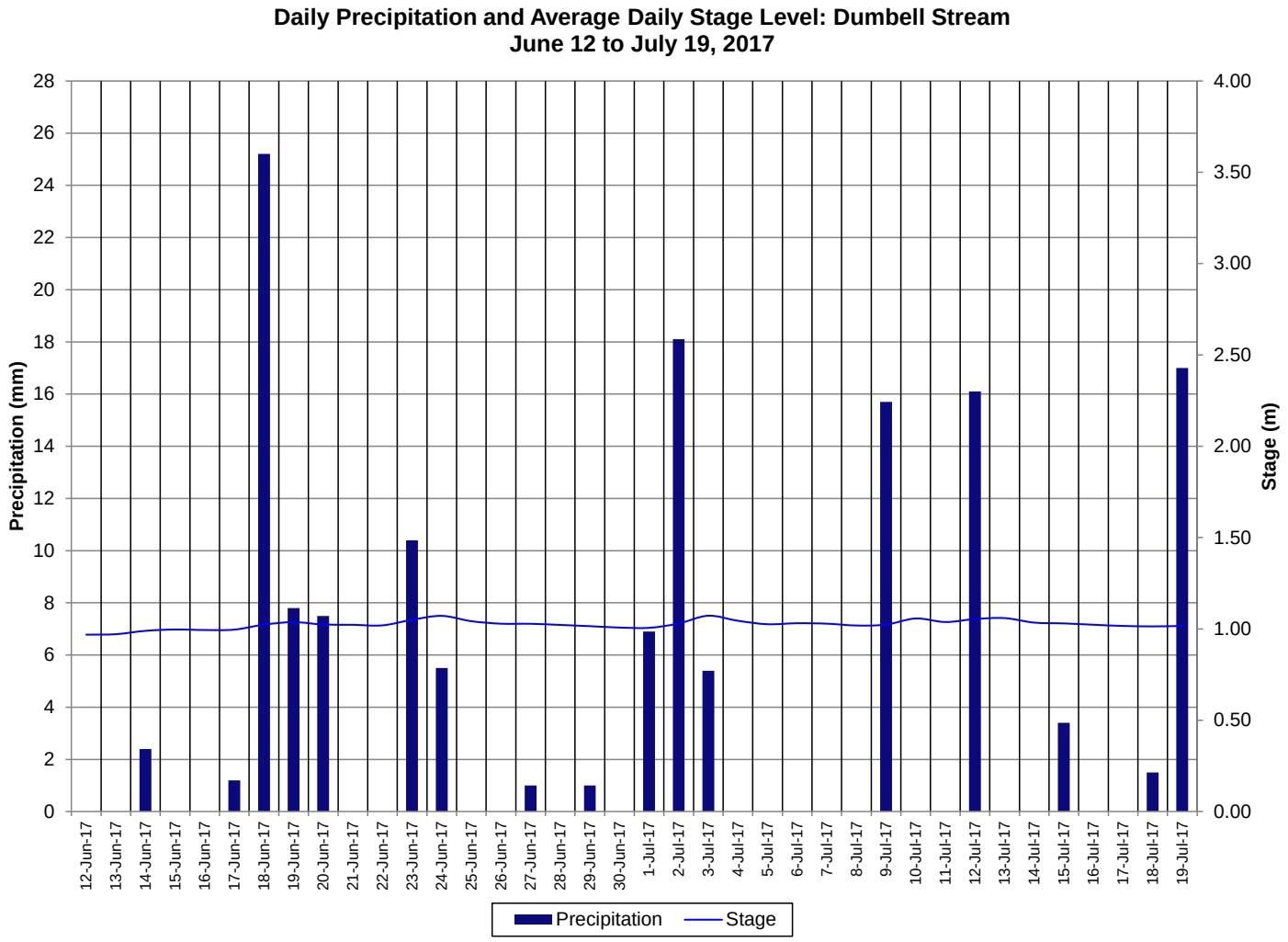

Figure 17: Precipitation and Stage –Dumbell Stream

Pumphouse Stream

- Water temperature ranged from 7.40 to 18.10^{o}C during this deployment period (Figure 18).
- Water temperature increased over the course of this deployment period, corresponding to increasing ambient air temperatures into summer (Figure 19).

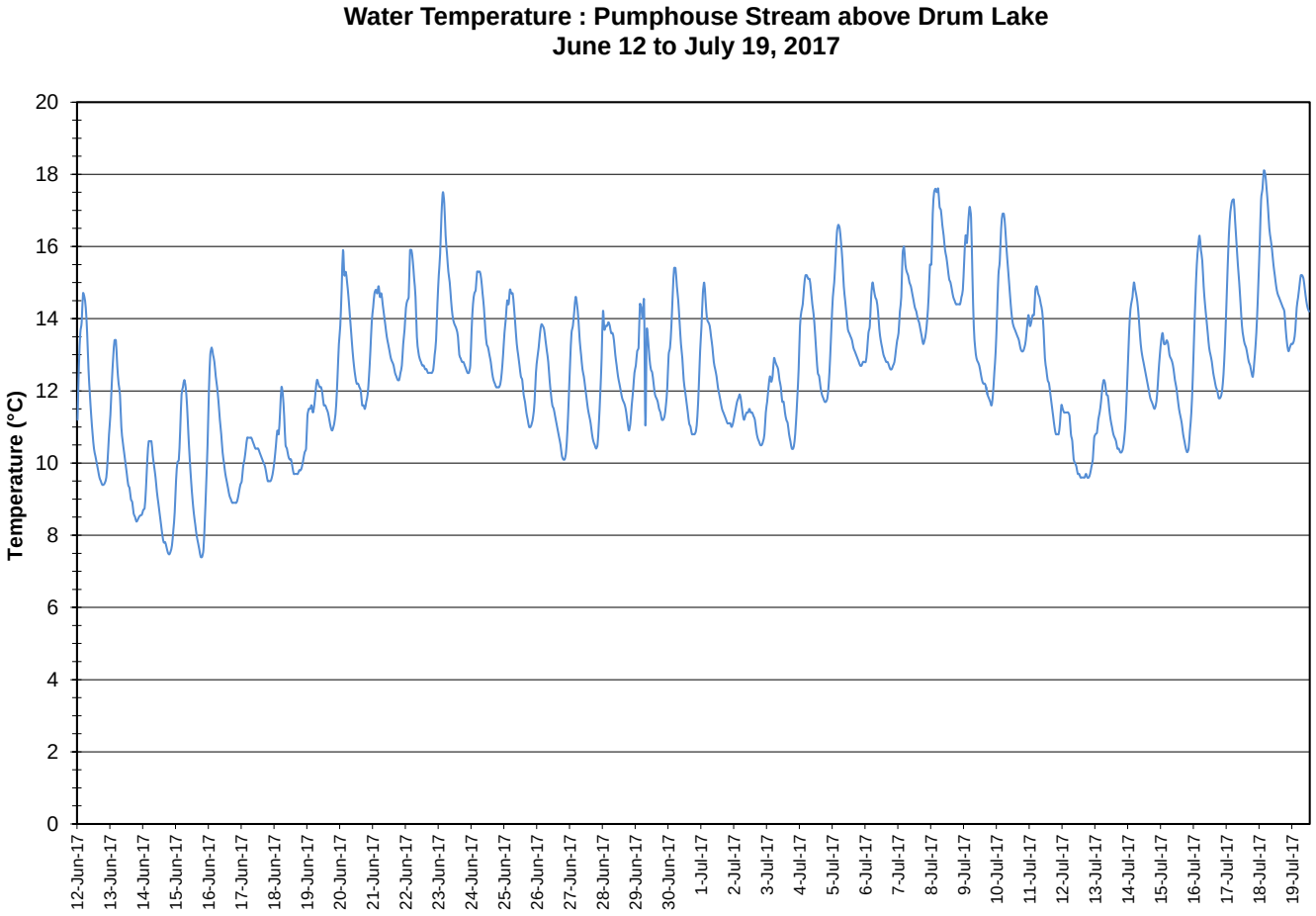

Figure 18: Water Temperature – Pumphouse Stream

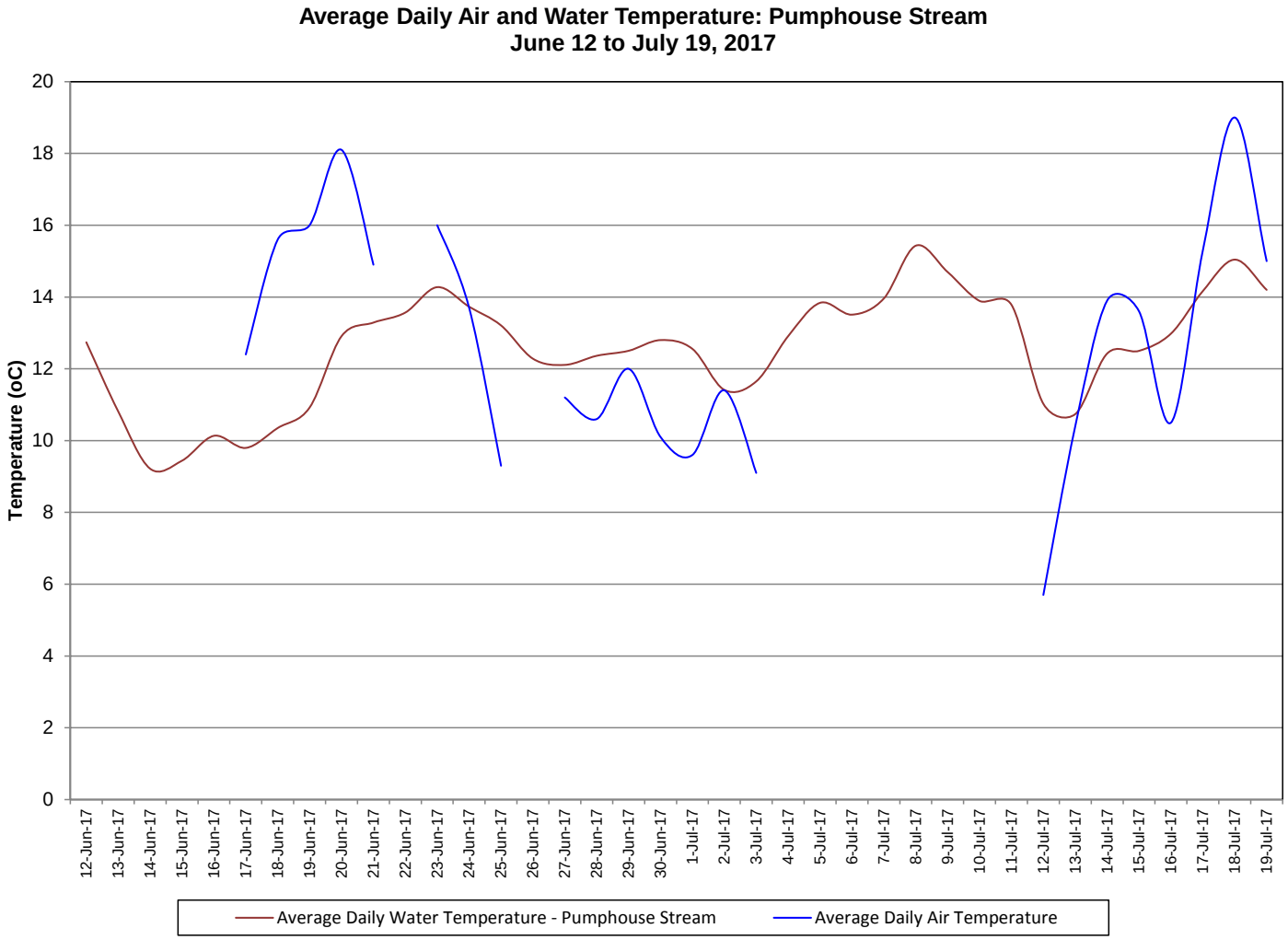

Figure 19: Average daily air and water temperatures – Pumphouse Stream

- pH ranged from 7.29 to 7.48 pH units (Figure 20). The median pH was 7.41.
- A large portion of this data was removed due to sensor drift.
- 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.

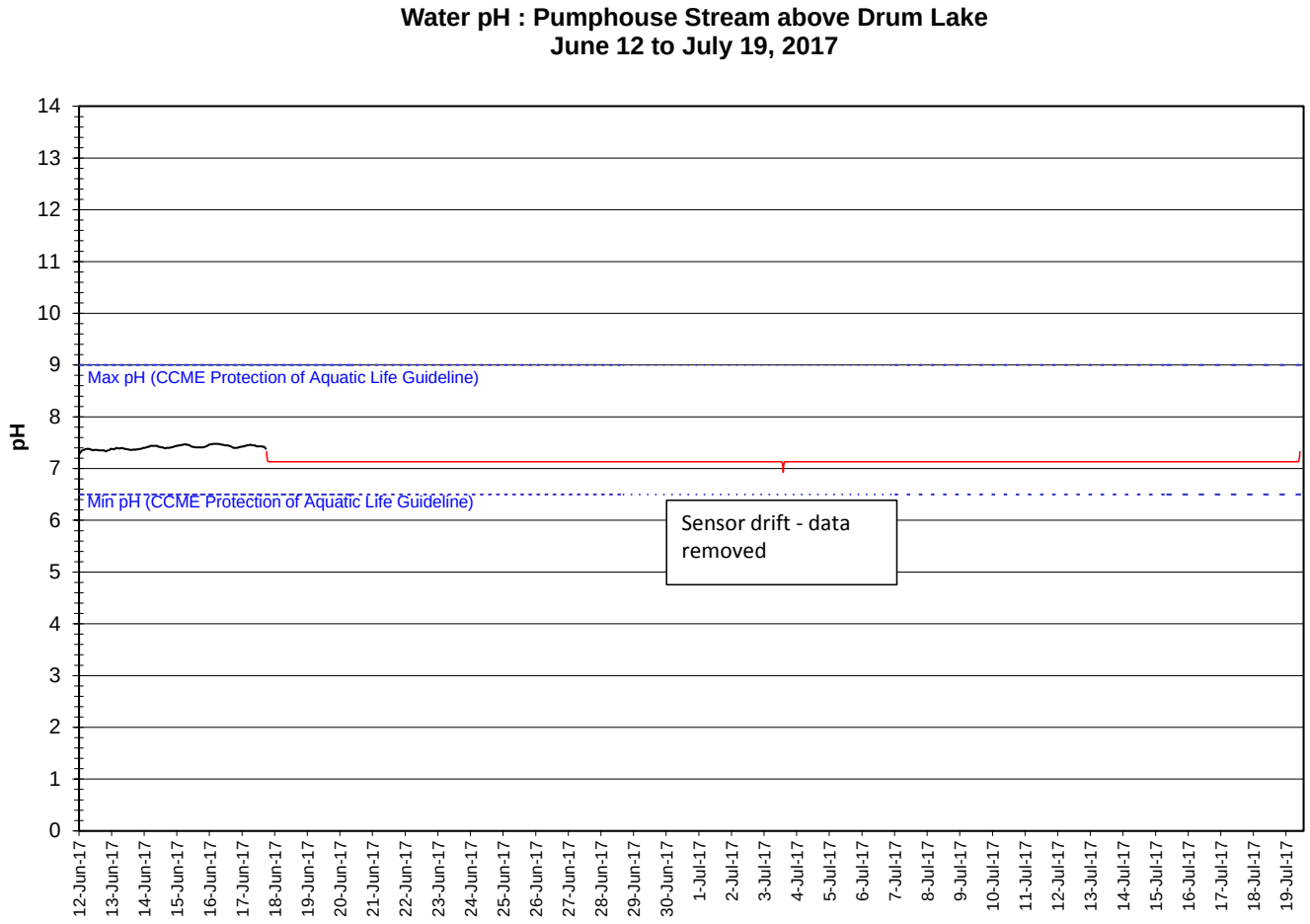

Figure 20: Water pH – Pumphouse Stream

- Specific conductivity ranged from 55.1 to 91.1 µs/cm, throughout the deployment period (Figure 21).
- 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.

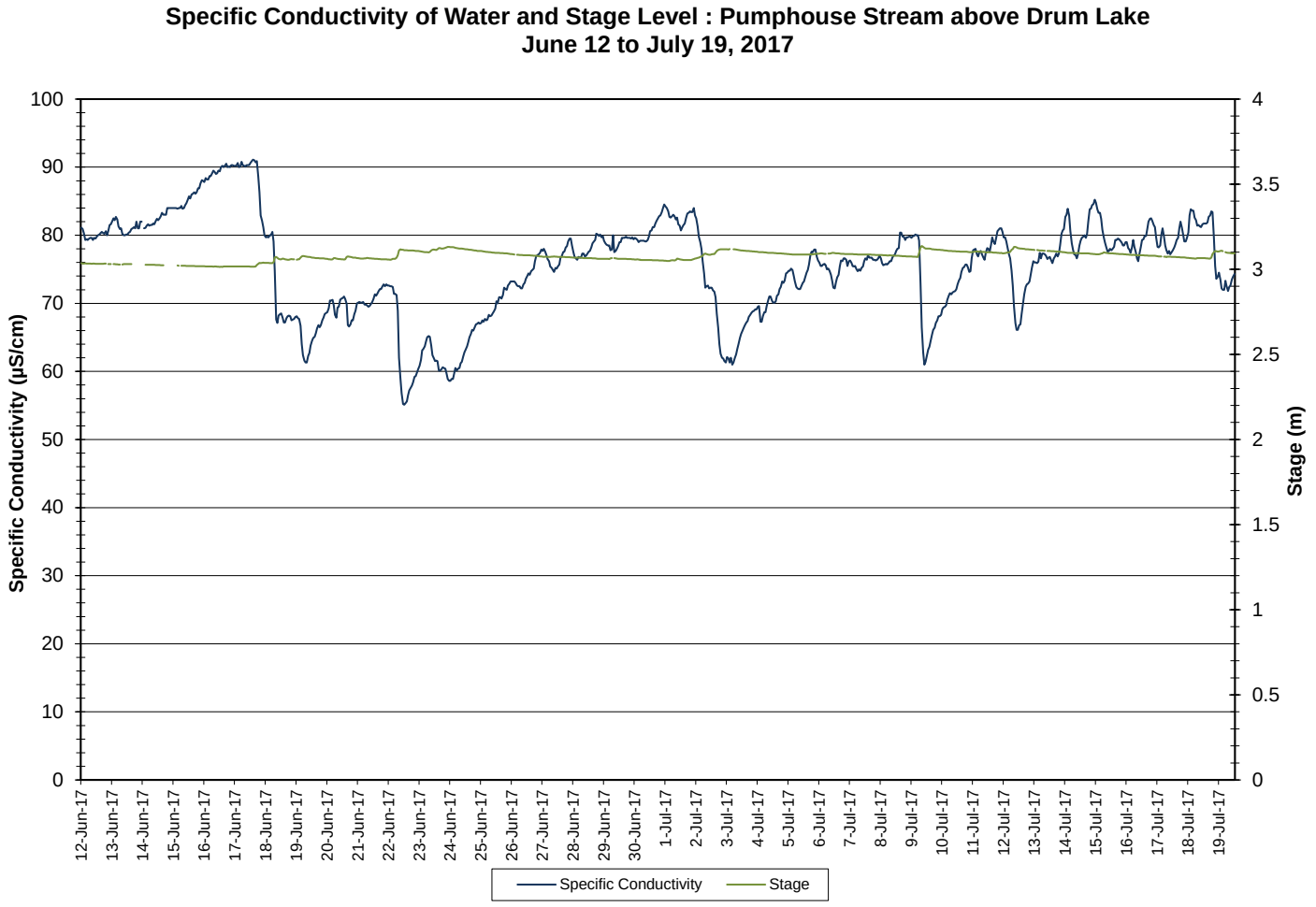

Figure 21: Specific Conductivity – Pumphouse Stream

- The saturation of dissolved oxygen ranged from 73.4 to 89.4% while the dissolved oxygen ranged from 7.68 to 9.62 mg/l with a median value of 8.54 mg/l (Figure 22).
- 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. Almost all values were below the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota of Early Life Stages of 9.5 mg/. The guidelines are indicated in blue on Figure 22.
- Dissolved oxygen fluctuated daily with decreases observed at night.

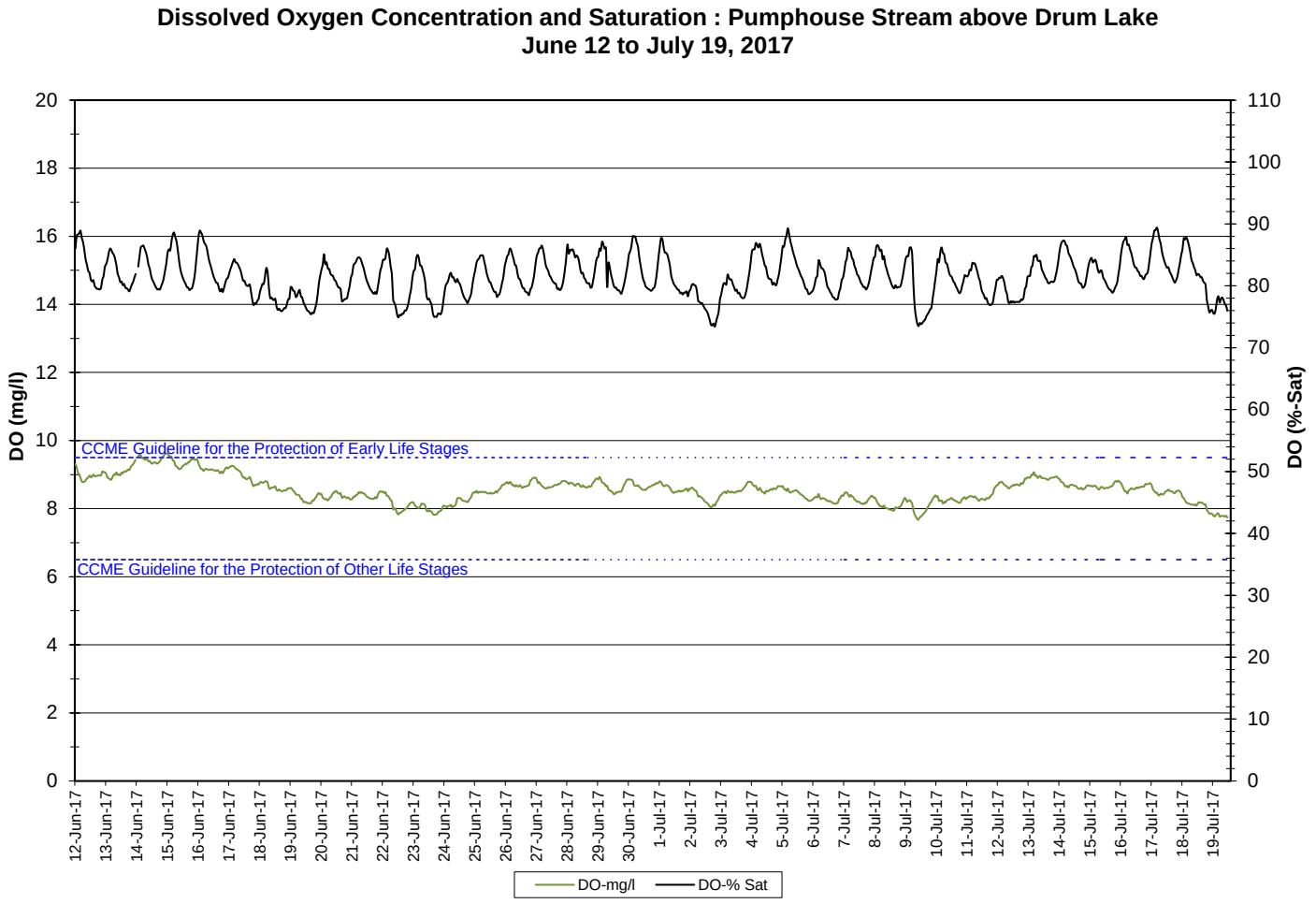

Figure 22: Dissolved Oxygen – Pumphouse Stream

- Turbidity values range from 0.0 to 262 NTU throughout the deployment period (Figure 23). The median value was 0.0 NTU.
- In some instances, turbidity spikes can be attributed to precipitation events. They are indicated on Figure 23 in red.

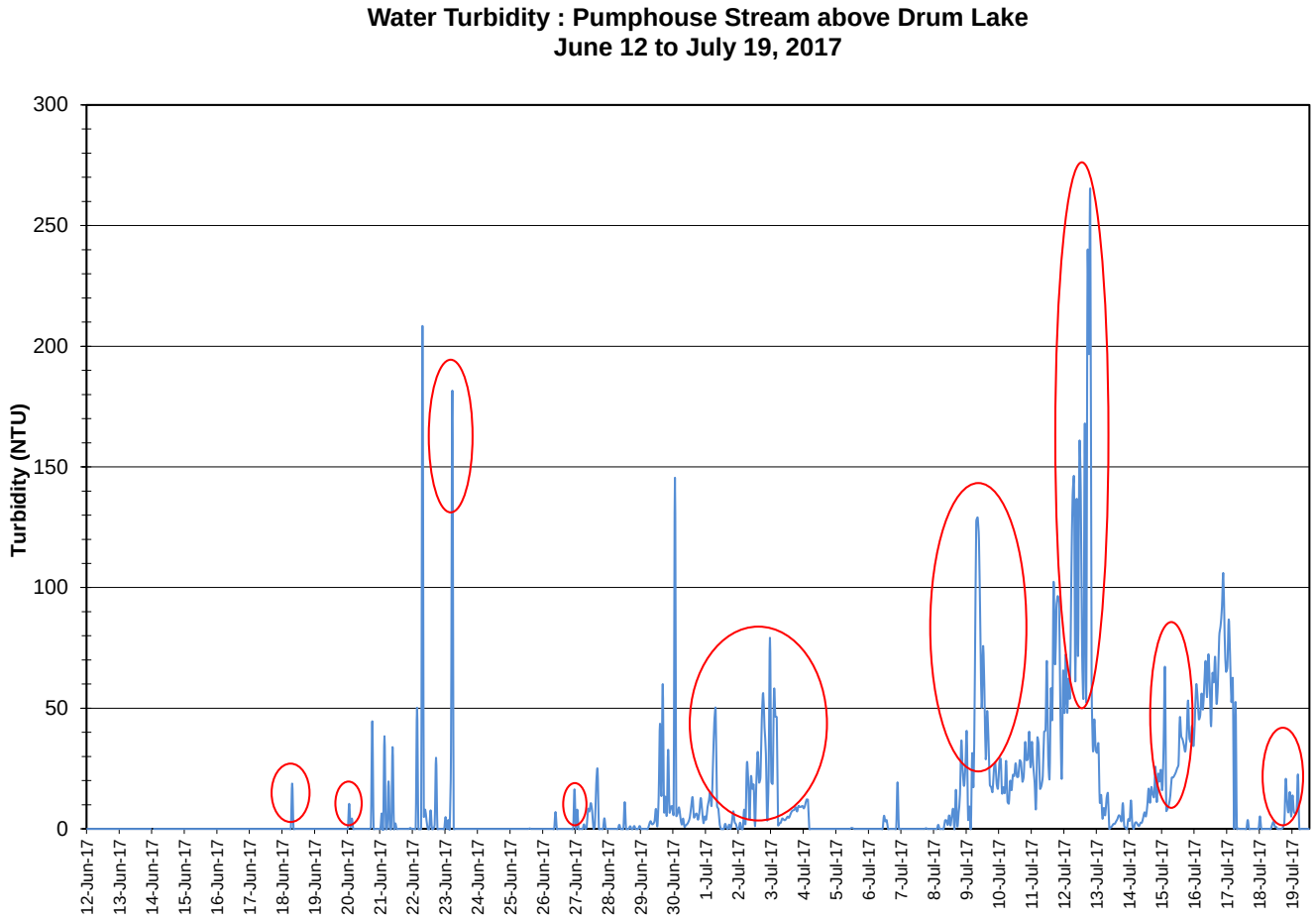

Figure 23: Turbidity – Pumphouse Stream

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Dumbell Stream (Figure 24).
- Stage increases slightly after the first week of the deployment period, and is then relatively stable for the remainder of the deployment period, with precipitation events causing periodic increases in stage.
- 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.

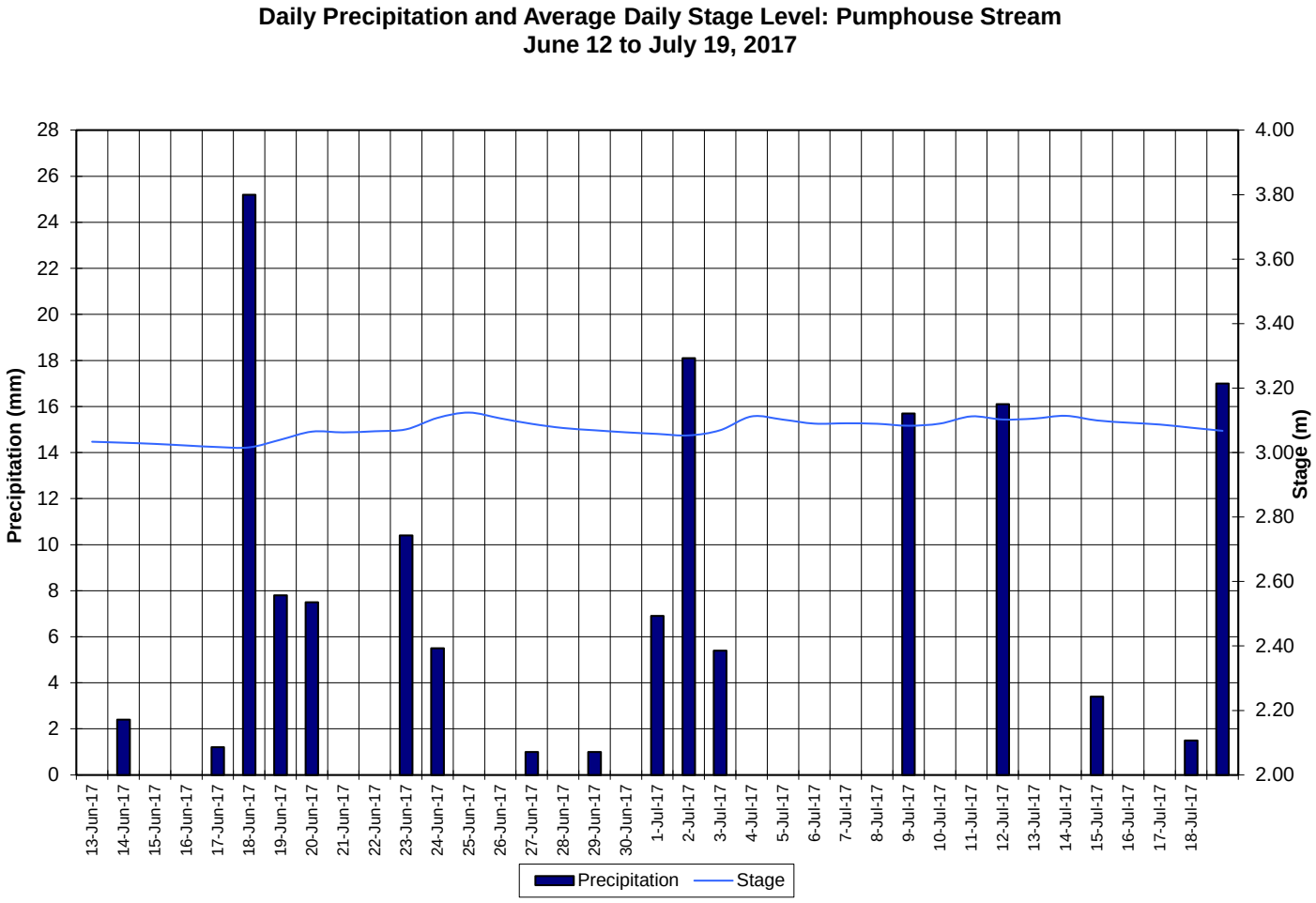

Figure 24: Precipitation and Stage –Pumphouse Stream

Conclusions

- Instruments were deployed starting June 11th and removed by July 19th, 2017.
- 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 Julienne Narrows, Dolomite Road and Pumphouse Stream. The temperature typically ranged between 7.40 and 18.50^{o} C, at these three stations, while Dumbell ranged lower at 2.01 to 7.22 ^{o}C.
- pH values were all within the recommended CCME Guidelines for the Protection of Aquatic Life. pH ranged between 7.29 and 8.28. Fluctuations were noted between day and night. There was a noticeable decrease in pH on the 3rd of July at Dolomite Road 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 44.0 µs/cm to 118.0 µs/cm at the Wabush Lake stations, 53.5 to 70.9 µs/cm at Dumbell Stream and 55.1 to 91.1 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, Dolomite Road and Pumphouse Stream were generally below the guideline while Julienne Narrows was generally above the guideline. All values from Dumbell Stream were above the 9.5 mg/L guideline.
- Turbidity at Dolomite Road remained at 0.0 NTU for entire deployment period. A large portion of data was removed from the Dolomite Road dataset, as the sensor malfunctioned. The median value was 0.0 NTU. Turbidity values at Julienne Narrows were higher than at Dolomite Road with a few large spikes.
- Turbidity at Dumbell Stream remained at 0.0 NTU for the majority of the deployment period. There were a few spikes during the deployment period which can be attributed to precipitation. The median value was 0.0 NTU.
- Turbidity at Pumphouse Stream had some high spikes. Several can be attributed to precipitation events. The median value was 0.0 NTU.
- Stage decreased at Dolomite Road and Julienne Narrows during this deployment period, and was stable at Dumbell Stream. At Pumphouse Stream, stage increased slightly after the first week of the deployment period before remaining stable for the remainder of the 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.

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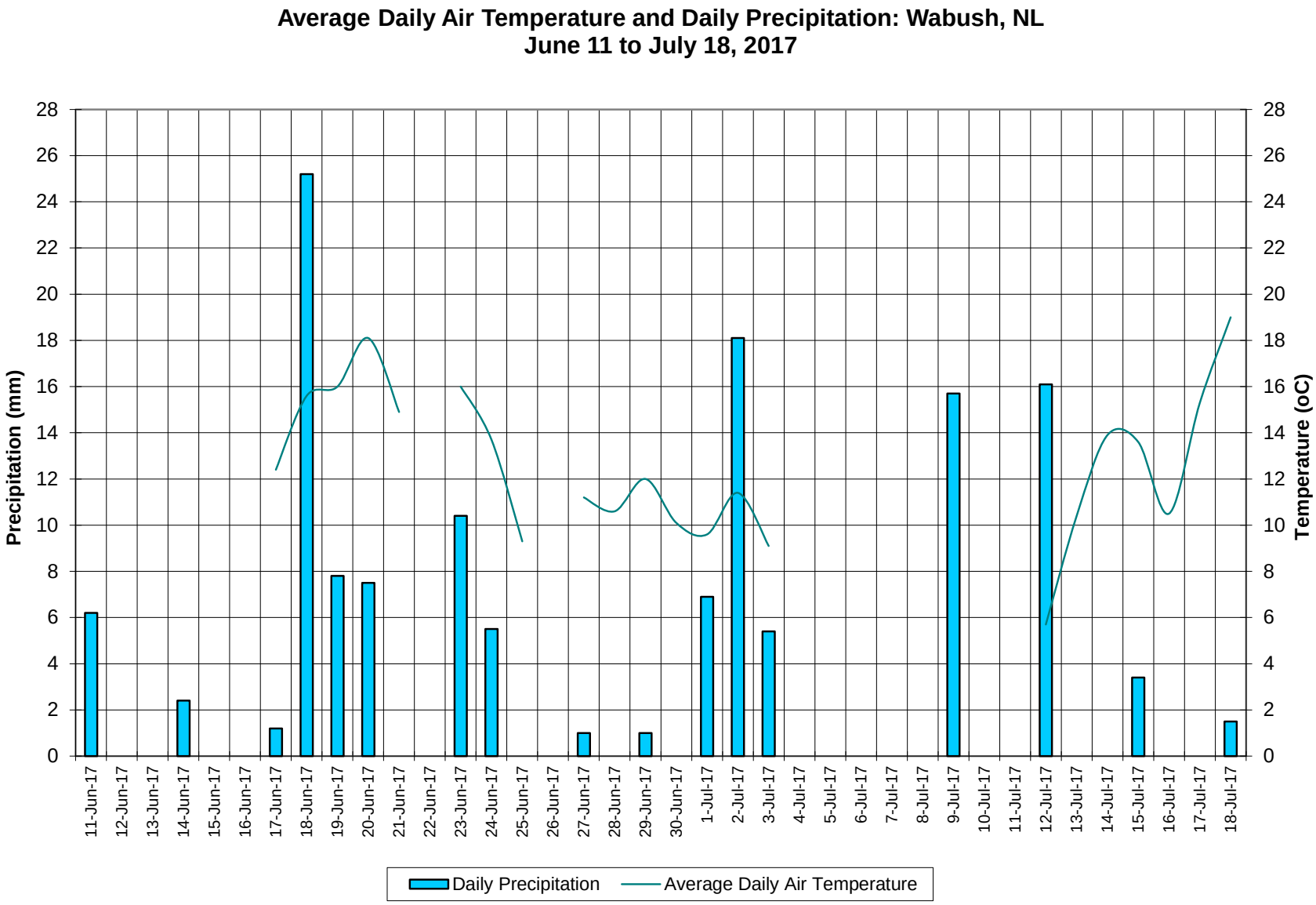
Appendix 1


Average Daily Air Temperature and Daily Precipitation: Wabush, NL
June 11 to July 18, 2017
Precipitation (mm)
Temperature (oC)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
11-Jun-17
12-Jun-17
13-Jun-17
14-Jun-17
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29-Jun-17
30-Jun-17
1-Jul-17
2-Jul-17
3-Jul-17
4-Jul-17
5-Jul-17
6-Jul-17
7-Jul-17
8-Jul-17
9-Jul-17
10-Jul-17
11-Jul-17
12-Jul-17
13-Jul-17
14-Jul-17
15-Jul-17
16-Jul-17
17-Jul-17
18-Jul-17
Daily Precipitation
Average Daily Air Temperature

Appendix 2 - Photos

Photo 1: First deployment at Pumphouse Stream

Photo 2: New hut at Pumphouse Stream